INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ENGLISH FOR COMMUNICATION**				
Course Code	AHS001				
Program	B. Tech				
Semester	I				
Course Type	Foundation				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	2	1
Course Coordinator	Dr. Jetty Wilson, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

II COURSE OVERVIEW:

The principle aim of the course is that the students will have awareness about the importance of English language in the contemporary times and also it emphasizes the students to learn this language as a skill (listening skill, speaking skill, reading skill and writing skill). Moreover, the course benefits the students how to solve their day-to-day problems in speaking English language. Besides, it assists the students to reduce the mother tongue influence and acquire the knowledge of neutral accent. The course provides theoretical and practical knowledge of English language and it enables students to participate in debates about informative, persuasive, didactic, and commercial purposes.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
English	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	LCD / PPT	x	Chalk & Talk	x	Assignments	x	MOOC
✓	Open Ended Experiments	✓	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could

be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
30 %	Understand
60 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

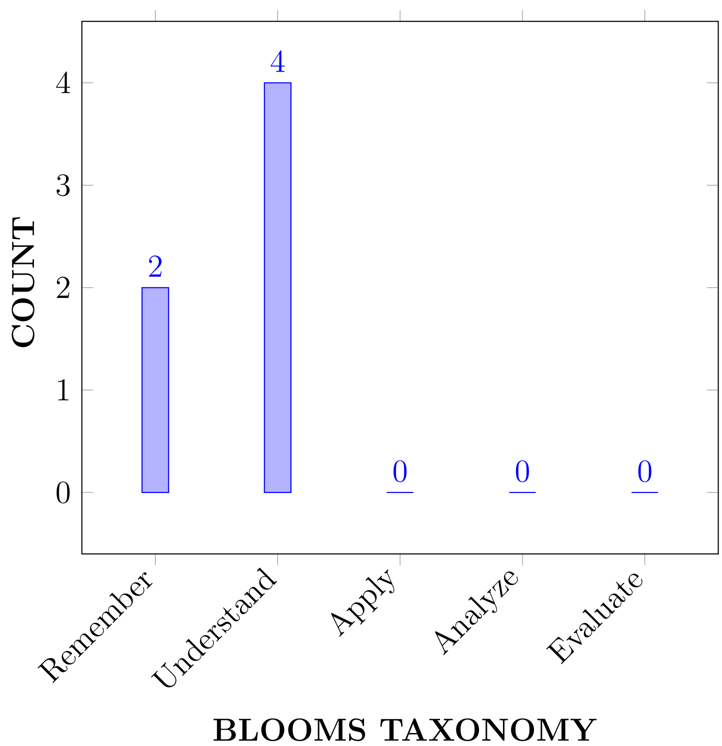
I	Communicate in an intelligible English pronunciation to meet the global standards.
II	Effectively use of four language skills (listening skill, speaking skill, reading skill and writing skill) in day-to-day affairs.
III	A critical aspect of speaking and reading for interpreting in-depth meaning between the sentences.
IV	Develop the art of writing in English keeping the standards of reader's understanding levels.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Describe** that Listening skills are essential to leadership which is useful in the real-world situations.	Remember
CO 2	**Illustrate** appropriate speaking strategies such as keeping the discussion going, turn-taking, asking for clarification or confirmation, paraphrasing, keeping the discussion on topic, and trying to reach a consensus.	Understand
CO 3	**Define** the value of English as a Lingua-Franca and recall the knowledge in soft skills for the perfect language usage.	Understand
CO 4	**Explain** the effective usage of functional English grammar and lexical items at academic and non-academic platforms.	Remember
CO 5	**Understand** the importance of critical reading to catch on the in-depth meaning of a written text at various levels of professional career.	Understand
CO 6	**Demonstrate** the role of written communication as a key aspect to meet the academic and professional challenges.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 10	**Communication :** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (Communication). "Students should demonstrate the ability to communicate effectively in writing / Orally." 1. Clarity (Writing); 2. Grammar/Punctuation (Writing); 3. References (Writing); 4. Speaking Style (Oral); 5. Subject Matter (Oral).	5	Seminar/ Conferences/ Research Papers IE/AAT / Discussion

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	-	-
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	✓-	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Discuss the heeds of functional grammar and punctuation tools in speaking and writing by generating the clarity of an audio text.	5
CO 2	PO 10	Illustrate essential aspects of grammar as well as punctuation marks for speaking or writing towards a discussion on a topic to give the clarity.	5
CO3	PO 10	Choose suitable grammatical structures and punctuation marks at speaking and writing areas maintaining clarity at professional platform.	5
CO4	PO 10	Interpret the grammatical knowledge and punctuation marks systematically towards providing the clarity in speaking and writing.	5
CO5	PO 10	Demonstrate the role of grammar and punctuation marks understanding the meaning between the sentences as well as paragraphs in speaking or writing for a clarity.	5
CO6	PO 10	Describe the clarity of grammatical usage and the obligation of punctuation marks in speaking and writing.	5

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 4	-	-	-	-		-	-	-	-	5	-		-	-	-
CO 5	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	5	-		-	-	- -

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	100	-		-	-	-
CO 2	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
CO 3	-		-	-	-	-	-	-	-	100	-	-	-	-	-
CO 4	-	-	-	-		-	-	-	-	100	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	100	-	-	- -	-	-
CO 6	-	-	-	-		-	-	-	-	100	-		-	-	- -

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -5 $<C \leq 40\%$ – Low/ Slight

2 - 40 % $<C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	
CO 2	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
TOTAL	-	-	-	-	-	-	-	-	-	18	-	-	-	-	-
AVERAGE	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**GENERAL INTRODUCTION AND LISTENING SKILL**
	Introduction to communication skills; Communication process; Elements of communication; Soft skills vs. hard skills; Importance of soft skills for engineers; Listening skills; Significance; Stages of listening; Barriers and effectiveness of listening; Listening comprehension.
MODULE II	**SPEAKING SKILL**
	Significance; Essentials; Barriers and effectiveness of speaking; Verbal and non-verbal communication. Generating talks based on visual prompts; Public speaking; Exposure to structured talks; Addressing a small group or a large formal gathering; Oral presentation; Power point presentation.
MODULE III	**VOCABULARY AND GRAMMAR**
	The concept of Word Formation; Root words from foreign languages and their use in English; Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives; Synonyms; Antonyms; Standard abbreviations; Idioms and phrases; One-word substitutes Sentence structure; Uses of phrases and clauses; Punctuation; Subject verb agreement; Modifiers; Articles; Prepositions.
MODULE IV	**READING SKILL**
	Significance, Techniques of reading, Skimming-Reading for the gist of a text, Scanning - Reading for specific information, Intensive, Extensive reading, Reading comprehension, Reading for information transfer, Text to diagram, Diagram to text.
MODULE V	**WRITING SKILL**
	Significance; Effectiveness of writing; Organizing principles of Paragraphs in documents; Writing Introduction and conclusion; Techniques for writing precisely, Letter writing; Formal and Informal letter writing, E-mail writing, Report Writing.

TEXTBOOKS

1. Handbook of English (Prepared by the faculty of English, IARE).

REFERENCE BOOKS:

1. 1. Norman Whitby, Business Benchmark: Pre-Intermediate to Intermediate – BEC Preliminary, Cambridge University Press, 2nd Edition,2008.

2. Devaki Reddy, Shreesh Chaudhary, Technical English, Macmillan, 1st Edition,2009.

3. Rutherford, Andrea J, Basic Communication Skills for Technology, Pearson Education,2nd Edition, 2010.

4. Raymond Murphy, Essential English Grammar with Answers, Cambridge University Press, 2nd Edition,2010.

5. Dr. N V Sudershan, President Kalam's Call to the Nation, Bala Bharathi Publications, Secunderabad, 1st Edition,2003

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on mapping COs with POs. (OBE)		
CONTENT DELIVERY (THEORY)			
2	Introduction to communication skills.	CO 1	T1:06.06
3	Communication process.	CO 1	T1:06.09
4	Soft skills vs hard skills.	CO 3	T1:09.10
5	Significance of LSRW skills.	CO 1	T1:10.11
6	Significance of listening skill.	CO 1	TI:12.16
7	Different stages of listening.	CO 1	T1:16.18
8	Barriers of listening skill.	CO 1	TI:18.21
9	Different types of listeners.	CO 1	TI:21.22
10	Effectiveness of listening skill.	CO 1	T1:22.24
11	Phonetics: Listening to the sounds of English language.	CO 1	T1:24.29
12	Introduction to speaking skills.	CO 2	T1:30.32
13	Effectiveness of speaking skills.	CO 2	T1:33.34
14	Verbal and non-verbal communication.	CO 2	T1:34.35
15	Generating talks based on visual or written prompts.	CO 2	T1:36.37
16	Developing public speaking skills.	CO 2	T1:38.39
17	Oral presentation with power-point.	CO 3	TI:39.42
18	The concept of word formation.	CO 4	T1:43.100
19	Antonyms and synonyms.	CO 4	TI:49.56
20	Idioms and phrases.	CO 4	TI:57.60
21	One-word substitutes.	CO 4	TI:60.62
22	Root words from foreign languages and their usage in English.	CO 4	TI:60.62
23	Sentence structure.	CO 4	T1:58.62
24	Punctuation tools and their role in a language.	CO 4	TI:63.66
25	Subject-verb agreement.	CO 4	TI:66.69
26	Usage of Adjectives.	CO 4	TI:70.73
27	Significance of articles and their usage	CO 4	TI:74.75
28	The usage of prepositions.	CO 4	T1:76.77
29	Significance of reading skill.	CO 5	T1:78.79
30	Different techniques of reading skill.	CO 6	T1:80.82
31	How to Read Your Textbook More Efficiently.	CO 6	TI:83.85
32	Different types of reading comprehension.	CO 6	TI:85.86
33	Reading for information transfer.	CO 6	TI:85.96
34	Significance and effectiveness of writing skill.	CO 6	TI:96.98

35	Organizing principles of a paragraph in documents and types of paragraphs.	CO 5	T1:101.103
36	Writing introduction and conclusion.	CO 5	T1:103.103
37	Techniques for writing precis.	CO 8	T1:103.103
38	Introduction to informal letters.	CO 7	TI:105.108
39	Introduction to formal letters.	CO 7	TI:109.110
40	Introduction of email writing and formal and informal emails.	CO 7	TI:111.112
41	Significance of Report Writing.	CO 8	TI: 113. 114
PROBLEM SOLVING/ CASE STUDIES			
42	The aspects to improve listening comprehension Discuss in detail.	CO 1	TI:10,11
43	Different types of listeners with examples	CO 1	TI: 19,21
44	The sounds of English language	CO 1	TI:23,27
45	verbal communication or written communication.	CO 2	TI: 27,30
46	Various difficulties in public speaking.	CO 2	TI: 32,33
47	Different ways of greeting people in formal and informal situation and discuss how do they matter in communication?	CO 2	TI: 35,37
48	'Oral presentation requires a good planning'.	CO 2	TI:36,38
49	Power point presentation and the ways to make Power point presentation.	CO 2	TI: 37,38
50	Methods that are used to establish the process of building vocabulary with examples from the most used words in spoken English.	CO 4	TI:39,41
51	The usage of idioms and phrases in spoken English.	CO 4	TI: 47,50
52	'Structure proposition-evaluation' -Reading technique.	CO 5	TI:56,58
53	Active reading, detailed reading, and speed-reading techniques used in different situations.	CO 5	TI: 79,81
54	The elements of paragraph writing in detail.	CO 8	TI:100,102
55	Logical bridges and Verbal bridges in writing.	CO 8	TI:102,104
56	Soft skills and Interpersonal Communication.	CO 8	TI:102,104
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Soft skills and Interpersonal Communication.	CO 1	TI 8,9
58	Language acquisition is a process.	CO 1	TI: 11,12
59	Communication.	CO 1	TI: 14,16
60	Time management.	CO 3	TI:9,10
61	Stress management.	CO 3	TI:9,10
DISCUSSION OF QUESTION BANK			
62	Soft Skills for difficult situations in terms of reassurance and reliability.	CO 3	TI:9,10
63	Verbal and non-verbal communication.	CO 2	TI: 34,35

64	Honesty, Respect, Self-Control and Accountability their role in building long lasting interpersonal skills?	CO 3	TI: 9,10
65	Etiquette and manners. Its importance in social, personal and professional communication.	CO 23	TI: 9,10
66	Problem solving and decision making.	CO 3	TI: 9,10

Signature of Course Coordinator **HOD**

INSTITUTE OF AERONAUTICAL ENGINEERING
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COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Name	**Linear algebra and Ordinary differential equations**				
Course Code	AHS002				
Program	B.Tech				
Semester	I				
Course Type	Foundation				
Regulation	IARE -R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms. L Indira, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	10+2	-	

II COURSE OVERVIEW:

The Linear algebra is a sub-field of mathematics concerned with vectors, matrices, and linear transforms. Calculus is the branch of mathematics which majorly deals with derivatives and integrals. Linear algebra is a key foundation to the field of machine learning. The course includes types of Matrices, Rank, methods of finding rank, Eigen values and Eigen vectors, maxima and minima of functions of several variables, solutions of higher order ordinary differential equations and Fourier series. Matrices are used in computer animations, color image processing. Eigen values are used by engineers to discover new and better designs for the future. The laws of physics are generally written down as differential equations. So, differential equations have wide applications in various engineering and science disciplines. This course enables the students to gain basic knowledge on the mathematics which is used in modeling the real time engineering problems very often.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Liner algebra and calculus	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

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Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

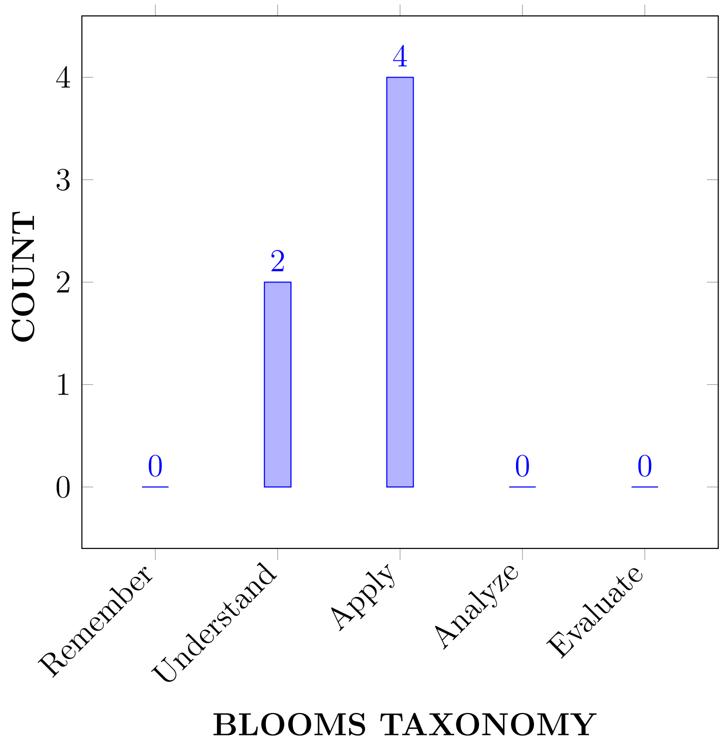
I	The principles of Eigen value analysis and linear transformations, Matrix rank finding methods.
II	The analytical methods for solving higher order differential equations with constant coefficients.
III	The calculus of functions of several variables and the concept of maxima-minima for a three-dimensional surface

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Calculate** the rank and inverse of real and complex matrices with elementary transformation methods.	Apply
CO 2	**Compute** the diagonally equivalent matrix and Cayley Hamiltonion equation of the given matrix by using Eigen values and Eigen vectors.	Apply
CO 3	**Interpret** the properties of differential equation of first order and first degree and orthogonal trajectories byusing integration factor method	Understand
CO 4	**Solve** the Second and higher order linear homogeneous and non homogeneous differential equations with constant coefficients by using substitution method.	Apply
CO 5	**Interpret** the extreme values for functions of several variables by using parial derivatives .	Understand
CO 6	**Apply** mean–value theorems in establishing some mathematical inequalities	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



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PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	-	-
PSO 2	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining. .	-	-
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-		-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	- -
CO 6	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Explain the role of rank and inverse of real and complex matrices in solving complex engineering problems by using elementary transformation methods (**principles of mathematics** and **scientific methodology**).	2
CO 2	PO 1	Determine the diagonally equivalent matrix of given matrix involved in the complex engineering problems modeled by matrices with help of Eigen values and Eigen vectors (**principles of mathematics** and **scientific methodology)**).	2
	PO 2	Understand the **statement** and **formulation** of a complex engineering problem **modeled** by matrices with help of Eigen values and Eigen vectors and diagonalization to **develop** the solution and reaching substantiated conclusions by the **interpretation of results**	5
CO 3	PO 1	Identify whether the given differential equation of first order and first degree is exact or not by using integration factor method (**principles of mathematics** and **scientific methodology**)	2
CO 4	PO 1	Solve the complex engineering problems modeled by Second and higher order linear homogeneous differential equations (principles of mathematics) with constant coefficients by using substitution method (**principles of mathematics** and **scientific methodology**)	2
	PO 2	Understand the **statement** and **formulation** of a complex engineering problem **Modeled** by linear differential equations and solve them using substitution method along with basic principles of mathematics to **develop** the solution and reaching substantiated conclusions by the **interpretation of results** .	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 5	PO 1	Explain the mean–value theorems for the single variable functions and apply them in the complex engineering problems modeled by functions of single variables with their geometrical interpretation (**principles of mathematics** and **scientific methodology**).	2
CO 6	PO 1	Interpret the extreme values for functions of several variables and apply them in the complex engineering problems modeled by functions of several variableswith the help of partial derivatives (**principles of mathematics** and **scientific methodology**).	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	67	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	67	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	4	-	-	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5Tech-talk	PO1,PO2	Open Ended Experiments	-
Assignments		concept video		mini project	

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**THEORY OF MATRICES**
	Real matrices: Symmetric, skew-symmetric and orthogonal matrices; Complex matrices: Hermitian, Skew- Hermitian and unitary matrices; Elementary row and column transformations, elementary matrix, finding rank of a matrix by reducing to Echelon form and normal form; Finding the inverse of a matrix using elementary row/column transformations: Gauss-Jordan method; Solving of linear system of equations by LU decomposition method.
MODULE II	**LINEAR TRANSFORMATIONS**
	Cayley-Hamilton theorem: Statement, verification, finding inverse and powers of a matrix; Linear dependence and independence of vectors; Linear transformation; Eigen values and Eigen vectors of a matrix; Properties of Eigen values and Eigen vectors of real and complex matrices; Diagonalization of matrix.
MODULE III	**DIFFERENTIAL EQUATIONS OF FIRST ORDER AND THEIR APPLICATIONS**
	Solution of first order linear differential equations by exact, non exact, linear equations; Bernoulli equation. Applications of first order differential equations: Orthogonal trajectories; Newton's law of cooling; Law of natural growth and decay.

MODULE IV	**HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS AND THEIR APPLICATIONS**
	Linear differential equations of second and higher order with constant coefficients, non-homogeneous term of the f(x)=e^{ax},sinax,cosaxand f (x) $= x^n$, $e^{ax}v(x)$, $x^n v(x)$; Method of variation of parameter; Application to electrical circuits and Simple Harmonic Motion
MODULE V	**FUNCTIONS OF SINGLE AND SEVERAL VARIABLES**
	Mean value theorems: Rolle's theorem, Lagrange's theorem, Cauchy's theorem-without proof; Functions of several variables: Partial differentiation, chain rule, total derivative, Euler's theorem, functional dependence, Jacobian, maxima and minima of functions of two variables without constraints and with constraints; Method of Lagrange multipliers

TEXTBOOKS

1. Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons Publishers, 9th Edition,2014. .
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 42nd Edition,2012.

REFERENCE BOOKS:

1. RK Jain & SRK Iyengar, "Advanced Engineering Mathematics", Narosa Publishers, 5th Edition,2016
2. Ravish R Singh, Mukul Bhatt, "Engineering Mathematics-1", Tata McGraw Hill Education, 1st Edition, 2009..
3. Srimanthapa & SubothC.Bhunia,"EngineeringMathematics", Oxford Publishers, 3rd Edition ,2015

WEB REFERENCES:

1. https://nptel.ac.in/courses/111/108/111108157

COURSE WEB PAGE:

1. lms.iare.ac.in

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	Theory of matrices: types of real matrices	CO1	T2:32.1R1:4.1 1
3	Real matrices:symmetric, skew-symmetric matrices	CO1	T2:32.1 R1:4.2
4	Real Matrices: orthogonal matrices	CO1	T2:32.1 R1:4.3
5	Complex matrices:Hermitian, Skew- Hermitian	CO1	T2:32.1 R1:4.3
6	Complex matrices: unitary matrices	CO1	T2:32.5 R1:4.6
7	Elementary row and column transformations	CO1	T2:32.5 R1:4.6
8	Rank of a matrix by echelon form	CO1	T2:32.4 R1:4.5

9	Rank of a matrix by normal form	CO1	T2:32.7 R1:4.8
10	Inverse of a matrix by Gauss-Jordan method	CO1	T2-7.1 R1:7.4
11	Eigen values of a matrix	CO2	T2-7.1 R1:7.4
12	Eigen vectors of a matrix	CO2	T2-7.1 R1:7.4
13	Diagonalizationof matrix by linear transformation.	CO 2	T2:7.1 R1:7.4
14	Cayley-Hamilton theorem- statement, verifications	CO 2	T2:7.1 R1:7.4
15	Applications of Cayley – Hamilton theorem	CO 2	T3-2.9 R1:2.1
16	Linear dependence and independence of vectors	CO 2	T3-2.5 R1:2.8
17	First order linear differential equations	CO3	T3-2.5 R1:2.8
18	Bernoulli's differential equations	CO3	T3-2.5 R1:2.8
19	Exact differential equations	CO3	T3-2.5 R1:2.8
20	Non exact differential equations	CO3	T3-2.5 R1:2.8
21	Equations reducible to exact form	CO3	T3-2.61 R1:2.10
22	Orthogonal trajectories	CO3	T1-7.1 R2:7.5
23	Newton's law of cooling	CO3	T3-2.61 R1:2.10
24	Law of natural growth and decay	CO3	T1-7.1 R2:7.6
25	Application method of Lagrange multipliers	CO3	T1-7.1 R2:7.7
26	Method of Lagrange multipliers	CO3	T3-2.5 R1:2.8
27	higher order Linear differential equations	CO4	T3-2.5 R1:2.8
28	Linear differential equations of second and higher order with polynomial coefficients	CO4	T3-2.5 R1:2.8
29	Non-homogeneous term of the type f (x) =e^{ax}	CO4	T3-2.5 R1:2.8
30	Q(x) is of the type f(x) = sinax or cosax	CO4	T2-7.1 R1:7.4
31	Non-homogeneous term of the type f (x) = X^n	CO4	T2:7.1 R1:7.4
32	Non-homogeneous term of the type f (x) = $e^{ax}V(x)$	CO4	T2:7.1 R1:7.4
33	Method of variation of parameters	CO4	T3-2.9 R1:2.1
34	Mean value theorems:1. Rolle's theorem	CO5,CO 6	T3-2.5 R1:2.8
35	Mean value theorems:2. Lagrange's theorem	CO5,CO 6	T3-2.5 R1:2.8
36	Mean value theorems:3. Cauchy's theorem	CO5,CO 6	T2:7.1 R1:7.4
37	Functions of several variables: Partial differentiation	CO5,CO 6	T3-2.9 R1:2.1
38	Jacobian transformations	CO5,CO 6	T3-2.5 R1:2.8
39	Functional dependence	CO5,CO 6	T2:7.1R1:7.4
40	Maxima and minima of functions with two variables	CO5,CO 6	T3-2.9 R1:2.1
41	Maxima and minima of functions with three variables	CO5,CO 6	T3-2.5R1:2.8
PROBLEM SOLVING/ CASE STUDIES			
42	Rank of the matrix by Echelon and normal form	CO1	T2:32.1 R1:4.2
43	Solving system of linear non homogeneous equations	CO1	T2:32.1 R1:4.3
44	Eigen values and eigen vectors of the matrix	CO2	T2:32.1 R1:4.3
45	Finding spectral matrix by linear transformation.	CO2	T2-7.1 R1:7.4
46	Verification of Caley- Hamilton theorem	CO2	T2-7.1 R1:7.4
47	Finding powers of the matrix by Caley -Hamilton theorem	CO2	T2:7.1 R1:7.4
48	Solving first order differential equations	CO3	T2:7.1 R1:7.4

49	Solving Non-Homogeneous Differential Equations.	CO3	T3-2.5 R1:2.8
50	Solving linear and exact differential equations	CO3	T3-2.5 R1:2.8
51	Finding C.F and P.I. of higher order differential equations	CO9	T3-2.5 R1:2.8
52	Solving Second Order Non-homogeneous differential equations by method of variation of parameters	CO4	T3-2.5 R1:2.8
53	Solving higher differential equations of different types	CO4	T3-2.61 R1:2.10
54	Jacobian transformation in Cartesian and Polar Forms	CO 5,CO 6	T2:7.1 R1:7.4
55	Finding functional relationship.	CO 5,CO 6	T3-2.9 R1:2.1
56	Finding max.and min. of functions of two variables	CO 5,CO 6	T3-2.5 R1:2.8
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Real, complex matrices and rank of a matrix	CO1	T3-2.5 R1:2.8
58	Eigen values and eigen vectors, diagonalization	CO2	T3-2.5 R1:2.8
59	First order linear, exact and non-exact D.Es.	CO3	T3-2.5 R1:2.8
60	Higher order differential equations	CO4	T3-2.5 R1:2.8
61	Mean value theorems, Jacobian transformations, functionally dependent and independent	CO5	T3-2.61 R1:2.10
DISCUSSION OF QUESTION BANK			
62	Theory of matrices	CO1	T2:7.1R1:7.4
63	Linear transformations	CO2	T3-2.9R1:2.1
64	First order and degree differential equations	CO3	T3-2.5R1:2.8
65	Higher order differential equations	CO4	T2:32.1R1:4.3
66	Functions of several variables	CO5, CO 6	T2-7.1R1:7.4

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ENGINEERING CHEMISTRY**				
Course Code	AHS005				
Program	B.Tech				
Semester	I				
Course Type	FOUNDATION				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	2	1
Course Coordinator	Dr V Anitha Rani, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	Vital principles of chemistry

II COURSE OVERVIEW:

The concepts developed in this course will aid in quantification of several concepts in chemistry that have been introduced at the Intermediate level. Technology is being increasingly based on the electronic, atomic and molecular level modifications. Quantum theory is more than 100 years old and to understand phenomena at nanometer levels; one has to base the description of all chemical processes at molecular levels.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering Chemistry	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
30 %	Understand
60 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

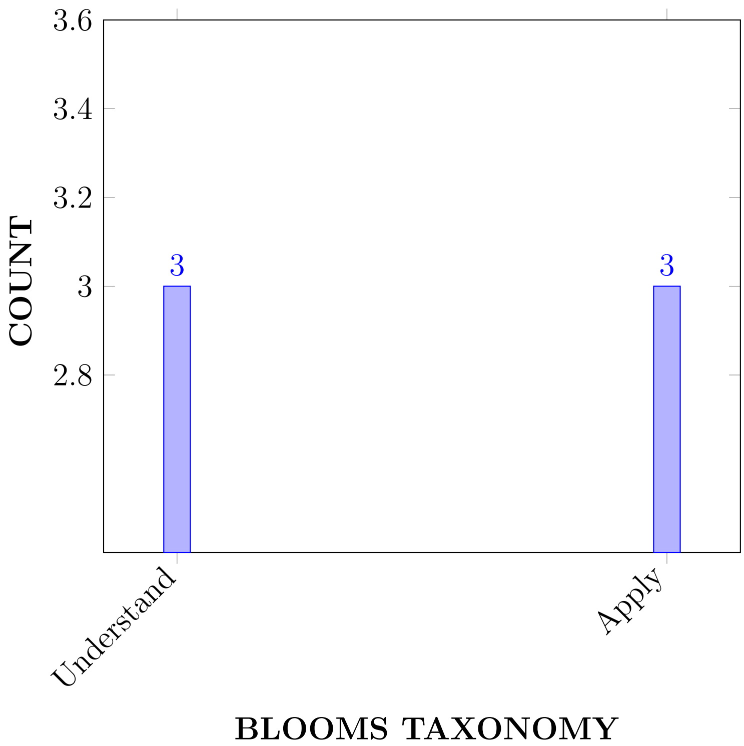
I	The concepts of electrochemical principles and causes of corrosion in the new development and breakthroughs efficiently in engineering and technology.
II	The different parameters to remove causes of hardness of water and their reactions towards the complexometric method.
III	The microscopic chemistry in terms of atomic, molecular orbitals and Intermolecular forces.
IV	The different molecular organic chemical reactions that are used in the synthesis of molecules.
V	The properties, separation techniques of natural gas and crude oil along with potential applications in major chemical reactions.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the operation of electrochemical systems for the production of electric energy, i.e. batteries.	Understand
CO 2	**Utilize** electrochemical cell parameters, electrochemical active surface area, current and over potential under given condition for calculating the electromotive force and electrode potential.	Apply
CO 3	**Illustrate** the electrochemical theory of corrosion process in metals for protection of different metals from corrosion.	Understand
CO 4	**Make use of** the basic electrochemical knowledge of corrosion processes and apply the concept for protection of different metals from corrosion.	Apply
CO 5	**Explain** the importance of different types of materials for understanding their composition and applications.	Understand
CO 6	**Choose** different types of solid, liquid and gaseous fuels in terms of calorific value for utilizing in industries and automobiles.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2.5	SEE/CIE/Quiz/ AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIE/Quiz/ AAT
PO 7	**Environment and sustainability:** understand the impact of the professional engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	SEE/CIE/Quiz/ AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	-	-
PSO 2	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining. .	-	-

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-	-	-	✓	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Explain the electrochemical properties for producing electrical energy (understand) by using principles of science for solving engineering problems.	2
CO 2	PO 1	Choose different electrodes for finding pH of unknown solutions by applying mathematical expressions of cell potential by using principles of science and mathematics for solving engineering problems	3
	PO 2	Identify the problem formulation and abstraction for calculating electrode potential under non standard conditions by applying Nernst equation from the provided information.	2
CO3	PO1	Explain the concept of corrosion processes in metals by exposing to acidic environment for solving engineering problems by applying the principles of science	3
	PO2	Identify the problem and formulate for finding the hardness of water in terms of CaCO3 equivalents with given information and data by applying principles of science.	2
CO4	PO1	Explain the formation of molecular orbitals by linear combination of atomic orbitals, splitting of d orbitals for formation of octahedral, tetrahedral and square planar complexes for solving engineering problems by applying the principles of science.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO5	PO1	Illustrate the structural and stereo isomers of optically active compounds, different types of molecular organic reactions for synthesizing drugs by using principles of science for solving engineering problems.	2
CO6	PO1	Classify different types of solid, liquid and gaseous fuels with their characteristics and calorific value by using principles of science and mathematics for solving engineering problems.	3
	PO2	Identify the given problem and formulate for finding the calorific value of fuel with the given information and data by applying principles of science.	2
	PO7	Make use of gaseous fuels like LPG, CNG to reduce the pollutants in atmosphere and know the impact in socio economic and environmental contexts for sustainable development.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	2	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	20.0	-	-	-	-	66.6	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-	-	2	-	-	-	-	-	-	-	-
TOTAL	15	3	-	-	-	-	2	-	-	-	-	-	-	-	-
AVERAGE	2.5	1	-	-	-	-	2	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	5 minutes video	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	-	-	-	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Early Semester Feedback	✓	End Semester OBE Feedback
x	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

UNIT I	ELECTROCHEMISTRY AND BATTERIES
	Electro chemical cells: Electrode potential, standard electrode potential, types of electrodes; Calomel, Quinhydrone and glass electrode; Nernst equation; Electrochemical series and its applications; Numerical problems; Batteries: Primary (Dry cell) and secondary batteries (Lead-acid storage battery and Lithium ion battery). Causes and effects of corrosion: Theories of chemical and electrochemical corrosion, mechanism of electrochemical corrosion; Types of corrosion: Galvanic, water-line and pitting corrosion; Factors affecting rate of corrosion; Corrosion control methods: Cathodic protection, sacrificial anode and impressed current; Surface coatings: Metallic coatings- Methods of coating- Hot dipping, cementation, electroplating and Electroless plating of copper.

UNIT II	**CORROSION AND ITS CONTROL**
	Corrosion: Introduction, causes and effects of corrosion; Theories of corrosion: Chemical and electrochemical corrosion with mechanism; Factors affecting the rate of corrosion: Nature of the metal and nature of the environment; Types of corrosion: Waterline and crevice corrosion; Corrosion control methods: Cathodic protection- sacrificial anodic protection and impressed current cathodic protection; Surface coatings: Metallic coatings, methods of application of metallic coatings-hot dipping(galvanizing, tinning), electroplating(copper plating); Organic coatings: Paints, its constituents and their functions
UNIT III	**WATER TECHNOLOGY**
	Water: Sources and impurities of water, hardness of water, expression of hardness-units; Types of hardness: Temporary hardness, permanent hardness and numerical problems; Estimation of temporary and permanent hardness of water by EDTA method; Determination of dissolved oxygen by Winkler's method; Boiler troubles: Priming, foaming, scales, sludges and caustic embrittlement. Treatment of water: Internal treatment of boiler feed water- carbonate, calgon and phosphate conditioning, softening of water by Zeolite process and Ion exchange process; Potable water-its specifications, steps involved in the treatment of potable water, sterilization of potable water by chlorination and ozonization, purification of water by reverse osmosis process.
UNIT IV	**MATERIALS CHEMISTRY**
	Materials chemistry: Polymers-classification with examples, polymerization-addition, condensation and co-polymerization; Plastics: Thermoplastics and thermosetting plastics; Compounding of plastics; Preparation, properties and applications of polyvinyl chloride, Teflon, Bakelite and Nylon-6, 6; Rubbers: Natural rubber its process and vulcanization; Elastomers: Buna-s and Thiokol rubber; Fibers: Characteristics of fibers, preparation properties and applications of Dacron; Characteristics of fiber reinforced plastics; Cement: Composition of Portland cement, setting and hardening of Portland cement; Lubricants: Classification with examples; Properties: Viscosity, flash, fire, cloud and pour point; Refractories: Characteristics and classification with examples..
UNIT V	**FUELS AND COMBUSTION**
	Fuel: Definition, classification of fuels and characteristics of a good fuels; Solid fuels: Coal; Analysis of coal: Proximate and ultimate analysis; Liquid fuels: Petroleum and its refining; Cracking: Fixed bed catalytic cracking; Knocking: Octane and cetane numbers; Gaseous fuels: Composition, characteristics and applications of natural gas, LPG and CNG; Combustion: Calorific value: Gross Calorific Value(GCV) and Net Calorific Value(NCV), calculation of air quantity required for complete combustion of fuel, numerical problems.

TEXTBOOKS

1. P. C. Jain and Monica Jain, "Engineering Chemistry", Dhanpat Rai Publishing Company, 16th Edition, 2017.
2. Shashi Chawla, "Engineering Chemistry", Dhanat Rai and Company, 2011, 1st Edition.
3. R.T. Morrison, RN Boyd and SK Bhattacharya, "Organic Chemistry", Pearson, 7th Edition, 2011
4. K.F. Purcell and J.C. Kotz, "Inorganic Chemistry", Cengage learning, 2017.

REFERENCE BOOKS:

1. K. P. C. Volhardt and N. E. Schore, "Organic Chemistry Structure and Functions", Oxford Publications, 7th Edition 2010.
2. B. H. Mahan, "University Chemistry", Narosa Publishers, 4th Edition, 2009.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on outcome based education		
CONTENT DELIVERY (THEORY)			
2	Concept of Electro chemical cells	CO1	T1,T2
3	Numerical problems on EMF: Galvanic Cells	CO 2	T1,T2
4	Types of Electrodes: Calomel, Quinhydrone and Glass electrode	CO 2	T1,T2
5	Nernst equation and its applications	CO 2	T1,T2
6	Batteries: Primary cells (dry cells)	CO 1	T1,T2
7	Secondary cells (lead-Acid cell). Applications of batteries	CO 1	T1,T2
8	Corrosion-Definition ,Causes and effects of corrosion, Theories of corrosion – Chemical corrosion theory	CO 1	T1,T2
9	Types of corrosion (water line and pitting), Factors affecting rate of corrosion	CO 1	T1,T2
10	Corrosion control methods – Cathodic protection and metallic coating.	CO 1	T1,T2
11	Hardness of water, expression of hardness-units; Types of hardness: Temporary hardness, permanent hardness and numerical problems.	CO 3	T1,T2
12	Estimation of temporary and permanent hardness of water by EDTA	CO 3	T1,T2
13	Potable water and its specifications, steps involved in its treatment of water.	CO 3	T1,T2
14	Boiler troubles – Priming and foaming, caustic embrittlement	CO 3	T1,T2
15	Treatment of boiler feed water – Internal treatment (Phosphate, carbonate and calgon conditioning)	CO 3	T1,T2
16	Ion exchange process, steps involved in the treatment of this process	CO 3	T1,T2
17	Sterilization of potable water by chlorination and ozonization	CO 3	T1,T2
18	purification of water by reverse osmosis process. Numerical problems	CO 3	T1,T2

19	Shapes of Atomic Orbitals	CO 4	T1,T2
20	Linear combination of Atomic orbitals (LACO)	CO 4	T1,T2
21	Molecular orbitals of diatomic molecules N2 O2 and F2.	CO 4	T1,T2
22	Molecular orbitals diatomic CO and NO molecule	CO 4	T1,T2
23	Crystal Field Theory (CFT), Salient Features of CFT-Crystal Fields	CO 4	T1,T2
24	Splitting of transition metal ion d- orbitals in Tetrahedral	CO 4	T1,T2
25	Splitting of transition metal ion Octahedral and square planar geometries	CO 4	T1,T2
26	Band structure of solids and effect of doping on conductance	CO 4	T1,T2
27	Introduction to representation of 3-dimensional structures	CO 5	T1,T2
28	Structural and stereoisomers of organic compounds	CO 5	T3
29	Configurations, symmetry and chirality.	CO 5	T3
30	Enantiomers, diastereomers, optical activity and Absolute configuration	CO 5	T3
31	Conformation alanalysis of n- butane	CO 5	T3
32	Nucleophilic substitution reactions, Mechanism of SN1, SN2 reactions	CO 5	T3
33	Electrophilic and nucleophilic addition reactions; Addition of HBr to Propene; Markownikoff and anti Markownikoff's additions	CO 5	T3
34	Grignard additions on carbonyl compounds, EliminationreactionsDehydro halogenations of alkylhalides	CO 5	T3
35	Oxidation reactions: Oxidation of alcohols using KMnO4 and chromicacid.	CO 5	T3
36	Reduction reactions: Reduction of carbonyl compounds using LiAlH4& NaBH4	CO 5	T3
37	Hydroboration of olefins	CO 5	T3
38	Structure, synthesis and pharmaceutical applications of Paracetamol and Aspirin.		T3
39	Definition, classification of fuels and characteristics of a good fuels	CO 5	T1,T2
40	Solid fuel Coal, analysis of coal- proximate analysis	CO 6	T1,T2
41	Analysis of coal -ultimate analysis.	CO 6	T1,T2
42	Liquid fuels: Petroleum and its refining Cracking: Fixed bed catalytic cracking;	CO 6	T1,T2
43	Knocking: Octane and cetane numbers	CO 6	T1,T2
44	Gaseous fuels: Composition, characteristics and applications of Natural gas, LPG and CNG	CO 6	T1,T2
45	Combustion: Calorific value-Gross calorific value(GCV) and net calorific value(NCV)	CO 6	T1,T2
46	Calculation of air quantity required for complete combustion of fuel, numerical problems.	CO 6	T1,T2
PROBLEM SOLVING			
1	Probelms on EMF	CO 1	T1:3.3.1; R3:3.2

2	Probelms on Nernst equation	CO 1	T2:16.5; R3:8.10
3	Determination of Electrode potential	CO 2	T2:16.5; R3:8.10
4	Determination of Hardness	CO 3	T1:3.3.1; R3:3.2
5	Determination of Hardness by EDTA	CO 3	T2:16.5; R3:8.10
6	Crystal field stabalization energy	CO 4	T2:16.5; R3:8.10
7	Proximate Analysis of coal	CO 6	T1:3.3.1; R3:3.2
8	ultimate Analysis of coal	CO 6	T2:16.5; R3:8.10
9	Dulungs Equation for coal analysis	CO 6	T2:16.5; R3:8.10
10	Probelms on Combustion	CO 6	T1:3.3.1; R3:3.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Electro Chemistry and Batteries	CO 1	T2:16.5; R3:8.10
2	Water and Its Treatment	CO 2	T1:3.3.1; R3:3.2
3	Molecular Structure and Theories of Bonding	CO 3	T2:16.5; R3:8.10
4	Streo chemistry,Reaction Mechanisim	CO 4	T2:16.5; R3:8.10
5	Fuels and Combustion	CO 6	T2:16.5; R3:8.10
DISCUSSION OF QUESTION BANK			
1	Electro Chemistry and Batteries	CO 1	T2:16.5; R3:8.10
2	Water and Its Treatment	CO 2	T1:3.3.1; R3:3.2
3	Molecular Structure and Theories of Bonding	CO 3	T2:16.5; R3:8.10
4	Streo chemistry,Reaction Mechanisim	CO 4	T2:16.5; R3:8.10
5	Fuels and Combustion	CO 6	T2:16.5; R3:8.10

Signature of Course Coordinator **HOD,ME**

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**APPLIED PHYSICS**				
Course Code	AHS007				
Program	B.Tech				
Semester	I				
Course Type	Foundation				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	2	1
Course Coordinator	Dr. Rizwana, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	Basics of Physics

II COURSE OVERVIEW:

This course develops abstract and critical reasoning by studying mathematical and logical proofs and assumptions as applied in basic physics and to make connections between physics and other branches of sciences and technology. The topics covered include dielectric and magnetic properties, acoustics of buildings, ultrasonics, equilibrium of system of forces, friction and dynamics of rigid bodies. The course helps students to gain knowledge of basic principles and appreciate the diverse applications in technological fields in respective branches and also in their lives.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Applied Physics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	X	Assignments	X	MOOC
X	Open Ended Experiments	X	Seminars	X	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or “choice” will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
50 %	Understand
50 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/Alternative Assessment Tool.

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz/AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz – Online Examination:
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT):
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, presentations, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table 3.

Assignment	Seminar	Presentations
40 %	40 %	20 %

VI COURSE OBJECTIVES:

The students will try to learn:

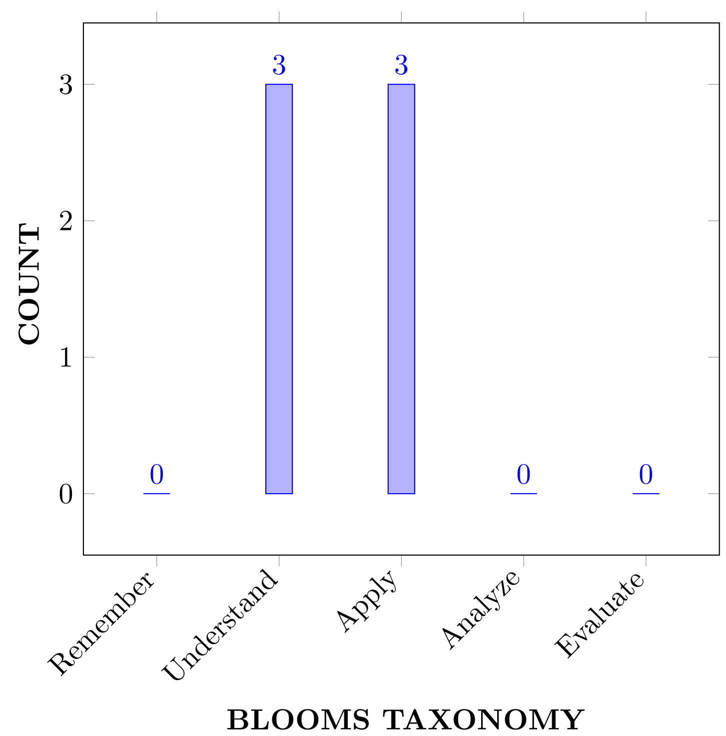
I	Develop the strong fundamentals of system of forces and friction.
II	Strengthen the knowledge of theoretical and technological aspects of dynamics of rigid bodies.
III	Correlate principles with applications of the dielectric and magnetic materials.
IV	Enrich knowledge in acoustics and ultrasonics.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the properties of dielectric and magnetic materials which are suitable for engineering applications.	Understand
CO 2	**Outline** the basic principles of acoustics of buildings and modern architectural acoustic techniques using Sabine's formula.	Understand
CO 3	**Demonstrate** the generation and applications of ultrasonic waves in different fields of science and industries.	Understand
CO 4	**Identify** the condition of equilibrium from basic concepts and the laws of forces.	Apply
CO 5	**Make use of** laws of friction to obtain equilibrium of a body lying on an inclined plane.	Apply
CO 6	**Apply** knowledge of parallel and perpendicular theorems to obtain Moment of inertia of different types of objects.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1	Laboratory experiments

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	✓
CO 2	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-	
CO 6	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Summarize** different types of polarizations and internal field due to the dipoles in the dielectric materials.	3
	PO 2	**Identify** the use of magnetic materials and their magnetization values for the **research based knowledge** and **technological development.**	4
	PSO3	**Ability** to determine remnant magnetization and coercive values from B-H curve by make use of modern computer tools and for gaining knowledge helpful for higher studies.	1
CO 2	PO 1	**Describe** the different types of acoustic defects and principles of acoustics of buildings.	3

Course Outcomes	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key competencies matched.**
	PO 4	**Identify** good acoustic materials based on their response to sound waves for **construction of buildings**.	2
CO 3	PO 1	**Demonstrate** the generation of ultrasonic waves using different methods and **describe** their properties.	3
	PO 2	**Relate** the given problem statement and **formulate** the relation between time and distance to **find out** the depth of sea using echo sounder.	4
CO 4	PO 1	**Illustrate** detailed **knowledge** of various kinds of forces and laws that govern these forces.	3
	PO 2	**Apply** the knowledge of different kind of forces to move the heavy bodies with minimum manpower and machine tools.	4
CO 5	PO 1	**Utilize** frictional properties to **derive** condition for equilibrium of a body lying on an inclined plane.	3
	PO 4	**Make use of** laws of frictional forces for the r**esearch based knowledge** and **technological development**.	2
CO 6	PO 1	**Outline** the consequences of moment of inertia by applying theorems to different types of objects.	3
	PO 2	**Identify the given problem** and **formulate** expressions for moment of inertia **information and data.**	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	4	-	-	-	-	-	-	-	-	-		-	-	1
CO 2	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	40	-	-	-	-	-	-	-	-	-		-	-	33
CO 2	100	-	-	20	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	40	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	100	-	-	20	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\ \% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-		-	-	1
CO 2	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	8	-	2	-		-	-	-	-	-	-	-	-	1
AVERAGE	3	2	-	1	-		-	-	-	-	-	-	-	-	1

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Presentation	✓	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

UNIT I	**DIELECTRIC AND MAGNETIC PROPERTIES**
	Dielectric Properties: Basic definitions, electronic, ionic and orientation polarizations-qualitative; Internal field in solids. Magnetic Properties: Basic definitions, origin of magnetic moment, Bohr magneton, classification of dia, para and ferro magnetic materials on the basis of magnetic moment, domain theory of ferro magnetism on the basis of hysteresis curve.
UNIT II	**ACOUSTICS AND ULTRASONICS**
	Acoustics: Reverberation, reverberation time, Sabine's formula (qualitative), absorption coefficient, measurement of absorption coefficient, factors affecting acoustics of an auditorium and their remedies; Ultrasonics: Introduction; Generation of ultrasonic waves; Magnetostriction method, piezoelectric method, properties, applications.

UNIT III	EQUILIBRIUM OF SYSTEM OF FORCES
	Introduction, basic concepts, system of forces, coplanar concurrent forces, force systems in plane, parallel forces in plane; Force systems in space, couples, resultant, Lami's theorem, triangle law of forces, polygon law of forces, condition of equilibrium.
UNIT IV	FRICTION
	Friction: Types of friction, limiting friction, laws of friction, angle of repose, equilibrium of body laying on rough inclined plane, Application of friction: ladder friction, wedge friction, screw friction.
UNIT V	DYNAMICS OF RIGID BODIES - MOMENT OF INERTIA
	Rotational motion, torque, angular momentum, relation between torque and angular momentum, angular momentum of system of particles, moment of inertia, expression for moment of inertia, radius of gyration, theorems on moment of inertia, moment of inertia of thin rod, rectangular lamina, circular disc.

TEXTBOOKS

1. Dr. K Vijay Kumar and Dr. S Chandralingam - "Modern Engineering Physics" Volume-1 & 2, S Chand. Co, 2018.
2. R. C Hibbler, "Engineering mechanics", Prentice Hall, 12th Edition, 2009.

REFERENCE BOOKS:

1. R. K. Gaur, S. L. Gupta, "Engineering Physics", Dhanpat Rai Publications, 8th Edition, 2001.
2. Timoshenko, D. H. Young, "Engineering mechanics", Tata Mc Graw Hill, 5th Edition, 2013.
3. Hitendra K Malik, A. K. Singh, "Engineering Physics", Mc Graw Hill Education, 1st Edition, 2009.
4. S. S. Bhavikatti, "A text book of Engineering mechanics", New age international, 1st Edition, 2012.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to OBE and its importance.		
CONTENT DELIVERY (THEORY)			
2	Basic definitions of dielectric materials	CO1	T1, T2, R1, R2
3	electronic, ionic and orientation polarizations	CO1	T1, T2, R1, R2
4-5	Internal field in solids	CO1	T1, T2, R1, R2
6	Basic definitions of magnetic materials	CO2	T1, T2, R1, R2
7	origin of magnetic moment, Bohr magneton	CO2	T1, T2, R1, R2

8-9	Classification ofdia, para and ferro magneticmaterials on the basis of magnetic moment	CO2	T1, T2, R1, R2
10	Domain theory of ferromagnetism on the basis of hysteresis curve	CO2	T1, T2, R1, R2
11	Acoustics: Reverberation, reverberation time, Sabine's formula	CO3	T1, T2, R1, R2
12	Absorption coefficient, measurement of absorption coefficient	CO3	T1, T2, R1, R2
13	Factors affecting acoustics of an auditorium and their remedies	CO3	T1, T2, R1, R2
14	Ultrasonics: Introduction	CO4	T1, T2, R1, R2
15	Generation: Magnetostriction method	CO4	T1, T2, R1, R2
16	Generation: Piezoelectric method	CO4	T1, T2, R1, R2
17	Properties and applications of ultrasonic waves	CO4	T1, T2, R1, R2
18	Introduction, basic concepts	CO5	T1, T2, R1, R4
19	System of forces, coplanar concurrent forces	CO5	T1, T2, R1, R4
20	Force systems in space	CO5	T1, T2, R1, R4
21	Parallel forces in plane	CO5	T1, T2, R1, R4
22	Couples, resultant	CO6	T1, T2, R1, R4
23	Lami's theorem	CO6	T1, T2, R1, R4
24	Triangle law of forces	CO6	T1, T2, R1, R4
25	Polygon law of forces	CO6	T1, T2, R1, R4
26	Condition of equilibrium	CO6	T1, T2, R1, R4
27	Friction: Introduction, types of friction	CO6	T1, T2, R1, R2
28	Limiting friction	CO7	T1, T2, R1, R2
29	Laws of friction & Angle of repose	CO7, CO8	T1, T2, R1, R2
30	Equilibrium of body laying on rough inclined plane	CO8	T1, T2, R1, R2
31	Ladder and Wedge friction	CO7, CO8	T1, T2, R1, R2
32	Wedge friction & Screw friction	CO7, CO8	T1, T2, R1, R2

33	Screw friction	CO7, CO8	T1, T2, R1, R2
34	Rotational motion, torque, angular momentum	CO9	T1, T2, R1, R2
35	Relation between torque and angular momentum	CO9	T1, T2, R1, R2
36	Angular momentum of system of particles, moment of inertia	CO9	T1, T2, R1, R2
37	Expression for moment of inertia	CO10	T1, T2, R1, R2
38	Radius of gyration	CO10	T1, T2, R1, R2
39	Theorems on moment of inertia	CO10	T1, T2, R1, R2
40	Moment of inertia of thin rod, rectangular lamina, circular disc.	CO10	T1, T2, R1, R2
PROBLEM SOLVING/ CASE STUDIES			
1	Electron polarizability of materials	CO 1	T1, T2, R1, R2
2	Internal filed of solids	CO 1	T1, T2, R1, R2
3	Susceptibility of magnetic materials	CO 2	T1, T2, R1, R2
4	Reverberation time of a room	CO 3	T1, T2, R1, R2
5	Intensity of sound	CO 3	T1, T2, R1, R4
6	Frequency of ultrasonic waves	CO 4	T1, T2, R1, R2
7	Young's modulus of quartz given fundamental frequency	CO 4	T1, T2, R1, R2
8	Resultant force acting on an object	CO 5	T1, T2, R1, R4
9	Concurrent forces in equilibrium	CO 5	T1, T2, R1, R4
10	Tension in a string attached to a weight	CO 6	T1, T2, R1, R4
11	Coefficient of static friction	CO 7	T1, T2, R1, R2
12	Frictional force acting on a body	CO 7	T1, T2, R1, R2
13	Motion of an object on an inclined plane	CO 8	T1, T2, R1, R2
14	Radius of gyration of a rod	CO 9	T1, T2, R1, R2
15	Moment of inertia of a rectangular block	CO 10	T1, T2, R1, R2

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Dielectric and magnetic properties	CO 1	T1, T2, R1, R2
2	Acoustics and ultrasonics	CO 2, 3	T1, T2, R1, R2
3	Equilibrium of system of forces	CO 4	T1, T2, R1, R4
4	Friction	CO 5	T1, T2, R1, R2
5	Dynamics of rigid bodies - moment of inertia	CO 6	T1, T2, R1, R2
DISCUSSION OF QUESTION BANK			
1	Dielectric and magnetic properties	CO 1,2	T1, T2, R1, R2
2	Acoustics and ultrasonics	CO 3, 4	T1, T2, R1, R2
3	Equilibrium of system of forces	CO 5, 6	T1, T2, R1, R4
4	Friction	CO 7, 8	T1, T2, R1, R2
5	Dynamics of rigid bodies - moment of inertia	CO 9,10	T1, T2, R1, R2

Signature of Course Coordinator **HOD, FE**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ENGINEERING DRAWING**				
Course Code	AME001				
Program	B.Tech				
Semester	I				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	4	-	-
Course Coordinator	R.Srinivas, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

II COURSE OVERVIEW:

One of the best ways to communicate one's ideas is through some form of picture or drawing. This is especially true for the engineer. An engineering drawing course focuses on usage of drawing instruments, lettering, construction of geometric shapes, etc. Students study use of dimensioning, shapes and angles or views of such drawings. Dimensions feature prominently, with focus on interpretation, importance and accurate reflection of dimensions in an engineering drawing. Other areas of study in this course may include projected views, pictorial projections and development of surfaces. This course also gives basic concepts for studying machine drawing, building drawing, circuit drawings etc.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering drawing	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Chalk & Talk	✓	Quiz	✓	Assignments	x	MOOC
✓	LCD / PPT	✓	Seminars	x	Mini Project	✓	Videos
x	Open Ended Experiments						

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS.

The emphasis on the experiments is broadly based on the following criteria:

	Experiment Based	**Programming based**
20%	Objective	Purpose
20%	Analysis	Algorithm
20%	Design	Programme
20%	Conclusion	Conclusion
20%	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

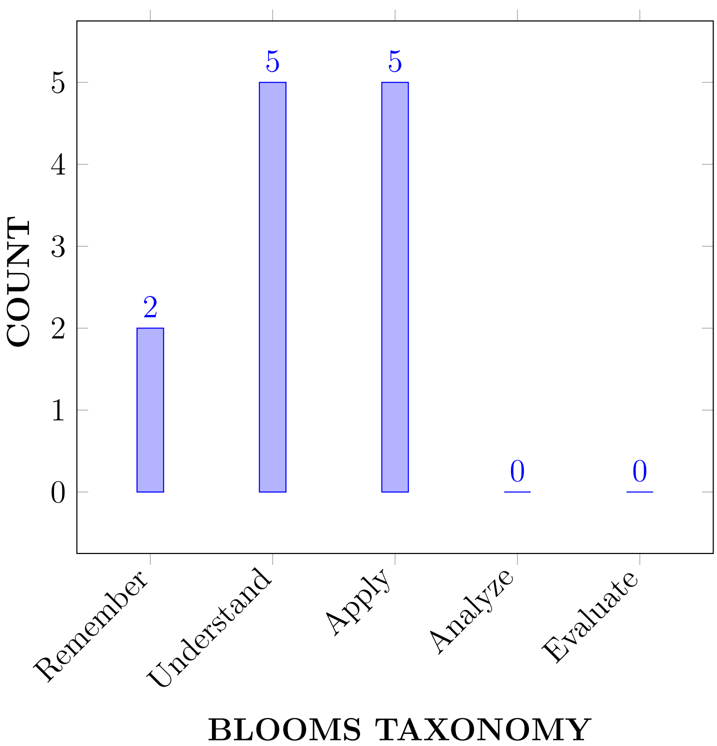
I	Understand the basic principles of engineering drawing and construction of curves used in engineering field
II	Apply the knowledge of interpretation of projection in different quadrants
III	Understand the projections of solids, when it is inclined to both planes simultaneously
IV	Convert the pictorial views into orthographic view and vice versa
IV	Create intricate details of components through sections and develop its surfaces

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** the instruments used in engineering drawing, conventional representations and placing dimensions for **producing flawless drawings in engineering applications**	Understand
CO 2	**Make use of** principles of orthographic projections for the representation **of three dimensional objects on a plane used in engineering field**	Apply
CO 3	**Draw** the isometric projection of three dimensional objects **for visualization of shape and size of the objects.**	Understand
CO 4	**Draw** the development of surfaces of regular solids and their cut sections **used in sheet metal work for making industrial needs.**	Understand
CO 5	**Visualize** the components by isometric projection by representing three dimensional objects in two dimensions **in technical and engineering drawings.**	Understand
CO 6	**Convert** the orthographic views into pictorial views and vice-versa **for designing and manufacturing of components in industries.**	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Assignments
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Assignments
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Assignments

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams	1	Assignments
PSO 2	**Problem solving skills:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	-	Assignments
PSO 3	**Successful career and Entrepreneurship:** To build the nation, by imparting technological inputs and managerial skills to become technocrats.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		✓	-	-
CO 2	✓	-	-	-	-	-	-	-	-	✓	-	-	✓	-	-
CO 3	✓	-	✓	-	-	-	-	-	-	✓	-	-	✓	-	-
CO 4	✓	-	✓	-		-	-	-	-	✓	-	✓	✓	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	✓	-	✓	-	-	-	-	-	-	✓	-	✓	✓	-	-
CO 6	✓	-	✓	-		-	-	-	-	✓	-	-	✓	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall the basic commands of AutoCAD for various curves and scales using **scientific principles** and **engineering fundamentals**	2
	PO 5	Understand Scales and Curves with different methods conceptually and apply them in modeling a **complex engineering** activity	1
	PSO 3	Make use of design **computational** and modeling **experimental tools** for building career paths towards innovative startups to be an entrepreneur.	2
CO 2	PO 1	Recall the basic commands of AutoCAD for various curves and scales using **scientific principles** and **engineering fundamentals**	2
	PO 3	Understand the given **problem statement** related to question formatted for engineering drawings and based upon type use different AutoCAD commands .	1
	PO 10	**Demonstrate** the autocad commands to develop sketches in multi sectional views of a solid object and **Illustrate** to other views	2
CO 3	PO 1	Develop expression for eccentricity and Identify the appropriate type of curve for **problem solving** using **engineering sciences.**	1
	PO 3	Use research based knowledge for different methods of drawing engineering curves and draw with **modern tools**	1
	PO 10	Develop the 3D images of the machine objects and check the **Interference** of the post manufactured objects	1
CO 4	PO 1	Apply the **engineering knowledge** to classify Cycloidal and involutes profiles in user Coordinate System to draw engineering problems.	1
	PO 3	Build practical experience in building the real time products, using **industry standard** and **collaboration technique** in the field of curves.	2
	PO 9	**Classify** the scales for all types of drawings and **Simplify** the image understanding	2
CO 5	PO 5	Recall various types of scales and **use principles of BIS**, and **engineering** fundamentals for engineering applications like maps, buildings, bridges.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	Make a use of an appropriate plane to draw different position of points and lines to solve **engineering problems** for **solution enhancement**	2
	PO 5	Recall various positions in coordinate system for points and lines **use principles of views**, and **engineering fundamentals** for completing the drawing	2
	PO 12	**Develop** the views of the plane projects and extend it to Solve unknown images and provide solutions apart from four planes of projections	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 3	3	-	1	-	-	-	-	-	-	2	-	-	-	-	-
CO 4	3	-	2	-		-	-	-	-	2	-	2	2	-	-
CO 5	3	-	2	-	-	-	-	-	-	2	-	2	2	-	-
CO 6	3	-	2	-	-	-	-	-	-	2	-		1	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	-	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 3	100	-	40	-	-	-	-	-	-	60	-	-	-	-	-
CO 4	100	-	60	-		-	-	-	-	60	-	60	60	-	-
CO 5	100	-	60	-	-	-	-	-	-	60	-	60	60	-	-
CO 6	100	-	60	-		-	-	-	-	60	-	-	60	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 3	3	-	1	-	-	-	-	-	-	2	-	-	-	-	-
CO 4	3	-	2	-	-	-	-	-	-	2	-	2	2	-	-
CO 5	3	-	2	-	-	-	-	-	-	2	-	2	2	-	-
CO 6	3	-	2	-	-	-	-	-	-	2	-	-	1	-	-
TOTAL	18	-	7	2	-	-	-	-	-	9	-	4	5	-	-
AVERAGE	3	-	1.75	-	-	-	-	-	-	1.8	-	2	1.67	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1	SEE Exams	PO 1	Assignments	PO 2
Laboratory Practices	PO 2	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 4	Open Ended Experiments	-
Seminars	PO 2				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**FUNDAMENTALS OF ENGINEERING DRAWING, SCALES AND CURVES**
	Introduction to engineering drawing: Drawing instruments and accessories, types of line, lettering practice and rules of dimensioning, geometrical constructions, basic geometrical shapes; Scales: Types of scales, units of length and their conversion, construction of scales, plain scale, diagonal scale, vernier scale; Curves used in engineering practice and their constructions; Conic sections, construction of ellipse parabola and hyperbola, special curves, construction of cycloid, epicycloids, hypocycloid and involutes
MODULE II	**ORTHOGRAPHIC PROJECTION, PROJECTION OF PLANES**
	Orthographic projection: Principles of orthographic projections, conventions, first and third angle projections, projection of points, projection of lines, lines inclined to single plane, lines inclined to both the planes, true lengths and traces; Projection of planes: Projection of regular planes, planes inclined to one plane, planes inclined to both planes, projection of planes by auxiliary plane projection method.
MODULE III	**PROJECTION OF SOLIDS**
	Projection of solids: Projections of regular solid, prisms, cylinders, pyramids, cones. Solids inclined to one plane, solids inclined to both planes, projection of solid by auxiliary Page — 5 plane projection method.

MODULE IV	**DEVELOPMENT OF SURFACES, ISOMETRIC PROJECTIONS**
	Development of surfaces: Development of lateral surface of right regular solids, prisms, cylinders, pyramids and cones; Isometric projections: Principle of isometric projection, isometric scale, isometric projections and isometric views, isometric projections of planes, prisms, cylinders, pyramids, and cones
MODULE V	**TRANSFORMATION OF PROJECTIONS**
	Transformation of projections: Conversion of isometric views to orthographic views and conversion of orthographic views to isometric views..

TEXTBOOKS

1. N. D. Bhatt, "Engineering Drawing", Charotar Publications, 49thEdition, 2012.
2. C. M. Agrawal, Basant Agrawal, "Engineering Drawing", Tata McGraw Hill, 2ndEdition, 2013.

REFERENCE BOOKS:

1. K.Venugopal, "Engineering Drawing and Graphics", New Age Publications, 2ndEdition, 2010
2. K. C. John, "Engineering Drawing", PHI Learning Private Limited", 2nd Edition, 2009.
3. Dhananjay. A. Johle, "Engineering Drawing", Tata McGraw Hill, 1st Edition, 2008

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on outcome based education		
CONTENT DELIVERY (THEORY)			
1	Principles of engineering drawing – various drawing instruments and their uses. (general exercises).	CO 1	T1:1.1
2	History of Manual Drafting	CO 1	T1: 2.3
3	Structure of drawing boards, lettering practice, dimensioning	CO 2	T1: 3.1
4	Basic geometrical shapes, scales and its uses, plain, diagonal scale	CO 1	T1:3.3
5	Curves used in engineering practice and their constructions	CO 1	T1: 4.3
6	Construction of ellipse parabola and hyperbola	CO 1	T1: 4.3.2
7	cycloid, epicycloids curves	CO 1	T1:3.3
8	Construction of hypocycloid and involutes	CO 2	T1:3.4, R1: 4.1
9	Principles of orthographic projections	CO 1	T1: 4.3
10	Conventions in Drawing – Lettering – BIS	CO 2	T1:1.1
11	auxiliary plane projection method	CO 2	T1: 2.1

12	True lengths and traces	CO 2	T1:2.2 R1: 2.2.3
13	Planes inclined to one plane	CO 1	T1: 2.3
14	Planes inclined to both planes	CO 2	T1: 3.1
15	Projection of planes by auxiliary plane	CO 1	T1:3.3
16	Plane projection method.	CO 2	T1:3.4, R1: 4.1
17	Principles of orthographic projections,	CO 2	T1: 4.1
18	Projection of solids inclined to single plane.	CO 1	T1: 4.3
19	Projection of solids inclined to a both planes.	CO 1	T1: 4.3.2
20	Projection of solids Auxiliary plane method	CO 1	T1:4.3
21	auxiliary plane projection method	CO 2	T1:2.2 R1: 2.2.3
22	True lengths and traces	CO 1	T1:2.2
23	Planes inclined to one plane	CO 2	R1: 2.2.3
24	Planes inclined to both planes	CO 1	T1: 2.3
25	Projection of planes by auxiliary plane	CO 1	T1: 3.1
26	Plane projection method.	CO 2	T1: 4.3
27	Principles of orthographic projections,	CO 1	T1: 4.3.2
28	Projection of solids inclined to single plane.	CO 2	T1: 3.1
29	Projection of solids inclined to a both planes.	CO 2	T1:3.3
30	Projection of solids Auxiliary plane method	CO 2	T1: 4.4
31	Draw the development of surfaces	CO 1	T1: 5.2
32	Draw the isometric projections	CO 2	T1: 5.2.3
33	Convert the pictorial views to orthographic views	CO 2	T1: 6.1
34	lateral surface Development	CO 2	T1: 8.1
35	Right regular solids, prisms, cylinders	CO 1	T1:8.1.2
36	Isometric projections	CO 1	T1: 3.1
37	Isometric scale	CO 1	T1:3.3
38	Transformation of projections:	CO 1	T1: 4.3
39	Conversion of isometric views to orthographic views	CO 2	T1: 4.3.2
40	Conversion of orthographic to isometric	CO 1	T1:3.3
PROBLEM SOLVING/ CASE STUDIES			
1	Calculating scales and proportions for all types of drawings	CO 1	R2:1.5
2	Estimating the lengths of curves in eclipse, hyperbola and parabola	CO 2	R2:5.5
3	Calculating points and planes of projections on V.P. and H.P.	CO 6	R2:6.5
4	Calculating surface area of section of prisms and pyramids	CO 4	R2:3.5
5	Conversion of orthographic to isometric	CO 2	R2:2.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Calculating curve points for ellipse, parabola and hyperbola	CO 3	R4:1.5
2	Tracking the point of projection of point on planes	CO 5	R3:2.5

3	Tracing the surfaces of two dimensional planes and its projections	CO 6	R4:5.5
4	Conversion of orthographic to oblique projections	CO 5	R1:3.5
5	Developing the surfaces of regular solids	CO 5	R3:2.5
6	Solids Inclined to one planes	CO 6	R2:5.5
DISCUSSION OF QUESTION BANK			
1	Path curve calculations of parabola and hyperbola	CO 1, 3	R4: 1.1
2	Points projection on planes in I quadrant	CO 2, 6	T1: 3.5
3	Planes and surfaces projection on vertical planes	CO 3, 4	T1: 3.5
4	Section of Solids surfaces projection on planes	CO 1, 2	T3: 2.5
5	Projection of Section of solids on both planes	CO 5, 6	T6: 3.5

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Course Title	**ENGLISH LANGUAGE AND COMMUNICATION SKILLS LABORATORY**				
Course Code	AHS008				
Program	B.Tech				
Semester	I	ME			
Course Type	Foundation				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Dr. Jetty Wilson , Professor				

I COURSE OVERVIEW:

This lab course is designed to introduce the students to create wide exposure on language learning techniques regarding the basic elements of Listening, Speaking, Reading and Writing. In this lab the students are trained in communicative English language skills, phonetics, word accent, word stress, rhythm and intonation, oral presentations, extempore and Prepared-seminars, group-discussions, presenting techniques of writing, participating role plays, telephonic etiquettes, asking and giving directions, information transfer , debates, description of persons, places, objects etc; . The lab encourages the students to work in a group, engage in peer-reviews and inculcate team spirit through various exercises on grammar, vocabulary, and pronunciation games etc. Students will make use of all these language skills in academic, professional and real time situations.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
English Language and Communication Skills Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Sofware based
20 %	To test the perfection of primary tonic stress accent, pre-tonic secondary stress accent and post-tonic secondary stress accent.
20 %	To test the performance to achieve neutralization of accent.
20 %	To test the awareness while pronouncing gemination, elision and assimilation.
20 %	To test the presentation skills in the ICS laboratory.
20 %	To test the subject knowledge through viva.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Sofware based**

Objective	Analysis	Design	Conclusion	Viva	Total
4	4	4	4	4	20

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

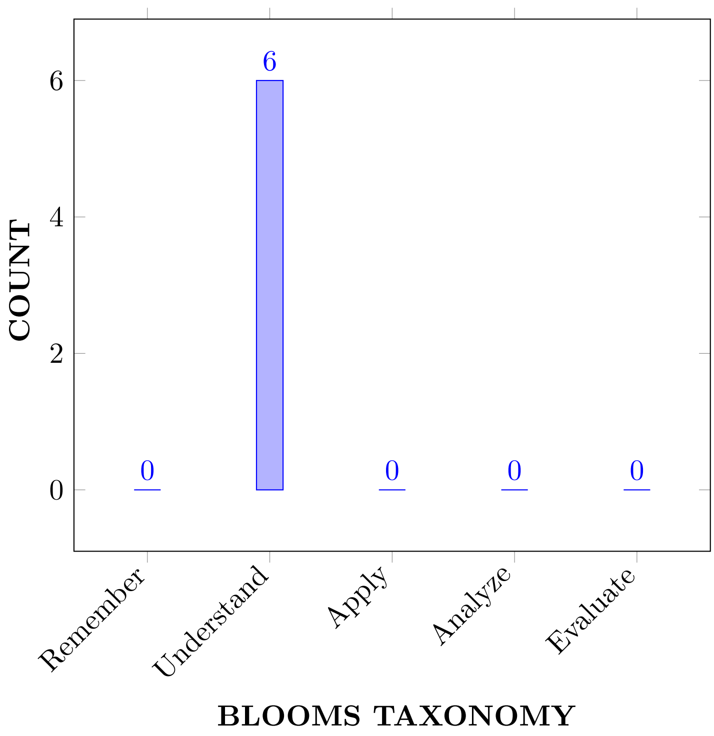
I	Facilitate computer-assisted multi-media instructions to make possible individualized and independent language learning.
II	The critical aspect of speaking and reading for interpreting in-depth meaning of the sentences.
III	Use language appropriately for social interactions such as public speaking, group discussions and interviews.
IV	Habituate using English speech sounds, word accent, intonation and rhythm.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Discuss** the prime necessities of listening skill for improving pronunciation in academic and non-academic purposes.	Understand
CO 2	**Summarize** the knowledge of English phonetics for speaking accepted language and describe the procedure of phonemic transcriptions and intonation patterns.	Understand
CO 3	**Express** about necessity of stressed and unstressed syllables in a word with appropriate length and clarity.	Understand
CO 4	**Explain** how writing skill fulfill the academic and non-academic requirements of various written communicative functions.	Understand
CO 5	**Generalize** appropriate concepts and methods from a variety of disciplines to solve problems effectively and creatively.	Understand
CO 6	**Classify** the roles of collaboration, risk-taking, multi-disciplinary awareness, and the imagination in achieving creative responses to problems.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Day-to-day evaluation / CIE/SEE
PO 10	**Communicate:** effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (Communication).	5	Day-to-day evaluation / CIE/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	ENGINEERING KNOWLEDGE: Graduates shall demonstrate sound knowledge in analysis, design, laboratory investigations and construction aspects of civil engineering infrastructure, along with good foundation in mathematics, basic sciences and technical communication.	-	-
PSO 2	BROADNESS AND DIVERSITY: Graduates will have a broad understanding of economical, environmental, societal, health and safety factors involved in infrastructural development, and shall demonstrate ability to function within multidisciplinary teams with competence in modern tool usage.	-	-
PSO 3	SELF LEARNING AND SERVICE: Graduates will be motivated for continuous self-learning in engineering practice and/ or pursue research in advanced areas of civil engineering in order to offer engineering services to the society, ethically and responsibly.	-	-

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 10	Discuss the heeds of functional **grammar** and **punctuation** tools in **speaking** and **writing** by generating the **clarity** of an audio text.	5
CO 2	PO 9	Define the meaning of **individual work** and **team work** and also participate effectively to develop **leadership** qualities among the **diverse teams** in **multidisciplinary** settings.	5
CO 3	PO 10	Describe the **clarity** of **grammatical** usage and the obligation of **punctuation** marks in **speaking** and **writing**.	5
CO 4	PO 10	Choose suitable **grammatical** structures and **punctuation** marks at **speaking** and **writing** areas maintaining **clarity** at professional platform.	5
CO 5	PO 10	Interpret the **grammatical** knowledge and **punctuation** marks systematically towards providing the **clarity** in **speaking** and **writing**.	5

CO 6	PO 10	Demonstrate the role of **grammar** and **punctuation** marks understanding the meaning between the sentences as well as paragraphs in **speaking** or **writing** for a **clarity**.	5

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 9	PO 10	-	PSO
CO 1	-	5	-	-
CO 2	3	-	-	-
CO 3	-	5	-	-
CO 4	-	5	-	-
CO 5	-	5	-	-
CO 6	-	5	-	

XII ASSESSMENT METHODOLOGY DIRECT:

Laboratory Practices	PO 9, PO 10	Student Viva	PO 9, PO 10	Certification	-
Assignments	-	-	-	-	

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**INTRODUCTION ABOUT ELCS LAB..**
	Introducing Self and Introducing Others – feedback.
WEEK II	**INTRODUCTION TO PHONETICS AND PRACTICING CONSONANTS**
	Describing a person or place or a thing using relevant adjectives – feedback.
WEEK III	**PRACTICING VOWEL SOUNDS.**
	JAM Sessions using public address system.
WEEK IV	**STRUCTURE OF SYLLABLES.**
	Giving directions with help of using appropriate phrases – activities.
WEEK V	**WORD ACCENT AND STRESS SHIFTS. – PRACTICE EXERCISES.**
	Starting a conversation, developing and closing appropriately using fixed expressions..

WEEK VI	**PAST TENSE AND PLURAL MARKERS.**
	Role Play activities.
WEEK VII	**WEAK FORMS AND STRONG FORMS.**
	Oral Presentation..
WEEK VIII	**INTRODUCTION TO INTONATION- USES OF INTONATION - TYPES OF INTONATION- PRACTICE EXERCISES.**
	Expresions In Various Situations.
WEEK IX	**NEUTRALIZATION OF MOTHER TONGUE INFLUENCE (MTI).**
	Sharing Summaries Or Reviews On The Topics Of Students' Choice.
WEEK X	**COMMON ERRORS IN PRONUNCIATION AND PRONUNCIATION PRACTICE THROUGH TONGUE TWISTERS.**
	Interpretation Of Proverbs And Idioms.
WEEK XI	**LISENING COMPREHENSION.**
	Etiquettes.
WEEK XII	**TECHNIQUES AND METHODS TO WRITE SUMMARIES AND REVIEWS OF VIDEOS.**
	Writing Messages, Leaflets And Notices Etc.
WEEK XIII	**COMMON ERRORS.**
	Resume Writing.
WEEK XIV	**INTRODUCTION TO WORD DICTIONARY.**
	Group Discussions – Video Recording – Feedback.
WEEK XV	**INTRODUCTION TO CONVERSATION SKILLS.**
	Mock Interviews.

TEXTBOOKS

1. ENGLISH LANGUAGE AND COMMUNICATION SKILLS: LAB MANUAL

REFERENCE BOOKS:

1. . Meenakshi Raman, Sangeetha Sharma, "Technical Communication Principles and Practices", Oxford University Press, New Delhi, 3rd Edition, 2015.

2. Rhirdion, Daniel, "Technical Communication", Cengage Learning, New Delhi, 1st Edition, 2009.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Introduction About Elcs Lab, Introducing Self And Introducing Others – Feedback.	CO 2	R1: 1.2
2	Introduction To Phonetics And Practicing Consonants, Describing A Person Or Place Or A Thing Using Relevant Adjectives – Feedback.	CO 2	R2: 25-30
3	Practicing Vowel Sounds,Jam Sessions Using Public Address System.	CO 2	R1: 28-29,49-54

4	Structure Of Syllables, Giving Directions With Help Of Using Appropriate Phrases – Activities.	CO 3	R1: 23-38
5	Word Accent And Stress Shifts. – Practice Exercises, Starting A Conversation, Developing And Closing Appropriately Using Fixed Expressions.	CO 3	R1: 2.4
6	Past Tense And Plural Markers,	CO 2	R3: 4.5
7	Weak Forms And Strong Forms,Oral Presentation.	CO 2	R3: 4.6
8	Introduction To Intonation- Uses Of Intonation - Types Of Intonation- Practice Exercises, Expresions In Various Situations.	CO 2	R2: 39-42
9	Neutralization Of Mother Tongue Influence (Mti), Sharing Summaries Or Reviews On The Topics Of Students' Choice.	CO 2	R2: 5.2
10	Common Errors In Pronunciation And Pronunciation Practice Through Tongue Twisters, Interpretation Of Proverbs And Idioms.	CO 2	R1:42-43
11	Lisening Comprehension, Etiquettes	CO 5	R1:44-48
12	Techniques And Methods To Write Summaries And Reviews Of Videos,Writing Messages, Leaflets And Notices Etc.	CO 4	R1:107-110
13	Common Errors, Resume Writing.	CO 4	R1:7.3
14	Introduction To Word Dictionary,Group Discussions – Video Recording – Feedback.	CO 5	R1:7.3
15	Introduction To Conversation Skills,Mock Interviews.	CO 6	R1: 54-58

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments.
1	**Effective listening skills can be used in professional and personal platforms in future.**
2	**By learning LSRW skills, students can enhance desired language skills to fulfill their needs.**
3	**Practicing presentation skills will boost confidence at work place.**
4	**The overall experiments of the laboratory will lead to be an effective communicator.**
5	**The Students will develop critical comprehensive skills to solve the career related problems in future.**

Signature of Course Coordinator **HOD**
Dr.Jetty Wilson , Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**ENGINEERING CHEMISTRY LABORATORY**				
Course Code	AHS103				
Program	B.Tech				
Semester	I	ME			
Course Type	FOUNDATION				
Regulation	IARE – R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
				3	2
Course Coordinator	Mr G Mahesh Kumar, Assiatant Professor				

I COURSE OVERVIEW:

The aim of this Engineering Chemistry laboratory is to develop the analytical ability of the students by better understanding the concepts experimental chemistry. The experiments carried out like preparation of aspirin, thiokol rubber, conductometry, potentiometry, physical properties like viscosity and surface tension of liquids. The volumetric analytical experiments like determination of hardness of water, dissolved oxygen and copper in brass can be carried out in the laboratory.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
10+2	-	-	Basic principles of chemistry laboratory	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering Chemistry laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing Further Experiments

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day-to-day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the principal from the panel of experts recommended by Chairman, BOS.
The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component	**Laboratory**		Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

A. Experiment Based

Objective	**Analysis**	**Design**	**Conclusion**	**Viva**	**Total**
2	2	2	2	2	10

B. Programming Based

Purpose	**Algorithm**	**Program**	**Conclusion**	**Viva**	**Total**
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

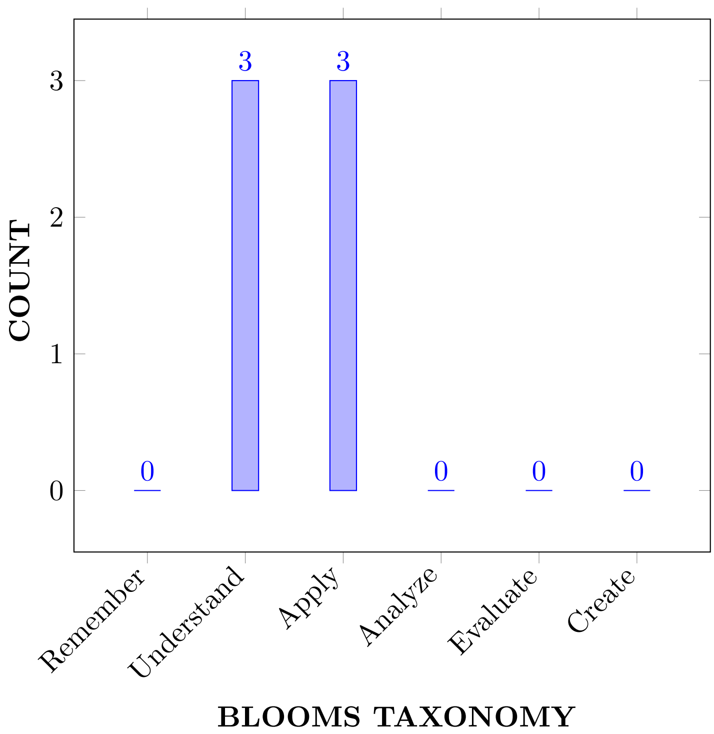
I	The basic principles involved in chemical analysis and mechanism of synthetic organic reactions.
II	The need and importance of quality of water for industrial and domestic use.
III	The measurement of physical properties like surface tension and viscosity.
IV	The knowledge on existing future upcoming devices, materials and methodology.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the mechanism of chemical reactions for synthesizing drug molecules.	Understand
CO 2	**Identify** the total hardness, dissolved oxygen in water by volumetric analysis for finding the hardness causing salts in water.	Apply
CO 3	**Make use of** conductometric and potentiometric titrations for finding the concentration of unknown solutions.	Apply
CO 4	**Choose** different types of liquids for finding the surface tension and viscosity of lubricants.	Apply
CO 5	**Explain** the preparation of synthetic rubbers for utilizing in industries and domestic purpose.	Understand
CO 6	**Relate** the importance of different types of materials for understanding their composition and applications.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	1	SEE/CIE
PO 7	**Environment and sustainability:** understand the impact of the professional engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	SEE/CIE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific outcomes		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	-	-
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications. .	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies..	-	-

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Explain the mechanism of chemical reactions for synthesizing drug molecules by applying mathematical expressions for finding the percentage of Aspirin by using principles of science for solving engineering problems.	3
CO 2	PO 1	Demonstrate the total hardness, dissolved oxygen in water by volumetric analysis for finding the hardness causing salts in water by applying mathematical expressions by using principles of science for solving engineering problems. .	3
	PO 2	Identify the problem and formulate for finding the hardness of water in terms of CaCO3 equivalents with given information and data by applying principles of science..	2
	PO 7	Identify the dissolved oxygen content in raw water and reduce the pollutants in atmosphere to protect aquatic organisms and know the impact in socio economic and environmental contexts for sustainable development..	2
CO 3	PO 1	Choose different electrodes for finding pH of unknown solutions by applying mathematical expressions of cell potential by using principles of science for solving engineering problems.	3
	PO 2	Identify the problem formulation and abstraction for calculating the concentration of unknown solutions by applying normality of standard solution from the provided information.	2
CO 4	PO 1	Choose different types of liquids for finding the surface tension and viscosity of lubricants by applying mathematical expressions by using principles of science for solving engineering problems..	3
	PO 2	Identify the problem formulation and abstraction for calculating viscosity and surface tension of test liquids by applying viscosity and surface tension of standard liquids, density of liquids from the provided information.	2
CO 5	PO 1	Explain the preparation of synthetic rubbers for utilizing in industries and domestic purpose by using principles of science for solving engineering problems.	2
CO 6	PO 1	Demonstrate the percentage of copper in brass, manganese dioxide in pyrolusite by volumetric analysis using mathematical expressions by using principles of science for solving engineering problems. .	3

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			Program specific outcomes
	PO 1	PO 2	PO 7	
CO 1	3	-	-	-
CO 2	3	2	2	-
CO 3	3	2	-	-
CO 4	3	2	-	-
CO 5	3	-	-	
CO 6	3	–	-	-

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK 1	**PREPARATIONS OF ORGANIC COMPOUNDS**
	Preparation of Aspirin
WEEK 2	**VOLUMETRIC ANALYSIS**
	Estimation of hardness of water by EDTA method
WEEK 3	**CONDUCTOMETRIC TITRATIONS**
	Conductometric titration of strong acid Vs strong base
WEEK 4	**POTENTIOMETRIC TITRATIONS**
	Potentiometric titration of strong acid Vs strong base
WEEK 5	**CONDUCTOMETRIC TITRATIONS**
	Conductometric titration of mixture of acid Vs strong base
WEEK 6	**POTENTIOMETRIC TITRATIONS**
	Potentiometric titration of weak acid Vs strong base
WEEK 7	**PHYSICAL PROPERTIES**
	Determination of surface tension of a given liquid using stalagmometer
WEEK 8	**PHYSICAL PROPERTIES**
	Determination of viscosity of a given liquid by using Ostwald's viscometer

WEEK 9	**VOLUMETRIC ANALYSIS**
	Estimation of dissolved oxygen in water
WEEK 10	**PREPARATIONS OF RUBBER**
	Preparation of Thiokol rubber
WEEK 11	**VOLUMETRIC ANALYSIS**
	Determination of percentage of copper in brass.
WEEK 12	**VOLUMETRIC ANALYSIS**
	Estimation of MnO 2 in pyrolusite

TEXTBOOKS

1. Vogel's, "Quantitative Chemical Analaysis", Prentice Hall, 6th Edition, 2000.

2. Gary D.Christian, "Analytical Chemistry",Wiley India, 6th Edition, 2007.

REFERENCE BOOKS:

1. A text book on experiments and calculation Engg. S.S. Dara.

2. Instrumental methods of chemical analysis, Chatwal, Anand, Himalaya Publications

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Preparation of Aspirin.	CO 1	R1, R2
2	Estimation of hardness of water by EDTA method.	CO 2	R1, R2
3	Conductometric titration of strong acid Vs strong base	CO 3	R1, R2
4	Potentiometric titration of strong acid Vs strong base.	CO 3	R1, R2
5	Conductometric titration of mixture of acid Vs strong base	CO 3	R1, R2
6	Potentiometric titration of weak acid Vs strong base	CO 3	R1, R2
7	Determination of surface tension of a given liquid using stalagmometer	CO4	R1, R2
8	Determination of viscosity of a given liquid by using Ostwald's viscometer	CO4	R1, R2
9	Estimation of dissolved oxygen in water	CO 2	R1, R2
10	Preparation of Thiokol rubber	CO 5	R1, R2
11	Determination of percentage of copper in brass.	CO 6	R1, R2
12	Estimation of MnO 2 in pyrolusite	CO6	R1, R2

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design Synthetic drugs such as Aspirin and paracitmal
2	Design Different methods to remove hardness causing salts from water
3	Conductivity based titeration
4	Potential based titeration
5	Stalagmometer based method
6	Ostwards method of Viscosity.
7	copper percentage methods

Signature of Course Coordinator **HOD,ME**
Mr G Mahesh Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**BASIC WORKSHOP**				
Course Code	AME101				
Program	B. Tech				
Semester	I				
Course Type	FOUNDATION				
Regulation	IARE-R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. B. Vijaya Krishna, Assistant Professor				

I COURSE OVERVIEW:

Engineering workshop Practice is intended to enhance the learning experience of the student about Engineering tools for cutting and measuring used in a workshop. Students are expected to gain experience in hands on training as well as knowledge to carry out a particular process for making a product using the basic manufacturing devices used in Workshop.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
-	-	-	-	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering Workshop Practice	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing Further Experiments

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day-to-day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the principal from the panel of experts recommended by Chairman, BOS.

The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component	**Laboratory**		Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

A. Experiment Based

Objective	**Analysis**	**Design**	**Conclusion**	**Viva**	**Total**
2	2	2	2	2	10

B. Programming Based

Purpose	**Algorithm**	**Program**	**Conclusion**	**Viva**	**Total**
-	-	-	-	-	-

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		**Strength**	**Proficiency Assessed by**
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	CIA

PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	Lab Exercises
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	3	SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

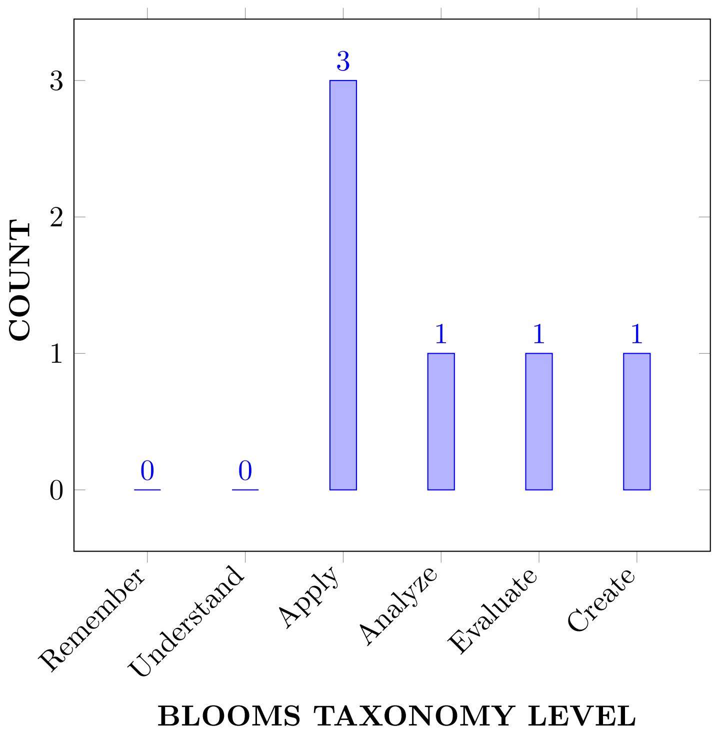
I	Identify and use of tools, types of joints in carpentry, fitting, tin smithy and plumbing operations.
II	Understand of electrical wiring and mould preparation and its components..
III	Observation of the function of lathe, shaper, drilling, boring, milling, grinding machines.

IX COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** the conventional representation of materials and machine elements of various machining processes	Apply
CO 2	**Determine** the ability to Produce Fitting jobs as per specified dimensions in addition to demonstrating proficiency with hand tools common to fitting.	Evaluate
CO 3	**Create** works of metal art using fire and furnace to convert given shape into useable elements using basic blacksmith techniques.	Create
CO 4	**Organize** the moulding techniques for producing casting of different and complex shapes using various patterns.	Apply
CO 5	**Develop** various engineering and household articles such as tin boxes, cans, funnels, ducts etc., from a flat sheet of metal.	Apply
CO 6	**Compare** various wiring diagrams using conduit system of wiring and Prepare different types of wiring joints on the given circuit boards using appropriate electrical tools.	Analyze

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge of engineering fundamentals to join given wooden pieces according to given sketch to develop required joint.	1
	PO 3	Conversion of given design into a practical output using design solution for complex engineering problems and design system components	2
	PO 5	Develop the given resources and engineering tools into proper fitment as given in the diagrammatical representation.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PSO 3	Make use of Experimental tools for Building Career Paths towards Innovation Startups, Employability in different mechanical trades.	2
CO 2	PO 1	Apply the knowledge of engineering fundamentals to join given metal pieces according to given sketch to develop required joint.	1
	PO 5	Develop the given resources and engineering tools into proper fitment as given in the diagrammatical representation.	2

	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PSO 3	Make use of Experimental tools for Building Career Paths towards Innovation Startups, Employability in different mechanical trades.	2
CO 3	PO 1	Apply the knowledge of engineering fundamentals to make metal rod into given required shape according to given sketch to develop required joint.	1
	PO 5	Develop the given resources and engineering tools into required shape as given in the diagrammatical representation.	2
	PSO 3	Make use of Experimental tools for Building Career Paths towards Innovation Startups, Employability in different mechanical trades.	2
CO 4	PO 1	Apply the knowledge of engineering fundamentals to make the casting product from given materials according to given sketch to develop required shape.	1
	PO 3	Conversion of given design into a practical output using design solution for complex engineering problems and design system components.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
CO 5	PO 5	Develop the given resources and engineering tools into required shape as given in the diagrammatical representation.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	
CO 6	PO 1	Apply the knowledge of engineering fundamentals to make the required electrical connection according to given circuit diagram to develop connection.	1
	PO 5	Develop the given resources and engineering tools into proper fitment as given in the diagrammatical representation.	2
	PO 11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2
	PSO 3	Make use of Experimental tools for Building Career Paths towards Innovation Startups, Employability in different mechanical trades.	2

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES				Program Specific Outcomes
	PO 1	PO 3	PO 5	PO 11	PSO 3
CO 1	1	2	2	2	2
CO 2	1	2		2	2
CO 3	1		2		2
CO 4	1	2		2	
CO 5			2	2	
CO 6	1		2	2	2

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 3,PSO 3	SEE Exams	PO 1, PO 3, PO 5,PSO 3	Seminars	-
Laboratory Practices	PO 1, PO 3,PO 5, PSO 3	Student Viva	PO 1, PO 5	Certification	-
Assignments		Mini projects	-		

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK 1	**CARPENTRY-I**
	Batch I: Preparation of Tenon joint as per given dimensions. Batch II: Preparation of Mortise joint as per given taper angle.
WEEK 2	**CARPENTRY-II**
	Batch I: Preparation of dove tail joint as per given taper angle. Batch II: Preparation of lap joint as per given dimensions.
WEEK 3	**FITTING - I**
	Batch I: Make a straight fit for given dimensions. Batch II: Make a square fit for given dimensions.
WEEK 4	**FITTING - II**
	Batch I: Make a V fit for given dimensions. Batch II: Make a semicircular fit for given dimensions.
WEEK 5	**BLACKSMITHY- I**
	Batch I: Prepare S-bend for given MS rod using open hearth furnace. Batch II: Prepare J-bend for given MS rod using open hearth furnace.

WEEK 6	**BLACKSMITHY- II**
	Batch I: Prepare Fan hook for given dimensions. Batch II: Prepare Round to Square for given dimensions.
WEEK 7	**MOULD PREPARATION-I**
	Batch I: Prepare a wheel flange mould using a given wooden pattern. Batch II: Prepare a bearing housing using an aluminum pattern.
WEEK 8	**MOULD PREPARATION-II**
	Batch I: Prepare a bearing housing using an aluminum pattern. Batch II: Prepare a wheel flange mould using a given wooden pattern.
WEEK 9	**TINSMITHY- I**
	Batch I: Prepare the development of a surface and make a rectangular tray for given dimensions. Batch II: Prepare the development of a surface and make a round tin for given dimensions.
WEEK 10	**TINSMITHY- II**
	Batch I: Prepare the development of a surface and make a Square Tin, for given dimensions. Batch II: Prepare the development of a surface and make a Conical Funnel for given dimensions.
WEEK 11	**ELECTRICAL WIRING-I**
	Batch I: Make an electrical connection of two bulbs connected in series. Batch II: Make an electrical connection of two bulbs connected in parallel.
WEEK 12	**ELECTRICAL WIRING-II**
	Batch I: Make an electrical connection of one bulb controlled by two switches connected.
	Batch II: Make an electrical connection of tube light.
WEEK 13	**DEMONSTRATION OF WELDING AND PIPE PLUMBING JOINTS**
	Batch I: Batch I: Demonstration of arc welding and gas welding.
	Batch II: : Preparation of pipe plumbing joints.

WEEK 14	**DEMONSTRATION OF MACHINE TOOLS**
	Batch I: Batch I: Familiarization of central lathe and shaping machine and it‘s working.
	Batch II: : Familiarization of drilling, milling and grinding machines and its working.

WEEK 15	**DEMONSTRATION OF MACHINE TOOLS**
	Batch I: Batch I: Familiarization of drilling, milling and grinding machines and its working.
	Batch II: : Familiarization of central lathe and shaping machine and it‘s working

TEXTBOOKS

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., Elements of Workshop Technology, Media promoters and publishers private limited, Mumbai, Vol. I 2014 and Vol. II 2012.
2. Kalpakjian S, Steven S. Schmid, Manufacturing Engineering and Technology, Pearson Education India Edition, 4th Edition, 2012.
3. Gowri P. Hariharan, A. Suresh Babu, Manufacturing Technology – I, Pearson Education, 2011.
4. Roy A. Lindberg, Processes and Materials of Manufacture, Prentice Hall India, 4 th Edition, 1998.
5. Rao P.N., Manufacturing Technology, Vol. I and Vol. II, Tata McGraw-Hill House, 2017

REFERENCE BOOKS:

1. Gowri P. Hariharan, A. Suresh Babu, Manufacturing Technology – I, Pearson Education, 2012.
2. Roy A. Lindberg, Processes and Materials of Manufacture, Prentice Hall India, 4th Edition, 2008.
3. Rao P.N., Manufacturing Technology, Vol. I and Vol. II, Tata McGraw-Hill House, 2017.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Tenon joint and Mortise joint.	CO 1, CO 2	T1:1.4, R1:1.2
2	Dove tail joint and Lap joint.	CO 1, CO 2	T1:1.5, R1:1.3
3	Straight fit and Square fit.	CO 3, CO 4	T2:12.2, R2:13.1
4	V fit and Semicircular fit.	CO 3, CO 4	T2:12.3, R2:13.4
5	S-bend and J-bend.	CO 5, CO 6	T3:9.1, R3:3
6	Fan and Round to Square shape.	CO 5, CO 6	T3:9.1, R3:3
7	Wheel flange and bearing housing.	CO 7, CO 8	T4:1.9, R2:1.8
8	Bearing housing and Wheel flange.	CO 7, CO 8	T4:2, R2:1.9
9	Rectangular tray and Round tin.	CO 9, CO 10	T5:1.4, R1:1.2
10	Make a Square Tin and Conical Funnel.	CO 9, CO 10	T5:1.7, R2:1.3
11	Series connection and parallel Connection.	CO 11, CO 12	T4:1.4, R1:1.2
12	One bulb controlled by two switches and tube light connection.	CO 11, CO 12	T5:7.1, R3:3.8

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Divided Tenon Joint:** It is the simplest form of Mortise and tenon joint and this joint is made by fitting a short tenon into a continuous groove. This joint has the advantage of being easy to cut and is often used to make cabinet doors and other light duty frame and panel assemblies.
2	**Cross Fitting:** It is the fundamental of type of fitting which are used fitting trade and it is formed by joining the two inclined shaped cut specimens together and is often used to join the universal bearings.
3	**Hexagonal Headed Bolt:** Hexagonal bolts are large bolts with a six-sided head used to fasten wood to wood, or metal to wood. These will have a tendency to spin as you tighten them.
4	**Open scoop:** Open scoop is used for accurately dispensing powders and granules hygienically. It is suitable for any hygienic application.
5	**T-Pipe Joint:** T-pipe is a type of fitting which is T-shaped having two outlets at 90 degrees to the main line. It is short piece of pipe with a lateral outlet.it is widely used as pipe fittings.
6	**Grooved Pulley:** Grooved pulley often used to for holding a belt, wire rope or rope and incorporated into a pulley. These sheave pins on a axle or bearing inside the frame of the pulley. This allows wire or rope to move freely, minimizing friction and wear on the cable.
7	**Bell Indicator circuit:** Bell indicator circuit is used where a bell and buzzers are needed to control from different locations. Bell indicator circuit is also known as hoteling circuit where an electric bell is controlled from more than one locations.

Prepared by: **HOD,ME**

Mr. B. VijayaKrishna Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

Mechanical Engineering

COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">IT WORKSHOP</td></tr>
<tr><td>Course Code</td><td colspan="5">ACS113</td></tr>
<tr><td>Programme</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td colspan="5">III</td></tr>
<tr><td>Course Type</td><td colspan="5">Foundation</td></tr>
<tr><td>Regulation</td><td colspan="5">IARE R-16</td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lectures</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>3</td><td>1.5</td></tr>
<tr><td>Chief Coordinator</td><td colspan="5">Ms B. Pravallika, Assistant Professor</td></tr>
</table>

I. COURSE OVERVIEW:

This course covers the basics of computer knowledge and demonstrates fundamental LaTex programming techniques, spreadsheet files and terms including the most common latex functions and the usage of the mathematical equations. This course helps to undertake future courses organization and management of local area networks (LANs) wide area networks (WANs). The applications of this course are to design, implement and maintain a basic web page.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
-	-	-	-	-

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
IT Workshop	70 marks	30 marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

	Open Ended Experiments	✔	Demo Video	✔	Lab Worksheets	✔	Viva Questions

V. EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS.

The emphasis on the experiments is broadly based on the following criteria:

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Table 1: Assessment pattern for CIA

Component	Laboratory		Total Marks
Type of Assessment	Day to day performance	Final internal lab assessment	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16^{th} week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

A. Experiment Based

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

B. Programming Based

Purpose	Algorithm	Program	Conclusion	Viva	Total
2	2	2	2	2	10

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Case study
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Lab Exercise
PO 3	**Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	3	Lab Exercise, Case study
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	Lab Exercise

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	2	Lab Exercise

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES:

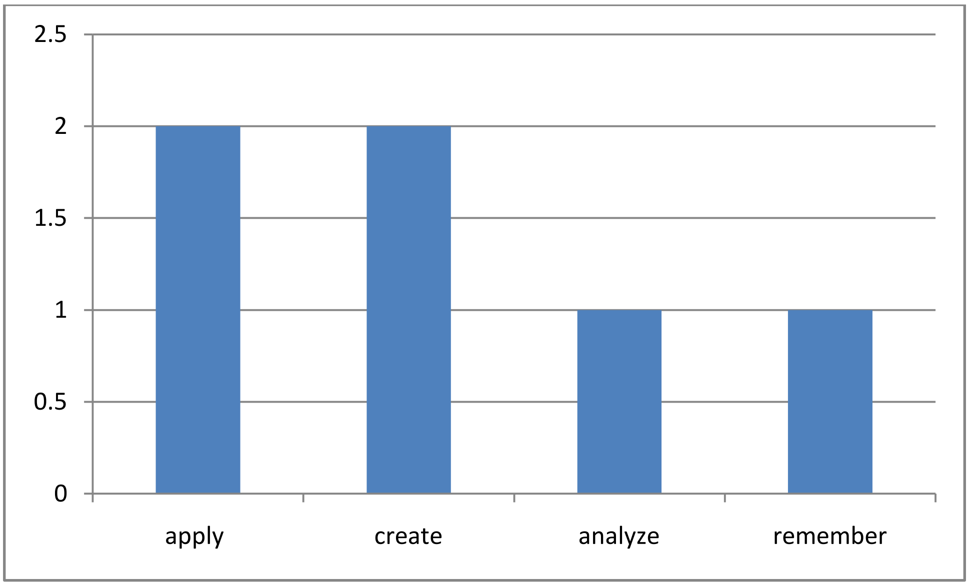
The students will try to learn	
I	Preambles of Latex file to define document class and layout options.
II	The various templates Mathematical documents, presentations, and reports from latex
III	The fundamental concepts of computer networking.
IV	How to Create a link within a web page.

IX. COURSE OUTCOMES:

After successful completion of the course, students will be able to:		
CO No	**Course Outcomes**	**Knowledge Level (Bloom's Taxonomy)**
CO 1	**Make use of** the LaTeX file to define document class and layout options for writing simple latex programs	Apply
CO 2	**Apply** the paragraphs, design pages, create lists, tables, references, and figures for preparing word documents and inserting figures using latex	Create
CO 3	**Make use of** the concepts beginning with basic formulas (inline) and centered and numbered equations (display math) and aligning multi-line	Apply

	equations to prepare mathematical documents	
C0 4	**Develop** large documents create complex projects building upon sub-files for writing technical papers	Create
CO 5	**Analyze** various methods to either create or import graphics into a LaTeX document	Analyze
CO 6	**List** the fundamental concepts of computer networking.	Remember

COURSE KNOWLEDGE COMPETENCY LEVELS



X. JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING

Course Outcomes	POs / PSOs	Justification for mapping (Students will be able to)	No. of key competencies
CO 1	**PO 1**	**Describe** latex, texworks, document class, and the installation of latex **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 2	**Describe** latex, texworks, document class, and the installation of latex **with Problem statement and system definition , Problem formulation and abstraction**	2
CO 2	**PO 1**	**Demonstrate** the use of latex for writing technical paper and maintenance **basic fundamentals of mathematics and engineering fundamentals.**	2
	PO 2	**Demonstrate** the use of latex for writing technical paper and maintenance for **the Problem statement and system definition, Problem formulation and abstraction, Information and data collection, Model translation**	3
	PO 3	**Demonstrate** the use of latex for writing technical paper and maintenance for **of Investigate and define a problem and identify constraints Manage the design process and evaluate outcomes,**	4
	PO 5	**Demonstrate** the use of latex for writing technical paper and maintenance **by Understanding of contexts in which engineering knowledge can be applied, Understanding use of technical literature , Understanding of appropriate codes of**	3

		practice and industry standards.	
	PSO 3	**Demonstrate** the use of latex for writing technical paper	1
CO 3	**PO 2**	**Make use of** basic formulas (inline) and centered and numbered equations (display math) and aligning multi-line equations to prepare mathematical documents for **the Problem statement and system definition, Problem formulation and abstraction , Information and data collection, Model translation**	4
	PO 3	**Make Use of** basic formulas (inline) and centered and numbered equations (display math) and aligning multi-line equations to prepare mathematical documents for the help of **Investigate and define a problem and identify constraints, Manage the design process and evaluate outcomes**	3
	PO 5	**Make Use of** basic formulas (inline) and centered and numbered equations (display math) and aligning multi-line equations to prepare mathematical documents **by Understanding of contexts in which engineering knowledge can be applied, Understanding use of technical literature , Understanding of appropriate codes of practice and industry standards.**	3
	PSO 3	**Make Use of** basic formulas (inline) and centered and numbered equations (display math) and aligning multi-line equations to prepare mathematical documents **by using a set of steps.**	1
CO 4	**PO 1**	**Define** large documents, create complex projects ,building upon sub-files for writing technical papers **for the knowledge of mathematics, science, and engineering fundamentals.**	3
	PO 2	**Define** Develop large documents create complex projects building upon sub-files for writing technical papers for **the Problem statement and system definition, Problem formulation and abstraction , Information and data collection, Model translation**	4
CO 5	**PO 2**	**Apply** various methods to either create or import graphics into a LaTeX document **Problem statement and system definition, Problem formulation and abstraction, Information and data collection, Model translation**	4
	PO 3	**Apply** various methods to either create or import graphics into a LaTeX document **Investigate and define a problem and identify constraints ,Understand customer and user needs**	4
	PO 5	**Apply** various methods to either create or import graphics into a LaTeX document **by Understanding of contexts in which engineering knowledge can be applied, Understanding use of technical literature , Understanding of appropriate codes of practice and industry standards.**	3
	PSO 3	**Apply** various methods to either create or import graphics into a LaTeX document **by using sequence of steps**	1
CO 6	**PO 1**	**Design** Understand the fundamental concepts of computer networking **with basic fundamentals of mathematics and engineering fundamentals.**	2
	PO 2	**Design** Understand the fundamental concepts of computer networking **by the Problem statement and system definition, Problem formulation and abstraction , Information and data collection, Model translation**	4
	PO 3	**Design** Understand the fundamental concepts of computer networking by **Investigate and define a problem and identify**	4

		constraints ,Understand customer and user needs, Manage the design process and evaluate outcomes	
	PO 5	**Design** Understand the fundamental concepts of computer networking **Understanding of contexts in which engineering knowledge can be applied, Understanding use of technical literature, Understanding of appropriate codes of practice and industry standards.**	3
	PSO 3	**Design** Understand the fundamental concepts of computer networking **by using sequence of steps**	1

3 = High; 2 = Medium; 1 = Low

XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Course Outcomes	Program Outcomes				Program Specific Outcomes
	PO1	**PO2**	**PO3**	**PO5**	**PSO2**
CO 1	3	2			
CO 2	2	3	3	2	3
CO 3		2	3	3	3
CO 4	3	3			
CO 5		2	2	3	2
CO 6	2	2	3	2	1

3 = High; 2 = Medium; 1 = Low

XII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	✔	SEE Exams	✔	Assignments	-	Seminars	-
Laboratory Practices	✔	Student Viva	✔	Mini Project	-	Certification	-

XIII. ASSESSMENT METHODOLOGIES–INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XIV. SYLLABUS

LISTOFEXPERIMENTS	
WEEK-1	**LaTeX FORMATTING**
Introduction of LaTex and LateX document formatting: Create a LaTeX document with following formatting: All margins with 1.5, headings with bold, text with normal, chapter name with blue color, line space with 1.5.	
WEEK-2	**TECHNICAL PAPER PREPARATION IN LaTeX**

Essential steps in writing the technical report:
Create a technical report according to IEEE format includes title of the paper, authors name and affiliations, abstract and keywords, introduction section, background section, and other sections, references.

WEEK-3	**FORMATTING MATHEMATICAL EQUATIONS IN LaTeX**

Create a LaTeX document with following mathematical equations along with equation numbers in Italic format: summation (represent in sigma symbol), integration, integral of summation, average of summation, trigonometric equations, polynomial and non-polynomial equations

WEEK–4	**GRAPHICS AND TABLES IN LaTeX**

Create a LaTeX documents with images and image caption at centre alignment, table with thick border and table caption with centre alignment, row height, content with cell centre alignment.

WEEK-5	**VARIOUS FORMATTING STYLES IN LaTeX**

Using LaTeX to create project certificate. Features to be covered:- Formatting Fonts in word, Drop Cap in word, Applying Text effects, Using Character Spacing, Borders and Colors, Inserting Header and Footer, Using Date and Time option in both LaTeX.

WEEK-6	**EXCEL SPREADSHEETS**

Spreadsheet Orientation: Accessing, overview of toolbars, saving spreadsheet files, Using help and resources. Creating a Scheduler:- Gridlines, Format Cells, Summation, auto fill, Formatting Text
Calculating GPA - Features to be covered:- Cell Referencing, Formulae in spreadsheet – average, std. deviation, Charts, Renaming and Inserting worksheets, Hyper linking, Count function, Sorting, Conditional formatting.

WEEK-7	**PREPARATION OF POWERPOINT PRESENTATION IN LaTeX**

Student should work on basic power point utilities and tools in Latex which help them create basic power point presentation. PPT Orientation, Slide Layouts, Inserting Text, Formatting Text, Bullets and Numbering, Auto Shapes, Lines and Arrows

WEEK-8	**WEBPAGES CREATION AND DESIGNING**

HTML, creating simple web pages, images and links, design of web pages.
Develop home page: Student should learn to develop his/her home page using HTML consisting of his/her photo, name, address and education details as a table and his/her skill set as a list.

WEEK-9	**WEB DESIGN FOR SAMPLE PROJECT**

Create a webpage with HTML describing your department. Use paragraph and list tags.
Apply various colors to suitably distinguish key words. Also apply font styling like italics, underline and two other fonts to words you find appropriate. Also use header tags.
Create links on the words e.g. “Wi-Fi” and “LAN” to link them to Wikipedia pages. Insert an image and create a link such that clicking on image takes user to other page. Change the background color of the page.
At the bottom create a link to take user to the top of the page.

WEEK-10	**NETWORK CONNECTIVITY**

Students should get connected to their Local Area Network and access the Internet. In the process they configure the TCP/IP setting. Finally students should demonstrate how to access the websites and email.

WEEK-11	**SURFING THE WEB**

Web Browsers, Surfing the Web: Students customize their web browsers with the LAN proxy settings, bookmarks, search toolbars and pop up blockers.

WEEK-12	**ROUTER CONFIGURATION**

Cabling a network using CCNA, basic and challenge router configuration, subnetting, practical test router connections and settings, troubleshooting challenges

TextBooks:

1 A beginner guide to latex,learn latex in easy tutorials by chetan Shirore,2012
2 Peterson, Davie, Elsevier,―ComputerNetworks‖,5 th Edition,2011

ReferenceBooks:

1.Introduction to Information Technology, ITL Education Solutions limited, Pearson Education India, 2005
2.LaTeX Companion – Leslie Lamport, PHI/Pearson.
3.David Anfinson and Ken Quamme, IT Essentials: PC Hardware and Software Companion Guide, Third

Edition, Cisco Press, 2008
WebReferences:
1. https://www.latex-tutorial.com/tutorials/https://tutorial.techaltum.com/webdesigning.html

XV. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Week No.	Topics to be covered	Course Outcomes	Reference
1	LaTex Formatting	CO 1	T1:4.1
2	Technical Paper Preparation In Latex	CO 1	T1:4.9,4.11
3	Formatting Mathematical Equations In Latex	CO 2	T1:3
4	Graphics And Tables In Latex	CO 3	T1:18
5	Various Formatting Styles In Latex	CO 3	T1:18
6	Excel Spreadsheets	CO 4	T1:10
7	Preparation Of Powerpoint Presentation In Latex	CO 5	T1:28
8	Webpages Creation And Designing	CO 5	T1:29
9	Web Design For Sample Project	CO 5	T1:35
10	Network Connectivity	CO 6	T2:24
11	Surfing The Web	CO 6	T2:26
12	Router Configuration	CO 6	T2:28

XVI. EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S. No.	Design Oriented Experiments
1	Assist student to design system calls in LaTex Systems.
2	Stimulate students to develop graphics programming
3	Encourage students to solve real time applications and prepare towards competitive examinations.

Prepared by:
Ms. B pravallika
Assistant Professor **HOD, CE**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

<table>
<tr><td>Department</td><td colspan="5">MECHANICAL ENGINEERING</td></tr>
<tr><td>Course Title</td><td colspan="5">ENGINEERING MECHANICS</td></tr>
<tr><td>Course Code</td><td colspan="5">AME002</td></tr>
<tr><td>Program</td><td colspan="5">B. Tech</td></tr>
<tr><td>Semester</td><td colspan="5">TWO</td></tr>
<tr><td>Course Type</td><td colspan="5">Foundation</td></tr>
<tr><td>Regulation</td><td colspan="5">IARE - R16</td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>3</td><td>1</td><td>4</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr. B D Y Sunil, Assistant Professor</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS002	1	Linear Algebra and Ordinary Differential Equations

II COURSE OVERVIEW:

Engineering Mechanics is a branch of Physics that deals with the study of the system of forces acting on a particle which is at rest or in motion. The course emphasizes thorough understanding of theories and principles related to static and dynamic equilibrium of rigid bodies to acquire the analytical capability required for solving engineering problems and is one of the foundation courses that forms the basis of many of the traditional branches of engineering such as aerospace, civil and mechanical engineering.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering Mechanics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	x	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	✓	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
%	Remember
%	Understand
%	Apply
%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

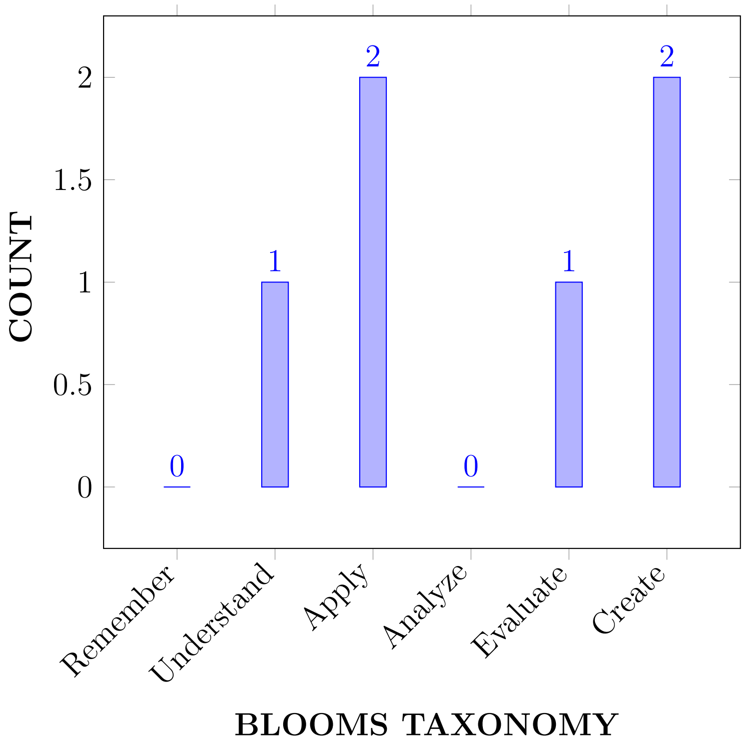
I	Develop the ability to work comfortably with basic engineering mechanics concepts required for analyzing dynamic structures.
II	Identify an appropriate structural system to studying a given problem and isolate it from its environment, model the problem using good free-body diagrams and accurate equilibrium equations.
III	Identify and model various types of loading and support conditions that act on structural systems, apply pertinent mathematical, physical and engineering mechanical principles to the system to solve and analyze the problem .
IV	Understand the meaning of impulse and momentum, virtual work and solve the field problems .
V	Solve the problem of equilibrium by using the principle of work and energy and vibrations for preparing the students for higher level courses such as, Mechanics of Solids, Mechanics of Fluids etc .

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** principles for rectilinear motion of particles to solve problems in motion curves, rigid body motion and fixed axis rotation.	Apply
CO 2	**Apply** D'Alembert's principle to a dynamic equilibrium system by introducing the inertia force for knowing the acceleration and forces involved in the system.	Apply
CO 3	**Develop** the relations for the motion of body in lift and on inclined plane to identify the unknown forces and the forces due to gravity.	Create
CO 4	**Understand** the concept of virtual work to solve problems involving displacements and time with respect to impact and impulse momentum equation.	Understand
CO 5	**Determine** the effect of law of conversation of energy when the system involves before and after collision.	Evaluate
CO 6	**Develop** the governing equation for momentum and vibrational phenomenon of mechanical system by using energy principles for obtaining co efficient and circular frequency.	Create

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	[CIE/Quiz/AAT]
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Seminar/ Conferences / Research papers

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Research papers / Group discussion / Short term courses

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	-	-	-		-	-	-	-	-	-		-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	✓	-	✓		-	-	-	-	-	-	-	✓	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Apply the knowledge and principals of mathematics to engineering problems for determining reactions and resultants of forces using the knowledge of mathematics and science fundamentals	2
	PO 2	Analyze and formulate the engineering problems to determine the reactions and resultants of given force systems. Analyze and identify the problem statement, formulation and abstraction for the development of solution.	4
CO2	PO 2	Collect the data from complex engineering problems and implement them to draw the free body diagrams and interpret the results	3
CO 3	PO 2	Formulate the force system of friction problem and identify the appropriate equilibrium equation and develop the solution from the first principles of mathematics.	4
	PO 4	Understand the principles of engineering and apply them to the friction systems by analyzing the condition of motion of rest of the body	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PO 1	Apply the mathematical principles and engineering fundamentals to identify the centroid and centre of gravity in engineering problems.	2
CO 5	PO 1	Use the fundamentals of engineering and science in identifying the moment of inertia for regular and composite sections and solids.	2
CO 6	PO 2	Formulate the problem statement and model the system for getting the solution for the movement of bodies involving forces	3
	PO 4	Understand the technical concepts of D'Alembert's principle and interpret the equilibrium conditions for various applications.	2
	PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-		-	-	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	3	-	2	-	-	-	-	-	-	-		2	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	40.0	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	40	-	18.2	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	-	-	-		-	-	-	-	-	-		-	-	-
CO 5	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	30.0	-	18.2		-	-	-	-	-	-		100	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	1	-	1	-	-	-	-	-	-	-	-	3	-	-
TOTAL	9	4	-	2	-	-	-	-	-	-	-	-	3	-	-
AVERAGE	3.0	1.0	-	1.0	-	-	-	-	-	-	-	-	3.0	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**KINEMATICS OF PARTICLES- RECTILINEAR MOTION**
	Motion of a particle – Rectilinear motion – motion curves – Rectangular components of curvilinear motion Kinematics of Rigid Body - Types of rigid body motion - Angular motion - Fixed Axis Rotation .
MODULE II	**KINETICS OF PARTICLE**
	Introduction-Definitions of Matter, body, particle, mass, weight, inertia, momentum. Newton's law of motion. Relation Between force and mass. Motion of a particle in rectangular coordinates. D'Alembert's Principle.Motion of Lift. Motion of body on an inclined plane. Motion of connected Bodies.
MODULE III	**IMPULSE AND MOMENTUM, VIRTUAL WORK**
	IMPULSE AND MOMENTUM Impulse And Momentum: Introduction-Impact, Momentum, Impulse and Impulsive forces, Units. Law of conservation of Momentum, Newton's law of collision of elastic bodies-coefficient of Restitution. Recoil of Gun. Impulse Momentum Equation. VIRTUAL WORK: Introduction – Principle of virtual work – Applications – Beams, Lifting machines, Simple framed structures
MODULE IV	**WORK ENERGY METHOD**
	Law of conservation of Energy, Application of Work Energy Method to particle motion and connected system- Work energy applied to Connected Systems - Work energy applied to Fixed Axis Rotation.

MODULE V	**MECHANICAL VIBRATIONS**
	Definitions and Concepts – Simple Harmonic Motion – Free vibrations, simple and Compound Pendulums – Torsion Pendulum – Free vibrations without damping: General cases.

TEXTBOOKS

1. R.C. Hibbler, "Engineering Mechanics", Prentice Hall, 12th Edition, 2009.
2. Engineering Mechanics - Statics and Dynamics by Ferdinand.L. Singer / Harper International Edition.
3. Engineering Mechanics/ S. Timoshenko and D.H. Young, Mc Graw Hill Book Company.

REFERENCE BOOKS:

1. S. Bhavikatti, "A Text Book of Engineering Mechanics", New Age International, 1st Edition, 2012.
2. A.K Tayal ,"Engineering Mechanics", Uma Publications, 14th Edition, 2013.
3. R.K. Bansal "Engineering Mechanics", Laxmi Publications, 8th Edition, 2013.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=pages/mech-btech-course-syllabi-ug20

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Discussion on Objectives and Outcomes of the course Engineering Mechanics		
CONTENT DELIVERY (THEORY)			
1	Introduction to motion of a particle	CO 1	T2:5.5 R1:1.12.1
2	Rectilinear motion	CO 1	T2:5.6 R1:1.12.3
3	Motion curves	CO 1	T2:5.10 R1:1.15
4	Rectangular components of curvilinear motion	CO 1	T2:5.15 R1:1.16
5	Difference between rectilinear motion and curvilinear motion	CO 1	T2:5.17 R1:1.13.1
6	Kinematics of Rigid Body	CO 1	T2:5.18 R1:1.13.2
7	Types of rigid body motion	CO 1	T2:5.19 R1:1.13.3
8	Angular motion	CO 1	T2:5.20 R1:1.7.1

9	Fixed Axis Rotation	CO 1	T2:5.24 R1:1.17.3
10	Introduction to kinetics	CO 2	T2:6.3 R1:2.6.1
11	Definitions of Matter, body, particle, mass, weight, inertia, momentum	CO 2	T2:6.5 R1:2.6.2
12	Newton's law of motion	CO 2	T2:5.5 R1:1.12.1
13	Relation Between force and mass	CO 2	T2:5.6 R1:1.12.3
14	Motion of a particle in rectangular coordinates	CO 2	T2:5.10 R1:1.15
15	D'Alembert's Principle.Motion of Lift	CO 2	T2:5.15 R1:1.16
16	Motion of body on an inclined plane, motion of connected Bodies	CO 2	T2:5.17 R1:1.13.1
17	Impulse And Momentum: Introduction- Impact, Momentum	CO 3	T2:5.18 R1:1.13.2
18	Impulse and Impulsive forces, Units	CO 3	T2:5.19 R1:1.13.3
19	Law of conservation of Momentum, Newton's law of collision of elastic bodies- coefficient of Restitution	CO 3	T2:5.20 R1:1.7.1
20	Recoil of Gun. Impulse Momentum Equation	CO 3	T2:5.24 R1:1.17.3
21	Introduction to virtual work	CO 4	T2:5.5 R1:1.12.1
22	Principle of virtual work – Applications	CO 4	T2:5.6 R1:1.12.3
23	Beams, Lifting machines	CO 4	T2:5.10 R1:1.15
24	Simple framed structures	CO 4	T2:5.15 R1:1.16
25	Introduction to work energy method	CO 5	T2:5.17 R1:1.13.1
26	Law of conservation of Energy	CO 5	T2:5.18 R1:1.13.2
27	Applications of Work Energy Method	CO 5	T2:5.19 R1:1.13.3
28	Applications of Work Energy Method to particle motion	CO 5	T2:5.20 R1:1.7.1
29	Applications of Work Energy Method to connected system	CO 5	T2:5.24 R1:1.17.3
30	Work energy applied to Connected Systems	CO 5	T2:6.3 R1:2.6.1
31	Work energy applied to Fixed Axis Rotation	CO 5	T2:6.5 R1:2.6.2
32	Introduction to mechanical vibrations	CO 6	T2:5.5 R1:1.12.1

33	Definitions and Concepts	CO 6	T2:5.6 R1:1.12.3
34	Simple Harmonic Motion	CO 6	T2:5.10 R1:1.15
35	Free vibrations	CO 6	T2:5.15 R1:1.16
36	Simple pendulum	CO 6	T2:5.17 R1:1.13.1
37	Compound pendulum	CO 6	T2:5.18 R1:1.13.2
38	Torsional pendulum	CO 6	T2:5.19 R1:1.13.3
39	Free vibrations without damping	CO 6	T2:5.20 R1:1.7.1
40	Free vibrations without damping general cases	CO 6	T2:5.24 R1:1.17.3
PROBLEM SOLVING/ CASE STUDIES			
1	Rectilinear motion of a particle	CO 1	T2:5.5 R1:1.12.1
2	Kinematics of Rigid Body	CO 1	T2:5.6 R1:1.12.3
3	Fixed Axis Rotation	CO 1	T2:5.10 R1:1.15
4	D'Alembert's Principle	CO 2	T2:5.15 R1:1.16
5	Motion of Lift	CO 2	T2:5.17 R1:1.13.1
6	Motion of body on an inclined plane	CO 2	T2:5.18 R1:1.13.2
7	Motion of connected Bodies	CO 2	T2:5.19 R1:1.13.3
8	Impact, Momentum, Impulse and Impulsive forces	CO 3	T2:5.20 R1:1.7.1
9	Newton's law of collision of elastic bodies	CO 3	T2:5.24 R1:1.17.3
10	Applications – Beams, Lifting machines, Simple framed structures	CO 4	T2:6.3 R1:2.6.1
11	Work energy applied to Connected Systems	CO 5	T2:6.5 R1:2.6.2
12	Work energy applied to Fixed Axis Rotation	CO 5	T2:5.5 R1:1.12.1
13	Simple Harmonic Motion	CO 6	T2:5.6 R1:1.12.3
14	simple and Compound Pendulums	CO 6	T2:5.10 R1:1.15
15	Torsion Pendulum	CO 6	T2:5.15 R1:1.16

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module – 1 – Kinematics of Particles - Rectilinear Motion	CO 1	T2:5.5 R1:1.12.1
2	Module – 2 – Kinetics of Particle	CO 2	T2:5.6 R1:1.12.3
3	Module – 3 – Impulse and Momentum, Virtual Work	CO 3, CO4	T2:5.10 R1:1.15
4	Module – 4 – Work Energy Method	CO 5	T2:5.15 R1:1.16
5	Module – 5 – Mechanical Vibrations	CO 6	T2:5.17 R1:1.13.1
DISCUSSION OF QUESTION BANK			
1	Module – 1 – Kinematics of Particles - Rectilinear Motion	CO 1	T2:5.5 R1:1.12.1
2	Module – 2 – Kinetics of Particle	CO 2	T2:5.6 R1:1.12.3
3	Module – 3 – Impulse and Momentum, Virtual Work	CO 3, CO4	T2:5.10 R1:1.15
4	Module – 4 – Work Energy Method	CO 5	T2:5.15 R1:1.16
5	Module – 5 – Mechanical Vibrations	CO 6	T2:5.17 R1:1.13.1

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**COMPUTATIONAL MATHEMATICS AND INTEGRAL CALCULUS**				
Course Code	AHS003				
Program	B. Tech				
Semester	II				
Course Type	Foundation				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms. V Subbalaxmi, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	I	Basic Principles of complex functions

II COURSE OVERVIEW:

The course focuses on more advanced Engineering Mathematics topics which provide with the relevant mathematical tools required in the analysis of problems in engineering and scientific professions. The course includes Types of Interpolation, Curve fitting, Numerical solutions of Ordinary Differential Equations, Multiple Integrals, Vector Calculus and Special functions. The mathematical skills derived from this course form a necessary base to analytical and design concepts encountered in the program.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computational Mathematics And Integral Calculus	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with

”either” or ”choice” will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
30 %	Understand
60 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:
The students will try to learn:

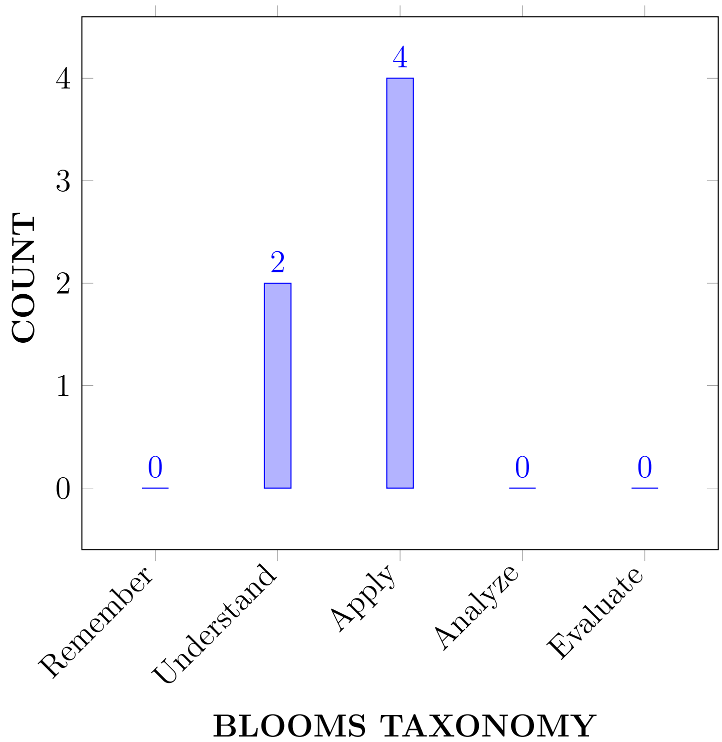
I	The basic principles involved in chemical analysis and mechanism of synthetic organic reactions. processes.
II	The need and importance of quality of water for industrial and domestic use..
III	The measurement of physical properties like surface tension and viscosity.
IV	The knowledge on existing future upcoming devices, materials and methodology.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Apply** numerical methods for solving algebric ,transcendental equations and interpolating the data	Apply
CO 2	**Make use of** least squares methods for fitting straight lines,the second degree, exponential and power curves .	Apply
CO 3	**Utilize** numerical methods for solving linear diffrential equations with initial conditions	Apply
CO 4	**Identify** the limits of definite integrals for calculating the area of solids.	Understand
CO 5	**Extend** vector operations and theorems for finding line,surface and volume integrals .	Apply
CO 6	**Determine** characterstics of special functions for solving proper and improper integrals	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	-	Seminar/ Conferences/ Research Papers
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies..	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-		-	-	-	-	-	-		-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-		-	-	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply** the **basic properties** of numerical methods for solving algebric ,transcendental equations and interpolating the data algebra and applicability in solving (complex) majority of functions by applying **Mathematical principles**.	2
	PO 2	**Apply** the of numerical methods as a **formulation** of mathematical function in **complex engineering problems** which transformations a algibric and transcendental equations using **principle of mathematics** to attain conclusion by the **interpretation of results** .	4
CO 2	PO 1	**Make use of** the **basic properties** of least squares methods for solving fitting straight lines,the second degree, exponential and power curves by using **Mathematical principle** .	2
CO3	PO 1	**Utilize** the **basic properties** of numerical methods for solving linear diffrential equations with initial conditions by applying **Mathematical principles**.	2
	PO 2	**Apply** the of numerical methods as a **formulation** of mathematical function in **complex engineering problems** linear diffrential equations with initial conditions using **principle of mathematics** to attain conclusion by the **interpretation of results** .	4
CO4	PO 1	**Identify** the **basic properties** of the limits of definite integrals for calculating the area of solids by applying **Mathematical principles**.	2
	PO 2	**Identify** the integrals for calculating the area as a **formulation** of mathematical function in **complex engineering problems** which multiple integral using **principle of mathematics** to attain conclusion by the **interpretation of results**	4
CO5	PO1	**Extend** the vector operations and theorems for finding line,surface and volume integrals by using **priniciples of Mathematics** .	2
CO6	PO1	**Identify** the **Formulation** of improper integrals and their classification for applicability in solving special functions by applying the **principles of mathematics**.	2
	PO 2	**Solve** the of improper integrals as a **formulation** of mathematical function in **complex engineering problems** which transformatimations of equations using **principle of mathematics** to attain conclusion by the **interpretation of results** .	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	4	-	-		-	-	-	-	-	-		-	-	-
CO 5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	4	-	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	40	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.7	40	-	-		-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	8	-	-	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester OBE Feedback	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ROOT FINDING TECHNIQUES AND INTERPOLATION**
	Solving algebraic and transcendental equations by bisection method, method of false position Newton-Raphson method; Interpolation: Finite differences, forward differences, backward differences and central differences; Symbolic relations; Newton's forward interpolation, Newton's backward interpolation; Gauss forward central difference formula, Gauss backward central difference formula; Interpolation of unequal intervals: Lagrange's interpolation, Newton's divided difference interpolation.
MODULE II	**CURVE FITTING AND NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS**
	Fitting a straight line; Second degree curves; Exponential curve, power curve by method of least squares. Taylor's series method; Step by step methods: Euler's, modified Euler's and Runge-Kutta method.
MODULE III	**MULTIPLE INTEGRALS**
	Double and triple integrals; Change of order of integration. Change of variables: Polar, cylindrical and spherical; Finding the area of a region using double integration and volume of a region using triple integration.
MODULE IV	**VECTOR CALCULUS**
	Scalar and vector point functions; Gradient, divergence, curl and their related properties; Solenoidal and irrotational vector point functions; Scalar potential function; Laplacian operator; Line integral, surface integral and volume integral; Vector integral theorems: Green‘s theorem in a plane, Stoke‘s theorem and Gauss divergence theorem without proofs.
MODULE V	**SPECIAL FUNCTIONS**
	Gamma function, properties of gamma function; Ordinary point and regular singular point of differential equations; Series solutions to differential equations around zero, Frobenius method about zero; Bessel‘s differential equation: Bessel functions properties, recurrence relations, orthogonality, generating function, trigonometric expansions involving Bessel functions.

TEXTBOOKS

1. Erwin Kreyszig, “Advanced Engineering Mathematics”, John Wiley & Sons Publishers, 10th Edition,2010
2. B. S. Grewal, “Higher Engineering Mathematics”, Khanna Publishers, 43rd Edition,2015

REFERENCE BOOKS:

1. T.K.V Iyengar, B.Krishna Gandhi, “Engineering Mathematics - III”, S. Chand & Co., 12th Edition, 2015..
2. Churchill, R.V. and Brown, J.W, “Complex Variables and Applications”, Tata Mc Graw-Hill, 8th Edition, 2012.

WEB REFERENCES:

1. http://www.efunda.com/math/math_home/math.cfm
2. http://www.ocw.mit.edu/resourcs/#Mathematics
3. http://www.sosmath.com
4. http://www.mathworld.wolfram.com

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	Define Algebraic and Transcendental equations	CO 1	T1:12.1,R1:4.2
3	Apply Bisection method to find the root	CO 1	T1:12.3, R1:4.4
4	Apply False Position method to find the root	CO 1	T1:12.3, R1:4.6
5	Apply Newton-Raphson method to find roots	CO 1	T1:12.3, R1:4.7
6	Define what interpolation is	CO 1	T1:12.4, R1:4.13
7	Explain the relation between symbols	CO 1	T1:12.4, R1:4.15
8	Solve the problems by Newton's forward method	CO 1	T1:12.4, R1:4.20
9	Solve the problems by Newton's backward method	CO 1	T1:22.9 R1:5.8
10	Solve the problems by Gauss forward method	CO 1	T1:13.1, R1:5.3
11	Solve the problems by Gauss backward method	CO 1	T1:13.2, R1:5.5
12	Solve the problems by lagrange's and Newtons dividend difference	CO 1	T1:13.3, R1:5.9
13	Define Algebraic and Transcendental equations	CO 1	T1:13.4, R1:5.10
14	Apply Bisection method to find the root	CO 1	T1:14.1, R1:6.1

15	Solve the problems by lagrange's and Newtons dividend difference	CO 1	T1:14.2 , R1:6.1
16	Solve a straight line	CO 2	T1:14.4, R1:6.2
17	Solve a second degree parabola	CO 2	T1:15.2 , R1:6.6
18	Solve an exponential curve	CO 2	T1:15.1, R1:7.4,
19	Solve the ODE by Taylor's series method	CO 3	T1:15.1, R1:6.5
20	Solve the ODE by Euler's Method- Euler's modified method	CO 3	T1:15.3, R1:7.9
21	Explain the ODE by Taylor's series method	CO 3	T2: 7.14, R1:1.6
22	Explain the ODE Euler's modified method	CO 3	T2: 7.15, R1:1.63
23	Solve the ODE by Runge-Kutta Methods	CO 3	T2: 7.15, R1:1.65
24	Calculate double and triple integrations	CO 4	T2: 16.5, R1:7.32
25	Use the Change of order for multiple integrals	CO 4	T2: 16.6, R1:7.36
26	Use the Change of variables in multiple integrals	CO 4	T2: 16.7, R1:7.36
27	Apply double integration for finding the area	CO 4	T2: 16.8, R1:7.41
28	Apply triple integration for finding the volume	CO 4	T2: 16.9, R1:7.42
29	Define vector calculus and vector fields and their properties	CO 5	T2: 16.9, R1:7.42
30	Determine Gradient, divergent and curl of vector fields	CO 5	T2: 7.14, R1:1.6
31	Calculate line integral along smooth path and find work done	CO 5	T2: 7.15, R1:1.65
32	Calculate the surface area of field	CO 5	T2: 7.15, R1:1.65
33	Calculate volume of field	CO 5	T2: 7.15, R1:1.65
34	Use Green's theorem to evaluate line integrals along simple closed contours on the plane	CO 5	T2: 16.5, R1:7.32
35	Use Stokes' theorem to give a physical interpretation of the curl of a vector field	CO 5	T2: 16.6, R1:7.36
36	Use the divergence theorem to give a physical interpretation of the divergence of a vector field	CO 5	T2: 16.7, R1:7.36
37	Apply gamma function for improper integrals	CO 6	T2: 16.7, R1:7.36
38	Motivation for series solution Ordinary and regular point of a differential equation	CO 6	T2: 16.8, R1:7.41

39	Transformation of non-zero singular point to zero singular point series solutions of differential equations around zero	CO 6	T2: 16.8, R1:7.41
40	Frobenius Method about zero	CO 6	T2: 16.9, R1:7.42
41	Explain the Bessel functions	CO 6	T2: 16.5, R1:7.32
42	Determine the solution of ordinary differential equations in series form	CO 6	T1:12.3, R1:4.4
43	Apply the Frobenius method to obtain a series solution for the given linear ODE	CO 6	T1:12.3, R1:4.7
44	Demonstrate Bessel's Differential equation	CO 6	T1:12.4, R1:4.13
PROBLEM SOLVING/ CASE STUDIES			
45	Solving problems on bisection,false position method	CO 1	T1:17.1-17.2 R1:16.1-16.2
46	Solving problems on Newton Raphson method	CO 1	T1:17.5-17.6 R1:16.3.1
47	Solving problems on interpolation methods	CO 1	T1:17.1-17.2 R1:16.1-16.2
48	Solving problems on straightlines ,second degree .exponential curves least squares method	CO 2	T1:17.5-17.6 R1:16.3.1
49	Solving problems onTaylor's series method	CO 3	T1:17.1-17.2 R1:16.1-16.2
50	Solving problems onStep by step methods: Euler's, modified Euler's	CO 3	T1:23.10 R1:8.1
51	Solving problems on Runge-Kutta method	CO 3	T1:23.1 R1:9.2
52	Solving problems on Double and triple integrals	CO 4	T1:23.1 R1:9.4
53	Solving problems on Vector integral theorems	CO 5	T1:23.1 R1:9.9
54	Solving problems on properties of gamma function	CO 6	T1:23.10 R1:8.1
55	Solving problems on properties of Bessel function, Recurrence relations of Bessel function, Generating function and orthogonality of Bessel function	CO 6	T1:17.1-17.2 R1:16.1-16.2
56	Solving problems onTrigonometric expansions involving Bessel function.	CO 6	T1:17.1-17.2 R1:16.1-16.2

DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions and terminology of Module I on Root finding techniques and interpolation	CO 1	T1:23.10 R1:6.8
58	Definitions and terminology of Module II on Curve fitting and numerical solution of ordinary differential equations	CO 2, CO 3	T1:23.10 R1:7.5
59	Definitions and terminology of Module III on Multiple integrals	CO 4	T1:23.10 R1:8.1
60	Definitions and terminology of Module IV on Vector calculus	CO 6	T2:27.12 R1:11.10
61	Definitions and terminology of Module V on Special functions	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF QUESTION BANK			
62	Discussion of Question Bank of Module I on Root Finding Techniques and Interpolation	CO 1	T1:23.10 R1:8.1
63	Discussion of Question Bank of Module II on Curve Fitting and Numerical Solution of Ordinary Differential Equations	CO 2, CO 3	T1:23.10 R1:6.8
64	Discussion of Question Bank of Module III on Multiple Integrals	CO 4	T1:23.10 R1:7.5
65	Discussion of Question Bank of Module IV on Vector calculus	CO 5	T2:27.12 R1:11.10
66	Discussion of Question Bank of Module V on Special Functions	CO 6	T1:17.1-17.2 R1:16.1-16.2

Course Coordinator: **HOD, ME**
Ms V Subbalaxmi , Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**MODERN PHYSICS**				
Course Code	**AHS008**				
Program	**B. Tech.**				
Semester	**II**				
Course Type	**FOUNDATION**				
Regulation	IARE-R 16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	0	0
Course Coordinator	Dr. Rizwana, Professor.				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	Basic Principles of Semiconductors

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	Basics of Physics

III COURSE OVERVIEW:

This course develops abstract and critical reasoning by studying mathematical and logical proofs and assumptions as applied in basic physics and to make connections between physics and other branches of sciences and technology. The topics covered include crystallography, X-ray diffraction, defects in crystals, LASERs, sensors, fiber optics, interference and diffraction. The course helps students to gain knowledge of basic principles and appreciate the diverse applications in technological fields in respective branches and also in their lives.

IV MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Modern Physics	70 Marks	30 Marks	100

V CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

VI EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

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The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
60 %	Understand
40 %	Apply
0 %	Analyze

Table 1: The expected percentage of cognitive level of questions in SEE

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz / Alternative Assessment Tool(AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz/ AAT	
CIA Marks	25	05	30

Table 2: Assessment pattern for CIA

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz –Online Examination:

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT):

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table.

Assignments	Seminar	Term paper
40%	40%	20%

VII COURSE OBJECTIVES:

The students will try to learn:

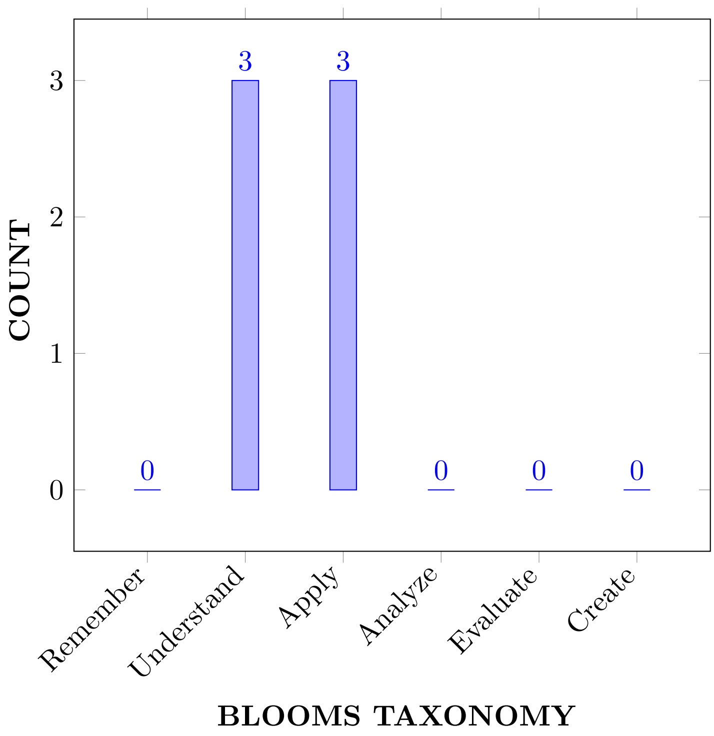
I	Develop strong fundamentals of crystal structures and properties.
II	Meliorate the knowledge of theoretical and technological aspects of LASERs and optical fibers.
III	Correlate principles with applications of the x-ray diffraction and defects in crystals.
IV	Enrich knowledge in modern engineering principles of interference and diffraction.

VIII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Make use of** space lattice, unit cell, lattice parameters and coordination number to calculate the packing factor of different crystal structures.	Apply
CO 2	**Apply** Bragg's law of X-Ray diffraction to study the defects in crystal with illustrative examples of point and line defects.	Apply
CO 3	**Compare** the concepts of Laser and normal lightin terms of mechanism and working principles for applications in different fields and scientific practices.	Understand
CO 4	**Utilize** the importance of sensor materialsin different real time applications.	Apply
CO 5	**Explain** functionality of components in optical fiber communication systemby using the basics of signal propagation, attenuation and dispersion.	Understand
CO 6	**Interpret** the phenomenon of interference and diffractionby using the principles of wave motion and superposition.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



IX PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

X HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Seminar

3 = High; 2 = Medium; 1 = Low

XI HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1	

3 = High; 2 = Medium; 1 = Low

XII MAPPING OF EACH CO WITH POs, PSOs:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	✓
CO 4	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-

XIII JUSTIFICATIONS FOR CO – (PO/PSO) MAPPING -DIRECT:

Course Outcomes	POs PSOs	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Make use of** basic concept of Crystallography and coordination number calculate the packing factor of BCC structure solid.	3
	PO 2	**Explain** the given problem statement and **formulate** the interplanar spacing of orthogonal crystal system for a given crystal structure information and data in reaching substantial conclusions by the **interpretation** of results.	4
CO 2	PO 1	**Illustrate** the X-Ray diffraction phenomena by Bragg's law.	3
	PO 2	**Understand** the given problem statement and **formulate** the concept of Burger's vector for material from the provided information and data in reaching substantial conclusions by the **interpretation** Defects in Solids.	4
CO 3	PO 1	**Summarize** detailed knowledge of fundamental and applied aspects of LASER, **analyze** key parameters and apply them to the functioning for real time application.	3
CO 4	PO 1	**Apply** the key concepts of characteristics of LASER for deriving Einstein coefficients and illustrate basic working mechanism of lasing action.	3
	PO 2	**Explain** the given problem statement and **formulate** the population inversion condition provided information and data by the **interpretation** of stimulated emission and excitation.	4
CO 5	PO 1	**Relate** functionality of components in optical fiber communication system by using the basics idea of signal propagation, attenuation and dispersion in optical fiber for solving engineering problems by **applying principles** of total internal reflection.	3

Course Outcomes	POs PSOs	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Understand** the given **problem statement** and **derive the expression** for numerical aperture and acceptance angle for optical fibre from the provided **information** and **data** by the **interpretation** of attenuation in optical fibers.	4
	PSO3	**Determine** the attenuation coefficient value for step index and graded index optical fibres by make use of modern computer tools and for gaining knowledge helpful for higher studies.	1
CO 6	PO 1	**Compare** the concepts of constructive and destructive interference phenomena and **working principles** for **applications** in different fields and **scientific practices**.	3
	PO 2	**Identify the given problem** and **formulate** Fraunhofer diffraction due to single slit with the given **information and data** by applying principles of maxima and minima.	4

XIV TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO/PSO) MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1
CO 4	3	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	4	-	-	-	-	-	-	-	-	-		-	-	-

XV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO/PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	40	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	40	-	20	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	-	-	50
CO 4	100	40	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	40	-	-	-	-	-	-	-	-	-		-	-	-

XVI COURSE ARTICULATION MATRIX (CO-PO/PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1-5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-		-	-	-	-	-	-	-	-	-	-	1
CO 4	3	2	-	-		-	-	-	-	-	-		-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-		-	-	-
TOTAL	18	10	-	1	-		-	-	-	-	-	-	-	-	1
AVERAGE	3	2	-	1	-		-	-	-	-	-	-	- -	-	1

XVII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Mini Project	-
Presentations	✓	Certification	-	Assignments	✓
Term paper	✓				

XVIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIX SYLLABUS:

UNIT I	CRYSTALLOGRAPHY AND CRYSTAL STRUCTURES
	Crystallography and crystal structures: Space lattice, unit cell, lattice parameters, crystal systems, Bravais lattices, directions and planes in crystals, Miller indices, interplanar spacing of orthogonal crystal systems, atomic radius, co-ordination number and packing factor of SC, BCC, FCC, NaCl and diamond structures.
UNIT II	X-RAY DIFFRACTION AND DEFECTS IN CRYSTALS
	X-ray diffraction: Bragg's law, Laue method, powder method and applications; Defects in crystals: Concepts of point defects, vacancies, substitutional, interstitial, frenkel, schottky defects, line defects and Burger's vector.
UNIT III	LASERS AND SENSORS
	Lasers: Characteristics of LASERS, spontaneous and stimulated emission of radiation, metastable state, population inversion, lasing action, ruby LASER, semiconductor diode LASER and applications of LASERS. Sensors: Introduction, basic principles, sensor materials and applications: principle of pressure, optical, acoustic and thermal sensing.
UNIT IV	FIBER OPTICS
	Fiber optics: Principle and construction of an optical fiber, acceptance angle, numerical aperture, types of optical fibers (Single mode, multimode, step index, graded index), attenuation in optical fibers, application of optical fibers and optical fiber communication system with block diagram.
UNIT V	INTERFERENCE AND DIFFRACTION
	Interference: Phase difference, path difference, coherence, conditions for constructive and destructive interference, interference in thin films due to reflected light, Newton rings experiment. Diffraction: Introduction, differences between interference and diffraction, types of diffraction, Fraunhofer diffraction due to single slit, N-slits, diffraction grating experiment.

TEXTBOOKS

1. Dr. K. Vijaya Kumar, Dr. S. Chandralingam, "Modern Engineering Physics", S.Chand & Co. New Delhi, 1^{st} Edition, 2010.

2. V. Rajendran, "Engineering Physics", Tata Mc Graw Hill Book Publishers, 1^{st} Edition, 2010.

REFERENCE BOOKS:

1. P. K. Palanisamy, "Engineering Physics", Scitech Publishers, 4^{th} Edition, 2014.

2. R. K. Gaur, S. L. Gupta, "Engineering Physics", Dhanpat Rai Publications, 8^{th} Edition, 2001.

3. A. J. Dekker, "Solid State Physics", Macmillan India ltd, 1^{st} Edition, 2000.

XX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT THEORY(DELIVERY)			
2	Space lattice, unit cell, lattice parameters.	CO 1	T1, T2, R1, R2
3	Crystal systems, Bravais lattices.	CO 1	T1, T2, R1, R2
4	Directions and planes in crystals, Miller indices	CO 1	T1, T2, R1, R2
5	Interplanar spacing of orthogonal crystal systems	CO 1	T1, T2, R1, R2,
6	Atomic radius, coordination number and packing factor of SC structure.	CO 1	T1, T2, R1, R2
7	Atomic radius, coordination number and packing factor of BCC structure	CO 2	T1, T2, R1, R2
8	Atomic radius, coordination number and packing factor of FCC structure	CO 2	T1, T2, R1, R2
9	Atomic radius, coordination number and packing factor of Diamond structure	CO 2	T1, T2, R1, R2
10	NaCl structure	CO 2	T1, T2, R1, R2
11	X-ray diffraction: Bragg's law	CO 2	T1, T2, R1, R2
12	Laue method	CO 2	T1, T2, R1, R2
13	Powder method and applications	CO 2	T1, T2, R1, R2
14	Defects in crystals: Concepts of point defects	CO 2	T1, T2, R1, R2
15	Frenkel, Schottky defects	CO 2	T1, T2, R1, R2
16	Line defects	CO 2	T1, T2, R1, R2
17	Line defects	CO 2	T1, T2, R1, R2
18	Burger's vector	CO 2	T1, T2, R1, R2

19	Problems	CO 2	T1, T2, R1, R2
20	Characteristics of LASERS, spontaneous and stimulated emission of radiation	CO 3	T1, T2, R1, R4
21	Metastable state, population inversion, lasing action	CO 3	T1, T2, R1, R4
22	Ruby LASER	CO 3	T1, T2, R1, R4
23	He-Ne LASER	CO 3	T1, T2, R1, R4
24	Semiconductor diode LASER and applications of LASERS	CO 4	T1, T2, R1, R4
25	Introduction to sensors, Basic principles of sensors	CO 4	T1, T2, R1, R4
26	Sensors	CO 4	T1, T2, R1, R4
27	Applications: pressure, force, strain sensors, magnetic sensing	CO 4	T1, T2, R1, R4
28	Optical sensing, acoustic and thermal sensing	CO 4	T1, T2, R1, R4
29	Fiber optics: Principle and construction of an optical fiber	CO 4	T1, T2, R1, R2
30	Acceptance angle	CO 4	T1, T2, R1, R2
31	Numerical aperture	CO 5	T1, T2, R1, R2
32	Types of optical fibers: Single mode, multimode fibers	CO 5	T1, T2, R1, R2
33	Step index, graded index fibers	CO 5	T1, T2, R1, R2
34	Attenuation in optical fibers	CO 5	T1, T2, R1, R2
35	Application of optical fibers	CO 5	T1, T2, R1, R2
36	Optical fiber communication system with block diagram	CO 5	T1, T2, R1, R2
37	Problems	CO 5	T1, T2, R1, R2
38	Interference: Phase difference, path difference, coherence, conditions for constructive and destructive interference	CO5	T1, T2, R1, R2
39	Interference in thin films due to reflected light	CO 5	T1, T2, R1, R2
40	Newton's rings experiment	CO 5	T1, T2, R1, R2
41	Newton's rings experiment	CO 6	T1, T2, R1, R2

PROBLEM SOLVING/ CASE STUDIES			
1	Space lattice, unit cell, lattice parameters.	CO 1	T1, T2, R1, R2
2	Crystal systems, Bravais lattices.	CO 1	T1, T2, R1, R2
3	Directions and planes in crystals, Miller indices	CO 1	T1, T2, R1, R2
4	Interplanar spacing of orthogonal crystal systems	CO 1	T1, T2, R1, R2,
5	Atomic radius, coordination number and packing factor of SC structure.	CO 1	T1, T2, R1, R2
6	Atomic radius, coordination number and packing factor of BCC structure	CO 2	T1, T2, R1, R2
7	Atomic radius, coordination number and packing factor of FCC structure	CO 2	T1, T2, R1, R2
8	Atomic radius, coordination number and packing factor of Diamond structure	CO 2	T1, T2, R1, R2
9	NaCl structure	CO 2	T1, T2, R1, R2
10	X-ray diffraction: Bragg's law	CO 2	T1, T2, R1, R2
11	Laue method	CO 2	T1, T2, R1, R2
12	Powder method and applications	CO 2	T1, T2, R1, R2
13	Defects in crystals: Concepts of point defects	CO 2	T1, T2, R1, R2
14	Frenkel, Schottky defects	CO 2	T1, T2, R1, R2
15	Line defects	CO 2	T1, T2, R1, R2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Crystallography and crystal structures	CO1,CO1	T1,T2
2	X-ray diffraction and defects in crystals	CO2, CO2	T1,T2
3	Lasers and sensors	CO3,CO4	T1,T2
4	Fiber Optics	CO5,CO5	T1,T2
5	Interference and Diffraction	CO6,CO6	T1,T2
DISCUSSION OF QUESTION BANK			
1	Crystallography and crystal structures	CO1, CO1	T1,T2
2	X-ray diffraction and defects in crystals	CO2, CO2	T1,T2
3	Lasers and sensors	CO3, CO4	T1,T2

4	Fiber Optics	CO5, CO5	T1,T2
5	Interference and Diffraction	CO6,CO6	T1,T2

Signature of Course Coordinator **HOD, FE**
Dr. Rizwana, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ENVIRONMENTAL STUDIES**				
Course Code	AHS009				
Program	B.Tech				
Semester	II				
Course Type	FOUNDATION				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr V Anitha Rani, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credit
10+2	-	-	Basic Principles of Science	-

II COURSE OVERVIEW:

Environmental study is interconnected interrelated and interdependent subject. Hence, it is multidisciplinary in nature. The present course is framed by expert committee of UGC under the direction of honorable supreme court to be as a core module syllabus for all branches of higher education and to be implemented in all universities over India. The course is designed to create environmental awareness and consciousness among the present generation to become environmental responsible citizens. The course description is multidisciplinary nature of environmental studies, natural resources Renewable and non-renewable resources Ecosystems Biodiversity and its conservation Environmental pollution Social issues and the environment Human population and the environment Pollution control acts and field work. The course is divided into five chapters for convenience of academic teaching followed by field visits.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Environmental Studies	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

x	Chalk & Talk	✓	Quiz	✓	Assignments	x	MOOC's
✓	LCD / PPT	✓	Seminars	x	Mini Project	✓	Videos
✓	Open Ended Experiments						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The emphasis on the questions is broadly based on the following criteria:

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
50%	Understand
50%	Apply
0 %	Analyze
0%	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz/AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

The AAT chosen for this course is given in section XI.

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

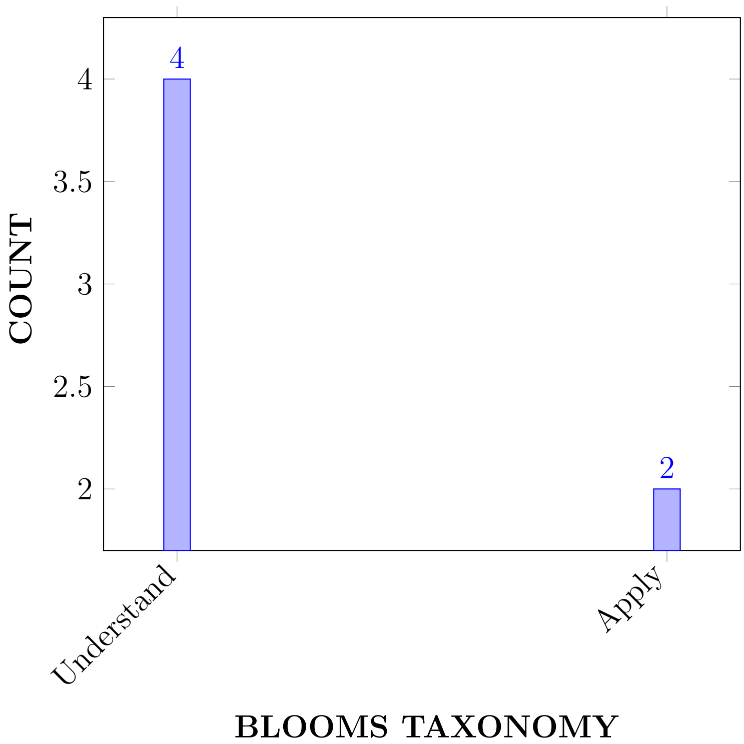
I	The interrelationship between living organism and environment.
II	The importance of environment by assessing its impact on the human world
III	The knowledge on themes of biodiversity, natural resources, pollution control and waste management.
IV	The constitutional protection given for the safety of environment.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the basic concept of environment, earths major cycle and its function related food chain, food web, and ecological pyramid for the importance of ecosystem and flow of energy in ecosystem	Understand
CO 2	**Classify** natural resource and necessity of natural resource conservationfor sustainable use and proper use.	Understand
CO 3	**Utilize** renewable and non-renewable energy resource for future growing energy needs.	Apply
CO 4	**Explain** the value of biodiversity hotspots, endangered and endemic species, in- situ and ex situ conservation methods for protecting the biodiversity.	Apply
CO 5	**Relate** the cause and effects of pollution related to Air, Water, Soil and Noise their control and treatment technologies.	Understand
CO 6	**Summarize** the concepts of Environmental Impact Assessment, global environmental problem, international summits, to minimize the problems towards sustainable future.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	CIE/Quiz/AAT
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/Quiz/AAT
PO 7	**Environment and sustainability:** understand the impact of the professional engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	-	-
PSO 2	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining. .	-	-
PSO 3.	-	-	

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 2	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 4	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 6	✓	-	-	✓	-	-	✓	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Explain the basic concept of environment, earths major cycle and its function related food chain, food web, and ecological pyramid for the importance of ecosystem and flow of energy in ecosystem by using principles of science for solving engineering problems.	2
	PO 7	Summarize about the toxicity of heavy metals on the biotic and abiotic components in in socio economic Environmental and politics contexts for Sustainable development.	3
CO 2	PO 1	Classify about different types of natural resources and their applicability and illustrate the utility of renewable resources efficiency by using principles of science for solving engineering problems.	2
	PO 7	Identify renewable and non renewable resources, Alternate energy resources and understand the impact in socio economic Environmental and politics contexts for Sustainable development.	3
CO3	PO 1	Explain the renewable and non renewable energy resource by using principles of science for solving engineering problems.	2
	PO 7	Utilize renewable and non renewable resources, Alternate energy resources and understand the impact in socio economic, politics and Environmental contexts for Sustainable development.	3
CO4	PO 1	Explain the fundamentals of Biodiversity and biotic resources, importance of biodiversity, the ecological values, India is mega diversity nation, the threats to biodiversity and importance of conservation of biodiversity by applying the principle of science for solving engineering problems.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 7	Demonstrate a comprehensive understanding of the world's biodiversity and the importance of its conservation, impact of biodiversity loss and National biodiversity act with the in socio economic, politics and Environmental contexts for Sustainable development.	3
CO5	PO 1	Relate the effect of pollutants on air, water and soil that causes the environmental pollution for solving engineering problems by applying the principles of science.	2
	PO 7	Explain the causes and effects of air pollution, water pollution, soil pollution and noise pollution and understand the impact in socio economic, politics and environmental contexts for sustainable development.	3
CO 6	PO 1	Explain the concepts of environmental impact assessment, global environmental problems, international summits, to minimize the problems towards sustainable future for solving engineering problems by applying the principles of science.	2
	PO 4	Recognize the methods and process of primary, secondary and tertiary treatment of waste water and understand the technology behind the pollution control devices.	2
	PO 7	Identify the environmental laws, population and its explosion green buildings in the context in socio economic, politics and Environmental contexts for Sustainable development.	3

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	3	-	-	-	-		-	-	-
CO 2	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 6	2	-	-	2	-	-	3	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 2	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 5	66.6	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 6	66.6	-	-	18	-	-	100	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	3	-	-	-	-	-	-	-	
CO 2	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 6	3	-	-	1	-	-	3	-	-	-	-	-	-	-	-
TOTAL	18	-	-	1	-	-	18	-	-	-	-	-	-	-	-
AVERAGE	3	-	-	1	-	-	3	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓	Seminars	✓
Concept Video	-	Mini Project	-	Student Viva	-	Mini Project	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
x	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

UNIT I	**ENVIRONMENT AND ECOSYSTEMS**
	Environment: Definition, scope and importance of environment, need for public awareness; Ecosystem: Definition, scope and importance of ecosystem, classification, structure and function of an ecosystem, food chains, food web and ecological pyramids, flow of energy; Biogeochemical cycles Hydrological cycle, Phosphorous cycle, Nitrogen cycle. Biomagnifications.
UNIT II	**NATURAL RESOURCES**
	INatural resources: Classification of resources, living and nonliving resources; Water resources: Use and over utilization of surface and ground water, floods and droughts, dams, benefits and problems; Mineral resources: Use and exploitation; Land resources; Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy source, case studies.
UNIT III	**BIODIVERSITY AND BIOTIC RESOURCES**
	Biodiversity and biotic resources: Introduction, definition, genetic, species and ecosystem diversity; Value of biodiversity: Consumptive use, productive use, social, ethical, aesthetic and optional values; India as a mega diversity nation; Endangered and Endemic species, Hot spots of biodiversity.Threats to biodiversity: Habitat loss, poaching of wildlife, human-wildlife conflicts; Conservation of biodiversity: In situ and ex situ conservation; National biodiversity act.
UNIT IV	**ENVIRONMENTAL POLLUTION, POLLUTION CONTROL TECHNOLOGIES AND GLOBAL ENVIRONMENTAL PROBLEMS**
	Environmental pollution: Definition, causes and effects of air pollution, water pollution, soil pollution, noise pollution; Solid waste: Municipal solid waste management, composition and characteristics of e-waste and its management; Pollution control technologies: Waste water treatment methods, primary, secondary and tertiary; Concepts of bioremediation; Global environmental problems and global efforts: Global Warming, Climate change, Sea level rise, ozone depletion, ozone depleting substances, deforestation and desertification; International conventions / protocols: Earth summit, Kyoto protocol and Montreal protocol.
UNIT V	**ENVIRONMENTAL LEGISLATIONS AND SUSTAINABLE DEVELOPMENT**
	Environmental legislations: Environmental protection act, air act1981, water act, forest act. municipal solid waste management and handling rules, biomedical waste management and handling rules2016, hazardous waste management and handling rules, Environmental impact assessment(EIA); Towards sustainable future: Concept of sustainable development, population and its explosion, crazy consumerism, environmental education, urban sprawl, concept of green building.

TEXTBOOKS

1. Benny Joseph, “Environmental Studies”, Tata Mc Graw Hill Publishing Co. Ltd, New Delhi, 1st Edition, 2006.
2. Erach Bharucha, “Textbook of Environmental Studies for Under Graduate Courses”, Orient Black Swan, 2nd Edition, 2013.
3. Dr. P. D Sharma, “Ecology and Environment”, Rastogi Publications, New Delhi, 12th Edition, 2015.

REFERENCE BOOKS:

1. Tyler Miller, Scott Spoolman, “Environmental Science”, Cengage Learning, 14th Edition, 2012.
2. Anubha Kaushik, “Perspectives in Environmental Science”, New Age International, New Delhi.4th Edition, 2006.
3. Gilbert M. Masters, Wendell P. Ela, “Introduction to Environmental Engineering and Science, Pearson, 3rd Edition, 2007

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Explain the scope and importance of Environment and need for Public Awareness	CO 1	T1:1.1.3 R1:2.1
2	Identify scope and importance of ecosystem	CO1	T1:1.1.4 R1:2.7.1
3	Explain Structure and function of ecosystem	CO1	T1:1.1.6 R1:2.7.4
4	Relate the Food chain food web and pyramids	CO1	T1:1.7.2 R1:2.15
5	Realate the Flow of energy	CO1	T1:1.7.2 R1:2.16
6	Explain the Biogeochemical cycles.	CO1	T1:1.7.6 R1:2.17
7	Interpret the Biomagnifications.	CO1	T1:1.7.3 R1:2.19
8	Classify the Living and non living resources	CO 2	T1:2.1 R1:2.21
9	Explain the Water resources: use and over utilization of surface and ground water	CO 2	T1:2.2.2 R1:2.3
10	Explain the Floods and Drought	CO 2	T1:2.2.4 R1:4.1

11	Relate dams: befit and problems	CO 2	T1:2.3.1 R1:4.3
12	Explain the Mineral resources: use and exploitation of minerals	CO 2	T1:2.4 R1:4.8
13	Relate the Energy resources and introduction and applications	CO 3	T1:2.5.2 R1:4.6
14	Explain the Wind energy and its application	CO 3	T1:2.5.3 R1:4.6
15	Explain Land resources	CO 2	T1:2.4 R1:4.8
16	Identify renewable and non renewable resources	CO 3	T1:2.5.3 R1:4.6
17	Recall the Biodiversity and Biotic introduction and definition.	CO 4	T1:3.1 R1:4.5
18	Relate the Classification of biodiversity	CO 4	T1:3.2.2 R1:4.8
19	Explain the Values of biodiversity	CO 4	T1:3.3.1 R1:4.7
20	Identify India is mega diversity nation	CO 4	T1:3.4 R1:4.9
21	Recognize Hot spots of biodiversity	CO 4	T1: 3.4 R1:4.10
22	Explain the Threats to biodiversity	CO 4	T1: 3.5 R1:1.10
23	Explain the Man wild life conflict	CO 4	T1:3.5.2 R1:1.10
24	Relate the Conservation of Biodiversity	CO 4	T1:3.7 R1:1.16
25	Recall National biodiversity act	CO 4	T1: 3.9 R1:1.16
26	Recall the Environmental pollution : Introduction and classification	CO 5	T1: 4.1 R1:1.16
27	Explain the Air pollution: primary and secondary pollutants, effects and its control	CO 5	T1: 4.2 R1:1.11
28	Explain the Water pollution: types effects and control of water pollution	CO 5	T1:4.6 R1:5.2
29	Explain the Soil pollution: sources effects and control of soil pollution	CO 5	T1: 4.8 R1:5.2
30	Explain the Noise pollution: sources effects and control of noise pollution	CO 5	T1: 4.13 R1:5.10
31	Explain the Municipal waste management	CO 5	T1: 4.16 R1:5.2.3
32	Explain the solid waste management	CO 5	T1:4.16.3 R1:5.2.4
33	Identify the E-waste: characteristics and its management	CO 5	T1: 5.5 R1:5.4
34	Explain the Global environmental problems: climate change and impact on human	CO 5	T1: 5.6 R1:5.5

35	Recognize the Ozone depletion and consequences	CO 5	T1: 5.10 R1:5.6
36	Summarize the International protocols	CO 5	T1: 4.1 R1:1.16
37	Relate the Environmental protection act.	CO 6	T1:7.3
38	Relate the air act, water act	CO 6	T1:7.3
39	Relate forest act, wild life act	CO 6	T1:7.3
40	Relate the Hazardous waste management and handling rules 2016	CO 6	T1:7.10
41	Illustrate the EIA structure and concept of sustainable development	CO 6	T1: 8.1
42	Identify towards sustainable features: concepts of sustainable development	CO 6	T1: 8.2
43	Relate the Consequences of population and its explosion	CO 6	T2: 8.2.3 T3:2
44	Explain the Crazy consumerism urban sprawl	CO 6	T2:8.2.3, T3:7
45	Explain the Environmental education	CO 6	T2:8.4, T3:7
46	Explain the Environmental ethics and concepts of green buildings	CO 6	T2:8.12, T3:15,21
PROBLEM SOLVING			
1	Food chain and pyramids	CO 1	T1:3.3.1; R3:3.2
2	Probelms on utilization of water	CO 1	T2:16.5; R3:8.10
3	Biodiversity	CO 2	T2:16.5; R3:8.10
4	kyto protocol	CO 3	T1:3.3.1; R3:3.2
5	Deforestation	CO 3	T2:16.5; R3:8.10
6	population	CO 4	T2:16.5; R3:8.10
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Environment and Ecosystems	CO 1	T2:16.5; R3:8.10
2	Natural Resources	CO 2	T1:3.3.1; R3:3.2
3	Biodiversity and Biotic Resouces	CO 3	T2:16.5; R3:8.10
4	Enivironment pollution	CO 4	T2:16.5; R3:8.10
5	Environmental Legistration and sustainable development	CO 6	T2:16.5; R3:8.10

DISCUSSION OF QUESTION BANK			
1	Environment and Ecosystems	CO 1	T2:16.5; R3:8.10
2	Natural Resources	CO 2	T1:3.3.1; R3:3.2
3	Biodiversity and Biotic Resouces	CO 3	T2:16.5; R3:8.10
4	Enivironment pollution	CO 4	T2:16.5; R3:8.10
5	Environmental Legistration and sustainable development	CO 6	T2:16.5; R3:8.10

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**COMPUTER PROGRAMMING**				
Course Code	ACS001				
Program	B.Tech				
Semester	II				
Course Type	Foundationl				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	4	2
Course Coordinator	Mr.P Ravinder , Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	ACSS001	I	Basic Programming Concepts	-

II COURSE OVERVIEW:

The course emphasis on the problem-solving aspects in using C programming. It is the fundamental course and is interdisciplinary in nature for all engineering applications. The students will understand programming language, programming, concepts of loops, reading a set of data, step wise refinements, functions, control structures, arrays, dynamic memory allocations, enumerated data types, structures, unions, and file handling. This course provides adequate knowledge to solve problems in their respective domains.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
PPSC	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	✓	MOOC
x	Open Ended Experiments	✓	Seminars	✓	Mini Project	✓	Videos
✓	Others: Quiz						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), and 10 marks for Alternative Assessment Tool (AAT).

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
37%	Remember
63 %	Understand
-	Apply
-	Analyze

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Alternative Assessment Tool (AAT).

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (Mid-term)	10	
	AAT-1	5	
	AAT-2	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			100

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

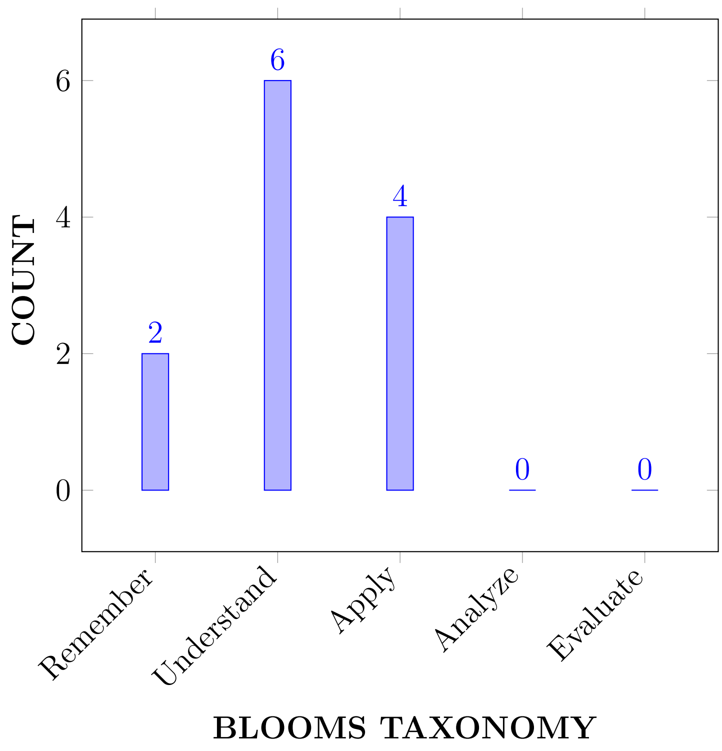
I	Learn adequate knowledge by problem solving techniques.
II	Understand programming skills using the fundamentals and basics of C Language.
III	Improve problem solving skills using arrays, strings, and functions
IV	Understand the dynamics of memory by pointers.
V	Study files creation process with access permissions.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** problem solving steps in terms of algorithms, pseudocode, flowcharts and programs with basic data types and operations for Mathematical and Engineering problems.	Understand
CO 2	**Implement** derived data types, operators in C program statements.	Apply
CO 3	**Construct** programs involving decision structures, loops, arrays and strings.	Apply
CO 4	**Make use of** various types of functions, parameters, and return values for complex problem solving.	Apply
CO 5	**Illustrate** the static and dynamic memory management with the help of structures, unios and pointers.	Understand
CO 6	**Extend** file input and output operations in implementation of real time applications.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES ARE ASSESSED:

Program	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7	**Environment and sustainability:** : Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** : Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Assignments
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Assignments
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Seminars, Viva
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1	5 minutes video

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	2	Projects
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	3	Lectures, Assignments
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	3	Lectures, Assignments

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	✓	-	-	-	-	✓	-	✓	-	-	-
CO 2	✓	✓	✓	-	✓	-	-	-	-	✓	-	✓	✓	-	-
CO 3	✓	✓	-	-	✓	-	-	-	-	✓	-	✓	✓	-	✓
CO 4	✓	✓	✓	-	✓	-	-	-	-	✓	-	✓	-	-	✓
CO 5	✓	-	-	-	✓	-	-	-	-	✓	-	✓	-	-	-
CO 6	✓	-	-	-	✓	-	-	-	-	✓	-	✓	✓	-	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand the basics of computers; **Fundamentals** of Computer System and memory organization, and **identify** the components of the computer system.	3
CO 2	PO 1	Developing algorithms and draw flowcharts for solving **mathematical** and **engineering problems** related to **areas of computer science.**	3
	PO 2	Understand the various symbols to **drawa** flowchart, **identify** the appropriate symbols to solve a problem, then **formulate** the solution, and **interpret** the result for the **improvement** of the solution.	5
	PO3	**Recognize** an appropriate control structure to **design** and **develop** a solution for a **real-time** scenario, and communicating effectively with engineering community.	3

	PO5	Describe the operators, their precedence, and associativity while evaluating expressions in **software program**.	1
	PSO1	Understand the features of procedural programming for **designing** and **analysing** computer programs for **problem-solving**.	3
CO 3	PO 1	Apply the knowledge of **mathematics, C language fundamentals** to design, develop, and debug programs to solve **engineering** problems	3
	PO 2	Understand the **problem statement**, identify the **data requirements, design**, and **develop** a system for an engineering problem, **validate** and **interpret** the results.	5
	PSO 1	**Understand** automatic type conversion rules to **determine** the magnitude and precision of a mixed datatype expression in the areas of **software development.**	4
CO 4	PO 1	Describe the **fundamental programming** constructs, and articulate how they are used to **develop a program** with a desired runtime execution flow.	3 2-4
	PO 2	**Identify** the appropriate datatypes to **formulate, develop** and **analyze** the solution to achieve **engineering** objectives.	5
	PO 3	Recognize right **data representation** formats based on the **requirements** for **developing programs** in **real-time scenarios** by **managing** the **design process**, and communicating effectively with **engineering** community.	7
	PO 5	Describe the operators, their precedence, and associativity while evaluating expressions in **software program.**	1
CO 5	PO 1	Understand branching statements, loop statements, and apply the fundamentals of **mathematics, science** and **engineering.**	3
	PO 2	Understand the **problem statement, control** the flow of data, **design** the solution and **analyse** the same to **validate** the results in a program to solve complex engineering problems.	5
	PO 3	**Recognize** an appropriate control structure to **design** and **develop** a solution for a **real-time** scenario, and **communicating** effectively with engineering community.	6
CO 6	PO 1	Make use of **engineering techniques** to design and develop solutions for real-time **computational problems.**	3

	PSO 1	**Identify** tasks in which the numerical techniques are **applicable, develop** programs, and hence use computers effectively to solve**real-time applications.**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	1	-	-	-	-	2	-	4	-	-	-
CO 2	3	5	3	-	1	-	-	-	-	2	-	3	3	-	-
CO 3	3	5	-	-	1	-	-	-	-	2	-	3	4	1	1
CO 4	3	5	7	-	1	-	-	-	-	2	-	3	-	1	1
CO 5	3	5	6	-	1	-	-	-	-	2	-	3	-	-	-
CO 6	3	-	-	-	1	-	-	-	-	2	-	3	2	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	100	-	-	-	-	40	-	50	-	-	-
CO 2	100	50	30	-	100	-	-	-	-	40	-	50	50	-	-
CO 3	100	50	-	-	100	-	-	-	-	40	-	50	67	50	50
CO 4	100	50	70	-	100	-	-	-	-	40	-	50	-	50	50
CO 5	100	50	60	-	100	-	-	-	-	40	-	50	-	-	-
CO 6	100	-	-	-	100	-	-	-	-	40	-	50	34	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - 0≤ C≤ 5% – No correlation
2 - 40 % <C < 60% –Moderate
1-5 <C≤ 40% – Low/ Slight
3 - 60% ≤ C < 100% – Substantial /High

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	3	-	-	-	-	2	-	2	-	-	-
CO 2	3	2	1	-	3	-	-	-	-	2	-	2	2	-	-
CO 3	3	2	-	-	3	-	-	-	-	2	-	2	3	-	2

CO 4	3	2	3	-	3	-	-	-	-	2	-	2	-	-	2
CO 5	3	2	3	-	3	-	-	-	-	2	-	2	-	-	-
CO 6	3	-	-	-	3	-	-	-	-	2	-	2	1	-	-
TOTAL	18	8	7	-	18	-	-	-	-	10	-	10	6	-	4
AVERAGE	3	2	2	-	3	-	-	-	-	1.67	-	1.67	2	-	2

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	✓	Student Viva	✓	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓	-	-	-	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to computers: Computer systems, computing environments, computer languages, creating and running programs, algorithms, flowcharts; Introduction to C language: History of C, basic structure of C programs, process of compiling and running a C program, C tokens, keywords, identifiers, constants, strings, special symbols, variables, data types; Operators and expressions: Operators, arithmetic, relational and logical, assignment operators, increment and decrement operators, bitwise and conditional operators, special operators, operator precedence and associativity, evaluation of expressions, type conversions in expressions, formatted input and output.
MODULE II	**CONTROL STRUCTRES**
	Control structures: Decision statements; if and switch statement; Loop control statements: while, for and do while loops, jump statements, break, continue, goto statements; Arrays: Concepts, one dimensional arrays, declaration and initialization of one dimensional arrays, two dimensional arrays, initialization and accessing, multi dimensional arrays; Strings concepts: String handling functions, array of strings.

MODULE III	**ARRAYS AND FUNCTIONS**
	Functions: Need for user defined functions, function declaration, function prototype, category of functions, inter function communication, function calls, parameter passing mechanisms, recursion, passing arrays to functions, passing strings to functions, storage classes, preprocessor directives. Pointers: Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers, pointers and arrays, pointers as functions arguments, functions returning pointers.
MODULE IV	**POINTERS AND STRUCTURES**
	Structures and unions: Structure definition, initialization, accessing structures, nested structures, arrays of structures, structures and functions, passing structures through pointers, self referential structures, unions, bit fields, typedef, enumerations; Dynamic memory allocation: Basic concepts, library functions.
MODULE V	**FILE HANDLING AND APPLICATIONS IN C**
	Files: Streams, basic file operations, file types, file opening modes, file input and output functions, file status functions, file positioning functions, command line arguments.

TEXT BOOKS

1. Byron Gottfried, —Programming with C, Schaum's Outlines Series, McGraw Hill Education, 3rd Edition, 2017.
2. Reema Thareja —Programming in C, Oxford university press, 2nd Edition, 2016.

REFERENCE BOOKS:

1. W. Kernighan Brian, Dennis M. Ritchie —The C Programming Language, PHI Learning, Second Edition, 1988.
2. YashavantKanetkar —Exploring C, BPB Publishers, Second Edition, 2003..
3. Schildt Herbert —C: The Complete Reference, Tata McGraw Hill Education, Fourth Edition, 2014.

Web References:

1. https://www.bfoit.org/itp/Programming.html
2. https://www.khanacademy.org/computing/computer-programming
3. https://www.edx.org/course/programming-basics-iitbombayx-cs101-1x-0
4. https://www.edx.org/course/introduction-computer-science-harvardx-cs50x

E-Text Books:

1. http://www.freebookcentre.net/Language/Free-C-Programming-Books-Download.htm
2. http://www.imada.sdu.dk/ svalle/courses/dm14-2005/mirror/c/
3. http://www.enggnotebook.weebly.com/uploads/2/2/7/1/22718186/ge6151-notes.pdf

MOOC Course:

1. https://www.alison.com/courses/Introduction-to-Programming-in-c
2. http://www.ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-s096-effective- programming-in-c- and-c-january-iap-2014/index.htm

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
1-2	Introduction to Computers: computer systems, computing environments, Computer languages, creating and running programs	CO 1	T2: 1.1-1.2
3-4	Algorithms, flowcharts; Introduction to C language: Computer languages, History of C, basic structure of C programs, process of compiling and running a C program	CO 2	T2: 2.1-2.2
5-6	C tokens, keywords, identifiers, constants, strings	CO 2	T2: 1.4-1.5
7-8	Special symbols, variables, data types	CO 3	T2:2.1-2.2
9-10	Operators and expressions	CO 3	T2: 2.3-2.6,7
11-12	Simple if, if-else, else if ladder, Nested if and Case Statement-switch statement	CO 3	T2:3.1-3.5
13-14	While, for and do while loops	CO 5	T2: 5.2-5.3
15–16	Jump statements, break, continue, goto statements	CO 2	T2: 6.1-6.6
17–18	Concepts, one dimensional arrays, declaration and initialization of one-dimensional arrays	CO 2	T2: 6.7
19–20	Two dimensional arrays, initialization and accessing	CO 2	T2: 8.1-8.3
21-22	Multi-dimensional arrays; Strings: Arrays of characters	CO 2	T2: 11.1-11.5
23-24	Variable length character strings, inputting character strings, character library functions, string handling functions	CO 3	T2: 4.1-4.5
25	Need for user defined functions, function declaration, function prototype	CO 3	T1:7 T2: 6.9
26	Category of functions, inter function communication, function calls	CO 3	T1:10T2:10.1-10.2
27	Parameter passing mechanisms, recursion, passing arrays to functions, passing strings to functions,	CO 3	T2:10.3-10.5
28	Storage classes, preprocessor directives	CO 3	T1:8.9
29	Structure definition, initialization, accessing structures, nested structures	CO 3	T2: 12.3-12.4
30	Unions, C programming examples, BitFields, typedef, enumerations	CO 3	T2:12.4
31-32	Arrays of structures, structures and functions, passing structures through pointers, self-referential structures	CO 3	T2:2.1-2.2

33-34	Unions, bit fields, typedef, enumerations	CO 5	T2: 2.3-2.6,7
35–36	Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers, pointers and arrays	CO 6	T2: 5.2-5.3
37	Pointers as functions arguments, functions returning pointers	CO 5	T2: 5.2-5.3
38	Dynamic memory allocation: Basic concepts, library functions	CO 5	T2: 6.1-6.6
39	Streams, basic file operations, file types, file opening modes, input and output operations with files	CO 5	T2:10.4
40-41	Special functions for working with files, file positioning functions	CO 6	R3:12.1-12.3
42	Command line arguments. Searching	CO 6	R3:12.4
43	Sorting algorithms bubble, insertion, selection	CO 6	T2:11.4 R7:13.1
44-45	Algorithm complexity through example programs	CO 6	T2:11.4 R7:13.1
46	Algorithms and Flowcharts	CO 1	T2:2.1-2.2, R4:1.4
47-48	Operators, Precedence and Associativity of Operators, Expression Evaluation	T2:2.3-2.6	
49-50	Simple if, if-else, else if ladder, Nested if and Case Statement-switch statement	CO 2	T2:3.1-3.5
51	While, for and do while loops, Jump statements, break, continue, goto statements	CO 3	T2:5.2-5.3,T2:6.1-6.6
52-53	One dimensional arrays	CO 3	T2: 8.1-8.2, R4:15.1
54-55	Strings and its operations	CO 3	T2: 8.3, R4: 15.1
56-57	User defined Functions, Parameter passing mechanisms, passing arrays to functions, passing strings to functions,	CO 4	T1:10, T2:10.1 10.2, T2:10.3-10.4, R4:8.3-8.5
58	Recursion	CO 4	T2:10.5
59	Pointer basics, pointer arithmetic, pointers to pointers, generic pointers, array of pointers, pointers and arrays Pointers as functions arguments, functions returning pointers, Dynamic Memory Allocation	CO 4	T2:3.1,R4:11.1
60	Storage classes, pre-processor directives	CO 5	T2:6.1-6.6

61-62	Structure definition, initialization, accessing structures	CO 5	T1:8.9,T2:2.3-2.5
63	Unions, bit fields, typedef, enumerations, command line arguments	CO 5	T2: 12.3-12.4,R4:13.4
64	File Handling	CO 6	T2:10.4,R4:14.1-14.4
65	Introduction	CO 2	T2:1.1-1.5,T2:2.1-2.6
66	Control Structures	CO 3	T2: 3.1 –3.5, T2:5.2 – 5.3
67	Arrays and Functions	CO 4	T2: 8.1 –8.3, R4:15.1
68	Pointer and Structures	CO 5	T2: 12.3–12.4,R4: 13.2–13.4,T1: 8.9
69	File Handling and Applications In C	CO 6	T2: 10.4,T2: 14.1– 14.4

Signature of Course Coordinator **HOD,CSE**
Mr. P Ravinder Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**COMPUTATIONAL MATHEMATICS LABORATORY**				
Course Code	AHS102				
Program	B.Tech				
Semester	II	ME			
Course Type	Foundation				
Regulation	IARE- R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms. B Praveena, Assistant Professor				

I COURSE OVERVIEW:

II. The aim of this course is to know about the basic principles of Engineering Mathematics and itsapplication in MATLAB by means of software. Nowadays the principles of MATLAB find widerange of applications in many situations such as signal processing and communications, imageandvideoprocessing,controlsystems,testandmeasurement,computationalfinance,andcomputational biology. Using MATLAB, one can analyze data, develop algorithms, and createmodelsandapplications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10 + 2	-	-	Basic Principles of Algebra and Calculus

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computational Mathematics Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

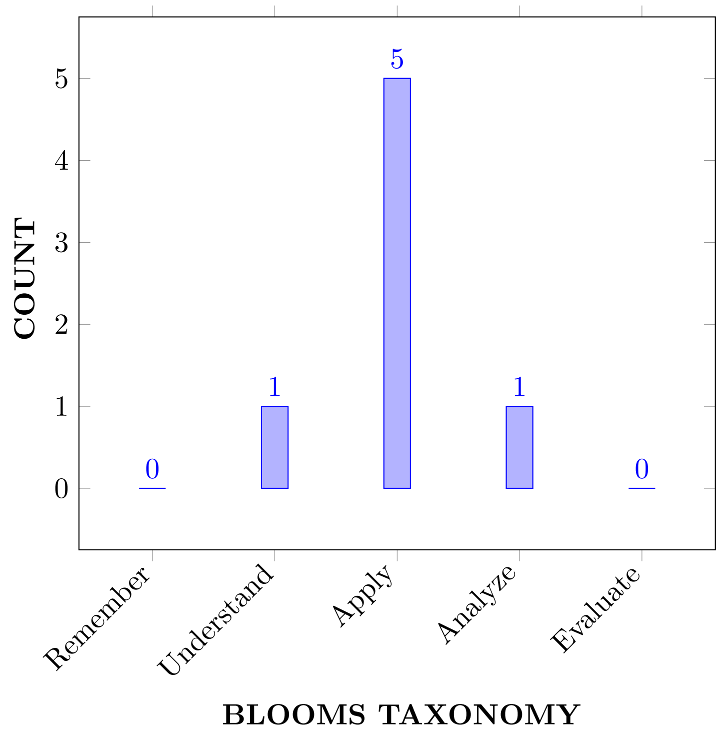
I	DemonstratethebasicprinciplesofMATLAB.
II	Analyze the applications of Algebraand Calculus using MATLAB software.
III	Estimate the roots of Algebraic and Transcendental equations..
IV	Evaluate the characteristics of given curves bymeans of plottingagraph.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Solve** the algebraic and transcendental equations with in given range rangeusing MAT LAB programs. .	Apply
CO 2	**Utilize** MAT LAB programs for verifying properties of limits,derivatives of a function.	Apply
CO 3	**Interpret** rank,eigen values and vectors with matrix transformations.	Understand
CO 4	**Utilize** MAT LAB programs for solving differential equations and multiple integrals.	Apply
CO 5	**Make use of** of MAT LAB programs for interpolating values of differential equations numerically.	Apply
CO 6	**Use** MAT LAB programs for vector operations on vector field.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises

PO 2	**Problem analysis:** Problem analysis: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	CIA
PO 4	**Conduct investigations of complex problems:**Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining	1	Presentation on real-world problems

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Utilize the concept of calibration to a considerable extent appreciate (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the **principles of Mathematics and Engineering**	3
	PO 2	Identify (given **problem statement**)MAT LAB commands for synthesizing and analyzing the given data (provided **information and data**) by principles of Mathematics.	4
	PO 4	Apply (given **problem statement**)MAT LAB commands for analyzing the given data **information and data**) by using various algebraic functions numerically.	2
	PSO 1	Apply (**knowledge**) properties, various types and patterns of fluid flow configurations (apply) for solving design problems by applying the **in various engineering streams following mathematical rules and conditons.**	1

CO 2	PO 1	Identify (understanding) the appropriate MAT LAB programs for verifying limitsand derivatives of the givenfunctions and Understand the major role of these functions which exists as solutions **for integrals and differential equations of elementary functions by applying the principles of mathematics.**	3
	PO 2	Identify (given **problem statement**) the given problem and formulate MAT LAB program for solving and make use of mathematical method **information**to facilitate physical interpretation of the results obtained.	4
	PO 4	Apply (given **problem statement**) the given problem and formulate MAT LAB program for solving and make use of mathematical method MAT LABcommands for synthesizing and analyzing the given data **information**in various engineering streams following mathematical rules and conditons.	2
	PSO 1	Apply (knowledge) MAT LAB commands for synthesizing and analyzing the given data **in various engineering streams following mathematical rules and conditons.**	1
CO 3	PO 1	Interpret (**knowledge**) the rank and inverse of real and complex matrices using MAT LAB programs.	3
	PO 2	Apply **problem statement** MAT LAB program for decomposing the given matrix for (**complex**) solving complex engineering problems following principles ofmathematics. **results**.	4
	PO4	Apply (knowledge) MAT LAB programfor finding Eigen values and Eigen vectors along **with basic principles of mathematics to develop the solution.**	2
	PSO 1	Apply (knowledge)MAT LAB commands for synthesizing and analyzing the given data **in various engineering streams following mathematical rules and conditons.**	1
CO 4	PO 1	Identify (knowledge) appropriate MAT LAB programsforfinding length of the curves and area of the surfacefor with respect to **the fundamental operations of arithmetic(knowledge) for majority of functions by principlesofMathematics.**	3
	PO 2	Interpret **problem statement and formulate** the suitable MAT LAB program for solving double and triple integral in the given region.	2
	PSO 1	Apply (knowledge) MAT LAB commands for synthesizing and analyzing the given data in various engineering streams	1
CO 5	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals**the knowledge of MAT LAB programs. toSolve the algebraic and transcendental equations numerically with in given range .	3

	PSO 1	Apply **problem statement** MAT LAB commands for synthesizing and analyzing the given data in various engineering streams following mathematical rules and conditons.	1
CO 6	PO 1	Develop **Mathematics and Engineering fundamentals** the formulation of differential calculus of complex engineering problems which transforms vector functions, gradient, Divergence and curl using principle of mathematics to the realworld engineering problems by using MAT LAB programs.	3
	PO 2	Apply **principles of Sciences and Engineering fundamentals** the formulation of integral transformations to complex engineering problems related to surface and volume, line and surface of different geometrical models using principle of mathematics in the domain of engineering to reach conclusions by interpretation of results.	2
	PSO 1	Apply **understand the innovative and dynamic challenges** MAT LAB commands for synthesizing and analyzing the given data in various engineering streams following mathematical rules and conditons.	1

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 2	PO 4	PSO 1
CO 1	3	2	1	1
CO 2	3	2	1	1
CO 3	3	2	1	1
CO 4	3	1	-	1
CO 5	3	-	-	1
CO 6	3	1	-	1

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**BASIC FEATURES**
	To Know the history and features of MATLAB, To Know the loca lenvironment of MATLAB
WEEK II	**ALGEBRA**
	Solving basic algebraic equations, Solving system of equations, Two dimensional plots.
WEEK III	**CALCULUS**
	Calculating limits, Solving differential equations, Finding definite integral.
WEEK IV	**MATRICES**
	Addition,subtraction and multiplication of matrices, Transpose of a matrix, Inverse of a matrix.
WEEK V	**SYSTEMOF LINEAREQUATIONS**
	Rank of a matrix, Gauss Jordan method, LU decomposition method.
WEEK VI	**LINEARTRANSFORMATION**
	Characteristic equation, Eigen values, Eigen vectors.
WEEK VII	**DIFFERENTIATIONANDINTEGRATION**
	a. Higher order differential equations, Double integrals, Triple integrals.
WEEK VIII	**INTERPOLATION AND CURVEFITTING**
	Lagrange polynomial, Straight linefit, Polynomial curve fit.
WEEK IX	**ROOT FINDING TECHNIQUES**
	Bisection method, Regulafalsemethod, NewtonRaphsonmethod.
WEEK X	**NUMERICAL DIFFERENTION AND INTEGRATION**
	Trapezoidal, Simpson‘smethod, Eulermethod, RungeKuttamethod.
WEEK XI	**3D PLOTTING**
	Line plotting, Surfaceplotting Volumeplotting.
WEEK XII	**VECTORCALCULUS**
	Gradient, Divergent, Curl.

TEXTBOOKS

1. 1. Dean G.Duffy, Advanced Engineering Mathematics with MATLAB, CRC Press,Taylorand Francis Group,6thEdition,NewDelhi,2015.

REFERENCE BOOKS:

1. 1.Cleve Moler,Numerical Computing with MATLAB,SIAM,Philadelphia,2ndEdition,2008.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Understanding thebasic featuresof MATLAB.	CO 1	T1:1.1 R1:2.21
2	Determination of roots of agiven polynomial.	CO 1	T1:15.1 R1:2.25
3	Verification of basic properties of limits.	CO 2	T1:2.1 R1:2.21
4	Determination ofrank,inverse,transpose and obtaining the solution to linear system of equationsofamatrix.	CO 3	T1-15.6 R1:2.32
5	Interpret the Eigen values and Eigenvectors of a matrix.	CO 3	T1:15.5 R1:2
6	Determination of derivatives and integration toa Given function.	CO 4	T1:2.1 R1:2.8
7	Determination of bestfit curve to the given data	CO 6	T1:3.0 R1:2.9
8	Calculation of areaenclosed bounded bya region.	CO 4	T1:14.5 R1:5.1
9	Solving the higher order differential equations.	CO 4	T1:3.1 R1:5.21
10	Plotting agiven surface bounded in a region.	CO 4	T1:14.3-14.8 R1:5.1
11	Determination of gradient,divergence and cur of avector. .	CO 5	T1:14.2 R1:2.2
12	Determination of roots to algebraic and transcendental equations by bisection method, Method of false position and Newton-Raphson method	CO 6	T1:2.2 R1:2.25

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Algebraic equations:** Apply MAT LAB programs to algebraic equations
2	**Differentiation:** Apply MAT LAB programs differential equations and matrices .
3	**Matrices:** Apply MAT LAB programs to eigen values and eigen vectors.
4	**Numerical methods** Apply MAT LAB programs to numerical methods
5	**Vector calculus:** Apply MAT LAB programs to vector calculus

Signature of Course Coordinator **HOD,CE**
Ms. B Praveena, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**ENGINEERING PHYSICS LABORATORY**				
Course Code	AHS105				
Program	B.Tech				
Semester	II	ME			
Course Type	FOUNDATION				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. K Saibaba, Assistant Professor				

I COURSE OVERVIEW:

This lab course provides hands on experience in a number of experimental techniques and developscompetenceintheinstrumentationtypicallyusedinphysics.This also develops student's expertise in applying physical concepts to practical problem and in learning about experimental techniques with advanced equipments. This laboratory includes experiments involving electromagnetism and optoelectronics.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
-	-	-	Basic principles of physics	2

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering Physics laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing Further Experiments

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day-to-day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the principal from the panel of experts recommended by Chairman, BOS.

The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component	**Laboratory**		Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

A. Experiment Based

Objective	**Analysis**	**Design**	**Conclusion**	**Viva**	**Total**
2	2	2	2	2	10

B. Programming Based

Purpose	**Algorithm**	**Program**	**Conclusion**	**Viva**	**Total**
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

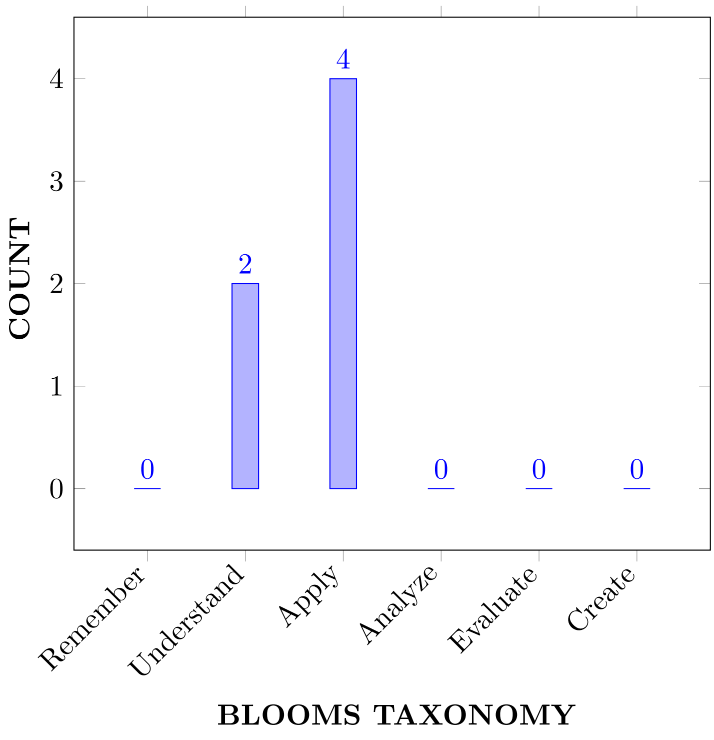
I	To familiarize with the lab facilities, equipment, standard operating procedures.
II	About the different kinds of functional electric and magnetic materials which paves a way for them to use in various technical and engineering applications.
III	The analytical techniques and graphical analysis to study the experimental data for optoelectronic devices.
IV	The applications of variation in the intensity of light due to natural phenomena like interference and diffraction.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Interpret** the least count values of Vernier calipers and Screw guage Apply the concept of hook's law and determine the rigidity modulus of wire.	Apply
CO 2	**Illustrate** principle, working and application of wave propagation and compare results with theoretical harmonics and overtones.	Understand
CO 3	**Investigate** the magnetic field induction produced at various points along the axis of current carrying coil and the magnetic field produced in a coil to verify the Tangent's law.	Apply
CO 4	**Examine** launching of light through optical fiber from the concept of light gathering capacity of numerical aperture.	Understand
CO 5	**Utilize** the method of minimum deviation and adjust the spectrometer to minimum deviation position also determine the dispersive power of prism by using spectrometer.	Apply
CO 6	**Investigate** V-I/L-I characteristics of various optoelectronic devices like Light Emitting Diode, Laser diode to understand their basic principle of functioning	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Laboratory experiments, internal and external lab examinations.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Laboratory experiments, internal and external lab examinations.
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Laboratory experiments, internal and external lab examinations.

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1	Laboratory experiments and Surveys

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Identify basic principle of Vernier caliperse and screw guage to determine their least count values and also finding the rigidity modulus of given wire.	2
	PO 2	Understand the Hoocks law and the rigidity modulus finding by using the given wire and bross or any metal disk .	4
	PO 1	Determine the energy gap of a semiconductor diode by making use of graphical analysis of current versus temperature curve.	2

CO 2	PO 1	Recall the theory of propagation of longitudinal and transverse waves and make use of number of loops formation in string to determine frequency of an electronically maintained tuning fork.	2
	PO 2	Understand the given problem statement of stationary wave propagation and formulate harmonics and overtones of fundamental frequency from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
CO 3	PO 1	Explain the variation of magnetic field at various points along the axis of current carrying coil and make use of mathematical expression of Tangent's law using Stewart Gee's apparatus.	2
	PO 2	Understand the given problem statement of current loop and formulate magnetic field induction at various points along the axis of current loop from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
	PO 1	Investigate the method of minimum deviation position and also determine the dispersive power of prism by using spectrometer. and adjust the spectrometer to minimum deviation position	2
	PO 2	Investigate the method of minimum deviation position and also determine the dispersive power of prism by using spectrometer. and adjust the spectrometer to minimum deviation position	4
	PO 4	Apply the concept of Newton's rings to determine the radius of curvature of convex lens	1
	PSO 3	Make use of modern simulation tool to get information about energy losses associated with a ferromagnetic material.	1
CO 4	PO 1	Interpret launching of light through optical fiber and make use of mathematical expression for analyzing light gathering capacity through numerical aperture.	2
	PO 4	Make use of optical fiber trainer kit and understand conversion of electrical to light energy..	1
CO 5	PO 1	Explain the concept of interference in Newton's rings and make use of it to determine the radius of curvature of convex lens.	2
	PO 4	Make use of microscope to get Newton's rings and understand the phenomenon of interference in reflected light.	1
	PO 1	Recollect the phenomena of diffraction from N-slits and make use of it for the determination of wavelength of a given laser.	1
	PO 1	Determine the thickness of a wire and radius of a disc using screw gauge and vernier calipers	1

CO 6	PO 1	Explain the V-I characteristics of light emitting diode with different colours of LEDs for different threshold voltage values.	2
	PO 1	Understand the phenomenon of recombination of electron-hole pair and determine the value of threshold voltage of a given LED.	2
	PO 1	Illustrate the variation of photo current with light intensity in a Laser diode.	1

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 2	PO 4	PSO 3
CO 1	3	2	-	-
CO 2	3	2	1	-
CO 3	3	-	-	1
CO 4	3	2	1	-
CO 5	3	-	1	-
CO 6	3	2	1	-

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK 1	**MEASUREMENT OF THICKNESS OF A WIRE AND RADIUS OF DISC**
	Determine the thickness of a wire and radius of a disc using screw gauge and vernier calipers .
WEEK 2	**TORSIONAL PENDULUM**
	Determination of rigidity modulus of the material of given wire using a torsional pendulum .
WEEK 3	**STEWART GEE'S APPARATUS**
	Determination of Magnetic field along the axis of current carrying coil – Stewart and Gee's method.
WEEK 4	**DETERMINATION OF FREQUENCY OF LONGITUDINAL WAVES**
	Determination of frequency of a given tuning fork in longitudinal mode.
WEEK 5	**DETERMINATION OF FREQUENCY OF TRANSVERSE WAVES**
	Determination of frequency of a given tuning fork in transverse mode.
WEEK 6	**WAVELENGTH OF LASER SOURCE-DIFFRACTION GRATING**
	To determine the wavelength of given source of laser using a plane transmission grating.
WEEK 7	**ADJUSTMENT AND MINIMUM DEVIATION IN SPECTROMETER**
	To study about spectrometer and to adjust spectrometer in minimum deviation position.
WEEK 8	**DISPERSIVE POWER OF A MATERIAL OF PRISM**
	Determination of the dispersive power the material of the given prism.
WEEK 9	**NEWTONS RINGS**
	Determination of radius of curvature of a given plano-convex lens.
WEEK 10	**NUMERICAL APERTURE OF GIVEN FIBER**
	To determine the numerical aperture of a given optical fiber.
WEEK 11	**LIGHT EMITTING DIODE**
	Studying V-I characteristics of LED
WEEK 12	**CHARACTERISTICS OF LASER DIODE**
	To study L-I characteristics of a laser diode.

TEXTBOOKS

1. 1 CL Arora, "Practical Physics", S Chand and Co.,New Delhi, 3rd Edition,2012.
2. 2 Vijay Kumar, Dr. T. Radha krishna, "Practical Physics for Engineering Students", S M Enterprises, 2nd Edition, 2014.

REFERENCE BOOKS:

1. 1 CF Coombs,"Basic Electronic Instrument Handbook", McGraw - HillBookCo.,1972.
2. 2 CH Bernardand CD Epp, John Wiley and Sons, " Laboratory Experiments in College Physics" Inc.,NewYork,1995.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Determine the thickness of a wire and radius of a disc using screw gauge and vernier calipers .	CO 1	T1:13.5
2	Determination of rigidity modulus of the material of given wire using a torsional pendulum .	CO 2	T1:13.5
3	Determination of Magnetic field along the axis of current carrying coil – Stewart and Gee's method.	CO 3, CO 4	TT1:14.7
4	Determination of frequency of a given tuning fork in longitudinal mode.	CO 3	T1:15.7
5	Determination of frequency of a given tuning fork in transverse mode.	CO 1	T1:16.8
6	To determine the wavelength of given source of laser using a plane transmission grating.	CO 6	T1:16.9
7	To study about spectrometer and to adjust spectrometer in minimum deviation position.	CO 4	T1:17.9
8	Determination of the dispersive power the material of the given prism.	CO 5	T1:18.10
9	Determination of radius of curvature of a given plano-convex lens.	CO 6	T1:19.10
10	Determine the numerical aperture of a given optical fiber.	CO 6	T1:19.9
11	Studying V-I characteristics of LED	CO 5	T1:23.10
12	Study L-I characteristics of a laser diode.	CO 5	T1:23.10

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	To determine the width of slit by using Laser light source by diffraction method
2	To study the bending losses and transmission losses of an optical Fiber
3	To Calculate carrier concentration og given semiconductor by using Hall Effect.
4	Study the characteristics of Photo diode.
5	To illustrate the interference pattern produced from the air wedge.
6	To determine energy loss of ferromagnetic material

Signature of Course Coordinator **HOD,ME**

Mr.K Saibaba, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**PROGRAMMING FOR PROBLEM SOLVING LABORATORY**				
Course Code	ACS101				
Program	B.Tech				
Semester	I	CE			
Course Type	Foundation				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. Ravinder, Assistant Professor				

I COURSE OVERVIEW:

The course covers the basics of programming and demonstrates fundamental programming techniques, customs and terms including the most common library functions and the usage of the preprocessor. This course helps the students in gaining the knowledge to write simple C language applications, mathematical and engineering problems. This course helps to undertake future courses that assume this programming language as a background in computer programming. Topics include variables, data types, functions, control structures, pointers, strings, arrays and dynamic allocation principles. This course in reached to student by power point presentations, lecture notes, and lab involve the problem solving in mathematical and engineering areas..

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSB02	II	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computer Programming Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

I	The hands on experience in design, develop, implementation and evaluation by using Asymptotic notation.
II	The demonstration knowledge of basic abstract data types (ADT) and associated algorithms for organizing programs into modules using criteria that are based on the data structures of the program.

III	The practical implementation and usage of non linear data structures for solving problems of different domain.
IV	The knowledge of more sophisticated data structures to solve problems involving balanced binary search trees, AVL Trees, B-trees and B+ trees, hashing.
V	The graph traversals algorithms to solve real-world challenges such as finding shortest paths on huge maps and assembling genomes from millions of pieces

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** problem solving steps in terms of algorithms, pseudocode and flowcharts for Mathematical and Engineering problems. .	Understand
CO 2	**Make use** the concept of operators, precedence of operators, conditional statements and looping statements to solve real time applications.	Apply
CO 3	**Demonstrate** the concept of pointers, arrays and perform pointer arithmetic, and use the pre-processor.m.	Understand
CO 4	**Analyze** the complexity of problems, modularize the problems into small modules and then convert them into programs.	Apply
CO 5	**Implement** the programs with concept of file handling functions and pointer with real time applications of C.	Apply
CO 6	**Explore** the concepts of searching and sorting methods with real time applications using c	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:**Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Viva-voce/Laboratory Practices
PO 2	**Problem analysis:**Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Viva-voce/Laboratory Practices
PO 3	**Design/development of solutions:**Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Viva-voce/Laboratory Practices
PO 5	**Modern Tool Usage:**Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2	Viva-voce/Laboratory Practices
PO 10	**Communication:**Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Viva-voce/Laboratory Practices
PO 12	**Life-long learning:**Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Viva-voce/Laboratory Practices

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	**Professional Skills:** The ability to research, understand and implement computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient analysis and design of computer-based systems of varying complexity. .	2	Viva-voce Laboratory Practices

PSO 2	**Software Engineering Practices:** The ability to apply standard practices and strategies in software service management using open-ended programming environments with agility to deliver a quality service for business success .	2	Viva-voce Laboratory Practices
PSO 3	**Successful Career and Entrepreneurship:** The ability to employ modern computer languages, environments, and platforms in creating innovative career paths, to be an entrepreneur, and a zest for higher studies. .	2	Viva-voce Laboratory Practices

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand (knowledge) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science**	3
	PO 5	Understand the (given **knowledge**) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineerig activities with an understanding of the limitations.	3
CO 2	PO 1	Understand (knowledge)the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science.**	3
	PO 5	Understand the (**knowledge**) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2
CO 3	PO 1	Understand (**knowledge**) the basic concept of algorithm analysis which provides theoretical estimates for the resources needed by any algorithm for a given computational problem. These estimates provide an insight into reasonable directions of search for efficient algorithms by applying the principles of **mathematics and science.**	3
	PO 5	Understand the (knowledge) appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	3

CO 4	PO 1	Describe (knowledge) the use sorting techniques as a basic building block in algorithm design and problem solving **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 5	Understand the **knowledge** appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	2
	PO 10	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **communicating effectively with engineering community.**	3
CO 5	PO 1	Outline the importance of searching algorithms to retrieve an element from any data structure where it is stored by **understanding and applying the fundamentals of mathematics, science and engineering.**	3
	PO 10	Understand the use of searching techniques that retrieve information stored within some data structure by **communicating effectively with engineering community**.	2
CO 6	PO 1	Outline the importance of searching algorithms to retrieve an element from any data structure where it is stored by **understanding and applying the fundamentals of mathematics, science and engineering**	2
	PO 10	Understand the use of searching techniques that retrieve information stored within some data structure by **communicating effectively with engineering communit.**	3
CO 7	PO 1	Make use of linear data structures to organize the data in a particular way so to use them in the most effective way by applying the **basic knowledge of mathematics, science, engineering fundamentals**	2
	PO 2	Build strong foundation of data Structures which tells the program how to store data in memory and forming some relations among the data and use them in **design and development of new products.**	2
	PO 3	Recognize the need of linear data structures such as linked list, array, stack and queue by **designing solutions for complex Engineering problems** in real-time.	1
	PSO 1	Acquire sufficient knowledge to develop real-time applications by making use of linear data structures in (**career building and higher studies.**	3
CO 8	PO 1	Describe (knowledge) the usage of data structures in organizing, managing, and storing different data formats that enables efficient access and modification by applying the **fundamentals of mathematics, science, and engineering.**	3

	PO 5	(**Modern Tool Usage:**)Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.	
	PO 3	Understand the applications of basic data structures such as stacks, queues, linked lists in (**designing and developing solutions of complex engineering applications.**	4
	PSO 1	Make use of modern computer tools for applying the basic data structure concepts in building real-time applications for a successful career.	
CO 9	PO 1	Apply the sophisticated hierarchical data structures to organize keys in form of a tree to use in many real-life applications by **using the principles of mathematics and engineering fundamentals.**	3
	PO 2	Make use of non-linear data structures such as balanced trees in by **identifying, formulating and analyzing complex engineering problems** such as databases, syntax tree in compilers and domain name servers etc. **with the help of basic mathematics and engineering sciences**.	3
	PO 3	Extend the concept of tree data structures to **design and develop solutions for complex engineering problems**.	3
	PSO 1	Make use of modern computer tools in implementing non-linear data structures for various applications to become a successful professional in the domain.	3
CO 10	PO 1	Demonstrate different tree structures in Python to implement real-time problems by **applying basic knowledge of science and engineering fundamentals.**	3
	PO 2	Illustrate the importance of tree data structures used for various applications **by identifying, formulating and analyzing complex engineering problems** such as operating systems and compiler design.	3
	PO 3	Make use of tree data structures to **design and develop solutions for complex engineering problems** and which is the key organizing factor in software design. Data structures can be used to organize the storage and retrieval of information stored in both main memory and secondary memory.	3
	PSO 1	Acquire sufficient knowledge in field of data structures and its applications by using modern computer tools so that new product development can take place, which leads to become successful entrepreneur and or to obtain higher education.	3

CO 11	PO 1	Understand (knowledge) the benefits of dynamic and static data structures implementations and choose appropriate data structure for specified problem domain **using knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	Recognize the need of dynamic and static data structures **in identifying, formulating and analyzing complex engineering problems.**	3
	PO 3	Describe (knowledge) the usage of static and dynamic data structures in designing solutions for complex Engineering problems.	3
	PSO 1	Build sufficient knowledge of dynamic data structures by using modern tools so that new product can be developed, which leads to become successful entrepreneur in the present market.	3
CO 12	PO 1	Build strong foundation of quickly determining the efficiency of an algorithm or data structure for solving computing problems with respect to performance by using knowledge of mathematics, science and engineering fundamentals.	3
	PO 2	Recognize the importance of suitable data structures in checking the efficiency of algorithms used for complex engineering problems.	3
	PO 3	Make use of broad usage of data structures in designing and developing of complex engineering applications.	3
	PSO 1	Extend the concept of data structures in solving complex engineering problems using modern engineering tools to become a successful professional in the domain.	3

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES				
	PO 2	PO 3	PO 5	PO 10	PSO 1
CO 1	3			2	
CO 2	3			2	
CO 3	3			2	3
CO 4	3			2	2
CO 5	2				2
CO 6	3				2
CO 7	3	2	2		2
CO 8	3		3	2	2
CO 9	2	2	3		2
CO 10	2	3	2		2
CO 11	3	2	2		2
CO 12	2	2	3		3

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**SEARCHING TECHNIQUES**
	Write python program for implementing the following searching techniques. a. Linear search. b. Binary search. c. Fibonacci search.
WEEK II	**SORTING TECHNIQUES**
	Write Python programs for implementing the following sorting techniques to arrange a list of integers in ascending order. a. Bubble sort. b. Insertion sort. c. Selection sort.
WEEK III	**SORTING TECHNIQUES**
	Write Python programs for implementing the following sorting techniques to arrange a list of integers in ascending order. a. Quick sort. b. Merge sort.
WEEK IV	**IMPLEMENTATION OF STACK AND QUEUE**
	Write Python programs to a. Design and implement Stack and its operations using Lists. b. Design and implement Queue and its operations using Lists
WEEK V	**APPLICATIONS OF STACK**
	Write Python programs for the following: a. Uses Stack operations to convert infix expression into postfix expression. b. Uses Stack operations for evaluating the postfix expression. .
WEEK VI	**IMPLEMENTATION OF SINGLE LINKED LIST**
	Write Python programs for the following: a. Uses functions to perform the following operations on single linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal b. To store a polynomial expression in memory using linked list. .
WEEK VII	**IMPLEMENTATION OF CIRCULAR SINGLE LINKED LIST**
	Write Python programs for the following: Uses functions to perform the following operations on Circular linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal .
WEEK VIII	**IMPLEMENTATION OF DOUBLE LINKED LIST**
	Write Python programs for the following: Uses functions to perform the following operations on double linked list. (i) Creation (ii) insertion (iii) deletion (iv) traversal in both ways .

WEEK IX	**IMPLEMENTATION OF STACK USING LINKED LIST**
	Write Python programs to implement stack using linked list.
WEEK X	**MPLEMENTATION OF QUEUE USING LINKED LIST**
	Write Python programs to implement queue using linked list
WEEK XI	**GRAPH TRAVERSAL TECHNIQUES**
	Write Python programs to implement the following graph traversal algorithms: a. Depth first search. b. Breadth first search.
WEEK XII	**IMPLEMENTATION OF BINARY SEARCH TREE**
	Write a Python program that uses functions to perform the following: a. Create a binary search tree. b. Traverse the above binary search tree recursively in pre-order, post-order and in-order. Count the number of nodes in the binary search tree.

TEXTBOOKS

1. Sutton, G.P., et al., —Rocket Propulsion Elements, John Wiley Sons Inc., New York, 1993
2. Martin J.L Turner , Rocket Space Craft Propulsion, Springers oraxis publishing, 2001

REFERENCE BOOKS:

1. Mathur, M., and Sharma, R.P., —Gas Turbines and Jet and Rocket Propulsion, Standard Publishers, New Delhi 1998
2. Cornelisse, J.W., Rocket Propulsion and Space Dynamics, J.W., Freeman & Co. Ltd., London, 1982.
3. Parker, E.R., Materials for Missiles and Spacecraft, McGraw-Hill Book Co. Inc., 1982.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Calibration of Venturimeter and Orifice meter.	CO 1	R1: 1.2
2	Determination of pipe flow losses in rectangular and circular pipes.	CO 2	R2: 3.5
3	Verification of Bernoulli's theorem	CO 3	R1: 3.4
4	Determination of Reynolds Number of fluid flow	CO 4	R1: 2.2
5	Determine the reaction forces produced by the change in momentum.	CO 5	R1: 2.4
6	Determine the efficiencyand draw theperformance curves ofcentrifugal pump.	CO 6	R3: 4.5
7	Determine the efficiencyand draw theperformance curves of reciprocating pump.	CO 6	R3: 4.6
8	Determine the performance characteristics of pelton wheel under constant head.	CO 6	R2: 5.1
9	Determine the performance characteristics of Francis turbine.	CO 6	R2: 5.2
10	Determine the rate of flow through weir.	CO 7	R1: 7.1
11	Determine the rate of flow through Nothches.	CO 7	R1:7.2
12	Determine the rate of flow through a Orifice meter	CO 7	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Twin vortex formation:** Demonstration of twin vortex formation and calculation of vortex size for different geometries.
2	**Open channel:** Demonstration of streamline at different angle of attack and calculation of separation point for different Reynolds number.
3	**Capillary action:** By modeling capillary action using two cups of water and a paper towel, you'll gain a better understanding of the importance of this process in trees.
4	**Buoyancy** Calculation of meta center and displacement volume for various geometries and materials.
5	**Flow through pipes:** Encourage students to design and analyze flow through pipes using ANSYS

Signature of Course Coordinator **HOD,AE**
Mr. P Ravinder, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**COMPUTER AIDED ENGINEERING DRAWING PRACTICE**				
Course Code	AME102				
Program	B.Tech				
Semester	II	ME			
Course Type	Core				
Regulation	R 16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Dr. VVSH Prasad, Professor				

I COURSE OVERVIEW:

Drawing is the accurate technique that develops the ability to visualize any object with all physical and dimensional configurations. During the process of design, the designer may have to carry out a large amount of computations to generate optimum design and develops engineering drawings for manufacturing a product using interactive computer graphics. The computer aided engineering drawing assists in preparation of 3D and 2D drawings to carry out sophisticated design and analysis. This course forms the foundation for the development of computer graphics and CAD/CAM technologies in the era of digital manufacturing

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC02	I	Linear Algebra and Calculus

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computer Aided Engineering Drawing	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

I	Application of the fundamental principles of engineering drawing using AutoCAD
II	Knowledge of intersection of solids in different quadrants
III	Ability to convert the pictorial views into orthographic view and vice versa
IV	Creation of intricate details of components through sections and develop its surfaces

V	Knowledge of the perspective projection of solids through vanishing and visual ray method

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** the use of draw, modify and dimension commands of AutoCAD for development of 2D and 3D drawings.	Understand
CO 2	**Apply** the principles of section of solids and developments of surfaces for formation of junctions of the joints.	Apply
CO 3	**Apply** the principle of intersection of solids for development of different views of the joints.	Apply
CO 4	**Demonstrate** the knowledge of principles of isometric projections for depicting the 3-Dimensional objects on 2D plane.	Understand
CO 5	**Make use of** the concept of orthographic projections for converting isometric view to orthographic views and Vice-versa	Apply
CO 6	**Illustrate** vanishing point method and visual ray method for development of perspective views of simple 2D and 3d objects.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	CIA
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises/ CIE/ SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises/ CIE/ SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises/ CIE/ SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies. .	3	Assignments/ Lab Exercises

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Demonstrate the use of basic commands of AutoCAD with the knowledge of **mathematical principles** and **engineering fundamentals**.	2

	PO 5	Demonstrate the use of basic commands of **modern tool** called AutoCAD with an understanding of its limitations	1
	PSO 3	Demonstrate the use of **computational** tool called AutoCAD for building career paths towards innovative startups to be an entrepreneur.	1
CO 2	PO 1	Develop the lateral surface of the joins with the knowledge of **mathematical principles** and **fundamentals of engineering** drawing.	2
	PO 3	**Understand the customer needs** of development of complex pipe joints, **establish innovative solutions** that are **fit for production**, **minimize the cost** with the **knowledge of management** of the sheet and **evaluate the outcomes** with the **knowledge of economic context of engineering processes**.	7
	PO 9	Develop the lateral surface of the joins **individually** or **as a part of team** with **maturity** and **self-direction** even if problem is defined vaguely, **getting along with others during the classroom periods and in the hands-on labs**, **helping each other in completing assignments** to become effective member during **industry oriented Mini-Project**	8
	PO 10	Communicate effectively about the **subject matter** of development of surface with proper **speaking style**.	2
CO 3	PO 1	Develop different views of the joins with the knowledge of **mathematical principles** and **fundamentals of engineering** drawing.	2
	PO 3	**Understand the customer needs** of developing different views of complex pipe joints, **establish innovative solutions** that are **fit for production**, **minimize the cost** with the **knowledge of management** of the sheet and **evaluate the outcomes** with the **knowledge of economic context of engineering processes**.	7
	PO 9	Develop different views of the joins **individually** or **as a part of team** with **maturity** and **self-direction** even if problem is defined vaguely, **getting along with others during the classroom periods and in the hands-on labs**, **helping each other in completing assignments** to become effective member during **industry oriented Mini-Project**	8
	PO 10	Communicate effectively about the **subject matter** of development of surface with proper **speaking style**.	2
	PSO 3	Demonstrate the use of **computational** tool called AutoCAD for development of different views of joints to be an entrepreneur.	1
CO 4	PO 1	Demonstrate the knowledge of **fundamentals of engineering** isometric drawing and **mathematical principles** for depicting the 3D objects on 2-D plane.	2

	PO 3	**Understand the customer needs** of development of isomeric vies of the complex objects , **establish innovative solutions** that are **fit for production**, and **evaluate the outcomes** with the **knowledge of economic context of engineering processes**.	5
	PO 9	Develop isomeric vies of the complex objects **individually** or **as a part of team** with **maturity** and **self-direction** even if problem is defined vaguely, **getting along with others during the classroom periods and in the hands-on labs**.	6
CO 5	PO 3	**Understand the customer needs** of development of isometric view from orthographic views, **establish innovative solutions** that are **fit for production**, **minimize the cost** with the **knowledge of management** of the space and **evaluate the outcomes** with the **knowledge of economic context of engineering processes**.	7
	PO 5	Demonstrate the use of basic commands of **modern tool** called AutoCAD with an understanding of its limitations	1
	PO 9	Develop the isometric view from orthographic views, **individually** or **as a part of team** with **maturity** and **self-direction** even if problem is defined vaguely, **getting along with others during the classroom periods and in the hands-on labs**, **helping each other in completing assignments** to become effective member during **industry oriented Mini-Project**	8
CO 6	PO 1	Demonstrate the knowledge of **fundamentals of engineering** perspective drawing and **mathematical principles** for depicting the 3D objects on 2-D plane.	2
	PO 5	Demonstrate the use of basic commands of **modern tool** called AutoCAD with an understanding of its limitations	1
	PSO 3	Demonstrate the use of **computational** tool called AutoCAD for building career paths towards innovative startups to be an entrepreneur.	1

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES					PSO'S
	PO 1	PO 3	PO 5	PO 9	PO 10	PSO 3
CO 1	3		2			3
CO 2	3	3		3	2	
CO 3	3	3		3	3	2
CO 4	3	2		2		
CO 5		3	3	3		
CO 6	2		2			3

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**INTRODUCTION TO ENGINEERING DRAWING**
	Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering..
WEEK II	**OVER VIEW OF COMPUTER AIDED DRAFTING**
	Practial session of ACAD editing and Modify Commands and practice.
WEEK III	**DEVELOPMENT OF SURFACES WITH SECTIONAL VIEW**
	Sections of right regular solids, prisms, pyramids, cylinders and cones, auxiliary views.
WEEK IV	**DEVELOPMENT OF SURFACES WITH SECTIONAL VIEW**
	Development of surfaces, development of surfaces of right regular solids prisms, pyramids, cylinders and cones.
WEEK V	**INTERSECTION OF SOLIDS**
	Intersection of prism versus prism and cylinder versus prism.
WEEK VI	**INTERSECTION OF SOLIDS**
	Intersection of cylinder versus cylinder and cylinder versus cone..
WEEK VII	**ISOMETRIC PROJECTIONS**
	Principles of isometric projections, Isometric views of lines, planes.
WEEK VIII	**ISOMETRIC PROJECTIONS**
	Isometric views of simple and compound solids, objects having spherical parts.
WEEK IX	**TRANSFORMATION OF PROJECTIONS**
	Conversion of isometric views to orthographic views.
WEEK X	**TRANSFORMATION OF PROJECTIONS**
	Conversion of orthographic views to isometric views.
WEEK XI	**PERSPECTIVE PROJECTIONS**
	Perspective view of points, lines, plane figures and simple solids, vanishing point method.
WEEK XII	**PERSPECTIVE PROJECTIONS**
	Perspective view of points, lines, plane figures and simple solids, visual ray method.

TEXTBOOKS

1. N. D. Bhatt, “Engineering Drawing”, Charotar Publications, New Delhi, 49th Edition, 2010.
2. C.M. Agarwal, Basant Agarwal, “Engineering Drawing”, Tata McGraw Hill, 2nd Edition, 2013.

REFERENCE BOOKS:

1. K. Venugopal, “Engineering Drawing and Graphics”. New Age Publications, 2nd Edition, 2010.
2. Dhananjay. A. Johle, “Engineering Drawing”, Tata McGraw Hill, 1st Edition, 2008.
3. S.Trymbaka Murthy, “Computer Aided Engineering Drawing”, I.K. International Publishers, 3rd Edition, 2011.
4. A.K.Sarkar, A.P Rastogi, “Engineering graphics with Auto CAD”, PHI Learning, 1stEdition, 2010.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
1	Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering.	CO 1	T1:1.4 R1:1.2
2	Principles of dimensions and their execution. Introduction to auto-cad.	CO 1, CO2	T1:1.5 R1:2.4
3	Sections of right regular solids, prisms, pyramids, cylinders and cones, auxiliary views.	CO 2	T1:2.5 R1:2.5
4	Development of surfaces, development of surfaces of right regular solids prisms, pyramids, cylinders and cones.	CO 3	T2:2.5 R1:2.6
5	Intersection of prism versus prism and cylinder versus prism.	CO 3	T1:22.7
6	Intersection of cylinder versus cylinder and cylinder versus cone.	CO 3	T1:6.3 R2:5.3
7	Principles of isometric projections, Isometric views of lines, planes.	CO 4	T1:7.5 R1:6.3
8	Isometric views of simple and compound solids, objects having spherical parts.	CO 5	T1:8.5 R1:6.8
9	Conversion of isometric views to orthographic views.	CO 6	T1:12.2 R3:13.1
10	Conversion of orthographic views to isometric views.	CO 5	T1:12.3 R1:13.2
11	Perspective view of points, lines, plane figures and simple solids, vanishing point method.	CO 4	T1:1.4 R1:1.2
12	Perspective view of points, lines, plane figures and simple solids, visual ray method.	CO 5	T1:1.5 R1:2.4

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Demonstrate the use of AutoCAD** for developing Bolts and Nuts.
2	**Draw the development** of lateral surfaces of Sphere.
3	**Draw the different views** of intersection of cone vs sphere.
4	**Draw the isometric projection** of the sphere resting on cube.
5	**Draw the orthographic view** of given isomeric view of sphere.
6	**Draw the perspective view** of an almerah or cupboard.

Signature of Course Coordinator **HOD, ME**
Dr. VVSH Prasad, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
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Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**PROBABILITY AND STATISTICS**				
Course Code	AHS010				
Program	B.Tech				
Semester	III	ME			
Course Type	Foundation				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. J Suresh Goud, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	Basic principles of statistics

II COURSE OVERVIEW:

The course focuses on more advanced Engineering Mathematics topics which provide with the relevant mathematical tools required in the analysis of problems in engineering and scientific professions. The course includes probability, random variables, probability distributions, correlation, regression, sampling distribution, testing of hypothesis and analysis of variance. The mathematical skills derived from this course form a necessary base to analytical and design concepts encountered in the program.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Fluid Dynamics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
30 %	Understand
60%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

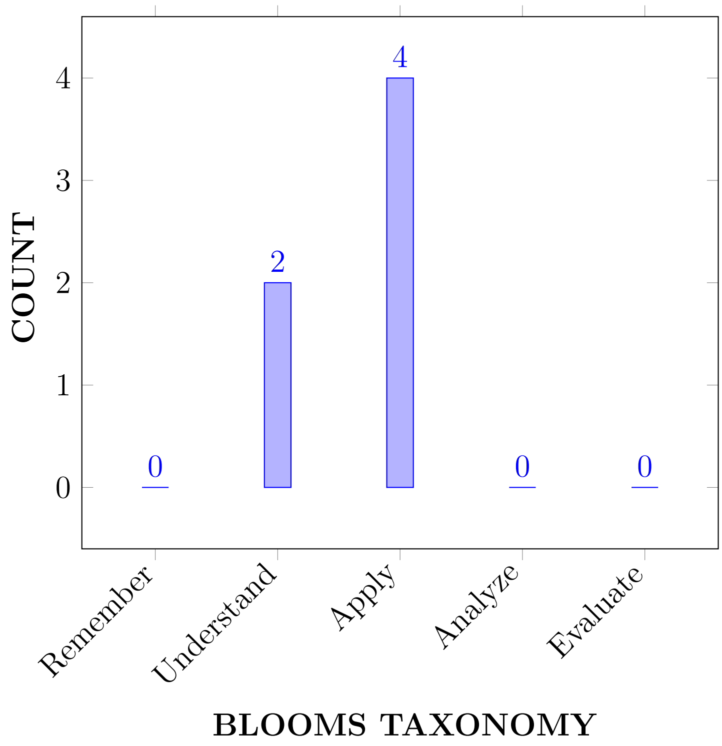
I	Enrich the knowledge of probability on single random variables and probability distributions.
II	Apply the concept of correlation and regression to find covariance.
III	Analyze the given data for appropriate test of hypothesis.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the parameters of random variate Probability distributions including Binomial, Poisson and Normal distribution by using their probability functions, expectation and variance.	Understand
CO 2	**Interpret** the concepts of discrete and continuous probability distribution, CLT problems, correlations and Regression Analysis for statistical forecasting.	Understand
CO 3	**Make use of** the concept of sampling distribution of statistical data by using behavior of the sample mean.	Apply
CO 4	**Apply** the concept of estimation in real-world problems of signal processing and testing of hypothesis to predict the significance difference, types of errors in the sample means.	Apply
CO 5	**Calculate** the role of statistical hypotheses, confidence intervals, the tests of hypotheses for large samples in making decisions over statistical claims in hypothesis testing	Apply
CO 6	**Identify** the tests of hypothesis for small samples and comparing three variables of ANOVA in making decisions over statistical claims in hypothesis testing	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentation on real-world problems
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Seminar
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Term Paper

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	-	-
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	-	-	✓	-	-	-	-	-	-	-		-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	**PO 1**	Explain (understanding) the concept of random variables and their role in solving complex engineering problems involving random events and uncertainty by using Mathematical functions (principles of mathematics).	2
	PO 4	The expected values, variances for the given discrete random variables will be quantitatively measured by using statistical computer software (R-software).	1
CO 2	**PO 1**	Interpret the Probability distributions such as Binomial, Poisson and Normal distribution (Understanding) with the support of evaluation of integrals (principles of mathematics) and appreciate their importance and applicability (Apply) in solving complex engineering problems involving uncertainty.	2
	PO 2	Understand the statement and formulation of a complex engineering problem which involves the events of uncertainty, Model it with suitable probability distribution and Apply the concepts of discrete or continuous distributions along with basic principles of mathematics to develop the solution and reaching substantiated conclusions by the interpretation of results	5
CO 3	**PO 1**	Interpret (Understand) the results of Bivariate and Correlation Analysis by using ratios, square roots, straight lines and planes (principles of mathematics) for statistical forecasting (Apply)in complex engineering problems involving bivariate or multivariate data.	2
CO 4	**PO 1**	Select appropriate statistical methods (understand) for solving some real-time complex engineering problems governed by correlation with the knowledge of fundamental principles of mathematics.	2
	PO 4	Interpret the results of Bivariate and Multivariate Regression and quantifying the degree of closeness between two or more variables by using statistical computer software (R-software, SPSS-software).	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 5	**PO 1**	Apply tests of hypotheses which involves the role of mathematical tools like statements, sets, ratios and percentages (principles of mathematics) for both large samples and small samples (knowledge) in making decisions over statistical claims that arise in complex engineering problems which requires sampling inspections.	2
	PO 2	Understand the statement and formulation of a complex engineering problem which needs verification of truth values of numerical or statistical hypothesis, collect the necessary information and data through sampling techniques, apply tests of hypotheses (both large and small samples) along with basic principles of mathematics to develop the solution and reaching substantiated conclusions by the interpretation of results	5
	PO 4	Make Use of R software package in computing confidence intervals, statistical averages and hypothesis testing. (Computer software relevance)	1
CO 6	**PO 1**	Identify the role of types of statistical hypotheses, types of errors, sampling distributions of means and confidence intervals with the aid of statements and sets, percentages (principles of mathematics) in hypothesis testing of complex engineering problems which requires sampling inspections.	2
	PO 4	Test for the assessment of goodness of fit of the given probability distribution model by using statistical quantitative methods and statistical computer software (R-software).	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	1	-	-	-	-	-	-	-		-	-	-
CO 5	2	5	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	-	-	1	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	9.0	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	50.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	-	-	9.0	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	50.0	-	9.0	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.7	-	-	9.0	-	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	1	-	-	-	-	-	-	-		-	-	-
TOTAL	18	4	-	4	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 4	Open Ended Experiments	-
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**SINGLE RANDOM VARIABLES AND PROBABILITY DISTRIBUTION**
	Random variables: Basic definitions, discrete and continuous random variables; Probability distribution: Probability mass function and probability density functions; Mathematical expectation; Binomial distribution, Poisson distribution and normal distribution.
MODULE II	**MULTIPLE RANDOM VARIABLES**
	Joint probability distributions, joint probability mass, density function, marginal probability mass, density functions; Correlation: Coefficient of correlation, the rank correlation; Regression: Regression coefficient, the lines of regression, multiple correlation and regression.
MODULE III	**SAMPLING DISTRIBUTION AND TESTING OF HYPOTHESIS**
	Sampling: Definitions of population, sampling, statistic, parameter; Types of sampling, expected values of sample mean and variance, sampling distribution, standard error, sampling distribution of means and sampling distribution of variance. Estimation: Point estimation, interval estimations; Testing of hypothesis: Null hypothesis, alternate hypothesis, type I and type II errors, critical region, confidence interval, level of significance. One sided test, two sided test.
MODULE IV	**LARGE SAMPLE TESTS**
	Test of hypothesis for single mean and significance difference between two sample means, Tests of significance difference between sample proportion and population proportion and difference between two sample proportions.
MODULE V	**SMALL SAMPLE TESTS AND ANOVA**
	Small sample tests: Student t-distribution, its properties: Test of significance difference between sample mean and population mean; difference between means of two small samples. Snedecor's F-distribution and its properties; Test of equality of two population variances Chi-square distribution and it's properties; Test of equality of two population variances Chi-square distribution, it's properties, Chi-square test of goodness of fit; ANOVA: Analysis of variance, one way classification, two way classification.

TEXTBOOKS

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and Sons Publishers, 9th Edition, 2014.
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 43rd Edition, 2012.

REFERENCE BOOKS:

1. T.K.V Iyengar, B.Krishna Gandhi, "Probability and Statistics", S. Chand & Co., 6th Edition, 2014.
2. G.C.Beri, "Business Statistics", Tata McGraw-Hill Publications, 2nd Edition, 2005.
3. Richard Arnold Johnson, Irwin Miller and John E. Freund, "Probability and Statistics for Engineers", Prentice Hall, 8th Edition, 2013.

WEB REFERENCES:

1. http://e4uhu.com/down/Applied/9th
2. https://toaz.info/32fa2f50-8490-42cf-9e6a-f50cb7ea9a5b
3. http://www.mathworld.wolfram.com

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	Course outcomes	Reference
OBE DISCUSSION			
1	Identify the types of sampling (random, stratified, systematic, cluster). Identify the misuses of statistics. Student will use appropriate statistical methods to collect, organize, display, and analyze relevant data. Probability & Statistics introduces students to the basic concepts and logic of statistical reasoning and gives the students introductory-level practical ability to choose, generate, and properly interpret appropriate descriptive and inferential methods. Identify the types of data (qualitative, quantitative, discrete, and continuous).		
CONTENT DELIVERY (THEORY)			
2	Introduction on probability, conditional probability	CO 1	T2:26.3
3	Mathematical mean, Discrete Random variables	CO 1	R2:21.48
4	Mean and variance, probability distribution of discrete Random variables.	CO 1	T2:26.6 R2:21.50
5	Continuous Random variables	CO 1	T2:26.7 R2:21.51
6	Mean and variance, probability distribution of continuous Random variables.	CO 1	T2:26.8
7	Properties of random variables	CO 1	T2:26.10
8	Binomial distribution	CO 1	T2:26.14 R2:21.55
9	Poisson distribution	CO 1	T2:26.15 R2:21.58
10	Normal distribution.	CO 1	T2:26.16 R2:21.61
11	Joint probability distributions	CO 2	T2:25.12 R2:21.24
12	joint probability mass, density function	CO 2	T2:25.16 R2:21.29
13	marginal probability mass, density functions	CO 2	T2:25.14 R2:21.31
14	Correlation	CO 2	T2:25.14 R2:21.33
15	Karl Pearson's Coefficient of correlation	CO 2	R2:21.33
16	Rank correlation and Properties of correlation	CO 2	T2:27.2 R2:21.64
17	The linear model to a bivariate data	CO 2	T2:27.2

18	Regression coefficients	CO 2	T2:27.2 R2:21.67
19	Properties of Regression coefficients	CO 2	T2:27.2
20	Angle between two lines of regression	CO 2	T2:27.3 R2:21.71
21	Lines of regression and the multiple correlation of bivariate data	CO 2	T2:27.4 R2:21.68
22	Sampling: Definitions	CO 3	T2:27.7 R2:21.74
23	Types of sampling	CO 3	T2:27.12 R2:21.75
24	Parameter vs. statistics, standard error	CO 3	T2:27.8 R2:21.72
25	Type I and type II errors,	CO 3	T2:27.8 R2:21.73
26	Estimation	CO 4	T2:27.14 R2:21.78
27	Point estimation	CO 4	T2:27.19 R2:21.814
28	interval estimations	CO 4	T2:27.12 R2:21.82
29	Critical region, confidence interval, level of significance. One sided test, two-sided test.	CO 5	T2:27.18 R2:21.82
30	Tests of significance of single mean	CO 5	T2:26.15 R2:21.58
31	Test of difference between means	CO 5	T2:26.16 R2:21.61
32	Tests of significance of single proportion	CO 5	T2:25.14 R2:21.33
33	Test of difference between proportions	CO 5	R2:21.33
34	Small sample tests Test of equality of two population variances	CO 6	T2:27.2 R2:21.64
35	Student t-distribution, its properties. Test of significance difference between sample mean and population mean.	CO 6	T2:27.2
36	difference between means of two small samples	CO 6	T2:26.16 R2:21.61
37	Snedecor's F-distribution properties.	CO 6	T2:25.12 R2:21.24
38	Chi-square distribution and it's properties	CO 6	T2:25.16 R2:21.29
39	Applications of chi square –Distribution	CO 6	T2:27.14 R2:21.78
40	Definition of Analysis of variance	CO 6	T2:27.19 R2:21.814
41	One way classification, two way classification	CO 6	T2:27.12 R2:21.82

PROBLEM SOLVING/ CASE STUDIES			
42	Problem solving session on discrete random variable	CO 1	T2:26.3
43	Problem solving session on continuous random variables	CO 1	R2:21.48
44	Problem solving session on Binomial distribution	CO 1	T2:26.6 R2:21.50
45	Problem solving session on Poisson distribution	CO 1	T2:26.7 R2:21.51
46	Problem solving session on Normal distribution	CO 1	T2:26.8
47	Problem solving session on Joint probability distributions	CO 1	T2:26.10
48	Problem solving session on Karl Pearson's correlation	CO 2	T2:26.14 R2:21.55
49	Problem solving session on Spearman's rank correlation, linear regression	CO 2	T2:26.15 R2:21.58
50	Problem solving session on sampling distribution of means	CO 3	T2:26.16 R2:21.61
51	Problem solving session on Estimation	CO 4	T2:25.12 R2:21.24
52	Problem solving session on point and internal estimation	CO 4	T2:25.16 R2:21.29
53	Problem solving session on large sample tests	CO 5	T2:25.14 R2:21.31
54	Problem solving session on t-test	CO 6	T2:25.14 R2:21.33
55	Problem solving session on F-test and chi square – test	CO 6	R2:21.33
56	Problem solving session on One way classification, two way classification	CO 6	T2:27.2 R2:21.64
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions & terminology discussion on probability and random variables	CO 1	T2:26.6 R2:21.50
58	Definitions & terminology discussion on joint probability distributions, correlation and regression..	CO 2	T2:26.7 R2:21.51
59	Definitions & terminology discussion on sampling distribution and Estimation.	CO 3, CO 4	T2:25.14 R2:21.33
60	Definitions & terminology discussion on Tests of Hypothesis.	CO 5	R2:21.33
61	Definitions & terminology discussion on Tests of significance and ANOVA.	CO 6	R2:21.33

DISCUSSION OF QUESTION BANK			
62	Question bank discussion on probability and random variables.	CO 1	T2:26.6 R2:21.50
63	Question bank discussion on joint probability distributions and correlation, regression.	CO 2	T2:26.7 R2:21.51
64	Question bank discussion on sampling distribution and Estimation.	CO 3,CO 4	T2:25.14 R2:21.33
65	Question bank discussion on Tests of Hypothesis.	CO 5	R2:21.33
66	Question bank discussion on Tests of significance and ANOVA.	CO 6	R2:21.33

Course Coordinator: **HOD ME**
Mr. J Suresh Goud

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICALL ENGINEERING

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**THERMODYNAMICS**				
Course Code	AME003				
Program	B.Tech				
Semester	III				
Course Type	CORE				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	0	0
Course Coordinator	Ms. N Santhisree, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB02	I	Linear Algebra Calculus
B.Tech	AHSB04	II	Waves And Optics

II COURSE OVERVIEW:

Thermodynamics is the science that deals with the relationship between heat and work and those properties of systems that bear relation to heat and work. General laws of energy transformations concerning all types of systems, mechanical, electrical and chemical may fall within the purview of this science. It is a science based on a number of empirical laws formed by experimentation from which all predictions concerning the physical behavior of the system may be deduced by logical reasoning. The findings have been formalized into the various laws of thermodynamics. The power cycles and refrigeration cycle based on thermodynamic system is studied. The students are familiarizing with standard charts and tables.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Thermodynamics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
16%	Remember
50 %	Understand
33 %	Apply
0 %	Analyze
0 %	Evaluate

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

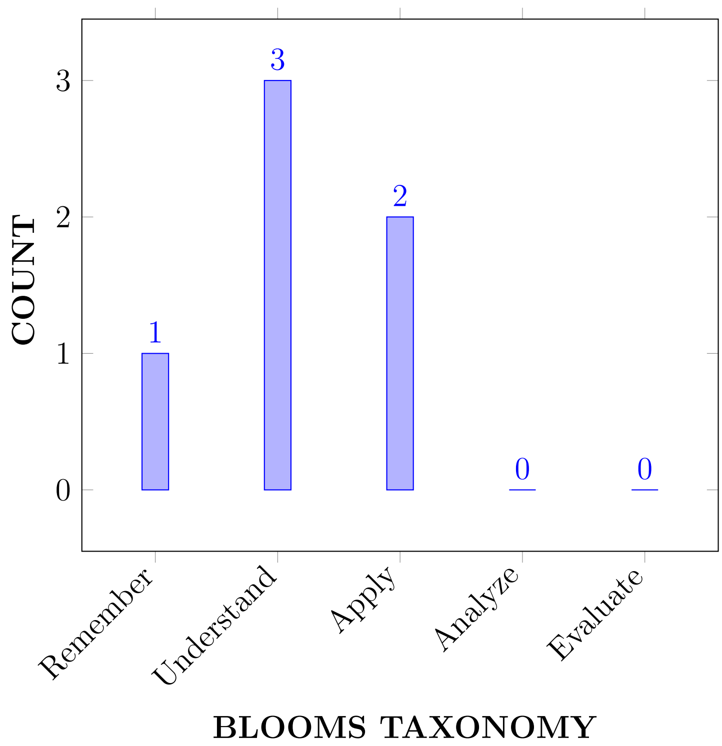
I	The fundamental knowledge on concepts of physics and chemistry for obtaining the axiomatic principles using thermodynamic co-ordinates.
II	The thermodynamic disorderness in the real time physical systems like external/internal heat engines, heat pumps to get the measure of performance characteristics.
III	The performance characteristics of open and closed systems of thermodynamic cycles for effective delineation of real time applications.
IV	The thermodynamic cycles such as power and refrigerant cycles to yield alternative solutions to conserve the environment.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Recall** the basic concepts of thermodynamic properties and working principles of energy conversions in physical systems by laws of thermodynamics.	Remember
CO 2	**Summarize** the equivalence of two statements of second law of thermodynamics and the entropy concepts for typical engineering problems.	Understand
CO 3	**Explain** the properties of pure substances and steam to emit relevant inlet and exit conditions of thermodynamic work bearing systems.	Understand
CO 4	**Apply** the significance of partial pressure and temperature to table the performance parameters of ideal gas mixtures.	Apply
CO 5	**Identify** the properties of air conditioning systems by practicing psychrometry chart and property tables.	Apply
CO 6	**Illustrate** the working of various air standard cycles and work out to get the performance characteristics.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Program Outcomes	
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2.6	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions	3	CIE/Quiz/AAT
PO 6	**The engineer and society:**Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice	1	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2.8	AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH POs, PSOs:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	✓	-	✓	-	-	-	-	-		-	✓	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 3	✓	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-
CO 4	✓	✓	✓	-	-	-	-	-	-	-	-		-	-	-
CO 5	✓	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-
CO 6	✓	✓	-	✓	-	-	-	-	-	-	-		-	✓	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall the thermodynamic properties and working principles of energy conversions in physical systems by fundamental laws of thermodynamics using the **knowledge of engineering fundamentals, science and mathematics.**	3
	PO 4	Recall the thermodynamic properties and working principles of energy conversions in physical systems by fundamental laws of thermodynamics using the **knowledge of engineering fundamentals, science and mathematics.**	7
	PO 6	Recall the thermodynamic properties and working principles of energy conversions in physical systems by fundamental laws of thermodynamics using the **knowledge of engineering fundamentals, science and mathematics.**	2
	PSO 2	Discuss the various fundamentals of thermodynamics applied in energy conversion **problems to real world systems to provide solutions for digital manufacturing.**	2

CO 2	PO 1	Recall the various statements of second law of thermodynamics and the properties applied to various thermodynamic systems using **(engineering fundamentals and science)** and derive the relationship between them using basic **(mathematical equations).**	3
	PO 2	Identify the fundamental properties like pressure, volume and temperature to **design the model** experimentally to recognize the significance of them in solving various engineering problems and creating solutions for **thermal systems.**	6
	PSO 2	Discuss the various fundamentals of thermodynamics applied in energy conversion **problems to real world systems to provide solutions for digital manufacturing.**	2
CO 3	PO 1	Interpret the properties of pure substances and steam using fundamental **knowledge of science and engineering** to evolve relationships using partial derivative **mathematical functions**.	3
	PO 3	Explain the customer requirement and identify the cost to correlate the properties of pure substances and steam to emit relevant inlet and exit conditions of thermodynamic **work bearing systems** used in various day to day applications..	4
	PSO 2	Recall the properties of steam and pure substances used in **thermal applications** to be applied in real life physical systems.	2
CO 4	PO 1	Show the significance of partial pressure and temperature using **fundamental engineering and science** to table the performance parameters of gaseous mixtures in **mathematical form**.	3
	PO 2	Identify, define, collect the properties to discuss partial pressures to **solve problems**and implement in different areas of research by **validating the results**.	4
	PO 3	Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues when dealing with performance of gaseous mixtures and their application on **real world problems**.	4
CO 5	PO 1	Understand the significance of psychrometry charts and Mollier diagram to determine the properties of air conditioning systems using the (**fundamentals of engineering, science and mathematical equations.**)	3

	PO 3	Find creative solution for various problems related to refrigeration and air conditioning systems in adverse climatic conditions across the various tropics of the world. Explore the problems in current HVAC systems and find avenues of innovations. Define problems in integration of air-conditioning and HVAC systems to find (**effective solutions**).	4
	PSO 2	Explain the significance of refrigeration and air-conditioning as a **thermal problem related to multiple manufacturing systems in the current digital era** of system cooling.	1
CO 6	PO 1	Evaluate the performance characteristics of various air standard cycles using the basic understanding of **engineering science, knowledge and mathematical equations.**	3
	PO 2	Using the fundamentals of air standard cycles explore the possibilities of combined cycles for creating **effective systems** to be used in **real world** having better efficiencies.	6
	PO 4	Recall the thermodynamic properties and working principles of energy conversions in physical systems by fundamental laws of thermodynamics using the **knowledge of engineering fundamentals, science and mathematics.**	7
	PSO 2	Discuss the various fundamentals of thermodynamics applied in energy conversion **problems to real world systems to provide solutions for digital manufacturing.**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	**Program Outcomes/ No. of Key Competencies Matched**												**PSO'S**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	7	-	2	-	-	-	-	-		-	2	-
CO 2	3	6	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 3	3	-	4	-	-	-	-	-	-	-	-	-	-	2	-
CO 4	3	4	4	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	4	-	-	-	-	-	-	-	-	-	-	1	-
CO 6	3	6	-	7	-	-	-	-	-	-	-		-	2	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	63	-	40	-	-	-	-	-		-	100	-
CO 2	100	60	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 3	100	-	40	-	-	-	-	-	-	-	-	-	-	100	-
CO 4	100	40	40	-	-	-	-	-	-	-	-		-	-	-
CO 5	100	-	40	-	-	-	-	-	-	-	-	-	-	50	-
CO 6	100	60	-	63	-	-	-	-	-	-	-		-	100	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - 0% $\leq$ C $\leq$ 5% – No correlation ***1*** - 5% < C $\leq$ 40% – Low/ Slight
2 - 40 % < C < 60% –Moderate
3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	3	-	2	-	-	-	-	-		-	3	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 3	3	-	2	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	2	2	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	2	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	3	-	3	-	-	-	-	-	-	-		-	3	-
TOTAL	18	8	6	6	-	2	-	-	-	-	-	-	-	14	-
AVERAGE	3	2.6	2	3	-	1	-	-	-	-	-	-	-	2.8	-

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	-				

XVII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**BASIC CONCEPTS AND FIRST LAW OF THERMODYNAMICS**
	System, control volume, surrounding, boundaries, universe, types of systems, macroscopic and microscopic viewpoints, concept of continuum, thermodynamic equilibrium, state, property, process, cycle, reversibility, quasi static process, irreversible process, causes of irreversibility, various flow and non-flow processes ,energy in state and in transition, types-work and heat, point and path function, Zeroth law of thermodynamics, concept of quality of temperature, Principles of thermometry, reference points,constant volume gas thermometer, ideal gas scale, PMMI Joule‘s experiments, first law of thermodynamics, corollaries first law applied to a process, applied to a flow system, steady flow energyequation.
MODULE II	**SECOND LAW OF THERMODYNAMICS**
	Thermal reservoir, heat engine, heat pump, parameters of performance, second Law of thermodynamics, Kelvin Planck and Clausius statements and their equivalence, Corollaries, PMM of second kind, carnot‘sprinciple, Carnot cycle and its specialties, thermodynamic scale of temperature, Clausius inequality, Entropy, principle of Entropy increase, availability and irreversibility, thermodynamic potentials, Gibbsand Helmholtz functions, Maxwell relations, elementary treatment of the Third Law of thermodynamics
MODULE III	**PURE SUBSTANCES AND GAS LAWS**
	Phase transformations, T-S and H-S diagrams, P-V-T surfaces, triple point at critical state properties during change of phase, dryness fraction, Mollier charts, various thermodynamic processes and energy transfer, steam calorimeter. Equation of state, specific and universal gas constants, throttling and free expansion processes, deviations from perfect gas model, Vander Waals equation of state.
MODULE IV	**MIXTURES OF PERFECT GASES**
	Mole fraction, mass friction, gravimetric and volumetric analysis, volume fraction, Dalton‘s law of partial pressure, Avogadro‘s laws of additive volumes, and partial pressure, equivalent gas constant, internal energy, enthalpy, specific heats and entropy of mixture of perfect gases; psychometric properties, dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature, specific humidity, relative humidity, saturated air, vapor pressure, degree of saturation, adiabatic saturation, Carrier‘s equation, Psychometric chart.
MODULE V	**POWER CYCLES**
	Otto, Diesel, Dual combustion cycles, description and representation on P-V and T-S diagram, thermal efficiency, mean effective pressures on air standard basis, comparison of cycles

TEXTBOOKS

1. P. K. Nag, "Engineering Thermodynamics", Tata McGraw Hill, 4th Edition, 2008.
2. Yunus Cengel, Michael A. Boles, "Thermodynamics-An Engineering Approach", Tata McGraw Hill, 7th Edition, 2011

REFERENCE BOOKS:

1. J. B. Jones, R. E. Dugan, "Engineering Thermodynamics", Prentice Hall of India Learning, 1st Edition,2009.
2. Y. V. C. Rao, "An Introduction to Thermodynamics", Universities Press, 3rd Edition, 2013
3. K. Ramakrishna, "Engineering Thermodynamics", Anuradha Publishers, 2nd Edition, 2011
4. Holman. J.P, "Thermodynamics", Tata McGraw Hill, 4thEdition, 2013.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112/108/112108148/
2. https://nptel.ac.in/courses/112/105/112105123/

COURSE WEB PAGE:

https://www.iare.ac.in/sites/default/files/UG20/Thermodynamics.pdf

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	System, control volume, surrounding, boundaries, universe, types of systems.	CO1	T2:2.3
3	Macroscopic and microscopic viewpoints, concept of continuum,	CO1	R1:2.6
4	Thermodynamic equilibrium, state, property, process, cycle, reversibility.	CO1	T1:2.6
5	Quasi static process, irreversible process, causes of irreversibility.	CO1	T2:2.7 R1:2.18
6	Various flow and non-flow processes ,energy in state and in transition, types-work	CO1	T2:2.22
7	Heat, point and path function, Zeroth law of thermodynamics.	CO1	T2:2.25
8	Concept of quality of temperature, Principles of thermometry, reference points.	CO1	T2:2.26 R1:2.55

9	Constant volume gas thermometer, ideal gas scale, PMMI Joule‘s experiments,	CO1	T2:2.16 R1:2.61
10	First law of thermodynamics, corollaries first law applied to a process	CO1	T2:2.30 R1:2.58
11	Applied to a flow system, steady flow energy equation.	CO1	T2:3.6 R1:4.29
12	Thermal reservoir, heat engine, heat pump	CO2	T2:3.14 R1:4.31
13	Parameters of performance, second Law of thermodynamics	CO2	T2:3.14 R1:4.33
14	Kelvin Planck, Claussius statements and their equivalence	CO2	R1:4.36
15	Corollaries, PMM of second kind, Carnot‘s principle	CO2	T2:3.18 R1:4.64
16	Carnot cycle and its specialties	CO2	T2:3.22
17	Thermodynamic scale of temperature, Claussius inequality	CO2	T2:3.28 R1:4.67
18	Entropy, principle of Entropy increase, availability and irreversibility	CO2	T2:4.2
19	Thermodynamic potentials	CO2	T2:4.3 R1:4.71
20	Gibbs and Helmholtz functions, Maxwell relations	CO2	R2:4.68
21-22	Elementary treatment of the Third Law of thermodynamics	CO2	T2:4.15 R1:5.74
23	Phase transformations, T-S and H-S diagrams, P-V-T surfaces,	CO3	T1:4.12 R2:5.75
24-25	Triple point at critical state properties during change of phase,	CO3	T1:4.8 R1:5.72
26	Dryness fraction, Mollier charts, various thermodynamic processes	CO3	T1:5.8 R1:5.73
27-28	Energy transfer, steam calorimeter.	CO3	T1:5.14 R1:6.78
29	Equation of state, specific and universal gas constants.	CO4	T2:5.19 R1:6.81
30-31	Throttling and free expansion processes	CO4	T1:6.4 R2:6.8
32	Deviations from perfect gas model, Vander Waals equation of state.	CO4	T2:7.7 R1:7.74
33-34	Mole fraction, mass friction, gravimetric and volumetric analysis, volume fraction,	CO4	T1:7.12 R2:8.75
35	Dalton‘s law of partial pressure, Avogadro‘s laws of additive volumes, and partial pressure	CO4	T1:7.8 R1:8.72
36	Equivalent gas constant, internal energy, enthalpy, specific heats	CO4	T1:8.8 R1:8.73

37	Entropy of mixture of perfect gases; psychometric properties	CO4	T1:9.14 R1:10.78
38-39	Dry bulb temperature, wet bulb temperature, dew point temperature,	CO5	T2:9.19 R1:10.814
40-41	Thermodynamic wet bulb temperature, specific humidity, relative humidity, saturated air.	CO5	T1:10.4 R2:11.68
42-44	Vapor pressure, degree of saturation, adiabatic saturation,Carrier‘s equation, Psychometric chart.	CO5	T2:10.7 R1:12.74
45-49	Otto, Diesel, Dual combustion cycles, Problems on cycles	CO6	T1:11.12 R2:12.75
50-51	Description and representation on P-V and T-S diagram,	CO6	T1:12.4 R2:13.68
52-59	Thermal efficiency, mean effective pressures on air standard basis. Comparison of cycles	CO6	T2:13.7 R1:14.74
PROBLEM SOLVING/ CASE STUDIES			
60	When a stationary mass of gas was compressed without friction at constant pressure, its initial state of 0.4m3 and 0.105MPa was found to change to final state of 0.20m3 and 0.105MPa. There was a transfer of 42.5kJ of heat from the gas during the process. Find the change in internal energy of the gas.	CO 1	T2:2.30 R1:2.58
61	Two thermometers one centigrade and other Fahrenheit are immersed in a fluid, after the thermometers reached equilibrium with the fluid, it is noted that both the thermometers indicate the same numerical values. Find the identical numerical values shown by the thermometers. Determine the corresponding temperature of the fluid, express in degrees Kelvin and degrees Rankine.	CO 1	T2:2.26 R1:2.55
62	A piston cylinder device operates 1kg of fluid at 20atm pressure with initial volume is 0.04m3 . Fluid is allowed to expand reversibly following pV 1 .45=C. So that the volume becomes double. The fluid is cooled at constant pressure until the piston comes back. What is the work done in each process?	CO 1	T2:2.22
63	A reversible heat engine is supplied with heat from two constant temperature sources at 900K and 600 K and rejects heat to a constant temperature at 300K to sink. The engine develops work equivalent to 91kJ/s and rejects heat at the rate of 56kJ/sec. Calculate (i) heat supplied by each source (ii) Thermal efficiency of engine.	CO 2	T2:3.14 R1:4.31

64	Three Carnot engine are arranged in series. The first engine takes 4000kJ of heat from a source at 2000K and delivers 1800kJ of work. The second and third engines deliver 1200kJ and 500kJ ofwork respectively. Compare the exhaust temperature of second and third Carnot engines?	CO 2	T2:3.22
65	Two bodies of equal capacities C and T1 and T2 from an adiabatically closed system. Determine the final temperature, if the system is brought to an equilibrium state. i) Freely, ii) reversibly, Proceed to find the maximum work which can be obtained from the system.	CO 2	T2:3.14 R1:4.33
66	Saturated steam has entropy of 6.76 kJ/kg K. Interpret the pressure, temperature, specific volume, enthalpy from Mollier chart.	CO 3	T1:5.8 R1:5.73
67	At a temperature of 423K, 1kg of nitrogen occupies volume of 200 liters. The gas undergoes constant expansion with fully resisted to a volume of 360 liters. Then the gas expanded isothermally to a volume of 500 liters. Sketch the process on p-V and T-S diagram. Find out overall change in entropy.	CO 4	T1:5.14 R1:6.78
68	Solve that for an ideal gas the slope of the constant volume line on the T-S diagram is more than that of the constant pressure line.	CO 4	T2:5.19 R1:6.81
69	Find the relative humidity and specific humidity for air at 30°C and having dew point temperature of 15°C. Show the process.	CO 5	T1:10.4 R2:11.68
70	A mixture of hydrogen and oxygen is to be made, so that the ratio of H2 to O2 is 2—1 by volume. If the pressure and temperature are 1bar and 25°C, respectively. Find the mass of oxygen required and volume of the container.	CO 4	T1:7.12 R2:8.75
71	An air water vapor mixture enters an adiabatic saturator at 30°C and leaves at20°C, which is the adiabatic saturation temperature? The pressure remains constant at 100kPa. Determine the relative humidity and humidity ratio of the inlet mixture.	CO 5	T1:10.4 R2:11.68
72	Calcualte an expression for the air standard efficiency on a volume basis of an engine working on the Otto cycle and represent the processes on p-V and T-S diagrams.	CO 6	T1:11.12 R2:12.75
73	Calculate an expression for air standard efficiency of diesel cycle.	CO 6	T1:11.12 R2:12.75
74	Calculate an expression for air standard efficiency of dual cycle.	CO 6	T1:11.12 R2:12.75

DISCUSSION OF DEFINITION AND TERMINOLOGY			
75	System, surroundings, boundary, thermodynamic equilibrium, process, PMM1, state extensive property, Zeroth law of thermodynamics	CO 1	T2:2.1
76	Reversible and Irreversible Processes, Second law of thermodynamics, enthalpy, entropy, Availability, Carnot Cycle, Carnot Heat Engine, PMM2, Entropy, Refrigerator, Heat pump	CO 2	T2:3.1
77	Ideal gas, pure substance , p-V-T surface, dryness fraction, steam tables vanderwall's equation	CO 3,4	T1:5.1
78	psychrometric chart, WBT and DBT, humidity ratio, relative humidity, absolute humidity, degree of saturation, adiabatic saturation	CO 5	T1:7.1
79	Otto, Diesel, Dual combustion cycles, Brayton cycle, air standard efficiency	CO 6	T1: 11.12
DISCUSSION OF QUESTION BANK			
80	Module I: Basic Concepts and First Law of Thermodynamics	CO 1	T2:2.1
81	Module II: Second Law of Thermodynamics	CO 2	T2:3.1
82	Module III: Pure Substances and Gas Laws	CO 3,4	T1:5.1
83	Module IV: Mixtures of Perfect Gases	CO 5	T1:7.1
84	Module V: Power Cycles	CO 6	T1: 11.12

Signature of Course Coordinator **HOD, ME**
Ms. N Santhisree, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	MECHANICAL ENGINEERING				
Course Title	MECHANICS OF SOLIDS				
Course Code	AME004				
Program	B. Tech				
Semester	THREE				
Course Type	Core				
Regulation	IARE-R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	2
Course Coordinator	Dr. K Viswanath Allamraju, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME002	II	Engineering Mechanics

II COURSE OVERVIEW:

Mechanics of Solids course is a broad multidisciplinary approach to understand and manipulate the thermo-mechanical and magnetic properties of materials. This course provides key information of physical behaviour of metals, normal stresses, constitutive relations and computing deflection of various structures with different boundary and loading conditions. The knowledge of the course leads to design the mechanical, aeronautical and civil structures.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Mechanics of Solids	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	x	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50 %	Understand
25%	Apply
15%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

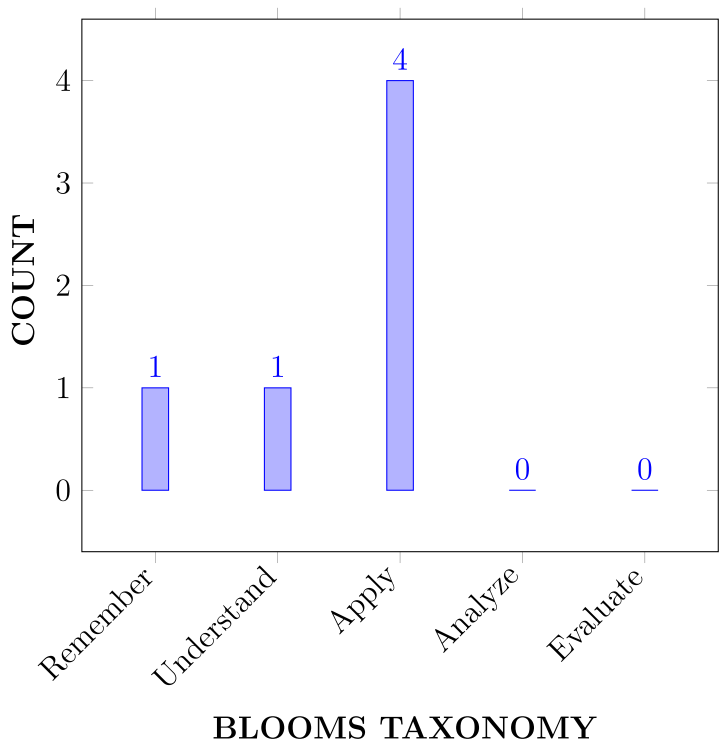
I	The fundamental knowledge of stress analysis, theories of failure, relationship between mechanical and metallurgical properties to design and analyse commonly used machine components.
II	The concepts of mechanics of deformable solids including stress – strain relations, methods for slope-deflection determination for structural applications.
III	To work in teams to research then communicate current applications of engineering materials in service, historical limitations of those materials, understand long-term sustainability, recycling and life cycle issues.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Relate** the concepts of stress and strain at a point as well as the stress-strain relationships for linear, elastic, homogeneous and isotropic materials.	Remember
CO 1	**Explain** the shear force and bending moment diagrams for different types of loads on cantilever, simply supported and over hanging beams.	Understand
CO 3	**Calculate** the moment of inertia, flexural stresses and draw the bending stress distribution diagrams of various beam sections.	Apply
CO 4	**Construct** the shear stress distribution diagrams for various beam sections by calculating stresses at different loacations.	Apply
CO 5	**Determine** the principal stresses, strains, maximum shearing stresses and angles acting on any arbitrary plane within a structural element.	Apply
CO 6	**Apply** the concept of torsion and calculate angle of twist, shear stress, etc. relating to Hooke's law to draw shear stress distribution within a circular shaft.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE / Quiz / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE / Quiz / AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	CIE / Quiz / AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 1	✓	✓	-	-		-	-	-	-	-	-		-	-	-
CO 3	✓	-	-	-		-	-	-	-	-	-	-	✓	-	-
CO 4	✓	-	-	-		-	-	-	-	-	-	-	-	-	
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	-	-	✓	-	-	-	-	-	-	-	-	✓	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 2	**Identify, formulate and analyse** the stress and strain at a point as well as the stress-strain relationships for linear, elastic, homogeneous and isotropic materials.	4
CO 1	PO 1	**Evaluate** shear force and bending moment diagrams for different types of loads on cantilever, simply supported and over hanging beams by **applying knowledge of science and engineering** fundamentals.	3
	PO 2	**Identify, formulate, and interpret Evaluate** shear force and bending moment diagrams for different types of loads on various kinds of beams.	4
CO 3	PO 1	**Apply** the knowledge of science, engineering fundamentals to calculate flexural stress, shear stress and draw distribution diagrams of various beam sections.	2
	PSO 1	**Formulate** and evaluate engineering concepts of flexural stresses in design of engineering components such as beams.	1
CO 4	PO 1	**Apply** the knowledge of science, engineering fundamentals to calculate shear stresses and draw distribution diagrams of various beam sections.	2
CO 5	PO 1	**Apply the knowledge of science and engineering** fundamentals to **determine** principal stresses, maximum shearing stresses and angles acting on any arbitrary plane within a structural element.	2
	PO 2	**Identify, formulate and analyse** principal stresses, strains, maximum shearing stresses and angles acting on any arbitrary plane in a structural element.	4
	PSO 1	**Formulate** and evaluate engineering concepts of principal stresses and strains in design of engineering components oblique sections.	1
CO 6	PO 1	**Apply** the **knowledge of mathematics and science** to **resolve** the angle of twist, shear stress, etc. relating to Hooke's law to **draw** shear stress distribution within a circular shaft.	3
	PO 4	Use research based knowledge, **analysis and interpret** data relating to pure torsion, to **draw** shear stress distribution within a circular shaft.	3
	PSO 1	**Formulate** and evaluate engineering concepts of torsion in design of engineering components such as shafts.	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 1	3	4	-	-		-	-	-	-	-	-		-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	4	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 6	3	-	-	3	-	-	-	-	-	-	-	-	1	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 1	100	40	-	-		-	-	-	-	-	-		-	-	-
CO 3	66.7	-	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 4	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	40	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 6	100	-	-	27	-	-	-	-	-	-	-	-	100	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation
1 -5 <C$\leq$ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 1	3	2	-	-		-	-	-	-	-	-		-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	-	-	1	-	-	-	-	-	-	-	-	3	-	-
AVERAGE	3	2	-	1	-		-	-	-	-	-	-	3	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments	-	-	-	-	

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

UNIT I	**SIMPLE STRESSES AND STRAINS**
	Elasticity and plasticity – Types of stresses and strains–Hooke's law– stress – strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson's ratio and volumetric strain – Elastic moduliand the relationship between them – Bars of varying section – composite bars – Temperature stresses. Strain energy – Resilience – Gradual, sudden, impact and shock loadings.
UNIT II	**SHEAR FORCE AND BENDING MOMENT**
	Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l., uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of a beam.
UNIT III	**FLEXURAL STRESSES AND SHEAR STRESSES**
	Theory of simple bending – Assumptions – Derivation of bending equation: $M/I = f/y = E/R$ Neutral axis – Determination bending stresses – section modulus of rectangular and circular sections (Solid and Hollow), I, T, Angle and Channel sections – Design of simple beam sections. Shear Stresses: Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I, T angle sections.
UNIT IV	**PRINCIPAL STRESSES AND STRAINS, THEORIES OF FAILURE**
	Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses – Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear – Mohr's circle of stresses – Principal stresses and strains – Analytical and graphical solutions. Theories of Failure: Introduction – Various theories of failure - Maximum Principal Stress Theory, Maximum Principal Strain Theory, Strain Energy and Shear Strain Energy Theory (Von Mises Theory).

UNIT V	**DESIGN OF CIRCULAR SHAFTS AND STRESSES IN PRESSURE VESSELS**
	Theory of pure torsion – Derivation of Torsion equations : T/J = q/r = GΘ/L – Assumptions made in the theory of pure torsion – Torsional moment of resistance – Polar section modulus – Power transmitted by shafts – Combined bending and torsion and end thrust – Design of shafts according to theories of failure. Thin Cylinders: Thin seamless cylindrical shells – Derivation of formula for longitudinal and circumferential stresses – hoop, longitudinal and Volumetric strains – changes in dia, and volume of thin cylinders– Thin spherical shells.

TEXTBOOKS

1. Donald R Askeland, Thomson, "Essentials of Material Science and Engineering", Thomson Press, 1st edition, 2005.

2. R. S. Kurmi, Gupta, "Strength of Materials", S Chand, New Delhi, 1st Edition, 2013.

REFERENCE BOOKS:

1. Jindal, "Strength of Materials", Pearson Education, 1st Edition, 2012.

2. Vazirani, Ratwani, "Analysis of Structures", Khanna Publishers, 19th Edition, 2014.

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1. https://nptel.ac.in/courses/112105171/1

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=pages/btech-course-descriptions-iare-r18-7

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to Outcome Based Education	-	-
CONTENT DELIVERY (THEORY)			
2	Types of stresses and strains	CO 1	T2:2.3
3	Hooke's law– stress – strain diagram for mild steel	CO 1	R1:2.6
4	Working stress – Factor of safety	CO 1	T1:2.6
5-6	Lateral strain, Poisson's ratio and volumetric strain	CO 1	T2:2.7 R1:2.18
7	Elastic moduli and the relationship between them	CO 2	T2:2.22
8	Slip, twinning, strain hardening, seasons cracking.	CO 2	T2:2.25
9	Bars of varying section	CO 2	T2:2.22

10-11	Composite bars – Temperature stresses.	CO 2	T2:2.26 R1:2.55
12	Strain energy – Resilience – Gradual, sudden, impact and shock loadings.	CO 3	T2:3.14 R1:4.33
13-14	Definition of beam – Types of beams – Concept of shear force and bending moment.	CO 3	T2:3.18 R1:4.64
15	S.F and B.M diagrams for cantilever.	CO 3	T2:3.22
16	S.F and B.M diagrams for simply supported and overhanging beams.	CO 2	T2:3.28 R1:4.67
17	Point loads, u.d.l and uniformly varying loads.	CO 3	T2:4.3 R1:4.71
18-19	combination of loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of a beam.	CO 3	T2:4.15 R1:5.74
20	Theory of simple bending – Assumptions .	CO 4	T1:4.12 R2:5.75
21	Derivation of bending equation: $M/I = f/y = E/R$ Neutral axis.	CO 4	T1:4.8 R1:5.72
22	Determination bending stresses – section modulus of rectangular and circular sections.	CO 4	T1:5.8 R1:5.73
23	– Determination bending stresses I, T, Angle and Channel sections – Design of simple beam sections.	CO 4	T1:5.14 R1:6.78
24	Shear Stresses: Derivation of formula	CO 4	T2:5.19 R1:6.81
25	Shear stress distribution across various beams sections like rectangular and circular.	CO 4	T1:6.4 R2:6.8
26	Shear stress distribution across various beams sectionsI, T angle sections	CO 4	T1:7.12 R2:8.75
27	Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses.	CO 5	T1:8.8 R1:8.73
28-29	Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear.	CO 5	T2:9.19 R1:10.814
30	Mohr's circle of stresses – Principal stresses and strains – Analytical and graphical solutions.	CO 5	T2:10.7 R1:12.74
31	Theories of Failure: Introduction – Various theories of failure	CO 5	T1:11.12 R2:12.75
32	Maximum Principal Stress Theory, Maximum Principal Strain Theory.	CO 5	T1:12.4 R2:13.68
33-34	Strain Energy and Shear Strain Energy Theory (Von Mises Theory).	CO 5	T2:13.7 R1:14.74
35	Theory of pure torsion – Derivation of Torsion equations : $T/J = q/r = G\Theta/L$	CO 6	T1:14.12 R2:15.75
36-37	Assumptions made in the theory of pure torsion – Torsional moment of resistance – Polar section modulus – Power transmitted by shafts.	CO 6	T2:9.19 R1:10.814

38-39	Combined bending and torsion and end thrust – Design of shafts according to theories of failure. Thin Cylinders: Thin seamless cylindrical shells	CO 6	T1:10.4 R2:11.68
40	Derivation of formula for longitudinal and circumferential stresses – hoop, longitudinal and Volumetric strains.	CO 6	T2:10.7 R1:12.74
PROBLEM SOLVING/ CASE STUDIES			
41	Thin spherical shells.	CO 1	T2:2.3
42	Working stress, factor of safety, lateral strain, Poisson's ratio and relationship between three elastic moduli	CO 1	T1:4.8 R2:4.68
43	Volumetric Strain and Bulk modulus	CO 1	T1:4.12 R2:5.75
44	Three elastic constants.	CO 1	T1:4.8 R2:4.68
45	Principal stresses	CO 2	T1:4.8 R1:5.72
46	Mohr's circle construction and problems	CO 2	T1:5.14 R1:6.78
47	Shear force and Bending moment diagrams	CO 2	T2:7.7 R1:7.74
48	Over-hanging beams and cantilevers.	CO 3	T1:8.8 R1:8.73
49	Problems on bending equation	CO 3	T1:12.4 R2:13.68
50	Shear stress distribution over different geometries.	CO 4	T2:13.7 R1:14.74
51	Shear stress distribution over I and T sections.	CO 4	T2:9.19 R1:10.814
52	Shear stress distribution over miscellaneous sections.	CO 5	T2:9.19 R1:10.814
53	Problems on bending stress distribution.	CO 5	T1:10.4 R2:11.68
54	Volumetric strain in shells	CO 6	T1:10.4 R2:11.68
55	Hoop stress in shells	CO 6	T2:10.7 R1:12.74
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	UNIT I: Simple Stresses and Strains	CO 1	T2:2.3
57	UNIT II: Shear Force and Bending Moment	CO 2	T2:3.14 R1:4.33
58	UNIT III:Flexural Stresses and Shear Stresses	CO 3, CO 4	T2:4.2 R1:5.72
59	UNIT IV:Principal stresses and strains, theories of failure	CO 5	T2:7.7 R1:7.74
60	UNIT V:Design of circular shafts and stresses in pressure vessels.	CO 6	T2:9.19 R1:10.814
DISCUSSION OF QUESTION BANK			
61	UNIT I: Simple Stresses and Strains	CO 1	T2:2.3

62	UNIT II: Shear Force and Bending Moment	CO 2	T2:3.14 R1:4.33
63	UNIT III:Flexural Stresses and Shear Stresses	CO 3, CO 4	T2:4.2 R1:5.72
64	UNIT IV:Principal stresses and strains, theories of failure	CO 5	T2:7.7 R1:7.74
65	UNIT V:Design of circular shafts and stresses in pressure vessels.	CO 6	T2:9.19 R1:10.814

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	MECHANICAL ENGINEERING				
Course Title	MECHANICS OF SOLIDS				
Course Code	AME004				
Program	B. Tech				
Semester	THREE				
Course Type	Core				
Regulation	IARE-R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	2
Course Coordinator	Dr. K Viswanath Allamraju, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME002	II	Engineering Mechanics

II COURSE OVERVIEW:

Mechanics of Solids course is a broad multidisciplinary approach to understand and manipulate the thermo-mechanical and magnetic properties of materials. This course provides key information of physical behaviour of metals, normal stresses, constitutive relations and computing deflection of various structures with different boundary and loading conditions. The knowledge of the course leads to design the mechanical, aeronautical and civil structures.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Mechanics of Solids	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	x	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with ”either” or ”choice” will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50 %	Understand
25%	Apply
15%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

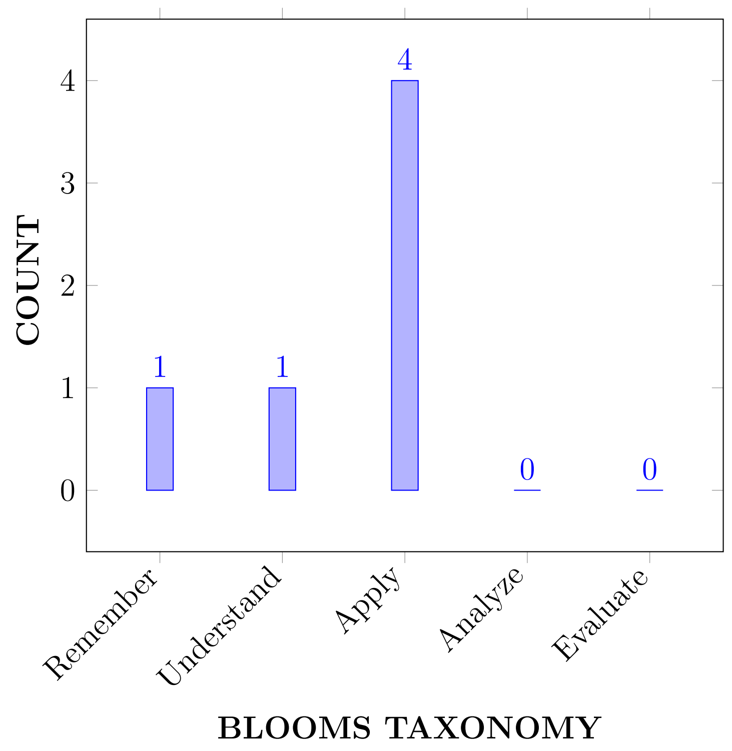
I	The fundamental knowledge of stress analysis, theories of failure, relationship between mechanical and metallurgical properties to design and analyse commonly used machine components.
II	The concepts of mechanics of deformable solids including stress – strain relations, methods for slope-deflection determination for structural applications.
III	To work in teams to research then communicate current applications of engineering materials in service, historical limitations of those materials, understand long-term sustainability, recycling and life cycle issues.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Relate** the concepts of stress and strain at a point as well as the stress-strain relationships for linear, elastic, homogeneous and isotropic materials.	Remember
CO 1	**Explain** the shear force and bending moment diagrams for different types of loads on cantilever, simply supported and over hanging beams.	Understand
CO 3	**Calculate** the moment of inertia, flexural stresses and draw the bending stress distribution diagrams of various beam sections.	Apply
CO 4	**Construct** the shear stress distribution diagrams for various beam sections by calculating stresses at different loacations.	Apply
CO 5	**Determine** the principal stresses, strains, maximum shearing stresses and angles acting on any arbitrary plane within a structural element.	Apply
CO 6	**Apply** the concept of torsion and calculate angle of twist, shear stress, etc. relating to Hooke's law to draw shear stress distribution within a circular shaft.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE / Quiz / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE / Quiz / AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	CIE / Quiz / AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 1	✓	✓	-	-		-	-	-	-	-	-		-	-	-
CO 3	✓	-	-	-		-	-	-	-	-	-	-	✓	-	-
CO 4	✓	-	-	-		-	-	-	-	-	-	-	-	-	
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	-	-	✓	-	-	-	-	-	-	-	-	✓	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 2	**Identify, formulate and analyse** the stress and strain at a point as well as the stress-strain relationships for linear, elastic, homogeneous and isotropic materials.	4
CO 1	PO 1	**Evaluate** shear force and bending moment diagrams for different types of loads on cantilever, simply supported and over hanging beams by **applying knowledge of science and engineering** fundamentals.	3
	PO 2	**Identify, formulate, and interpret Evaluate** shear force and bending moment diagrams for different types of loads on various kinds of beams.	4
CO 3	PO 1	**Apply** the knowledge of science, engineering fundamentals to calculate flexural stress, shear stress and draw distribution diagrams of various beam sections.	2
	PSO 1	**Formulate** and evaluate engineering concepts of flexural stresses in design of engineering components such as beams.	1
CO 4	PO 1	**Apply** the knowledge of science, engineering fundamentals to calculate shear stresses and draw distribution diagrams of various beam sections.	2
CO 5	PO 1	**Apply the knowledge of science and engineering** fundamentals to **determine** principal stresses, maximum shearing stresses and angles acting on any arbitrary plane within a structural element.	2
	PO 2	**Identify, formulate and analyse** principal stresses, strains, maximum shearing stresses and angles acting on any arbitrary plane in a structural element.	4
	PSO 1	**Formulate** and evaluate engineering concepts of principal stresses and strains in design of engineering components oblique sections.	1
CO 6	PO 1	**Apply** the **knowledge of mathematics and science** to **resolve** the angle of twist, shear stress, etc. relating to Hooke's law to **draw** shear stress distribution within a circular shaft.	3
	PO 4	Use research based knowledge, **analysis and interpret** data relating to pure torsion, to **draw** shear stress distribution within a circular shaft.	3
	PSO 1	**Formulate** and evaluate engineering concepts of torsion in design of engineering components such as shafts.	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 1	3	4	-	-		-	-	-	-	-	-		-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	4	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 6	3	-	-	3	-	-	-	-	-	-	-	-	1	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 1	100	40	-	-		-	-	-	-	-	-		-	-	-
CO 3	66.7	-	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 4	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	66.7	40	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 6	100	-	-	27	-	-	-	-	-	-	-	-	100	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 1	3	2	-	-		-	-	-	-	-	-		-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	-	-	1	-	-	-	-	-	-	-	-	3	-	-
AVERAGE	3	2	-	1	-		-	-	-	-	-	-	3	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments	-	-	-	-	

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

UNIT I	**SIMPLE STRESSES AND STRAINS**
	Elasticity and plasticity – Types of stresses and strains–Hooke's law– stress – strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson's ratio and volumetric strain – Elastic moduliand the relationship between them – Bars of varying section – composite bars – Temperature stresses. Strain energy – Resilience – Gradual, sudden, impact and shock loadings.
UNIT II	**SHEAR FORCE AND BENDING MOMENT**
	Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l., uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of a beam.
UNIT III	**FLEXURAL STRESSES AND SHEAR STRESSES**
	Theory of simple bending – Assumptions – Derivation of bending equation: $M/I = f/y = E/R$ Neutral axis – Determination bending stresses – section modulus of rectangular and circular sections (Solid and Hollow), I, T, Angle and Channel sections – Design of simple beam sections. Shear Stresses: Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I, T angle sections.
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	Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses – Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear – Mohr's circle of stresses – Principal stresses and strains – Analytical and graphical solutions. Theories of Failure: Introduction – Various theories of failure - Maximum Principal Stress Theory, Maximum Principal Strain Theory, Strain Energy and Shear Strain Energy Theory (Von Mises Theory).

UNIT V	**DESIGN OF CIRCULAR SHAFTS AND STRESSES IN PRESSURE VESSELS**
	Theory of pure torsion – Derivation of Torsion equations : T/J = q/r = GΘ/L – Assumptions made in the theory of pure torsion – Torsional moment of resistance – Polar section modulus – Power transmitted by shafts – Combined bending and torsion and end thrust – Design of shafts according to theories of failure. Thin Cylinders: Thin seamless cylindrical shells – Derivation of formula for longitudinal and circumferential stresses – hoop, longitudinal and Volumetric strains – changes in dia, and volume of thin cylinders– Thin spherical shells.

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XIX COURSE PLAN:

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7	Elastic moduli and the relationship between them	CO 2	T2:2.22
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20	Theory of simple bending – Assumptions .	CO 4	T1:4.12 R2:5.75
21	Derivation of bending equation: $M/I = f/y = E/R$ Neutral axis.	CO 4	T1:4.8 R1:5.72
22	Determination bending stresses – section modulus of rectangular and circular sections.	CO 4	T1:5.8 R1:5.73
23	– Determination bending stresses I, T, Angle and Channel sections – Design of simple beam sections.	CO 4	T1:5.14 R1:6.78
24	Shear Stresses: Derivation of formula	CO 4	T2:5.19 R1:6.81
25	Shear stress distribution across various beams sections like rectangular and circular.	CO 4	T1:6.4 R2:6.8
26	Shear stress distribution across various beams sectionsI, T angle sections	CO 4	T1:7.12 R2:8.75
27	Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses.	CO 5	T1:8.8 R1:8.73
28-29	Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear.	CO 5	T2:9.19 R1:10.814
30	Mohr's circle of stresses – Principal stresses and strains – Analytical and graphical solutions.	CO 5	T2:10.7 R1:12.74
31	Theories of Failure: Introduction – Various theories of failure	CO 5	T1:11.12 R2:12.75
32	Maximum Principal Stress Theory, Maximum Principal Strain Theory.	CO 5	T1:12.4 R2:13.68
33-34	Strain Energy and Shear Strain Energy Theory (Von Mises Theory).	CO 5	T2:13.7 R1:14.74
35	Theory of pure torsion – Derivation of Torsion equations : $T/J = q/r = G\Theta/L$	CO 6	T1:14.12 R2:15.75
36-37	Assumptions made in the theory of pure torsion – Torsional moment of resistance – Polar section modulus – Power transmitted by shafts.	CO 6	T2:9.19 R1:10.814

38-39	Combined bending and torsion and end thrust – Design of shafts according to theories of failure. Thin Cylinders: Thin seamless cylindrical shells	CO 6	T1:10.4 R2:11.68
40	Derivation of formula for longitudinal and circumferential stresses – hoop, longitudinal and Volumetric strains.	CO 6	T2:10.7 R1:12.74
PROBLEM SOLVING/ CASE STUDIES			
41	Thin spherical shells.	CO 1	T2:2.3
42	Working stress, factor of safety, lateral strain, Poisson's ratio and relationship between three elastic moduli	CO 1	T1:4.8 R2:4.68
43	Volumetric Strain and Bulk modulus	CO 1	T1:4.12 R2:5.75
44	Three elastic constants.	CO 1	T1:4.8 R2:4.68
45	Principal stresses	CO 2	T1:4.8 R1:5.72
46	Mohr's circle construction and problems	CO 2	T1:5.14 R1:6.78
47	Shear force and Bending moment diagrams	CO 2	T2:7.7 R1:7.74
48	Over-hanging beams and cantilevers.	CO 3	T1:8.8 R1:8.73
49	Problems on bending equation	CO 3	T1:12.4 R2:13.68
50	Shear stress distribution over different geometries.	CO 4	T2:13.7 R1:14.74
51	Shear stress distribution over I and T sections.	CO 4	T2:9.19 R1:10.814
52	Shear stress distribution over miscellaneous sections.	CO 5	T2:9.19 R1:10.814
53	Problems on bending stress distribution.	CO 5	T1:10.4 R2:11.68
54	Volumetric strain in shells	CO 6	T1:10.4 R2:11.68
55	Hoop stress in shells	CO 6	T2:10.7 R1:12.74
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	UNIT I: Simple Stresses and Strains	CO 1	T2:2.3
57	UNIT II: Shear Force and Bending Moment	CO 2	T2:3.14 R1:4.33
58	UNIT III:Flexural Stresses and Shear Stresses	CO 3, CO 4	T2:4.2 R1:5.72
59	UNIT IV:Principal stresses and strains, theories of failure	CO 5	T2:7.7 R1:7.74
60	UNIT V:Design of circular shafts and stresses in pressure vessels.	CO 6	T2:9.19 R1:10.814
DISCUSSION OF QUESTION BANK			
61	UNIT I: Simple Stresses and Strains	CO 1	T2:2.3

62	UNIT II: Shear Force and Bending Moment	CO 2	T2:3.14 R1:4.33
63	UNIT III:Flexural Stresses and Shear Stresses	CO 3, CO 4	T2:4.2 R1:5.72
64	UNIT IV:Principal stresses and strains, theories of failure	CO 5	T2:7.7 R1:7.74
65	UNIT V:Design of circular shafts and stresses in pressure vessels.	CO 6	T2:9.19 R1:10.814

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Code	AEE018				
Program	B.Tech				
Semester	III	AE/ME/CE			
Course Type	Foundation				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms.B Navothna, Assistant Professor,EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS002	I	Linear Algebra and Ordinary Differential Equations
B.Tech	AHS003	I	Computational Mathematics and Integral Calculus

II COURSE OVERVIEW:

Basic Electrical and Electronics Engineering course deals with the concepts of electrical circuits, basic law's of electricity, different methods to solve the electrical networks and the instruments to measure the electrical quantities. This course focuses on the construction, operational features of energy conversion devices such as DC and AC machines, Transformers. It also emphasis on basic electronics semiconductor devices and their characteristics and operational features.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Basics of Electrical and Electronics Engineering	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
67%	Understand
33%	Apply
0%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

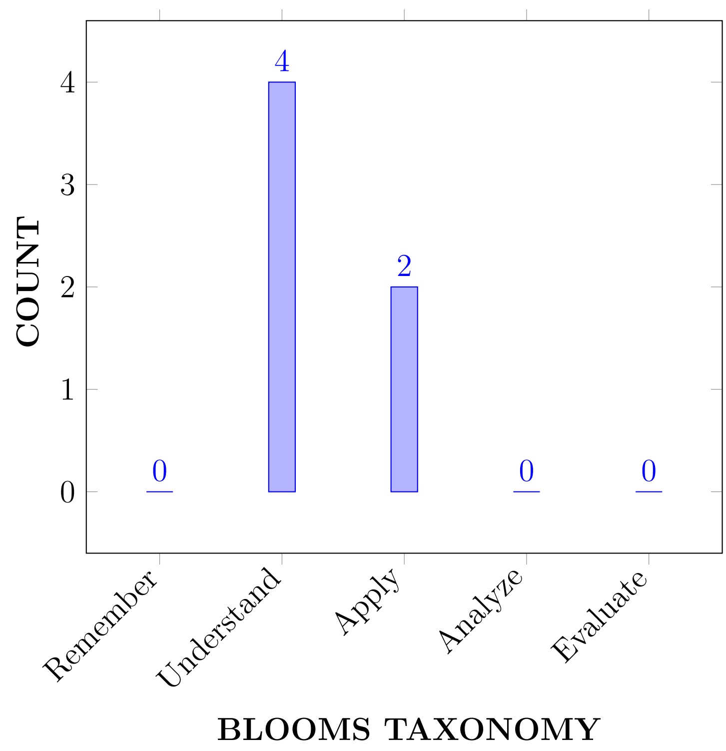
I	Understanding of the basic elements encountered in electric networks, and operation of measuring instruments.
II	The construction and working principle of DC generator, DC motor, andtypes of DC machines based on field excitation method.
III	Analyze the characteristics of alternating quantities and AC machines.
IV	Illustrate the V-I characteristics of various diodes and bi-polar junction transistor.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Solve** complex electrical circuits by applying network reduction techniques for reducing into a simplified circuit.	Apply
CO 2	**Differentiate** the working of moving iron and moving coil type instruments for computing electrical qunatities using suitable instrument.	Understand
CO 3	**Demonstrate** the construction, principle and working of DC machines for their performance analysis.	Understand
CO 4	**Illustrate** alternating quantities of sinusoidal waveform and working , construction of single phase transformers,induction motors, alternators for analysis of AC waveforms and AC machines.	Understand
CO 5	**Apply** the PN junction characteristics for the doide applications such as switch and rectifier.	Apply
CO 6	**Extend** the biasing techniques for bipolar and uni-polar transistor amplifier circuits considering stability condition for establishing a proper operating point.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE / CIE / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE / CIE / AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	1	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	**PO 1**	Recollect the concept of electricity is described through scientific principles, importance Kirchhoff laws in relation with law of conservation of energy and charge circuits are explained using mathematical principles and various source transformation techniques are adopted for solving complex circuits.	3
	PO 2	Derive standard expressions for equivalent resistances, inductances and capacitance by using series-parallel networks i.e mathematical calculations.	1
	PSO 1	Solve complex electrical circuits by applying basic circuit concepts by using computer programs.	1
CO 2	**PO 1**	Understand the working principles of indicating instruments and classify types based on construction engineering disciplines.	3
CO 3	**PO 1**	The principle of operation and characteristics of DC machines are explained by applying engineering fundamentals including device physics.	3
CO 4	**PO 1**	Understand about alternating quantities of an AC signal and working of single phase transformers,induction motors and alternators using engineering principles and mathematical equations.	3
	PSO 1	Develop equivalent circuit of single phase transformer referred to both sides by developing computer programs.	1
CO 5	**PO 1**	Outline of materials and brief description of formation of semi-conductor devices by using basic fundamentals of science and engineering.	3
	PO 2	Recognize (knowledge) the working and characteristics of diode and understand application which is rectifier circuit using engineering knowledge, and types of rectifiers.	3
CO 6	**PO 1**	List out various transistor configurations and discuss their working using principles of science and mathematical principles.	3
	PO 2	Explain the concept of biasing and load lines and their applicability in solving problems and working of transistors as switch and amplifier.	3

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3

CO 1	3	1	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 5	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	10	-	-	-	-	-	-	-	-	-	-	25	-	-
CO 2	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	-	-	-	-	-	-	-	-	-	-	-	25	-	-
CO 5	100	25	-	-	-	-	-	-	-	-	-		-	-	-
CO 6	100	25	-	-	-	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\ \% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-		-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-		-	-	-
TOTAL	**18**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**
AVERAGE	**3**	**0.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.3**	**0**	**0**

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ELECTRICCIRCUITS,ELECTROMAGNETISM AND INSTRUMENTS**
	Electrical Circuits: Basic definitions, types of elements, Ohm's Law, resistive networks, inductive networks, capacitive networks, Kirchhoff's Laws, series, parallel circuits and star delta transformations, simple problems, Faradays law of electromagnetic induction; Instruments: Basic principles of indicating instruments, permanent magnet moving coil and moving iron instruments.
MODULE II	**DC MACHINES**
	DC Machines: Principle of operation of DC generator, EMF equation, principle of operation of DC motors, torque equation, types of DC machines, applications, three point starter.
MODULE III	**ALTERNATING QUANTITIES AND AC MACHINES**
	Alternating Quantities: Sinusoidal AC voltage, average and RMS values, form and peak factor, concept of three phase alternating quantity; Transformer: Principle of operation, EMF equation, losses, efficiency and regulation. Three Phase Induction Motor: Principle of operation, slip, slip torque characteristics, efficiency, applications; Alternator: Principle of operation, EMF Equation, efficiency, regulation by synchronous impedance method.
MODULE IV	**SEMICONDUCTOR DIODE AND APPLICATIONS**
	Semiconductor Diode: P-N Junction diode, symbol, V-I characteristics, half wave rectifier, full wave rectifier, bridge rectifier and filters, diode as a switch, Zener diode as a voltage regulator.
MODULE V	**BIPOLAR JUNCTION TRANSISTOR AND APPLICATIONS**
	Bipolar junction: Working principle of transistors, DC characteristics, CE, CB, CC configurations, biasing, load line, applications.

TEXTBOOKS

1. A Chakrabarti, "Circuit Theory", Dhanpat Rai Publications, 6thEdition,2004.
2. K S Suresh Kumar, "Electric Circuit Analysis", Pearson Education, 1stEdition,2013.
3. WillianmHayt, Jack E Kemmerly S M Durbin, "Engineering Circuit Analysis", Tata McGraw Hill, 7thEdition,2010.
4. J P J Millman, C CHalkias, SatyabrataJit, "Millmans Electronic Devices and Circuits", Tata McGraw Hill, 2ndEdition,1998.
5. R L Boylestad, Louis Nashelsky, "Electronic Devices and Circuits", PEI / PHI, 9th Edition, 2006.
6. V K Mehta, Rohit Mehta, —Principles of electrical engineering, S CHAND, 1st Edition, 2003.

REFERENCE BOOKS:

1. David A Bell, "Electric Circuits", Oxford University Press, 9thEdition,2016.
2. U A Bakshi,Atul P Godse "Basic Electrical and Electronics Engineering"TechnicalPublications, 9thEdition,2016.

3. A Bruce Carlson, “Circuits”, Cengage Learning, 1stEdition,2008.

4. M Arshad, “Network Analysis and Circuits”, Infinity Science Press, 9thEdition,2016.

WEB REFERENCES:

1. http://www.igniteengineers.com
2. http://www.ocw.nthu.edu.tw
3. http://www.uotechnology.edu.iq

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courses/aeronautal-engineering-autonomous/basics -of-electrical-and-electronics-engineering

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
2	Electrical Circuits: Basic definitions, Types of elements	CO 1	T1-5.2 to 5.3
3	Ohm's Law, Kirchhoff Laws	CO 1	T1-5.4 to 5.5
4	Series, parallel circuits	CO 1	T1-5.5 to 5.8
5	Derivation for Star-delta and delta-star transformations	CO 1	T1-5.8 to 5.9
6	Mesh analysis and Nodal Analysis	CO 1	T1-5.11 to 5.12
7	Working of moving iron type instruments	CO 2	T1-5.14 to 5.15
8	Working of moving coil type inst0ruments	CO 2	T1-5.16 to 5.16
9	Principle of operation for DC generators	CO 3	R2-7.1 to 7.2
10	Construction and EMF equation for DC generators	CO 3	R2-7.4
11	Types of DC generators	CO 3	R2-7.3
12	Principle of operation for DC motors	CO 3	R2-7.3.1 to 7.3.2
13	Back EMF, torque equation for DC motors	CO 3	R2-7.3.3 to 7.3.6
14	Types of DC motors	CO 3	R2-7.6

15	Losses and efficiency for DC generators, motors	CO 3	T1-13.1 to 13.3
16	Principle of operation for Single Phase Transformers	CO 4	T1-13.1 to 13.3
17	Construction and EMF equation for Single Phase Transformers	CO 4	T1-13.5 to 13.6
18	Types of transformers and turns ratio	CO 4	T1-13.6 to 13.7
19	Operation of transformer under no load	CO 4	T1-13.7 to 13.9
20	Operation of transformer under on load	CO 4	T1-13.8
21	Equivalent circuit for Transformers	CO 4	T1-17.1 to 17.2
21	Phasor diagrams of transformer	CO 4	T1-17.3 to 17.4
22	Losses of Transformers	CO 4	T1-17.6 to 17.7
23	Efficiency of Transformers	CO 4	T1-13.11
24	Regulation for Transformers	CO 4	T1-13.12
25	Three Phase Induction motor: Principle of operation	CO 4	T1-13.13
26	slip, slip -torque characteristics	CO 4	T1-13.14
27	Alternators: Introduction, principle of operation	CO 4	T1-13.19
28	Constructional features	CO 4	T1-13.20
29	Understand the concept of P-N junction diode, symbol	CO 5	T1-13.8
30	Learn the V-I characteristics of P-N junction diode	CO 5	T1-17.1 to 17.2
31	Discuss the concept of half wave rectifier and full wave rectifier	CO 5	T1-17.3 to 17.4
32	Understand the bridge rectifiers and filters	CO 5	T1-17.6 to 17.7
33	Discuss the concept of diode as a switch, Zener diode as a voltage regulator	CO 5	T1-13.11
34	Know the concept of Transistors and Understand the configurations	CO 6	T1-13.12
35	Understand the DC characteristics of transistor	CO 6	T1-13.13
36	Understand the biasing and load line analysis.	CO 6	T1-13.13
37	Discuss how transistor acts as an amplifier.	CO 6	T1-13.13
PROBLEM SOLVING/ CASE STUDIES			
38	Numerical Examples on electrical quantities, Ohm's law, KCL, KVL	CO 1	T1-5.8 to 5.9
39	Numerical Examples on series, parallel elements and star to delta transformation and mesh analysis	CO 1	T1-5.5 to 5.8
40	Numerical Examples on nodal analysis and alternating quantities	CO 1	T1-6.8 to 6.9
41	Numerical Examples on Superposition theorem	CO 1	T1-6.2 to 6.3

42	Numerical Examples on reciprocity and maximum power transfer theorems	CO 1	R2-7.1 to 7.2
43	Numerical Examples on Thevenin's and Norton's theorems	CO 1	T1-13.1 to 13.3
44	Numerical Examples on EMF equation and types of DC generators	CO 3	T1-13.6 to 13.7
45	Numerical Examples on torque equation of DC motor	CO 3	T1-13.1 to 13.3
46	Numerical Examples on types of DC motors	CO 3	T1-13.13
47	Numerical Examples on EMF equation and equivalent circuit of 1 phase transformer	CO 4	T1-13.16 to 13.18
48	Numerical Examples on, efficiency for Transformers	CO 4	T1-13.14
49	Numerical Examples on, regulation for Transformers	CO 4	T1-13.16 to 13.18
50	Numerical Examples on EMF of Alternators	CO 4	T1-13.19
51	Numerical Examples on regulation of Alternators	CO 4	T1-13.20
52	Numerical Examples on Rectifiers	CO 5	T1-13.19
53	Numerical Examples on transistors	CO 6	T1-13.19
DISCUSSION OF DEFINITION AND TERMINOLOGY			
54	Definitions on basics of electrical circuits and electrical instruments	CO 1	T1-5.1 to 5.3
55	Definitions on DC machines	CO 2	T1-6.1 to 6.3
56	Definitions on single phase AC circuits and AC machines	CO 3	R2-7.1 to 7.2
57	Definitions on semiconductor diode and applications	CO 5	T1-13.1 to 13.3
58	Definitions on bipolar junction transistor and applications	CO 6	T1-13.11
DISCUSSION OF QUESTION BANK			
59	Questions from electrical circuits and electrical instruments	CO 1	T1-5.1 to 5.3
60	Questions from DC machines	CO 2	T1-6.1 to 6.3
61	Questions from single phase AC circuits and AC machines	CO 3	R2-7.1 to 7.2
62	Questions from semiconductor diode and applications	CO 5	T1-13.1 to 13.3
63	Questions from bipolar junction transistor and applications	CO 6	T1-13.11

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**METALLURGY AND MECHANICS OF SOLIDS LABORATORY**				
Course Code	AME104				
Program	B.Tech				
Semester	III	ME			
Course Type	CORE				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. A Somaiah, Assistant Professor				

I COURSE OVERVIEW:

Materials and mechanics of solids laboratory is designed to examine samples to detect surface and internal flaws, determine micro structural features, evaluate heat treatments and ensure conformance to required specifications. Root cause failure analysis can also be performed when performance issues occur with metal products. One of the principle concerns of an engineer is the analysis of materials used in structural applications. The term structure refers to any design that utilizes materials that support loads and keeps deformation within acceptable limits. Designing machines, structures, and vehicles, which are reliable as well as safe and cost effective, requires a proper knowledge of engineering as well as material selection.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME002	II	Engineering Mechanics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Metallurgy and Mechanics of Solids Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

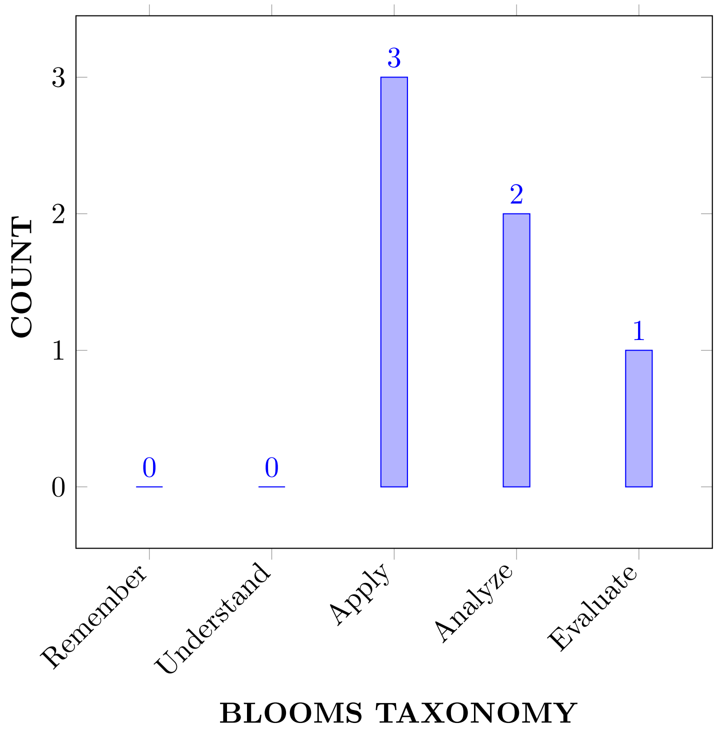
I	The processes of cold/hot working, re-crystallization, grain growth and micro structural properties of materials.
II	The parameters such as factor of safety, Poisson's ratio, three elastic moduli and their relationships in the selection and characterization of a material.
III	The theory of pure torsion, bending, stiffness, slope and deflection of beams.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Utilize** the concepts crystallography, crystal structures, crystallographic planes, and miller indices to analyse the microstructural properties of materials.	Apply
CO 2	**Make use of** the Jominy end quench test apparatus to measure the capacity of steel hardenability in depth under a given set of conditions.	Apply
CO 3	**Distinguish** the regions of elasticity and plasticity, stress-strain relationships under various types of loads by conducting a tensile test on universal testing machine.	Apply
CO 4	**Analyze** the mechanical properties of a material by conducting compression and torsion tests on different materials.	Analyze
CO 5	**Compare** the hardeness values of ferrous and non ferrous materials by conducting experiments on Rockwell and Brinell's hardness testing machines.	Analyze
CO 6	**Determine** the impact strength of a material by adopting Charpy and Izod test procedures.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises/CIA/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	Lab Exercises/CIA/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Apply the knowledge of Sciences and Engineering principles** to **identify** the properties and micro structural behaviour of different materials to know their specifications.	3
	PO 2	**Identify and analyse the principles** to **utilize** appropriate materials in design considering engineering properties and micro structural characteristics, sustainability, cost and weight.	4
CO 2	PO 1	**Apply** the knowledge of **science and engineering principles** to **analyze** mechanical properties of materials, specifically capacity of a steel hardenability over a depth for different condintions.	3

	PO 2	**Identify, formulate and analyse** the stresses, strains at a point with their relationships for a given material and variation of hardenability of a material.	3
CO 3	PO 1	**Apply the knowledge of science and engineering principles** to **distinguish** the regions of elasticity, plasticity and phenomena of strain hardening of different materials by conducting a test on suitable machine.	2
	PO 4	**Analyze** and **interpret** the data obtained in a graphical form by conducting a tensile test on universal testing machine on a selected material.	2
CO 4	PO 1	**Apply** the knowledge of **science and engineering principles** to **analyze** the mechanical properties of materials by conducting compression and torsion tests on suitable machines.	2
	PSO 1	**Identify** and **evaluate** compression and torsion properties of different materials and **calculate** the modulus of rigidity of a material.	3
CO 5	PO 2	**Identify** the engineering materials, **determine and compare** the hardnes values with both Rockwell and Brinell test procedres.	3
	PO 4	**Analyze** and **interpret** the values of hardness for different ferrous and non ferrous materials using different scales on Rockwell hardness machine.	2
CO 6	PO 2	**Identify and analyse** the impact strengths for different materials by adopting Charpy and Izod test procedures and **determine** the toughness of materials.	3

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 2	PO 4	PSO 1
CO 1	3	4		
CO 2	3	3		
CO 3	2		2	
CO 4	2			3
CO 5		3	2	
CO 6		3		

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**MICROSTRUCTURE OF PURE METALS**
	Preparation and study of the micro Structure of pure metals like iron, cu and al.
WEEK II	**MICROSTRUCTURE OF STEELS**
	Preparation and study of the microstructure of mild steels, low carbon steels, high–C steels.
WEEK III	**MICROSTRUCTURE OF CAST IRON**
	Study of the micro structures of cast irons.
WEEK IV	**MICROSTRUCTURE OF COPPER**
	Study of the micro structures of copper.
WEEK V	**MICROSTRUCTURE OF HIGH CARBON STEEL**
	Study of the micro structures of high carbon steel
WEEK VI	**TENSION TEST**
	To Find percentage of elongation and youngs modulus of a material.
WEEK VII	**TORSION TEST**
	To find the torsional rigidity of a material.
WEEK VIII	**Brinell HARDNESS TEST**
	To find the Hardness number of given material.
WEEK IX	**Rockwell HARDNESS TEST**
	To find the Hardness number of given material.
WEEK X	**SPRING TEST**
	Testing on compressive and elongation springs.
WEEK XI	**COMPRESSION TEST**
	Compression test on concrete cube.
WEEK XII	**Charpy IMPACT TEST**
	To find the Imapct strength of a given specimen

WEEK XIII	**IZOD IMAPCT TEST**
	To find the Imapct strength of a given specimen
WEEK XIV	**SHEAR TEST**
	Punch shear test on aluminium sheet.

TEXTBOOKS

1. H Modi, Seth, Hydraulics, Fluid Mechanics and Hydraulic Machinery, Rajsons, Publications, 21st Edition, 2017.

2. Pulkrabek, Engineering Fundamentals of IC Engines, Pearson Education, 2nd Edition, 2008.

REFERENCE BOOKS:

1. Dr. R K Bansal, A Text Book of Fluid Mechanics and Hydraulic Machines, Laxmi Publications, 9th Edition, 2015.

2. Mathur, Sharma, IC Engines, DhanpatRai and Sons, 3rd Edition, 2008.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Preparation and study of the micro Structure of pure metals like iron, cu and al..	CO 1, CO 2	T1:7.10
2	Preparation and study of the microstructure of mild steels, low carbon steels, high–C steels.	CO 1, CO 2	T1:11.5
3	Study of the micro structures of cast irons.	CO 3	T1:7.7
4	Study of the micro structures of copper.	CO 4, CO 5	T1:21.12
5	Study of the micro structures of high carbon steel	CO 5, CO 6	T1:21.5
6	To Find the percentage of elongation and youngs modulus of a material.	CO 4, CO 6	T1:23.2
7	Find the torsional rigidity of a material.	CO 4, CO 6	T1:24.3
8	Find the Hardness number of given material.	CO 6	R2:2.6
9	Find the Hardness number of given material.	CO 5, CO 6	T2:3.18
10	Testing on compressive and elongation springs.	CO 5, CO 6	T2:3.18
11	Compression test on concrete cube.	CO 5, CO 6	R2:7.12
12	Find the Imapct strength of a given specimen.	CO 6	T2:3.18
13	Find the Imapct strength of a given specimen.	CO 5, CO 6	R2:9.12
14	Punch shear test on aluminium sheet.	CO 6	T2:8.18

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**NDT:** Determination of internal defects using non destructive testing.
2	**Deflection:** Determine the slope and deflection for cantilever and simply supported beams.
3	**Shear Test:** Determine the shear stress for a riveted joint
4	**Deformation:** Determine the deformation of a tapering composite bar by applying the principle of superposition

Signature of Course Coordinator **HOD, ME**
Mr. A Somaiah, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**MACHINE DRAWING THROUGH CAD LABORATORY**				
Course Code	AME105				
Program	B.Tech				
Semester	III	ME			
Course Type	CORE				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Dr.G.V.R. Seshagiri Rao,AssociateProfessor				

I COURSE OVERVIEW:

Machine drawing is used to communicate the necessary technical information required for manufacture and assembly of machine components. Students practice the development of drawings of machine components as per Bureau of Indian Standards (BIS) and assembly using industry leading mechanical design softwares. This course is central to developing students ability to easily develop a full range of products, from single parts to assemblies containing thousands of components with accurate fit and therefore involves economic, societal, safety and manufacturing aspects.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
Foundation	AMEC03	II	Computer Aided Engineering Drawing	1.5

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Manufacturing TEchnology Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing Further Experiments

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day-to-day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the principal from the panel of experts recommended by Chairman, BOS.

The emphasis on the experiments is broadly based on the following criteria given in Table: 1

Experiment Based	Programming based
20 %	To test the preparedness for the experiment
20 %	To test the performance in the laboratory
20 %	To test the calculations and graphs related to the concern experiment
20 %	To test the results and the error analysis of the experiment
20 %	To test the subject knowledge through viva– voice

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component	**Laboratory**		Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Experiment Based

Preparation	Performance	Calculations and Graph	Results and Error Analysis	Viva	Total
2	2	2	2	2	10

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		Strength	Proficiency Assessed by
PO2	**Problem analysis:** Identify, formulate, review researchliterature, and analyze complex engineering problems reachingsubstantiatedconclusionsusing-firstprinciplesofmathematics, naturalsciences,and engineeringsciences.	3	Lab Experiments/CIE/SEE
PO3	**Design/development of solutions:** Design solutions forcomplexengineeringproblemsanddesign-systemcomponentsor processes that meet the specified needs with appropriateconsiderationforthepublichealthandsafety,andthecultural, societal,andenvironmentalconsiderations.	3	Lab Experiments/CIE/SEE
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Lab Experiments/CIE/SEE
PO5	**Modern tool usage:** Create, select, and apply appropriatetechniques, resources, and modern engineering and IT toolsincludingpredictionand modelingto complexengineering activitieswithanunderstandingofthelimitations.	3	Lab Experiments/CIE/SEE
PO 9	**Individual and Teamwork :** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Lab Experiments/CIE/SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Experiments/CIE/SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	2	Lab Experiments/CIE/SEE

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

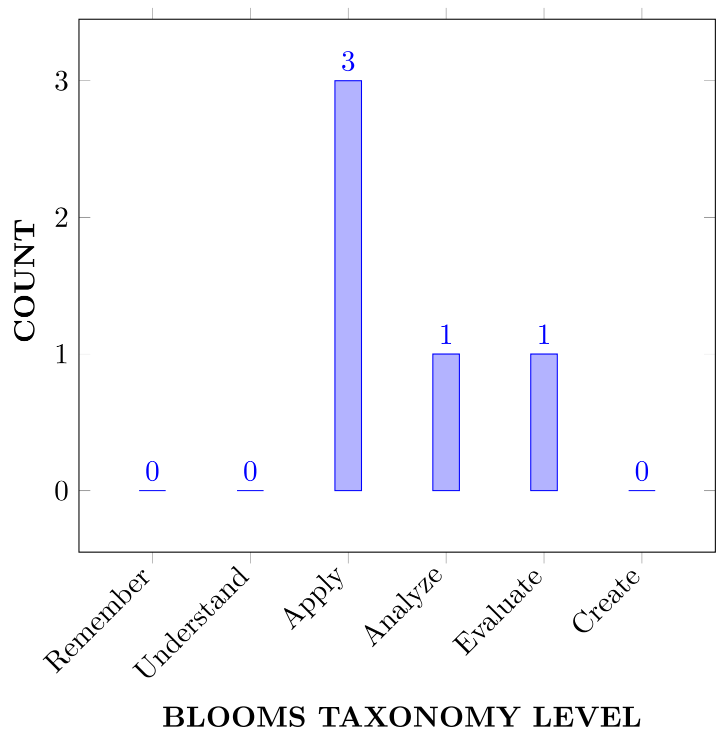
I	The Code of drawing practice as per BIS conventions for mechanical elements using AutoCAD.
II	The 2D drawing of joints, couplings, bearings and keys and their sectional views.
III	The preparation of component drawings, assembly drawings and bill of materials for selected assemblies.
IV	The part drawings of the assembly of various machines and engine components.

IX COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Select** the conventional representation of materials and machine elements for assembly drawing work. .	Apply
CO 2	**Classify** tthe different types of sectional views to expose internal surfaces of machine elements.	Analyze
CO 3	**Explain** the importance of the linking functional and visualization aspects in the preparation of the part drawings for the design process.	Evaluate
CO 4	**Identify** the different types of couplings are used for fastening components that require frequent assembly and disassembly.	Apply
CO 5	**Develop** detailed assembly drawings of Engine parts, Tailstock, Machine vice and safety valves to facilitate its manufacture.	Apply

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 2	Identify the various mechanical machine elements to illustration of their materials and shape in an assembly drawings	2
CO 2	PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using CAD/CAM softwares.	1
	PO 2	Identify the various mechanical machine elements to illustration of their materials and shape in an assembly drawings	2
CO 3	PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using CAD/CAM softwares.	1
	PO 3	Design solutions for complex engineering problems and design system components for the public health and safety, and the cultural, societal, and Environmental considerations.	3
CO 4	PO 5	Apply appropriate techniques, resources, and modern engineering tool for modeling of various machine components to complex engineering activities with an understanding of the limitations.	2
	PO 3	Design solutions for complex engineering problems and design system components for the public health and safety, and the cultural, societal, and Environmental considerations.	3
CO 5	PO 4	Use research-based knowledge and research methods including design of mechanical components, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	4
	PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using CAD/CAM softwares.	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2
	PO 10	Write effective reports and design documentation, make effective presentations, and give and receive clear instructions on complex engineering activities.	3

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE	PROGRAM OUTCOMES						PSO'S
OUTCOMES	PO 2	PO 3	PO 4	PO 5	PO 9	PO 10	PSO 1
CO 1	3						2
CO 2	3						2
CO 3		3		3	3		
CO 4		3	3				
CO 5					3	1	2

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	✓	Mini projects	-		

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK 1	**CONVENTIONAL REPRESENTATION**
	Conventional representation of materials, common machine elements and parts such as screws, nuts, bolts, keys, gears, webs and ribs; Introduction to AutoCAD.
WEEK 2	**SECTIONAL VIEWS**
	Types of sections, selection of section planes and drawing of sections and auxiliary sectional views, parts not usually sectioned.
WEEK 3	**DIMENSIONING**
	Methods of dimensioning, general rules for sizes, and placement of dimensions for holes, centers, and curved and tapered features
WEEK 4	**MACHINE ELEMENTS**
	Drawing of machine elements and simple parts; Selection of orthogonal views and additional views for the following machine elements and parts with drawing proportion, popular forms of screw threads, bolts, nuts and stud bolts.

WEEK 5	**KEYS AND COTTER JOINTS**
	Keys, cotter joints, and knuckle joint.
WEEK 6	**RIVETED JOINTS**
	Riveted joints for plates.
WEEK 7	**COUPLINGS**
	Shaft couplings and spigot joint.
WEEK 8	**BEARINGS**
	Journal, pivot, and collar bearing.
WEEK 9	**ASSEMBLY DRAWINGS-I**
	Assembly drawings for the Engine parts–stuffing box, Eccentrics, I.C. engine connecting rod.
WEEK 10	**ASSEMBLY DRAWINGS-II**
	Assembly drawings for the Screw jack
WEEK 11	**ASSEMBLY DRAWINGS-III**
	Assembly drawings for the Machine vice and tailstock
WEEK 12	**ASSEMBLY DRAWINGS-IV**
	Assembly drawings for the Rams-bottom Safety Valve.

TEXTBOOKS

1. K.L. Narayana, P. Kannaiah, K. Venkata Reddy,Machine Drawing, New Age Publishers, 3rd Edition, 2012
2. K.C. John, Text book of Machine Drawing, PHI Eastern Economy, 1st Edition, 2010.
3. P.S Gill, Machine Drawing, S.K Kataria& Sons, 1st Edition, 2013

REFERENCE BOOKS:

1. N. D. Bhatt, V. M Pancahal, Machine Drawing, Charotar, 1st Edition, 2014.
2. R. K. Dhavan, A Text book of Machine drawing, S.Chand Publication & Co, New Delhi, 2nd Edition, 2008.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Conventional representation of materials, common machine elements and parts such as screws, nuts, bolts, keys, gears, webs and ribs; Introduction to AutoCAD.	CO1	T1:1.8-2.5
2	Types of sections, selection of section planes and drawing of sections and auxiliary sectional views, parts not usually sectioned.	CO 1, CO 2	T1:4.1-5.6
3	Methods of dimensioning, general rules for sizes, and placement of dimensions for holes, centers, and curved and tapered features	CO 1, CO 2	T1:1.1-2.1

4	Drawing of machine elements and simple parts; Selection of orthogonal views and additional views for the following machine elements and parts with drawing proportion, popular forms of screw threads, bolts, nuts and stud bolts.	CO1, CO 2	T1:5.1-7.4
5	Keys, cotter joints, and knuckle joint.	CO 3	T1:7.5
6	Riveted joints for plates.	CO 3	T1:8.1-8.6
7	Shaft couplings and spigot joint.	CO 4	T1:9.1-9.10
8	Journal, pivot, and collar bearing.	CO 4	T1:12.1-12.5
9	Assembly drawings for the Engine parts–stuffing box, Eccentrics, I.C. engine connecting rod.	CO 5	R1:13.2
10	Assembly drawings for the Screw jack	CO 5	T1:15.5
11	Assembly drawings for the Machine vice and tailstock	CO 5	T1:15.6-15.8
12	Assembly drawings for the Rams-bottom Safety Valve	CO 5	T1:15.9

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1.	Explore the application of AutoCAD software and Design of various machine elements as Per BIS.
2.	Instead of 2D drawings develop the components or assembly of components in 3D using AutoCAD software.
3.	Prepare the real time machine components in reverse engineering.
4.	To illustrate new designs by using pictorial drawings for understanding exploded assemblies.

Prepared by: **HOD,ME**
Dr.Gvr Seshagiri Rao, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**BASIC ELECTRICAL AND ELECTRONICS ENGG LAB**				
Course Code	AEE103				
Program	B.Tech				
Semester	III	AE/ME/CE			
Course Type	Foundation				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Ms. B Navothna, Assistant Professor				

I COURSE OVERVIEW:

The objective of the Basic Electrical Engineering Laboratory lab is to expose the students to the electrical circuits and give them experimental skill. It also aims to get the knowledge of the different electronic devices like diodes, rectifiers, transistors. It provides hands-on experience by examining the electrical characteristics of various AC and DC machines.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS006	I	Engineering Physics
B.Tech	AHS002	I	Linear Algebra and Ordinary Differential Equations

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Basic Electrical and Electronics Engineering Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

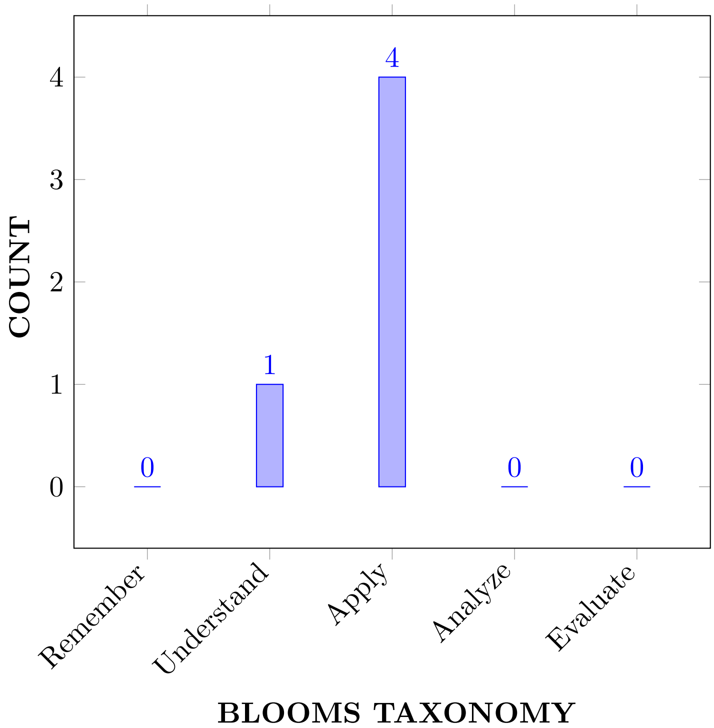
I	Implement different circuits and verify circuit concepts for DC circuits.
II	Gain knowledge on semiconductor devices like diode and transistor.
III	Interpret different transistor configurations.
IV	The operation and characteristics of AC machines and DC machines.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Solve** the electrical circuit source resistance, currents, voltage and power by applying various network reduction techniques.	Apply
CO 2	**Apply** magnetization characteristics of dc shunt generator for calculating the critical resistance and speed control methods and performance characteristics of DC Shunt machine and Transformer for efficiency.	Apply
CO 3	**Acquire** basic knowledge on the working of PN-junction diode, Zener diode to plot their V-I characteristics.	Understand
CO 4	**Identify** transostor configuration and their working to deduce its working as switch and amplifier.	Apply
CO 5	**Explore** the knowledge and skills of employability to succeed in national and international level competitive examinations.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Laboratory experiments internal and external lab exam

PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	1	Laboratory experiments internal and external lab exam
PO 9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Laboratory experiments internal and external lab exam
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3	Laboratory experiments internal and external lab exam
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	3	Laboratory experiments internal and external lab exam

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	1	-

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Recollect the concept of electricity is described through scientific principles, importance Kirchhoff laws in relation with law of conservation of energy and charge circuits are explained using **knowledge of mathematics, science and engineering fundamentals.**and various source transformation techniques are adopted for solving complex circuits.	3
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice **in solving the circuits**	1

	PO 9	Work effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **in solving the circuits**.	3
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society **in solving the circuits**.	3
	PO 12	The preparation and ability to engage in independent and life-long learning in the broadest context of technological change **in solving the circuits**.	3
	PSO 1	Solve complex electrical circuits by applying basic circuit concepts **by using computer programs.**	1
CO 2	PO 1	Apply (knowledge) magnetization characteristics DC shunt generator and performance characteristics of DC shunt machine by **analyzing complex engineering problems using the principles of mathematics, engineering science.**	3
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice **in applying magnetization characteristics DC shunt generator and performance characteristics of DC shunt machine**	1
	PO 9	Work effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **in applying magnetization characteristics DC shunt generator and performance characteristics of DC shunt machine**	3
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society **in applying magnetization characteristics DC shunt generator and performance characteristics of DC shunt machine**	3
	PO 12	The preparation and ability to engage in independent and life-long learning in the broadest context of technological change **in applying magnetization characteristics DC shunt generator and performance characteristics of DC shunt machine**.	3
CO 3	PO 1	Understand the working of PN-junction diode,Zener diode by using principles of **mathematics and engineering science**	3
	PO 2	Acquire the knowledge on working of PN-junction diode **for its validity.**	1
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice **by understanding the working of PN-junction diode,Zener diode**	1
	PO 9	Work effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **by understanding the working of PN-junction diode,Zener diode**	3

	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society **by understanding the working of PN-junction diode,Zener diode**	3
	PO 12	The preparation and ability to engage in independent and life-long learning in the broadest context of technological change **by understanding the working of PN-junction diode,Zener diode**.	3
CO 4	PO 1	Identify transistor configuration by using principles of **mathematics and engineering science**	3
	PO 2	Identify the different transistor configuration for its applications **for its validity.**	1
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice **by identifying transistor configuration**	1
	PO 9	Work effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **by identifying transistor configuration**	3
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society **by identifying transistor configuration**	3
	PO 12	The preparation and ability to engage in independent and life-long learning in the broadest context of technological change **by identifying transistor configuration**.	3
CO 5	PO 1	Demonstrate the knowledge of electrical circuits and semiconductor diodes **using principles of mathematics, science and engineering fundamentals.**	3
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice **in demonstration of electrical circuits and semiconductor diodes**	1
	PO 9	Work effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **in demonstration of electrical circuits and semiconductor diodes**	3
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society **in demonstration of electrical circuits and semiconductor diodes**	3
	PO 12	The preparation and ability to engage in independent and life-long learning in the broadest context of technological change **in demonstration of electrical circuits and semiconductor diodes**	3

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES						PROGRAM SPECIFIC OUT-COMES
	PO 1	PO 2	PO 8	PO 9	PO10	PO12	PSO1
CO 1	3		1	3	3	3	
CO 2	3		1	3	3	3	1
CO 3	3	1	1	3	3	3	
CO 4	3	1	1	3	3	3	
CO 5	3		1	3	3	3	

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**KVL AND KCL**
	Verification of Verification of Kirchhoff's current law and Voltage law using hardware.
WEEK II	**OHM'S LAW**
	Verification of Ohm's law.
WEEK III	**MAGNETIZATION CHARACTERISTICS**
	Magnetization characteristics of DC shunt generator.
WEEK IV	**SWINBURNE'S TEST**
	Swinburne's test on DC shunt machine
WEEK V	**OPEN CIRCUIT AND SHORT CIRCUIT TEST**
	Open circuit and short circuit test on single phase transformer.
WEEK VI	**BRAKE TEST**

	Study the performance characteristics of three phase induction motor by brake test .
WEEK VII	**SYNCHRONOUS IMPEDENCE METHOD**
	Determine the regulation of alternator using synchronous impedance method .
WEEK VIII	**P-N JUNCTION DIODE**
	Volt Ampere characteristics of p-n junction diode.
WEEK IX	**ZENER DIODE**
	Understand the zener diode characteristics.
WEEK X	**HALF WAVE RECTIFIER**
	Build half wave rectifier circuit.
WEEK XI	**RECTIFIERS**
	Build full wave rectifier circuit.
WEEK XII	**COMMON BASE TRANSISTOR**
	Understand transistor common base characteristics.
WEEK XIII	**COMMON EMITTER TRANSISTOR**
	Understand transistor common emitter characteristics.
WEEK XIV	**CRO**
	Study of CRO.

TEXTBOOKS

1. A Sudhakar, Shyammohan S Palli, “Circuits and Networks”, Tata McGraw-Hill, 4th Edition, 20103
2. P S Bimbhra, “Electrical Machinery”, Khanna Publishers, 1 st Edition,2011.

REFERENCE BOOKS:

1. A Chakrabarti, “Circuit Theory”, Dhanpat Rai Publications, 6th Edition, 2006.
2. K S Suresh Kumar, “Electric Circuit Analysis”, Pearson Education, 1st Edition, 2013.
3. Etter, “Introduction to MATLAB 7”, Pearson Education, 1st Edition, 2008.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
1	Verification of Verification of Kirchhoff’s current law and voltage law.	CO 1	T1:1.1
2	Verification of Ohm’s.	CO 1	T1:2.1
3	Magnetization characteristics of DC shunt generator.	CO 2	T1:2.4
4	Swinburne’s test on DC shunt machine.	CO 2	T1:6.1
5	Open circuit and short circuit test on single phase transformer.	CO 2	T1:4.6
6	Study the performance characteristics of three phase induction motor by brake test.	CO 2	T1:5.1

7	Determine the regulation of alternator using synchronous impedance method.	CO 2	R3: T1:4.1
8	Volt Ampere characteristics of p-n junction diode.	CO 3	T1:4.7
9	Understand the zener diode characteristics.	CO 2	T2:4.11
10	Build half wave rectifier circuit.	CO 3	T2:4.11
11	Build full wave rectifier circuit.	CO 3	T2:4.12
12	Understand transistor common base characteristics.	CO 4	T2:4.14
13	Understand transistor common emitter characteristics.	CO 4	T2:1.1
14	Study of CRO.	CO 3	T2:5.4

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Include more DC Electrical network theorems.

Signature of Course Coordinator **HOD,ME**
Ms. B Navothna, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**MATHEMATICAL TRANSFORM TECHNIQUES**				
Course Code	AHS011				
Program	B. Tech				
Semester	IV				
Course Type	Foundation				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms. P Rajani, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB02	I	Linear Algebra and Calculus
B.Tech			
B.Tech			

II COURSE OVERVIEW:

The course focuses on more advanced engineering mathematics topics which provide with the relevant mathematical tools required in the analysis of problems in engineering and scientific professions. The course includes types of matrices, difference calculus methods and differential equations. The mathematical skills derived from this course form a necessary base to analytical and design concepts encountered in the program.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Mathematical Transform Techniques	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with

"either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
30%	Understand
60 %	Apply
%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

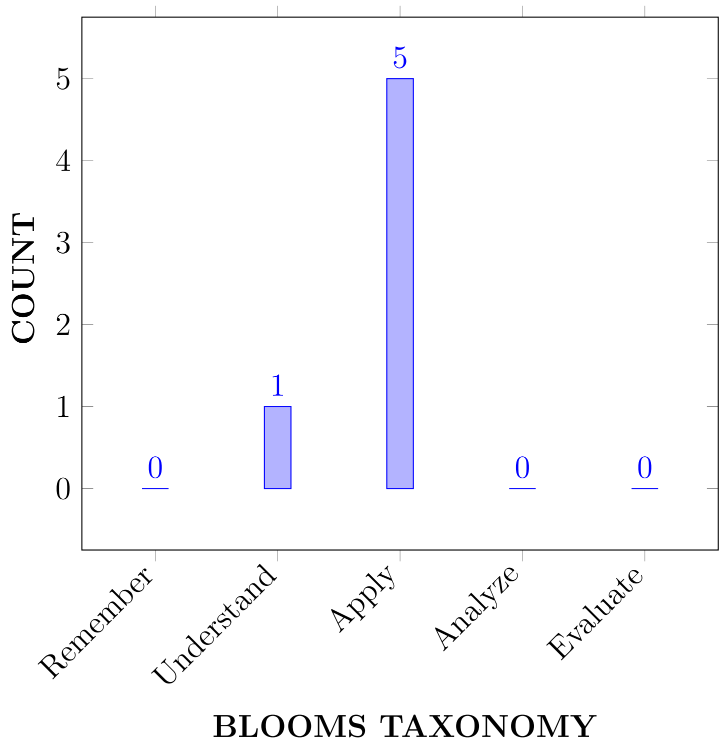
I	The operation of non-periodic functions by Fourier transforms.
II	The transformation of ordinary differential equations in Laplace field and its applications
III	Z-transforms to solve the difference equations
IV	The partial differential equation for solving non-linear equations

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the nature of the Fourier series that represent even and odd functions.	Understand
CO 2	**Apply** to compute the Fourier series of the function with one variable.	Apply
CO 3	**Identify** the role of Fourier transform non-periodic functions up to infinity as a mathematical function in transforming a signal from the time domain to the frequency domain	Apply
CO 4	**Explain** the properties of Laplace and inverse transform to various functions the integral transforms operations of calculus to algebra in linear differential equations	Apply
CO 5	**Compute** the Z-transforms and inverse of Z-transforms to difference equations by using the methods of partial fractions and convolution method.	Apply
CO 6	**Solve** the linear, nonlinear partial differential equation by the method of Lagrange's ,separiable and Charpit to concern engineering field	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	2	Seminar/ Conferences/ Research Papers
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	✓	-	-	-	-	-	-	-	-	✓	-	-
CO 4	✓	-	-	-		-	-	-	-	-	-		-	-	-
CO 5	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	✓	-	-		-	-	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Explain** the Fourier Series to the periodic functions for solving complex engineering problems of various functions such as continuous, piecewise continuous, step and impulsive functions with **principle of mathematics.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	**Apply** the Fourier series (understand) to complex engineering problems of various functions such as continuous, piecewise continuous, step and impulsive functions with principle of mathematics.	2
CO3	PO 1	**Identify** the mathematical function as a signal form from the time domain to the frequency domain in the **complex engineering problems** by (apply) Fourier transformation. **Principle of Mathematics**	2
	PO 2	**Apply** the Fourier integral transform as a **formulation** of mathematical function in **complex engineering problems** which transforms a non-periodic functions using **principles of mathematics** to attain conclusions by the **interpretation of results**	4
	PO4	Explain the integral transforms in solving ordinary differential equations will be **quantitatively measured** by using **MATLAB computer software**.	1
	PSO1	Describe the integral transforms concern Mechanical Engineering (apply) which converts operations of calculus to algebra in solving linear differential equations **in the design and implementation of complex systems.**.	1
CO4	PO 1	**Explain** the properties of Laplace and inverse transform (understand) to **complex engineering problems** of various functions the integral transforms operations of calculus to algebra in linear differential equations with **principle of mathematics**	2
CO5	PO2	**Compute** the statement of the Z-transforms and inverse of Z-transforms in **complex engineering problems** which difference equations by using the methods of partial fractions and convolution method using **principle of mathematics** related to engineering by **the interpretation of results**.	4
	PSO 1	**Compute** the properties of complex Z transform concern Mechanical Engineering which intensifies (apply) the boundary value problems in **the design and implementation of complex systems**.	1
CO6	PO1	**Solve** the linear, nonlinear partial differential equation related to **complex engineering problems** such as the method of Lagrange's ,separable and Charpit to the physical problems of engineering **Principle of Mathematics**	2
	PO2	**Solve** the **statement and formulation** of Lagrange's linear equation (understand) related to **complex engineering problems**, solutions are attained based on **principles of mathematics** to the physical problems of engineering by **the interpretation of results**	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	4	-	1	-	-	-	-	-	-	-	-	1	-	-
CO 4	2	-	-	-		-	-	-	-	-	-		-	-	-
CO 5	-	4	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 6	2	4	-	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40	-	9	-	-	-	-	-	-	-	-	50	-	-
CO 4	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	40	-	-	-	-	-	-	-	-	-	-	50	-	-
CO 6	66.7	40	-	-		-	-	-	-	-	-		50	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	1	-	-	-	-	-	-	-	-	2	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
TOTAL	15	6	-	1	-	-	-	-	-	-	-	-	4	-	-
AVERAGE	3	2	-	1	-	-	-	-	-	-	-	-	2	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester OBE Feedback	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**FOURIER SERIES**
	Definition of periodic function, determination of Fourier coefficients; Fourier expansion of periodic function in a given interval of$length 2\pi$; Fourier series of even and odd functions; Fourier series in an arbitrary interval; Half- range Fourier sine and cosine expansions.
MODULE II	**FOURIER TRANSFORMS**
	Fourier integral theorem, Fourier sine and cosine integrals; Fourier transforms; Fourier sine and cosine transform, properties, inverse transforms, finite Fourier transforms.
MODULE III	**LAPLACE TRANSFORMS**
	Definition of Laplace transform, linearity property, piecewise continuous function, existence of Laplace transform, function of exponential order, first and second shifting theorems, change of scale property, Laplace transforms of derivatives and integrals, multiplied by t, divided by t, Laplace transform of periodic functions. Inverse Laplace transform: Definition of Inverse Laplace transform, linearity property, first and second shifting theorems, change of scale property, multiplied by s, divided by s; Convolution theorem and applications.
MODULE IV	**Z –TRANSFORMS**
	Z-transforms: Elementary properties, inverse Z-transform, convolution theorem, formation and solution of difference equations.
MODULE V	**PARTIAL DIFFERENTIAL EQUATIONS AND APPLICATIONS**
	Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions, solutions of first order linear equation by Lagrange method; Charpit's method; method of separation of variables; One dimensional heat and wave equations under initial and boundary conditions.

TEXTBOOKS

1. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 36thEdition, 2010.
2. N.P. Bali and Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, Reprint, 2008.
3. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill New Delhi, 11th Reprint,2010.

REFERENCE BOOKS:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, 9thEdition, 2006.

2. Veerarajan T., "Engineering Mathematics for first year", Tata McGraw-Hill, New Delhi, 2008.

3. D. Poole, "Linear Algebra: A Modern Introduction", Brooks/Cole, 2ndEdition, 2005.

4. Dr. M Anita, "Engineering Mathematics-I", Everest Publishing House, Pune, First Edition, 2016

WEB REFERENCES:

1. http://www.efunda.com/math/math_home/math.cfm

2. http://www.ocw.mit.edu/resourcs/#Mathematics

3. http://www.sosmath.com

4. http://www.mathworld.wolfram.com

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	Define periodic function	CO 1	T1:22.5 R1:2.3
3	Solve Fourier coefficients	CO 1	T1:22.5 R1:2.4
4	Apply Fourier series for (0, 2π)	CO 1	T1:22.6 R1:2.6
5	Determine even and odd function	CO 2	T1:22.7 R1:4.4
6	Determine Fourier series in (0,2l), (-l,l) and also half range series in (0, l)	CO 1	T1:22.7 R1:4.10
7	Determine half range series in (0, π)	CO 2	T1:22.8 R1:4.15
8	Apply Fourier integral theorem to find integrals	CO 2	T1:22.9 R1:5.4
9	Apply Fourier sine and cosine integrals to find integrals	CO 3	T1:22.9 R1:5.8
10	Define and apply Fourier transforms	CO 3	T1:23.10 R1:6.8.
11	Use properties to solve the given functions	CO 3	T1:23.10 R1:6.13

12	Define and apply Inverse transforms	CO 3	T1:23.9 R1:7.5
13	Define and apply Finite Fourier transforms	CO 3	T1:23.10 R1:7.5
14	Define Laplace transform and its property	CO 4	T1:23.10 R1:8.1
15	Define piecewise continuous function	CO 4	T1:23.1 R1:9.2
16	Define and apply shifting theorem, change of scale property	CO 4	T1:23.1 R1:9.4
17	Solve derivatives and integrals, multiplied by t,divided by t	CO 74	T1:23.1 R1:9.9
18	Define periodic functions	CO 4	T1:23.1 R1:9.10
19	Solve Inverse Laplace transform	CO 4	T2:27.5 R1:10.2
20	Define and apply shifting theorem	CO 4	T2:27.7 R1:11.3
21	Solve multiplied by s, divided by s	CO 4	T2:27.8 R1:11.6
22	Define change of scale property	CO 4	T2:27.7 R1:11.3
23	Divided by s Define Z-transforms, Elementary properties	CO 5	T2:27.12 R1:11.8
24	Change of scale property Define inverse Z-transform	CO 5	T2:27.12 R1:11.9
25	Define inverse Z-transform	CO 5	T2:27.12 R1:11.10
26	Formulate partial differential equations	CO 6	T2:27.14 R1:12.3
27	Solving difference equations by Z transforms	CO 5	T2:27.1 R1:12.7
28	Solve by Charpit's method	CO 6	T2:27.17 R1:12.15
29	Apply method of separation of variables	CO 6	T2:18.2 R1:13.1
30	Define inverse Z-transform	CO 5	T2:18.3-18.5 R1:13.2 , 13.3
31	Elementary properties	CO 5	T1:17.1-17.2 R1:16.1-16.2
32	Elimination of arbitrary constants(Formation of PDE)	CO 6	T1:17.1-17.2 R1:16.1-16.2

33	Elimination of arbitrary functions(Formation of PDE)	CO 6	T1:17.5-17.6 R1:16.3.1
34	Non-Linear Partial differential equation of first order (Standard forms I, II ,III and IV)	CO 6	T1:17.1-17.2 R1:16.1-16.2
35	Non-Linear Partial differential equation of first order Standard forms V	CO 6	T1:17.5-17.6 R1:16.3.1
36	Non-Linear Partial differential equation	CO 6	T1:17.1-17.2 R1:16.1-16.2
37	Non-Linear Partial differential equation of first order Standard forms VI	CO 6	T1:17.1-17.2 R1:16.1-16.2
38	Lagrange's Linear equation- Method of grouping	CO 6	T1:17.5-17.6 R1:16.3.1
39	Lagrange's Linear Equation -Method of Multipliers	CO 6	T1:17.1-17.2 R1:16.1-16.2
40	Elimination of arbitrary constants(Formation of PDE)	CO 6	T1:17.1-17.2 R1:16.1-16.2
41	Elimination of arbitrary functions(Formation of PDE)	CO 6	T1:17.5-17.6 R1:16.3.1
42	Non-Linear Partial differential equation of first order (Standard forms II)	CO 6	T1:17.5-17.6 R1:16.3.1-16.2
43	Non-Linear Partial differential equation of first order (Standard forms III)	CO 6	T1:17.5-17.6 R1:16.3.1-16.2
44	Non-Linear Partial differential equation of first order (Standard forms IV)	CO 6	T1:17.5-17.6 R1:16.3.1-16.2

PROBLEM SOLVING/ CASE STUDIES			
45	Solving problems on Fourier sine and cosine integral	CO 2	T1:17.1-17.2 R1:16.1-16.2
46	Solving problems on finite Fourier transforms	CO 3	T1:17.5-17.6 R1:16.3.1
47	Solving problems on Laplace Transform of First, second shifting theorems and change of scaleproperty	CO4	T1:17.1-17.2 R1:16.1-16.2
48	Solving problems on Inverse Laplace transforms of derivatives, integrals, multiplied by s, divided by s	CO 4	T1:17.5-17.6 R1:16.3.1
49	Solving problems on Convolution theorem	CO 4	T1:17.1-17.2 R1:16.1-16.2
50	Solving problems on Inverse Laplace transforms of derivatives, integrals, multiplied by s, divided by s	CO 4	T1:23.10 R1:8.1
51	Solving problems on Inverse Laplace transforms of derivatives, integrals, multiplied by s, divided by s	CO 4	T1:23.1 R1:9.2
52	Solving problems on first shifting theorems and change of scale property	CO 4	T1:23.1 R1:9.4
53	Solving problems on second shifting theorems and change of scale property	CO 4	T1:23.1 R1:9.9
54	Gauss divergence theorem	CO 4	T1:23.10 R1:8.1
55	Solving problems on formation of partial differential equations by elimination of arbitrary constants	CO 6	T1:17.1-17.2 R1:16.1-16.2
56	Solving problems on formation of partial differential equations by elimination of arbitrary functions	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions and terminology on Fourier series	CO 1,2	T1:23.10 R1:6.8
58	Definitions and terminology on Fourier transforms	CO 3	T1:23.10 R1:7.5
59	Definitions and terminology on Laplace transforms	CO 4	T1:23.10 R1:8.1
60	Definitions and terminology on z transforms	CO 5	T2:27.12 R1:11.10

61	Definitions and terminology on partial differential equations	CO 6	T1:17.1-17.2 R1:16.1-16.2
DISCUSSION OF QUESTION BANK			
62	Desccsion of Fourier series	CO 1,2	T1:23.10 R1:8.1
63	Desccsion of Fourier transforms	CO 3	T1:23.10 R1:6.8
64	Desccsion of Laplace transforms	CO 4	T1:23.10 R1:7.5
65	Desccsion of z transforms	CO 5	T2:27.12 R1:11.10
66	Desccsion of partial differential equations	CO 6	T1:17.1-17.2 R1:16.1-16.2

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Production Technology**				
Course Code	AME006				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3		
Course Coordinator	Dr. G. Naveen Kumar, Professor, ME				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME005	III	Metallurgy and material science

II COURSE OVERVIEW:

The primary objective of this course is to introduce the concept of manufacturing technology with the help of various processes widely employed in industries. The course consists of casting, welding, sheet metal forming, extrusion and forging processes with the related details of equipment and applications. Introduces the different manufacturing processes and breakeven analysis. Engineering materials, laying emphasis on ferrous and non-ferrous materials along with the heat treatment of metals. Discusses the special casting processes and metal-forming processes respectively.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Production Technology	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50%	Understand
40%	Apply

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

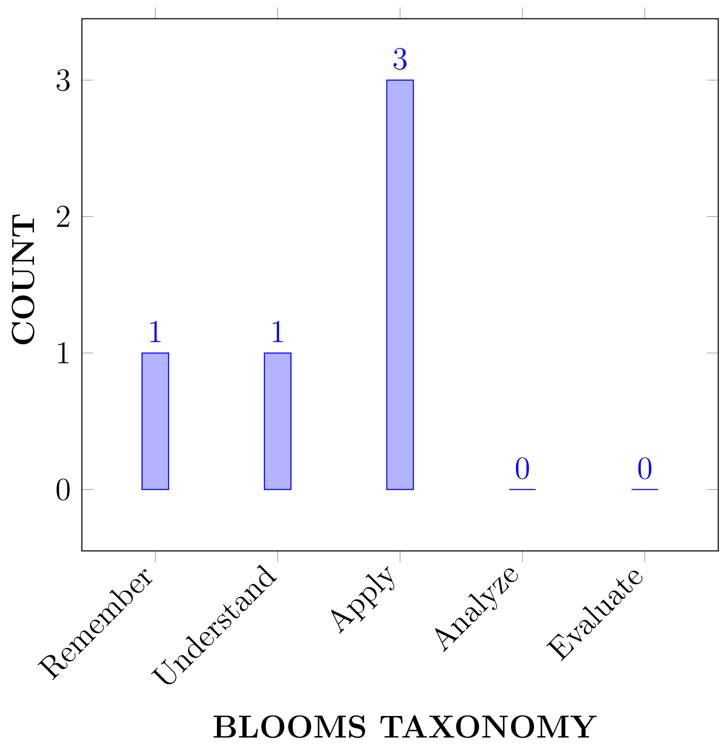
I	Comprehensive understanding of different manufacturing processes for product development.
II	The knowledge in thermal, metallurgical aspects during casting and welding for defect free manufacturing components.
III	Select process parameters, equipment for material processing

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	Outline the steps involved in making a casting the desired pattern for automotive industry components cylinder heads, engine blocks etc.	Remember
CO 2	Demonstrate use of different welding techniques for various industrial applicationss	Apply
CO 3	Categorize various defects and shortcomings during gas welding operation such as TIG, MIG and Spot welding etc. for real time applications.	Understand
CO 4	Apply the appropriate metal forming techniques, for producing components like hexagonal bolt, nut etc.	Apply
CO 5	Explain the working principle of hot and cold extrusion processes and their application in industries for making of pipes and tubes.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Seminar/ conferences/ Research papers
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Discussion on Innovations/ Presentation

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	-	Research papers/ Industry exposure
PSO 2	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining.	-	Research papers/ Industry exposure -
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies..	2	Research papers/ Industry exposure

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	✓	✓	-		-	-	-	-	-	-		-	-	✓
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	2
CO 2	PO 1	Identify (knowledge) in suitable techniquies involved in design,welding to achieve error free components using in solving (complex) engineering problems by applying the principles of mathematics and engineering fundamentals.	2
	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design. .	3
CO 3	PO 3	Identify the various properties of welding techniques using analytical and mathematical process.	3
CO 4	PO 2	Make use of the metal forming techniques used in Design, Model Creation and Validation of component Parts by Problem Analysis.	4
	PO3	Understand the given problem statement related to their working principle and based upon type of manufacturing process.	2
	PSO3	Identify the principle involved in rolling process by Qualitative and Quantitative methods to their engineering problems.	2
CO 5	PO 1	Apply the basic mathematical principles used in formulation of engineering problems	2
	PO 2	Understand the working principle used in forging Process by Natural Science and Engineering Sciences.	2
	PSO3	Identify the principle involved in Hot and Cold Extrusion process by Qualitative and Quantitative methods to their engineering problems	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	4	2	-		-	-	-	-	-	-		-	-	2
CO 5	2	2	-	-	-	-	-	-	-	-	-	-	-	-	2

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
CO 2	66.7	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
CO 3	0.0	0.0	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
CO 4	0	40	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
CO 5	66.7	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	1	-	-	-	-	-	-	-	-	-	-	-	3
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3
TOTAL	6	2	2	-	-	-	-	-	-	-	-	-	-	-	6
AVERAGE	3	1	1	-	-	-	-	-	-	-	-	-	-	-	3

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	CASTING
	Casting: Steps involved in making a casting, its applications, patterns and types of patterns, pattern allowances and their construction, types of casting processes, solidification of casting.
MODULE II	WELDING-I
	Welding:Welding types, Oxy-fuel gas welding, cutting, standard time and cost calculations, arc welding process, forge welding, resistance welding, thermit welding.
MODULE III	WELDING-II
	Welding: Inert gas welding, TIG welding, MIG welding, friction welding, induction pressure welding, explosive welding, electron beam welding, laser welding, soldering and brazing. Heat affected zone in welding, welding defects, causes and remedies, destructive and non-destructive testing of welds.
MODULE IV	FORMING
	Forming: Hot working, cold working, strain hardening, recovery, re-crystallization and grain growth, comparison of properties of cold and hot worked parts, rolling fundamentals, theory of rolling, types of rolling mills and products; Forces in rolling and power requirements, stamping, forming and other cold working processes: Blanking and piercing, bending and forming, drawing and its types, wire drawing and tube drawing; coining; hot and cold spinning, types of presses and press tools, forces and power requirements for the above operations
MODULE V	EXTRUSION, FORGING
	Extrusion of Metals: Basic extrusion process and its characteristics, hot extrusion and cold extrusion, forward extrusion and backward extrusion, impact extrusion, extruding equipment, tube extrusion and Pipe making, hydrostatic extrusion, forces in extrusion; Forging processes: Forging operations and principles, tools, forging methods, Smith forging, drop forging, roll forging, forging hammers: Rotary forging, forging defects, cold forging, swaging, forces in forging operations

TEXTBOOKS

1. P. N. Rao, "Manufacturing Technology", Tata McGraw-Hill, 2ndEdition,2013.
2. Hajra Chowdhary, "Workshop Technology", Asia Publishing House, 2ndEdition,2008.

REFERENCE BOOKS:

1. Sarma P C, "Production Technology", S.Chand CO, New Delhi, 7thEdition,2006.
2. R. K. Jain, "Production Technology", Khanna Publishers, 17thEdition,2013.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112/107/112107144/

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
	Discussion on Outcome Based Education		
CONTENT DELIVERY (THEORY)			
1	Introduction to manufacturing processes.	CO 1	T2:2.3
2	Review on casting and pattern	CO 1	R1:2.6
3	Discuss the casting processes and their types	CO 1	T1:2.6
4	Describe the solidification of casting	CO 1	T2:2.7 R1:2.18
5	Describe the welding techniques	CO 2	T2:2.22
6	Discuss the effect of TIG and MIG welding	CO 3	T2:2.25
7	Discuss the effect of Heat affected zone in welding	CO 3	T2:2.26 R1:2.55
8	Discuss the welding defects	CO 3	T2:2.16 R1:2.61
9	Discuss the causes and remedies	CO 3	T2:2.30 R1:2.58
10	Introduction to destructive and non-destructive testing of welds.	CO 3	T2:3.6 R1:4.29
11	Classifying and Demonstration of metal forming	CO 4	T2:3.14 R1:4.31
12	Discuss the hot and cold working.	CO 4	T2:3.14 R1:4.33
13	Discuss the strain hardening recovery and recrystallization	CO 4	R1:4.36
14	Comparison of properties of cold and hot worked parts	CO 4	T2:3.18 R1:4.64
14	Comparison of properties of cold and hot worked parts	CO 4	T2:3.18 R1:4.64
15	Introduction to rolling	CO 4	T2:3.22

16	Demonstration of working of rolling operations	CO 4	T2:3.28 R1:4.67
17	Classifying rolling types.	CO 4	T2:4.2
18	Demonstration of rolling theory	CO 4	T2:4.3 R1:4.71
19	Introduction to mills and products and stamping	CO 4	T1:4.8 R2:4.68
20-21	Demonstration of forces in rolling and their calculations	CO 4	T2:4.15 R1:5.74
22	Discuss stamping forming and other cold operations.	CO 4	T1:4.12 R2:5.75
23-24	Explanation of blanking and piercing operations	CO 4	T1:4.8 R1:5.72
25	Introduction to drawing and its types.	CO 4	T1:5.8 R1:5.73
26-27	Discuss the wire and tube drawing techniques	CO 4	T1:5.14 R1:6.78
28	Explain extrusion of metals	CO 5	T2:5.19 R1:6.81
29-30	Discuss the characteristics of extrusion types	CO 5	T1:6.4 R2:6.8
31	Describe the importance of impact and extruding equipment.	CO 5	T2:7.7 R1:7.74
32-34	Describe hydrostatic extrusion, forces in extrusion	CO 5	T1:7.12 R2:8.75
35	Draw and Describe Forging operations and principles	CO 5	T1:8.8 R1:8.73
36	Discuss the tools, forging methods.	CO 5	T1:9.14 R1:10.78
37-38	Describe the Smith forging, drop forging	CO 5	T2:9.19 R1:10.814
39-40	Describe the importance of roll forging, forging hammers.	CO 5	T1:10.4 R2:11.68
41-43	Discuss the rotary forging, forging defects	CO 5	T2:10.7 R1:12.74
44-45	Describe the cold forging, swaging, forces in forging operations.	CO 5	T1:11.12 R2:12.75
PROBLEM SOLVING/ CASE STUDIES			
1	Explain various manufacturing processes. As an engineer when would you prefer selecting Casting as a manufacturing process?	CO 1	T2:2.3
2	Why coarse sand is better for steel casting than fine grained sand? Why is it that as castings increase in size, it is often better to use increasing coarse sand?	CO 1	T2:4.3
3	Compare the solidification times for castings of three different shapes of same volume: Cubic, cylindrical(with height equal to its diameter) and spherical.	CO 1	T1:2.3

4	Explain different types of flames with neat sketches in gas welding process. Give applications for each type.	CO 2	T1:2.3
5	Discuss parameters used in resistance spot welding process. Give the industrial applications of spot welding process.	CO 2	T2:2.3
6	Explain the effect of “Thermal conductivity” and “Thermal expansion” on welding process.	CO 2	T2:2.3
7	What are the types of rolling processes? What products are made by rolling processes?	CO 3	T2:2.3
8	Explain working principle of hydraulic and pneumatic press hot working and cold working process?	CO 3	T2:2.3
9	How are Blanking and piercing operations perform simultaneously in making compound die?	CO 3	T2:2.3
10	How do you find the forces in extrusion operation?	CO 4	T2:2.3
11	Summarize the key aspect of rapid prototyping. Explain With an example the historical development of rapid prototype technologies?	CO 4	T2:2.3
12	Explain, with suitable example, how rapid prototyping and tooling are the good examples as part of computer integrated Manufacturing.	CO 4	T2:2.3
13	How is cross sectional area of metal affected with application of force in the direction perpendicular to length axis in smith forging?	CO 5	T2:2.3
14	How internal cavities are can be overcome during extrusion of a metal?	CO 5	T2:2.3
15	What are the defects identified in forging and give remedies for each defects?	CO 5	T2:2.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	CASTING	CO 1	T2:2.3
2	WELDING -I	CO 2	T2:2.3
3	WELDING -II	CO 3	R2:5.1
4	FORMING	CO 4	T1:7.5
5	EXTRUSION AND FORGING	CO 5	T1: 4.1
DISCUSSION OF QUESTION BANK			
1	CASTING	CO 1	T2:7.3
2	WELDING -I	CO 2	T2:7.3
3	WELDING -II	CO 3	R2:5.1
4	FORMING	CO 4	T1:7.5
5	EXTRUSION AND FORGING	CO 5	T1: 4.1

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	Mechanical Engineering				
Course Title	Applied Thermodynamics				
Course Code	AME007				
Program	B. Tech				
Semester	FOUR				
Course Type	Core				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. G Aravind Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME003	III	Thermodynamics

II COURSE OVERVIEW:

Applied thermodynamics is the science of relationship between heat, work, and systems that analyze energy processes. The aim of this course is to apply the thermodynamic cycles, develop the power from a heat engines for various industrial and domestic applications. It makes use of the properties of thermodynamics to transform heat into work. Gasoline and diesel engines, jet engines, and steam turbines that generate electricity are all examples of heat engines. The proper understanding of compressors and refrigeration in various fields of engineering is addressed. Thus there is great relevance for this course for mechanical engineers.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Applied Thermodynamics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	x	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
40%	Understand
40%	Apply
10%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

I	The concepts related to the operation of internal combustion engines based upon the fundamental engineering sciences of thermodynamics.
II	The techniques for improving the efficiencies and performance of compressors and refrigeration systems retained to practical applications such as irrigation, air conditioning and refining oil and gas..
III	The performance of Heat Engines in real-time applications by applying the various testing parameters of an engine.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Classify** the fuel injection and ignition system to pretend the application of combustion chamber types such as T-head and overhead.	Understand
CO 2	**select** normal and abnormal combustion which affects the importance of flame front and flame propagation and knocking of engine variables	Remember
CO 3	**Experiment** with the testing and performance of an Internal combustion engine such as fuel consumption, power, efficiencies, and heat balance sheet.	Apply
CO 4	**Explain** the principle of operation related to the working of fan, blowers and compressors and their applications in industries/ factories and how do they differ with each other.	Understand
CO 5	**Solve** numerically related to the performance of all the variations in the velocity triangles pretended to single and multi-stage air compressors with industrial applications.	Apply
CO 6	**Outline** the basic concepts of refrigeration and vapor compression refrigeration systems with superheating and sub cooling to find out COP of refrigeration.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIA/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIA/SEE
PO 3	**Design/development of solutions::** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	1	CIA/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	CIA/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Formulate and evaluate concepts of thermo-fluid systems to provide solutions for inter disciplinary engineering applications sustainable designs for new generation automotive systems.	2	CIA/SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	✓	-
CO 4	✓	✓	-	-	-	✓	-	-	-	-	-	-	-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	✓	-	-	-	✓	-	-	-	-	-	-	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Identify (knowledge) in suitable methods involved in basic components of an IC Engine and the working of a 2-stroke and 4- Stroke engines in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** related to the components of IC engine based on various **data collection** of parts related to the usage in 2-stroke and 4-stroke engines in **validating the experimental design solutions** and also **Interpretation of results.**	5
CO 2	PO 3	Identify the various normal and abnormal combustion which knocking using **analytical and mathematical process.**	3
CO 3	PO 1	Apply the basic **mathematical principles** used in formulation of **engineering problems**	3
	PO 2	Understand the testing and performance of an Internal combustion by **information and data collection** related to various parameters and validate the **experimental data** in a heat balance sheet documentation and also **Interpretation of results**	5

	PO 4	Understanding of an **ability to apply a systems approach to engineering problems** and ensuring the **quality issues** related to performance and also **ability to work with technical uncertainty** meeting the **industry standards** such as fuel consumption, power, efficiencies, and heat balance sheet.	4
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications for** sustainable designs for new generation automotive systems.	2
CO 4	PO 1	Develop (knowledge, understand and apply) the basic tools used for **engineering problems** by applying the principles of **mathematics and engineering fundamentals.**	2
	PO 2	Identify the principle working of fan, blowers and compressors as well as material Selection and **identification model and validating the solutions** and also **Interpretation of results**	5
	PO 6	Understand the use of fan, blowers and compressors in industry usage and relevant legal requirements governing engineering activities, **including personnel, health, safety, and risk and for a high level of professional and ethical conduct in engineering.**	2
CO 5	PO 1	Explain understand the process parameter using complex the functions of engineering problems by applying the principles of **mathematics and engineering fundamentals.**	2
	PO 2	Categorize the concept of single and multi-stage compressors based upon the **data collection** with different **model transition to validate the solution** development for industrial applications.	4
CO 6	PO 1	Develop (knowledge, understand and apply) the basic tools used for **engineering problems** by applying the principles of **mathematics and engineering fundamentals.**	2
	PO 2	Identify the basic principles of refrigeration and identify the **problem statement and model** with VCRS system with the help of sub and super cooling and validate for a better feasible **solution development.**	4
	PO 3	**Understand the user needs of user-defined problems, use creativity** in building prototype applying the methods of model analyses **for innovative solutions, evaluate the outcomes to achieve engineering objectives.**	3
	PO 7	Explain the basic concepts of refrigeration and vapor compression refrigeration systems that **impact of the professional Engineering solutions in societal and Environmental contexts**	1

	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications for** sustainable designs for new generation automotive systems.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	5													
CO 2			3												
CO 3	2	5		4										2	
CO 4	2	5				2									
CO 5	2	4													
CO 6	2	4	3											2	

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	50.0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO 2	0	0	30.0	0	0	0	0	0	0	0	0	0	0	0	0
CO 3	66.7	50.0	0	36.6	0	0	0	0	0	0	0	0	0	66.6	0
CO 4	66.7	50.0	0	0	0	40.0	0	0	0	0	0	0	0	0	0
CO 5	66.7	40.0	0	18.0	0	0	0	0	0	0	0	0	0	0	0
CO 6	66.7	40.0	30.0	0	0	0	33.3	0	0	0	0	0	0	66.6	0

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	1	-	-	-	-	-	-	-	-	-	2	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 4	3	2	-	-	-	1	-	-	-	-	-	-	-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	1	-	-	-	1	-	-	-	-	-	-	-	-
TOTAL	24	8	1	1	-	-	-	-	-	-	-	-	-	4	-
AVERAGE	3.0	2.0	1.0	1.0										2.0	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments	-	-	-	-	

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**IC ENGINES,FUEL INJECTION AND LUBRICATION SYSTEMS**
	I. C Engines: Four and two stroke engine, SI and CI engines, valve and port timing diagrams, fuel injection systems for SI engines, fuel injection systems for CI engines, ignition systems, cooling and lubrication system, fuel properties and combustion, Stoichiometry.
MODULE II	**COMBUSTION IN SI AND CI ENGINES**
	Combustion in SI engines and CI engines: Normal combustion and abnormal combustion, importance of flame speed and effect of engine variables, type of abnormal combustion, pre-ignition and knocking, fuel requirements and fuel rating, anti-knock additives, combustion chamber, requirements, types; Combustion in CI Engines: Four stages of combustion, delay period and its importance, effect of engine variables, diesel Knock, need for air movement, open and divided combustion chambers and nozzles used, fuel requirements and fuel rating
MODULE III	**TESTING AND PERFORMANCE,COMPRESSORS**
	Testing and performance: Parameters of performance, measurement of cylinder pressure, fuel consumption, air intake, exhaust gas composition, brake power, determination of frictional losses and indicated power, performance test, heat balance sheet and chart.Compressors: Classification, of compressors, fans, blower and compressor, positive displacement and dynamic types, reciprocating and rotary types.

MODULE IV	ROTARY AND AXIAL CENTRIFUGAL COMPRESSORS
	Rotary, dynamic and axial flow (positive displacement): Roots blower, vane sealed compressor, mechanical details and principle of working efficiency considerations; Centrifugal compressors: mechanical details and principle of operation, velocity and Pressure variation, Energy transfer, impeller blade shape-losses, slip factor, and power input factor, pressure coefficient and adiabatic coefficient, velocity diagrams, power; Axial flow compressors: Mechanical details and principle of operation, velocity triangles and energy transfer per stage degree of reaction, work done factor, isentropic efficiency, pressure rise calculations, polytropic efficiency.
MODULE V	REFRIGERATION
	Refrigeration: Mechanical refrigeration and types, units of refrigeration, air refrigeration system, details and principle of operation, applications of air refrigeration, vapour compression refrigeration systems, calculation of COP, effect of superheating and sub cooling, desired properties of refrigerants and common refrigerants, vapour absorption system, mechanical details, working principle, use of p-h charts for calculations.

TEXTBOOKS

1. V. Ganesan, "I.C. Engines", Tata McGraw-Hill, 3rd Edition, 2011
2. K. Rajput, "Thermal Engineering", Lakshmi Publications, 1st Edition, 2011.
3. B. John Heywood, "Internal Combustion Engine Fundamentals", Tata McGraw-Hill, 2nd Edition,2011.

REFERENCE BOOKS:

1. Mathur, Sharma, "IC Engines", DhanpatRai& Sons, 3rd Edition, 2008.
2. Pulkrabek, "Engineering Fundamentals of IC Engines", Pearson Education, 2nd Edition,2008.
3. Rudramoorthy, "Thermal Engineering", Tata McGraw-Hill, 5th Edition 2003.
4. C P. Arora, "Refrigeration and Air Conditioning", Tata McGraw-Hill Education,2013.

WEB REFERENCES:

1. https://nptel.ac.in/courses/thermal engineering

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=pages/btech-course-descriptions-iare-UG20

AKANKSHA lEARNING MANAGEMENT SYSTEM:

1. https://lms.iare.ac.in/index.php?route=account/login

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	References
OBE DISCUSSION			
1	Course Description on Outcome Based Education(OBE): Course Objectives ,Course Outcomes(CO),Program Outcomes(PO) and CO-PO Mapping	-	lms/ iare.ac.in
CONTENT DELIVERY (THEORY)			
2	Define Heat engine and working of SI and CI engines	CO 1	T2:2.3
3	Illustrate crank angle valve and port diagrams	CO 1	T1:2.6
4	Explain different Fuel injection and ignition systems for CI engines	CO 1	T2:2.22
5	Explain Cooling and Lubrication system	CO 1	T2:2.26 R1:2.55
6	Illustrate different fuels and its properties with their stoichiometry.	CO 1	T2:2.16 R1:2.61
7	Discuss phenomena of combustion process	CO 2	T2:2.30 R1:2.58
8-9	Emphasize Normal and abnormal combustion phenomena.	CO 2	T2:3.6 R1:4.29
10-11	Discuss Importance of flame speed and its effect on engine variables	CO 2	T2:3.14 R1:4.31
12	Demonstrate Knocking and its additives	CO 2	T2:3.14 R1:4.33
13-14	Illustrate different types of combustion chambers	CO 2	R1:4.36
15	Explain Four stages of combustion in C.I. Engines. Discuss delay period	CO 2	T2:3.18 R1:4.64
16-18	Discuss knocking and its effect on engine variables.	CO 2	T2:3.22
19	What is the need for air movement and discuss different combustion chambers.	CO 2	T2:3.28 R1:4.67
20-21	What are the fuel requirements, performance characteristics	CO 3	T2:4.2
22	Determination of frictional power, efficiency, brakes power.	CO 3	T1:4.8 R2:4.68
23	Discuss sankey diagram for heat balance sheet by means of losses.	CO 3	T2:4.15 R1:5.74
24	Performance analysis of IC engines and Classify compressors and types	CO 4	T1:4.12 R2:5.75
25	Explain the working of roots blower vane sealed compressor and its mechanisms and Mechanism details of centrifugal compressors	CO 4	T1:5.14 R1:6.78
26-28	Define power input factor, pressure coefficient and adiabatic coefficient	CO 4	T1:6.4 R2:6.8
29	Draw velocity diagrams and find power	CO 4	T2:7.7 R1:7.74

30-31	Discuss working principle of Axial flow compressor and find the efficiency and work done factor, isentropic, polytropic efficiency.	CO 5	T1:7.12 R2:8.75
32	Define refrigerating effect and its principle of operation and Air refrigeration system	CO 6	T1:9.14 R1:10.78
33	Discuss vapour compression system components and calculate cop.	CO 6	T1:10.4 R2:11.68
34	Explain vapour absorption system-mechanical details-working principle and Problems on p-h chart.	CO 6	T2:10.7 R1:12.74
35	Numerical problems: Testing and performance of engine parameters,Calculation of efficiencies of IC engine,heat balance sheet	CO 6	T1:1.5 R1:2.4
36	Single stage,multi and air compressor	CO 5	T1:2.5 R1:2.6
37	Velocity diagram for compressor	CO 5	T1:18.10 R1:17.7
38	Air refrigeration system	CO 6	T1:18.10 R1:17.7
39	Vapour compression refrigeration system	CO 5	T1:19.3 R1:18.2
40	Vapour absorption refrigeration system	CO 6	T1:19.5 R1:18.4
PROBLEM SOLVING/ CASE STUDIES			
41	Parameters of performance, measurement of cylinder pressure,	CO 3	T2:2.3
42	Parameters of performance, measurement offuel consumption	CO 3	T1:4.8 R2:4.68
43	Parameters of performance, measurement of air intake	CO 3	T1:4.12 R2:5.75
44	exhaust gas composition	CO 3	T1:4.8 R2:4.68
45	brake power	CO 3	T1:4.8 R1:5.72
46	determination of frictional losses and indicated power	CO 3	T1:5.14 R1:6.78
47	performance test	CO 3	T2:7.7 R1:7.74
48	heat balance sheet and chart	CO 3	T1:8.8 R1:8.73
49	mechanical details and principle of operation, velocity and Pressure variation,	CO 4	T1:12.4 R2:13.68
50	Energy transfer, impeller blade shape-losses, slip factor, and power input factor.	CO 5	T2:13.7 R1:14.74
51	pressure coefficient and adiabatic coefficient	CO 5	T2:9.19 R1:10.814
52	velocity diagrams, power; Axial flow compressors,Mechanical details and principle of operation	CO 5	T2:9.19 R1:10.814

53	velocity triangles and energy transfer per stage degree of reaction	CO 5	T1:10.4 R2:11.68
54	work done factor, isentropic efficiency	CO 5	T1:10.4 R2:11.68
55	work done factor, isentropic efficiency	CO 5	T2:10.7 R1:12.74
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Module I: IC engines,fuel injection and lubrication system	CO 1	T2:2.3
57	Module II: Combustion in SI and CI engines	CO 2	T2:3.14 R1:4.33
58	Module III:Testing and performance,Compressors	CO 3, CO 4	T2:4.2 R1:5.72
59	Module IV:Rotary and Axial Centrifugal Compressors	CO 5	T2:7.7 R1:7.74
60	Module V:Refrigeration	CO 6	T2:9.19 R1:10.814
DISCUSSION OF QUESTION BANK			
61	Module I: IC engines,fuel injection and lubrication system	CO 1	T2:2.3
62	Module II: Combustion in SI and CI engines	CO 2	T2:3.14 R1:4.33
63	Module III:Testing and performance,Compressors	CO 3, CO 4	T2:4.2 R1:5.72
64	Module IV:Rotary and Axial Centrifugal Compressors	CO 5	T2:7.7 R1:7.74
65	Module V:Refrigeartion	CO 6	T2:9.19 R1:10.814

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Kinematics of Machinery**				
Course Code	AME009				
Program	B.Tech				
Semester	IV				
Course Type	Foundation				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr K. Viswanath Allamraju, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB002	II	Engineering Mechanics
B.Tech	AMEB001	II	Engineering Drawing

II COURSE OVERVIEW:

Mechanical devices are designed to have mobility to perform certain functions. The theory behind the study of Kinematics of Machine leads us to design machines by understanding the relationship between the geometry and the motion of various parts of machine. This course will provide the knowledge on how to analyze the motions of mechanisms and design synthesis mechanisms to give required mobility. This includes relative motion analysis and design of gears, gear trains, cams, linkages and steering mechanism gears by adopting simultaneously both graphical and analytical approaches to estimate displacement, velocity and acceleration of links in a machine.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Kinematics of Machines	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
25%	Understand
50 %	Apply
25%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

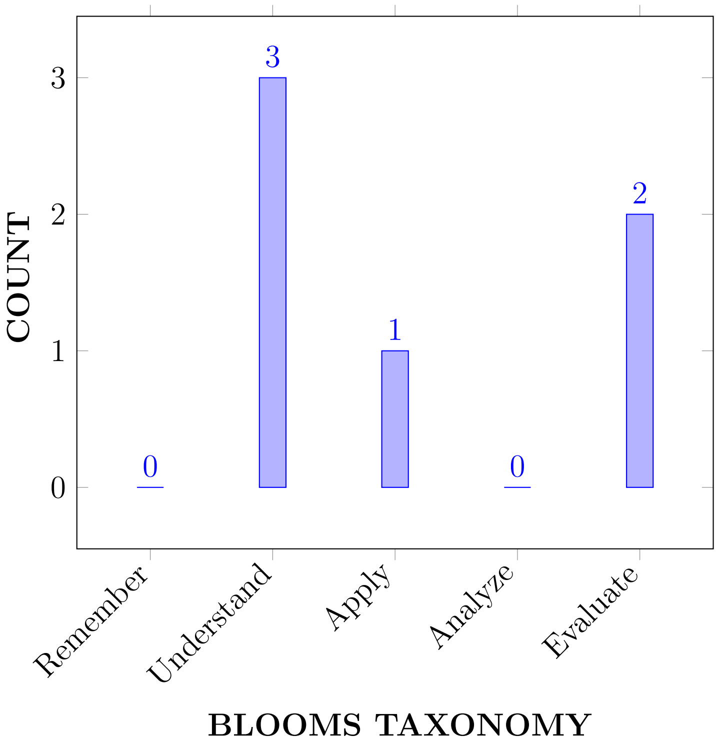
I	The basic concepts of Machine design to develop Mechanisms and Machines by using type synthesis , number synthesis and dimensional synthesis.
II	The Kinematics from the geometric point of view to determine mobility ,velocity and acceleration using graphical methods.
III	The Mechanisms with lower pairs to obtain steering, copying and straight line motions in automobiles and other allied applications.
IV	The Kinematic analysis and synthesis of cams imparting motion to knife edged, roller and mushroom followers , Gears and Gear trains..

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Discuss** thetypes of the kinematic synthesis for building a mechanism/Machine for mobility.	Understand
CO 2	**Illustrate** the velocity and acceleration analysis of various mechanisms by relative velocity method and I Center method.	Understand
CO 3	**Identify** the various mechanisms for the approximate straight line motions.	Apply
CO 4	**Justify** the importance of steering gear mechanisms for optimum operation of automobile vehicles.	Evaluate
CO 5	**Develop** the Cam profiles for different motions of various followers .	Evaluate
CO 6	**Illustrate** the design function of planetary gear train system and its methods of evaluationfor gear train value.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/Quiz/AAT
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	CIE/Quiz/AAT
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	CIE/Quiz/AAT
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	CIE/Quiz/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2	CIE/Quiz/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Quiz
PSO 3	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining.	2	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	✓	-		-	-	-
CO 2	✓	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 4	✓	✓	✓	-	-	-	-	-	-	-	-		-	-	-
CO 5	✓	-	-	-	-	-	-	✓	-	-	✓	-	✓	-	-
CO 6	✓	-	-	✓	-	-	-	-	-	-	-	✓	-	-	✓

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to classify various kinematic systems	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Identify the problem statement dentify the problem statement, formulation , data collection ,validation and interpretation** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	5
	PO 10	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and determine the velocity of various mechanisms at different conditions	3
	PO 2	Illustrate the performance parameters of four bar mechanisms **first principles of Mathematics and engineering sciences and identify the problem statement, formulation , data collection ,validation and interpretation.**	5
	PO 5	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	1
CO 3	PO 1	Identify the velocity and acceleration values of mechanisms **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 7	**Identify the problem statement, socio economic and environmental** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	2
CO 4	PO 1	Justify the knowledge of different forces (**scientific Principles and mathematical principles**) for steering gear mechanisms and describe different performance parameters.	3
	PO 2	Determine the condition for correct steering **and also identify the problem statement, formulation , data collection ,validation and interpretation** of various steering mechanisms	5
2-4	PO 3	**Identify the customer needs, investigate, innovate** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 5	PO 1	Develop the fundamentals of engineering and science in identifying the cam profile **using the fundamentals of engineering and mathematical equations**	3
	PO 8	**Identify the problem statement and apply ethics to** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to CAM profile diagrams	2
	PO 11	**Identify the problem statement for quality, budget, schedule** (mission requirement), to select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to CAM profiles	6
	PS O1	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	1
CO 6	PO 1	Formulate the problem statement and model the system for getting the solution of cams to regulate the speed of machines**using fundamentals of science &and engineering fundamentals.**	3
	PO 4	Understand the technical concepts of followers and interpret the equilibrium conditions for various applications for **complex engineering problems.**	5
	PO 12	Investigate and define a problem and identify constraints of mechanisms **environmental and sustainability limitations, health and safety and risk assessment issues** when dealing with performance of followers and their application on real world problems	4
	PSO 3	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	5	-	-	-	-	-	-	-	2	-		-	-	-
CO 2	3	5	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 4	3	5	5	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	2	-	-	6	-	1	-	-

CO 6	3	-	-	5	-	-	-	-	-	-	-	4	-	-	1

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	50	-	-	-	-	-	-	-	50	-		-	-	-
CO 2	100	50	-	-	50	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	50	-	-	-	-	-	-	-	-
CO 4	100	50	50	-	-	-	-	-	-	-	-		-	-	-
CO 5	100	-	-	-	-	-	-	50	-	-	50	-	100	-	-
CO 6	100	-	-	50	-	-	-	-	-	-	-	50	-	-	50

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -5 $< C \leq 40\%$ – Low/ Slight

2 - 40 % $< C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	2	-		-	-	-
CO 2	3	2	-	-	3	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 4	3	2	2	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	2	-	-	2	-	3	-	-
CO 6	3	-	-	2	-	-	-	-	-	-	-	2	-	-	2
TOTAL	18	6	2	2	3	-	2	2	-	2	2	-	3	-	2
AVERAGE	3	2	2	2	3	-	2	2	-	2	2	-	3	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams		SEE Exams		Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 4	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**MECHANISMS and MACHINES**
	Mechanisms: Elements or links, classification, rigid link, flexible and fluid link, types of kinematic pairs types of constrained motion, kinematic chain, mechanism, machine, structure, inversion of mechanism, inversions of quadric cycle chain, single and double slider crank chains, mechanical advantage, Grubler's Criterion.
MODULE II	**KINEMATICS, PLANE MOTION OF BODY, ANALYSIS OF MECHANISMS**
	Kinematics: Velocity and acceleration, motion of link in machine, determination of velocity and acceleration, Graphical method, application of relative velocity method, plane motion of body: Instantaneous center of rotation, centroids and axodes, three centers in line theorem, graphical determination of instantaneous center, determination of angular velocity of points and links by instantaneous center method. Klein's construction, Coriolis acceleration, determination of Coriolis component of acceleration; Analysis of mechanisms: Analysis of slider crank chain for displacement, velocity and acceleration of slider, acceleration diagram for a given mechanism.
MODULE III	**STRAIGHT LINE MOTION MECHANISMS, STEERING GEARS, HOOKE'S JOINT**
	Straight-line motion Mechanisms: Exact and approximate copied and generated types, Peaucellier, Hart and Scott Russul, Grasshopper, Watt, TChebicheff and Robert mechanisms, pantograph. Steering gears: Conditions for correct steering, Davis Steering gear, Ackerman's steering gear, Hooke's joint: Single and double Hooke's joint, velocity ratio, application, problems.
MODULE IV	**CAMS, ANALYSIS OF MOTION OF FOLLOWERS**
	Cams: Definitions of cam and followers, their uses, types of followers and cams, terminology, types of follower motion, uniform velocity, simple harmonic motion and uniform acceleration; Maximum velocity and maximum acceleration during outward and return strokes in the above three cases; Analysis of motion of followers: Tangent cam with roller follower, circular arc cam with straight, concave and convex flanks
MODULE V	**HIGHER PAIRS, GEAR TRAINS**
	Higher Pairs: friction wheels and toothed gears, types, law of gearing, condition for constant velocity ratio for transmission of motion, velocity of sliding, form of teeth, cycloidal and involute profiles, phenomena of interferences, methods of interference; Condition for minimum number of teeth to avoid interference, expressions for arc of contact and path of contact of pinion and gear pinion and rack arrangements; Introduction to helical, bevel and worm gearing; Gear trains: Introduction, types, simple and reverted gear trains, epicyclic gear train; Methods of finding train value or velocity ratio of epicyclic gear trains, selection of gear box, differential gear for an automobile.

TEXTBOOKS

1. Amithab Ghosh, Asok Kumar Malik, "Theory of Mechanisms and machines", East West Press Pvt Ltd, 2001.
2. S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 4th Edition, 2014
3. R. L. Norton, "Kinematics and Dynamics of Machinery", McGraw-Hill, 1st Edition, 2009.
4. P.L. Balleny, "Theory of Machines and Mechanisms", Khanna publishers, 2013.

REFERENCE BOOKS:

1. J. S. Rao, R.V. Dukkipati, "Mechanism and Machine Theory", New Age Publication, 1st Edition, 2013.
2. Uiker, Penock, Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition,2013.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to kinematic pairs	CO1	T2 17.2
2	Determination of degree of freedom, problems.	CO2	T2 17.1
3	inversion of mechanism – inversions of quadric cycle chain, single and double slider crank chains .	CO2	T2 17.8
4	Mechanical Advantage and Grubler's Criterion	CO2	T2 17.6
5	Velocity of link in machine, Vector diagram for velocity.	CO1	T2 17.3
CONTENT DELIVERY (THEORY)			
6	Relative velocty method of four bar mechansim	CO2	T2 17.4
7	Relative velocty method of slider crank mechansim	CO3	T2 12.1
8	Determination of Velocity using Graphical method using relative velocity method.	CO3	T2 12.6
9	Acceleration of link in machine, Vector diagram for Acceleration.	CO3	T2 8.2
10	Watt, T.Chebicheff and Robert Mechanisms - Pantograph.	CO4	T2 8.9
11	Conditions for correct steering – Davis Steering gear, Ackerman's steering gear.	CO4	T2 15.1
12	Single and double Hooke's joint – Velocity Ratio – application – problems.	CO4	T2 15.8
13	Definitions of cam and followers, their uses	CO4	T2 15.9
14	Types of followers and cams, Terminology, Types of follower motion	CO5	T2 15.13
15	Uniform velocity, Simple harmonic motion	CO5	T2 13.12
16	Uniform acceleration. Maximum velocity and maximum acceleration during outward and return strokes in the various cases.	CO5	T2 13.11
17	Analysis of motion of followers: Tangent cam with Roller follower	CO5	T2 13.7

18	Cam mechanisms	CO5	T2 13.13
19	Synthesis of tangent cam	CO5	R3 16.12
20	Synthesis of circular arc cam	CO5	R3 16.18
21	Problems on Cam profiles	CO5	R3 16.21
22	Fundamentals of toothed gear	CO6	T2:16.1
23	Friction wheels and toothed gears and types of gears.	CO6	T2 16.3,4
24	Law of gearing -Condition for constant velocity ratio for transmission of motion - Velocity of sliding.	CO6	T2:16.5,6
25	Problems on toothed gears	CO6	T2:16.14
26	Form of teeth, cycloidal and involute profiles	CO6	R318.12
27	Phenomena of interferences – Methods of interference.	CO 5	T2:21.2
28	Condition for minimum number of teeth to avoid interference	CO 5	T2:21.1
29	Problems on Condition for minimum number of teeth to avoid interference	CO 5	T2:22.1
30	lenght of Path of contact	CO 5	T2:22.2
31	Length of Arc of contact	CO 5	R3 22.10
32	Contact ratio	CO 5	R322.4
33	Pinion and Rack arrangements	CO 5	R3 22.3
34	Introduction to Helical, Bevel and worm gearing.	CO 5	R3 22.13
35	Types of gears	CO 5	R3 22.12
36	Types of gear trains	CO6	T2.18.1
37	Epicyclic gear train.Methods of finding train value or velocity ratio of Epicyclic gear trains.	CO6	T2 18.6
38	Selection of gear box-Differential gear for an automobile.	CO6	R3 23.9
39	Problems on epicyclic gear train	CO6	R3 23.11
40	Tabular method	CO6	R3 23.4
41	Analytical method	CO6	R3 23.5
42	Equation of motion of gears	CO6	R3 23.12
43	Sun and Plant gears	CO6	R3 24.4
44	Annualr gear wheel	CO6	R3 24.5
45	Problems on sun and planet gear	CO6	R3 24.6
PROBLEM SOLVING/ CASE STUDIES			
46	Problems on annular gear.	CO6	R3 24.4
47	Problems on epicyclic gear train	CO6	R3 23.18
48	Applying velocity ratio in solving problems	CO6	R3 23.18
49	Law of gearing	CO6	R323.23
50	Applications of gear trains to real world problems	CO10	R3 23.14
51	Uniform velocity, Simple harmonic motion	CO5	T2 13.12
52	Uniform acceleration. Maximum velocity and maximum acceleration during outward and return strokes in the various cases.	CO5	T2 13.11
53	Analysis of motion of followers: Tangent cam with Roller follower	CO5	T2 13.7
54	Cam mechanisms	CO5	T2 13.13

55	Synthesis of tangent cam	CO5	R3 16.12
56	Synthesis of circular arc cam	CO5	R3 16.18
57	Problems on Cam profiles	CO5	R3 16.21
58	Fundamentals of toothed gear	CO6	T2:16.1
59	Friction wheels and toothed gears and types of gears.	CO6	T2 16.3,4
60	Law of gearing -Condition for constant velocity ratio for transmission of motion - Velocity of sliding.	CO6	T2:16.5,6
61	Problems on toothed gears	CO6	T2:16.14
DISCUSSION OF DEFINITION AND TERMINOLOGY			
62	Uniform velocity, Simple harmonic motion	CO5	T2 13.12
63	Uniform acceleration. Maximum velocity and maximum acceleration during outward and return strokes in the various cases.	CO5	T2 13.11
64	Analysis of motion of followers: Tangent cam with Roller follower	CO5	T2 13.7
65	Cam mechanisms	CO5	T2 13.13
66	Synthesis of tangent cam	CO5	R3 16.12
DISCUSSION OF QUESTION BANK			
67	Crank and Slotted lever mechanism, Degrees of freedom of various mechanisms	CO 1	R4:2.1
68	Velocity and acceleration diagrams by relative velocity method and I center method	CO 2	T4:7.3
69	Condition for correct steering, Davis steering gear mechanism	CO 3	R4:5.1
70	Cam profiles of knofe edge follower, roller follower and flat faced follower	CO 4	T1:7.5
71	Length of Path of contact, Length of arc of contact and contact ratio, speed of gears	CO 5,6	T1: 4.1

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**Mechanics of Fluids and Hydraulic Machines**				
Course Code	AME008				
Program	B.Tech				
Semester	IV	ME			
Course Type	Foundation				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	2
Course Coordinator	Mr. G Sarat Raju, Assistant Professor				

I COURSE OVERVIEW:

Fluid mechanics is that branch of science which deals with the behavior of the fluids (liquids or gases) at rest as well as in motion. Thus this branch of science deals with the static, kinematics and dynamic aspects of fluids. The proper understanding of mechanics of fluids is critical in various branches of engineering. The primary motive of this course is to examine, through the laws of fluid mechanics and thermodynamics, the means by which the energy transfer is carried out in the turbomachinery, together with the differing behavior of individual types in operation.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME002	II	Engineering Mechanics
B.Tech	AME003	III	Thermodynamics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Mechanics of Fluids and Hydraulic Machines	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	x	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking an average of two CIA examinations or the marks scored in the make-up examination.

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The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
60 %	Understand
30 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

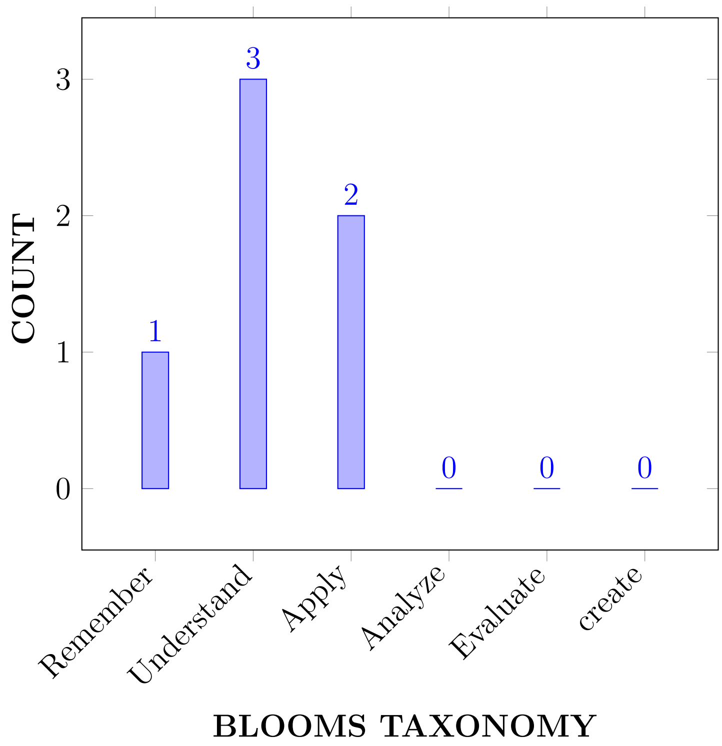
I	The fundamental knowledge of fluids, their properties and behaviour under various conditions of closed conduit and external flow systems.
II	The development of various static and dynamic fluid flow governing equations from the fundamental conservation laws of motion studied under basic physics and classical mechanics.
III	The application of boundary layer theory, Euler's equation, continuity and impulse-momentum equation in fluid flows.
IV	The concepts of fluid mechanics and hydraulics to apply in real world engineering applications such as hydraulic turbines and pumps in power stations.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Relate** the basic properties, various types and patterns of fluid flow configurations that are encountered in fluid flows.	Remember
CO 2	**Apply** the basic laws of conservation for various phenomena of fluid flow systems by understanding appropriate parametric assumptions and limitations.	Apply
CO 3	**Outline** the regimes and separation of boundary layer during external fluid flow systems.	Understand
CO 4	**Compare** the total and hydraulic gradient lines for distinct cases of losses during a closed conduit fluid flow systems.	Understand
CO 5	**Demonstrate** the theories, phenomena and working principles of hydraulic machines.	Understand
CO 6	**Make use of** the dimensionless parameters, model analysis to analyze prototypes of hydraulic pumps.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	3	CIE/Quiz/AAT
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	SEE/CIA

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	AAT

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-		-	-	✓
CO 3	✓	✓	✓	-	-	-	-	-	-	-	-		-	-	-
CO 4	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Identify (knowledge) the basic properties, various types, patterns of fluid flow configurations and to a considerable extent appreciate (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the principles of **mathematics, science**	2
CO 2	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use mathematical principles for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics.	3
	PO 2	Understand the given problem statement and formulate (complex) fluid flow engineering phenomena and systems for deriving various governing equations of fluid mechanics from the provided information and substantiate with the interpretation of variations in the results.	4
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur, and to desire higher studies in the field of fluid mechanics.	2

CO 3	PO 1	Relate (knowledge, understand, and apply) the regimes and separation of the boundary layer during external fluid flow (complex) engineering problems by applying the principles of **mathematics, science, and fluid engineering fundamentals.**	2
	PO 2	Understand the given problem statement and formulate boundary layer phenomena of external fluid flow (complex) engineering problems from the provided information and data in reaching substantiated conclusions by the interpretation of results.	4
	PO 3	Recognize (knowledge) the characteristics of boundary layer regimes and processes, understand the corresponding context of the engineering knowledge, technical uncertainty of the boundary layer causing the separation, analyze key regimes of the boundary layer by applying the displacement measures incorporating the systems approach.	4
CO 4	PO 1	**Identify and interpret** the working of breaking system used in automobile and its **result** on vehicle.	3
CO 5	PO 1	**Understand** the working of different steering **mechanisms** using kinematics of machines fundamentals	2
	PO 2	**Identify, formulate, and interpret** the various steering gear mechanisms and **Understand** the importance toe in toe out	4
	PSO 1	**Select** the appropriate steering by using new manufacturing methods.	2
CO 6	PO 1	Recognize (knowledge) the importance and application (apply) of dimensions, units, and dimensional homogeneity in solving (complex) engineering problems with specific emphasis on fluid mechanics by applying the principles of **mathematics and engineering fundamentals.**	2

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched											PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	-	-	-	-	-	2	-	-	-	-		1	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-		2	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-		-
CO 5	2	4	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 6	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	40	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.6	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 3	66.6	-	-	-	-	-	-	-	-	-	-		100	-	-
CO 4	100	-	-	-	-	-	-	-	-	-	-	-	100		-
CO 5	66.6	40	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 6	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

2 - 40 % <C < 60% –Moderate

1-5 <C$\leq$ 40% – Low/ Slight

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	1	-	-	3	-	-	-	-	-	-		-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-		3	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	3		-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	-				

XVI ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVII SYLLABUS:

MODULE I	**FLUID STATICS**
	Definition of fluid, Newton's law of viscosity, Units and dimensions-Properties of fluids, mass density, specific volume, specific gravity, viscosity, compressibility and surface tension, Control volume-application of continuity equation and momentum equation, Incompressible flow.
MODULE II	**FLUID KINEMATICS AND DYNAMICS**
	Fluid Kinematics: Kinematics of fluid flow- Eulerian and Lagrangian descriptions, Stream line, path line, streak line and stream tube, classification and description of flows for one and three dimensions. Fluid Dynamics: Euler's equation of motion, Bernoulli equation for flow along a streamline and applications, Measurement of flow.
MODULE III	**BOUNDARY LAYER CONCEPTS AND CLOSED CONDUIT FLOW**
	Concept of boundary layer – Definition, characteristics along with the thin plate, laminar, transition, and turbulent boundary layers, separation of the boundary layer, measures of boundary layer thickness. Closed conduit flow: – Darcy Weisbach equation, friction factor, Head loss in pipe flow, Moody's diagram. Exact flow solutions in channels and ducts, Couette and Poisuielle flow, laminar flow through circular conduits, and circular annuli.
MODULE IV	**FLUID MACHINES**
	Classification of water turbines, heads, and efficiencies, velocity triangles- Axial, radial, and mixed flow turbines- Pelton wheel, Francis turbine, and Kaplan turbines, working principles – draft tube- Specific speed, unit quantities, performance curves for turbines – governing of turbines
MODULE V	**PUMPS**
	Pumps: Theory of rotodynamic machines, various efficiencies, velocity components at entry and exit of the rotor, velocity triangles, Centrifugal pumps, working principle, work done by the impeller, performance curves – Cavitation in pumps- Reciprocating pump–working principle.

TEXTBOOKS

1. R.K. Rajput, "Fluid Mechanics and Hydraulic Machines", S. Chand and Co, 6th Edition, 1998

2. H Modi, Seth, "Hydraulics, Fluid Mechanics and Hydraulic Machinery", Rajsons, Publications, 20th Edition, 2013.

REFERENCE BOOKS:

1. D.S. Kumar, "Fluid Mechanics and Fluid Power Engineering", Kotaria and Sons, 9th Edition 2013..

2. Dr. R K Bansal, "A Text Book of Fluid Mechanics and Hydraulic Machines", Laxmi Publications, 9th Edition, 2015.

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
1	Introduction to fluid mechanics, statics, units and dimensions.	CO 1	T1:1.4 R1:1.2
2-3	Properties of fluids: mass density, specific volume, specific gravity, compressible and incompressible flow.	CO 1	T2:1.5 R2:2.4
4	Viscosity and Newton's law of viscosity.	CO 1	T1:1.6
5	Surface tension and Control volume	CO 1	T2:1.7 R2:2.4
6-7	Continuity equation in 1D, 2D and 3D	CO 1	T1:7.5 R1:6.3
8	Applications of continuity equation	CO 1	T1:7.5 R2:6.3
9	Momentum equation and its applications.	CO 1	T2:7.5
10	Fluid Kinematics: Kinematics of fluid flow- Eulerian and Lagrangian descriptions.	CO 1	T2:22.7
11	Stream line, path line, streak line and stream tube.	CO 2	T1:22.7
12-13	Classification and description of flows for one and three dimensions.	CO 2	T1:7.5 R2:6.3
14	Fluid Dynamics: Euler's equation of motion.	CO 1	T1:12.2 R2:13.1
15-16	Bernoulli equation for flow along a stream line and applications.	CO 3	T1:12.3
17-18	Measurement of flow.	CO 3	T1:2.5 R2:2.6
19	Concept of boundary layer – Definition.	CO 3	T2:12.3 R1:13.2
20-21	Characteristics along thin plate, laminar, transition and turbulent boundary layers.	CO 3	T2:12.3 R2:13.2
22	Separation of boundary layer, measures of boundary layer thickness.	CO 4	T2:11.2 R2:10.2
23	Closed conduit flow: Darcy Weisbach equation and friction factor,	CO 4	T2:16.3 R2:15.3
24-25	Head losses in pipe flow, Moody's diagram.	CO 4	T1:16.7 R2:15.3
26	Exact flow solutions in channels and ducts; Couette and Poisuielle flow	CO 4	T1:17.6 R1:16.8
27	Laminar flow through circular conduits and circular annuli.	CO 4	T1:17.9 R2:16.11

28	Classification of water turbines, heads, efficiencies and Working principle of Pelton wheel turbine.	CO 4	T1:18.3 R2:17.2
29	Velocity triangles of Pelton wheel turbine.	CO 4	T1:18.10 R2:17.7
30-31	Working principle and velocity triangles of Francis turbine.	CO 5	T2:18.15 R2:17.9
32-33	Working principle and velocity triangles of Kaplan turbine.	CO 5	T1:18.18 R1:17.11
34	Draft tube and Specific speed.	CO 5	T1:18.4 R1:17.8
35	Unit quantities and performance curves for turbines.	CO 5	T2:18.5 R2:17.9
36	Governing of turbines.	CO 5	T1:18.6 R2:17.10
37	Dimensional Analysis: Need for dimensional analysis, methods of dimension analysis.	CO 6	T1:19.2 R2:18.5
38	Similitude, types of similitude dimensionless parameters, application of dimensionless parameters.	CO 6	T1:19.5 R2:18.7
39	Model analysis.	CO 6	T1:19.9 R1:18.11
40	Pumps: Theory of rotodynamic machines, various efficiencies.	CO 6	T1:19.3 R2:18.2
41	Centrifugal pumps, working principle, work done by the impeller.	CO 6	T1:19.3 R1:18.2
42-43	Centrifugal pumps, velocity components at entry and exit of the rotor, velocity triangles.	CO 6	T1:19.3 R1:18.2
44	Performance curves and cavitation in pumps	CO 6	T1:19.4 R1:18.3
45	Reciprocating pump–working principle.	CO 6	T1:19.5 R2:18.4
PROBLEM SOLVING/ CASE STUDIES			
46	An oil film of thickness 1.5mm is used for lubrication between a square plate of size 0.9m x 0.9m and an inclined plane having an angle of inclination 200. The weight of the square is 392.4 N and it slides down the plane with a uniform velocity of 0.2 m/s. Determine the dynamic viscosity of the oil.	CO 1	T1:1.6
47	An orifice meter with orifice diameter 15 cm is inserted in a pipe of 30 cm diameter. The pressure difference measured by a mercury oil differential manometer on the two sides of the orifice meter gives a reading of 50 cm of mercury. Calculate the rate of flow of oil of specific gravity 0.9 when the co-efficient of discharge of the meter = 0.64.	CO 2	T1:7.5 R2:6.3

48	A thin plate is moving in still atmospheric air at a velocity of 5 m/s. the length of the plate is 0.6 m and width 0.5 m. Calculate i) the thickness of the boundary layer at the end of the plate and ii) drag force on one side of the plate. Take density of air as 1.24kg/m3 and kinematic viscosity 0.15 stokes.	CO 3	T2:12.3 R1:13.2
49	A horizontal pipe of diameter 1000 mm is suddenly contracted to a diameter of 500 mm. The pressure intensities in the large and smaller pipe is given as 13.734 N/cm2 and11.772N/cm2 respectively. Calculate the loss of head due to contraction if Cc = 0.62. Also determine the rate of flow of water.	CO 4	T1:16.7 R2:15.3
50	A Kaplan turbine develops 20MW power at an average head of 69 m. assuming speed ratio of 4, flow ratio of 1.2, diameter of the boss = 0.35 x diameter of the runner and an overall efficiency of 90the diameter, speed and specific speed of the turbine.	CO 5	T1:18.18 R1:17.11
51	The diameter of an impeller of a centrifugal pump at inlet and outlet are 30 cm and 60 cm respectively. Determine the minimum starting speed of the pump, if it works against a head of 30 m.	CO 6	T1:19.3 R1:18.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
52	Fluid, Newton's law of viscosity, Properties of fluids, mass density, specific volume, specific gravity, viscosity, compressibility and surface tension	CO 1	T1:1.4
53	Kinematics of fluid flow- Eulerian and Lagrangian descriptions, Euler's equation of motion, Bernoulli equation for flow along a stream line and applications	CO 2	T2:22.7
54	Laminar, transition and turbulent boundary layers, Darcy Weisbach equation, friction factor, Head loss in pipe flow, Moody's diagram	CO 3,4	T2:12.3
55	Pelton wheel, Francis turbine and Kaplan turbines, draft tube, Specific speed, performance curves for turbines	CO 5	T1:18.3
56	Centrifugal pumps, Reciprocating pump and their working principle	CO 6	T1:19.3
DISCUSSION OF QUESTION BANK			
57	Module I: Fluid Statics	CO 1	T1:1.4
58	Module II: Fluid Kinematics and Dynamics	CO 2	T2:22.7
59	Module III: Boundary Layer Concepts and Closed Conduit Flow	CO 3,4	T2:12.3
60	Module IV: Fluid Machines	CO 5	T1:18.3
61	Module V: Pumps	CO 6	T1:19.3

Signature of Course Coordinator **HOD, ME**
Mr. G Sarat Raju, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**Computational Mechanical Engineering Laboratory**				
Course Code	AME106				
Program	B.Tech				
Semester	IV	ME			
Course Type	Practical				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. G. Aravind Reddy, Assistant Professor				

I COURSE OVERVIEW:
The aim of this course is to write programme for analysis of mechanical structures through mathematical modeling. It is a high-level language for numerical computation, visualization and application development. It also provides an interactive environment for iterative exploration, design and problem solving. It provides vast library of mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, numerical integration and solving ordinary differential equations. It provides built-in graphics for visualizing data and tools for creating custom plots. MATLAB's programming interface gives development tools for improving code quality maintainability and maximizing performance.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME002	II	Engineering Mechanics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computational Mechanical Engineering Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:
Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

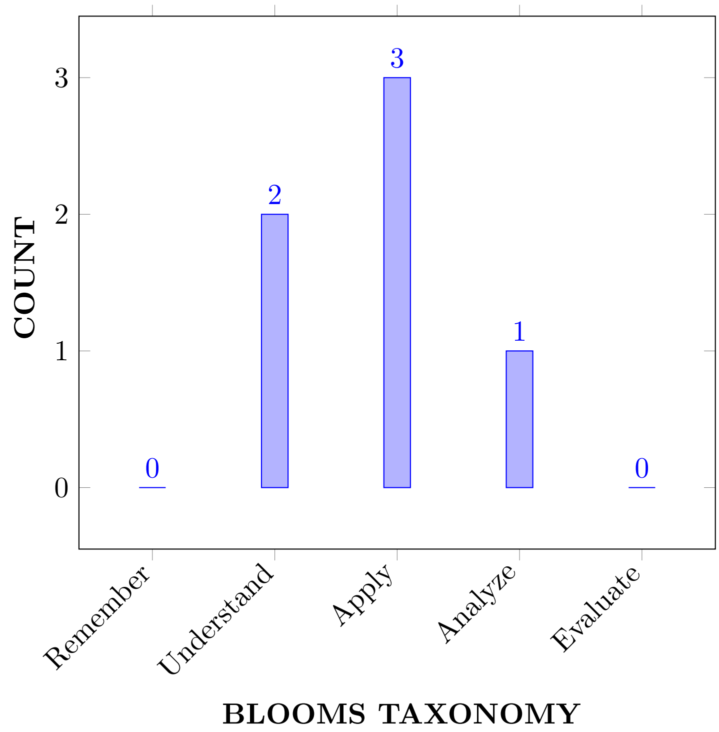
I	Develop MAT LAB programs for simple and complex engineering problems.
II	Interpret the output graphical plots for the given governing equation.
III	Apply the MATLAB programming to real time applications.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Discuss** the MAT files, .M files, Script files for numerical computation, visualization and application development. .	Understand
CO 2	**Observe** the 2D and 3D plotting and graphics for effective interpretation of results in relation to analytical calculations.	Apply
CO 3	**Observe** the kinematics of a four bar mechanism through the MATLAB for fabricating the robotic mechanism.	Apply
CO 4	**Discuss** MATLAB programs to yield output parameters of various structures.	Understand
CO 5	**Analyze** the thermal properties of a piston by MATLAB for optimizing the design of a internal combustion engine.	Analyze
CO 6	**Determine** the displacement and velocity of a single degree of freedom system.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcome		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises/ CIE/ SEE

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Lab Exercises/ CIE/ SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Lab Exercises/ CIE/ SEE
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Exercises/ CIE/ SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises/ CIE/ SEE
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Lab Exercises/ CIE/ SEE
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	Lab Exercises/Projects
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises/ CIE/ SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises/ CIE/ SEE
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2	Lab Exercises/Projects
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Lab Exercises/Projects

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Specific Program Outcome		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	3	Lab Exercises/ CIE/ SEE
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	2	Lab Exercises/ CIE/ SEE

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the **principles of Mathematics(differentiation an integration) and Engineering(FEM)** in solving fluid flow problems.	2
	PSO 2	**Formulate and Evaluate the fluid flow problems** using the FEM technique.	2
CO 2	PO 1	Apply the **principles of Mathematics and Engineering** in solving fluid flow problems.	2
	PSO 2	**Formulate and Evaluate the fluid flow problems** using the Ansys-CFX software.	2
	PSO 3	**Make use of Computational tool** Ansys-CFX for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1
CO 3	PO 1	Apply the **principles of Mathematics(differentiation an integration) and Engineering(FEM)** in solving fluid flow problems.	2
	PSO 2	**Formulate and Evaluate the fluid flow problems** using the Matlab coding.	2
	PSO 3	**Make use of Computational tool** Matlab for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1
CO 4	PO 1	Apply the **principles of Mathematics and Engineering** in solving Heat flow problems.	2
	PSO 2	**Formulate and Evaluate the heat transfer problems** using the Ansys software.	2
	PSO 3	**Make use of Computational tool** Ansys for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1
CO 5	PO 1	Apply the **principles of Mathematics and Engineering** in solving conjugate Heat flow problems.	2

	PSO 2	**Formulate and Evaluate the heat transfer problems** using the Ansys-Fluent software.	2
	PSO 3	**Make use of Computational tool** Ansys-Fluent for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1
CO 6	PO 1	Apply the **principles of Mathematics and Engineering** in solving thermal stress problems.	2
	PSO 2	**Formulate and Evaluate the thermal stress analysis problems** using the Ansys software.	2
	PSO 3	**Make use of Computational tool** Ansys for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES	PSO'S	
	PO 1	PSO 2	PSO 3
CO 1	2	2	
CO 2	2	2	1
CO 3	2	2	1
CO 4	2	2	1
CO 5	2	2	1
CO 6	2	2	1

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**FEATURES OF MATLAB**
	Types of windows, Variables, logical operations, Assignment statements, Matrices, Vectors, Scalars, Transpose matrix, Product, summation and inverse matrices.

WEEK II	**USES OF MATLAB.**
	Algorithm development, Scientific and engineering graphics, Modeling, simulation, and prototyping, Application development, including Graphical User Interface building, Math and computation,Data analysis, exploration, and visualization
WEEK III	**MATHEMATICAL PROBLEMS IN MATLAB**
	Plotting the graph for sin(x), cos(x), tan(x), csc(x), Hold on command application in drawing the multiple plots
WEEK IV	**FORMULATION OF IDEAL AND REAL GAS PROBLEMS IN MATLAB PROGRAM**
	The gas law, for example, P = f(n,T,V) [=nRT/V], plotting between P and T, P and V, analysis, interpretation of graphs.
WEEK V	**DYNAMICS AND VIBRATION ANALYSIS-I IN MATLAB PROGRAM**
	The constant of the spring is k = 3 kN/m and the tension in the cable is 30 N. When the cable is cut, (a) derive an expression for the velocity of the block as a function of its displacement x, (b) determine the maximum displacement xm and the maximum speed vm, (c) plot the speed.
WEEK VI	**DYNAMICS AND VIBRATION ANALYSIS-II IN MATLAB PROGRAM**
	The constant of the spring is k = 5 kN/m and the tension in the cable is 50 N. When the cable is cut, (a) derive an expression for the velocity of the block as a function of its displacement x, (b) determine the maximum displacement xm and the maximum speed vm, (c) plot the speed.
WEEK VII	**THERMAL STRESS ANALYSIS OF PISTON-I IN MATLAB PROGRAM**
	The data is taken for the design of piston through which various geometries of the piston can be found out which are mentioned below. The material of the piston is Aluminum alloy 6061. Design of the Piston can be done by general programme in MATLAB Software. .
WEEK VIII	**THERMAL STRESS ANALYSIS OF PISTON-II IN MATLAB PROGRAM**
	The data is taken for the design of piston through which various geometries of the piston can be found out which are mentioned below. The material of the piston is Aluminum alloy 3003. Design of the Piston can be done by general programme in MATLAB Software.
WEEK IX	**ANALYSIS OF KINEMATICS IN FOUR BAR MECHANISM IN MATLAB PROGRAM**
	For a given geometry of four bar mechanism, drawing the plots of velocity, acceleration of the links at various angles.

WEEK X	**ANALYSIS OF KINEMATICS IN FOUR BAR MECHANISM IN MATLAB PROGRAM**
	For a given geometry of slider crank mechanism, drawing the plots of velocity, acceleration of the links at various angles.
WEEK XI	**REVISION TO ALL MATLAB PROBLEMS**
	IF else, While else commands, 2D plots, frequency calculation of vibration systems.
WEEK XII	**REVISION TO ALL MATLAB PROBLEMS**
	Thermal analysis, Vibration analysis, preparation for semester end exam.

TEXTBOOKS

1. Agam Kumar Tyagi, "MATLAB and Simulink for Engineers", Oxford University Press 1st Edition, 2012.
2. S.S.Rao, Vibration Problems, CRC press, 4 th Edition, 2014.

REFERENCE BOOKS:

1. Delores M. Etter, David C. Kuncicky , Holly Moore, "Introduction to MATLAB 7", Pearson Education Inc, 1st Edition,, 2009.
2. Rao. V. Dukkipati , "MATLAB for ME Engineers" , New age Science, 1st Edition, 2008.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Types of windows, Variables, logical operations, Assignment statements, Matrices, .	CO 1	T1: 1.1 , R1: 1.3, 1.4 ,R2: 1.7
2	Vectors, Scalars, Transpose matrix, Product, summation and inverse matrices.	CO 2	T1: 1.2, R1: 1.8
3	Algorithm development, Scientific and engineering graphics, Modeling, simulation, and prototyping, Application development, including Graphical User Interface building, Math and computation,Data analysis, exploration, and visualization	CO 3	T1: 1.15, R1: 1.16
4	Plotting the graph for sin(x), cos(x), tan(x), csc (x), Hold on command application in drawing the multiple plots.	CO 2	T1: 1.6
5	The gas law, for example, $P = f(n,T,V)$ [$= nRT/V$], plotting between P and T, P and V, analysis, interpretation of graphs.	CO 2	T1: 2.2, R2: 2.6

6	HThe constant of the spring is k = 3 kN/m and the tension in the cable is 30 N. When the cable is cut, (a) derive an expression for the velocity of the block as a function of its displacement x, (b) determine the maximum displacement xm and the maximum speed vm, (c) plot the speed.	CO 4	T1: 2.6, R3: 2.10
7	Plots interpretation of 2D and 3D.	CO 4	T1: 3.2, R2: 3.3,
8	Thermal stress analysis of piston.	CO 4	T1: 3.5
9	Degree of freedom, Equations of motion.	CO 5	T1:2.13, 2.14, R1: 2.16
10	Kinematics, four bar mechanism, slider crank mechanism, analysis.	CO 5	T1: 2.15, R1: 2.15
11	Velocity analysis, acceleration analysis.	CO 5	T1: 3.9, R1: 3.9
12	Applications of matlab in 2 dof and 3 dof.	CO 6	T1: 6.1, R2: 6.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Using MATLAB to Build Model Calibration Tools for Multiscale Modeling
2	Damage characterization and modeling of 7075-T651 aluminum plate. using matlab simulink

Signature of Course Coordinator **HOD,ME**
Mr. G. Aravind Reddy, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**PRODUCTION TECHNOLOGY LABORATORY**				
Course Code	AME107				
Program	B.Tech				
Semester	IV	ME			
Course Type	CORE				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Dr. G. Naveen Kumar, Professor				

I COURSE OVERVIEW:

The aim of this course is to conduct experiments chiefly encompasses Metal casting, Welding, Press working and processing of Plastics. It inculcates knowledge and skill to the students starting from preparing a wooden pattern to completion of a casting which also comprises different Sand testing techniques. Also, students can understand broadly Welding and press working skills employed in Industries. One of the most outstanding features of plastics is the ease with which they can be processed. Production Technology lab also throws light on processing of plastics by Blow and Injection molding machines

II COURSE PRE-REQUISITES:

Level	**Course Code**	**Semester**	**Prerequisites**
UG	AME005	III	Metallurgy and material science

III MARKS DISTRIBUTION:

Subject	**SEE Examination**	**CIE Examination**	**Total Marks**
Production Technology Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Probing Further Experiments (last)	✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day-to-day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the principal from the panel of experts recommended by Chairman, BOS.

The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		**Strength**	**Proficiency Assessed by**
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises/CIA/SEE

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Lab Exercises/CIA/SEE
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Lab Exercises/CIA/SEE
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

I	Understand about the casting of different materials.
II	Knowledge on different kinds of production processes and practices available for shaping or molding several daily used parts for industries.
III	Understand and Practice different welding processes.
IV	Knowledge on selection of process parameters, equipment for material processing.

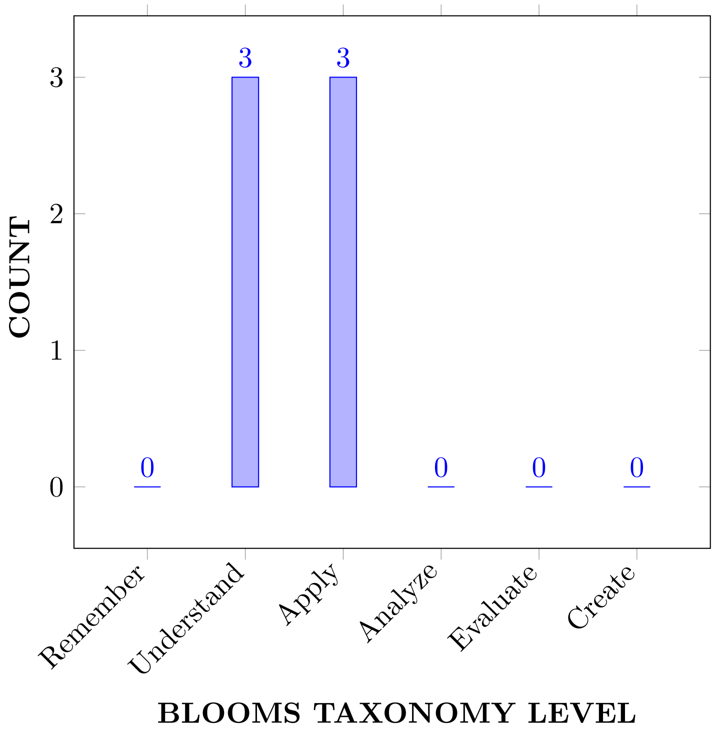
IX COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** the design steps involved in making a castings for automotive components.	Apply
CO 2	**Demonstrate** practical usage of Gas welding and ARC welding Techniques for making Lap and Butt joints.	Understand
CO 3	**Make use of** different types of welding techniqies for Industrial Applications.	Apply
CO 4	**Identify** various defects during gas welding,arc welding process and their causes and remedies.	Apply

CO 5	**Demonstrate** working principle of various sheet metal forming process such as Hydraulic press, deep drawing and bending operation.	Understand
CO 6	**Explain** the various process in making of plastic components for engineering / domestic applications.	Understand

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Selection of operations which have to be carried out casting process for a specific application, need the knowledge of science and **engineering fundamentals and engineering fundamentals.**	2
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 2	PO 1	Identify (knowledge) in suitable techniques involved in design,welding to achieve error free components using in solving (complex) engineering problems by applying the principles of **mathematics** and **engineering fundamentals**	2
	PO2	Understand the given problem statement and **apply data validation techniques** to **solve** (complex) specific engineering problems related to design.	2

CO 3	PO 1	Apply the operational principles of different welding equipments for quality weldingby applying the **knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	Understand the given **problem statement and apply data validation techniques** to resolve specific engineering problems related to wedling strength by identification of process adoption for the specially develop component.	2
CO 4	PO1	Identify the causes and remedies of welding defects using **Scientific Principles** of Methodology and **engineering** fundamentals.	2
CO 5	PO 2	Make use of the metal forming techniques used in **Design**, Model Creation and **Validation** of component Parts by **Problem Analysis**.	2
	PO3	Understand the given **problem statement** related to their working principle and based upon type of **manufacturing process**.	2
	PSO3	Identify the scientific principle involved in rolling process by **Qualitative and Quantitative** methods to their engineering problems.	2
CO 6	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 2	PO 3	PSO 3
CO 1	2			2
CO 2	2	2		
CO 3	3	2		
CO 4	2			
CO 5		2	2	2
CO 6				2

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-	Mini projects	-		

XIII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK 1	**PATTERN MAKING**
	Pattern design and making, casting drawing.
WEEK 2	**SAND PROPERTIES TESTING**
	Sand properties testing for strengths and permeability..
WEEK 3	**METAL CASTING**
	Moulding, melting and casting.
WEEK 4	**ARC WELDING**
	ARC welding lap and butt joint. .
WEEK 5	**SPOT WELDING**
	Spot welding, TIG welding.
WEEK 6	**PLASMA WELDING AND BRAZING**
	Plasma welding and brazing (water plasma device). .
WEEK 7	**APPLICATION OF SIMPLE AND COMPOUND DIE**
	Blanking and piercing, operation and study of simple, compound and progressive press tool.
WEEK 8	**APPLICATION OF PROGRESSIVE DIE T**
	Hydraulic press: deep drawing and extrusion operation.
WEEK 9	**MECHANICAL PRESS WORKING**
	Bending and other operation.
WEEK 10	**PROCESSING OF PLASTICS**
	Injection moulding..
WEEK 11	**PROCESSING OF PLASTICS**
	Blow moulding.
WEEK 12	**BEYOND SYLLABUS**
	MIG welding exercises and Riveting of a plates..

TEXTBOOKS

1. P. N. Rao, “Manufacturing Technology”, Tata McGraw-Hill, 2nd Edition, 2013
2. Hajra Chowdhary, “Workshop Technology”, Asia Publishing House, 2nd Edition, 2008.

REFERENCE BOOKS:

1. . R. K. Jain, “Production Technology”, Khanna Publishers, 18th Edition, 2013
2. HMT, “Production Technology”, McGraw-Hill Education, 1st Edition, 2013.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
1	Pattern design and making, casting drawing.	CO1	T1:2.1.5 T2:2.3
2	Sand properties testing for strengths and permeability.	CO1	T2:2.1.5 R1:2.6
3	Moulding, melting and casting.	CO 1	T1:2.6 R3:3.6.5
4	ARC welding lap and butt joint.	CO 2	T2:2.7 R2:2.18
5	Spot welding, TIG welding	CO 3	T2:2.22 R3:3.1.1
6	Plasma welding and brazing (water plasma device).	CO 3	T1:2.5.1 T2:2.25
7	Blanking and piercing, operation and study of simple, compound and progressive press tool.	CO 5	T2:2.26 R3:2.55
8	Hydraulic press: deep drawing and extrusion operation.	CO 5	T2:2.3 R3:2.6
9	Bending and other operation.	CO 5	T2:2.3 R1:2.6
10	Injection moulding.	CO 6	T1:2.6
11	Blow moulding.	CO 6	T2:2.7 R1:2.18
12	MIG welding exercises and Riveting of a plates.r	CO 3	T2:2.22

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design and develop Gating system for cating process.
2	Optimization of welding Process parameters for optimal weld strength using a Design of Experiments approach.
3	Design and Development of Welded joints
4	Design developBlanking and piercing dies
5	Design and develop ofHydraulic press, deep drawing and bending dies
6	Design and develop Injection and blow moulding dies

Prepared by: **HOD,ME**

Dr. G. Naveen Kumar, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**Mechanics of Fluids and Hydraulic Machines Laboratory**				
Course Code	AME108				
Program	B.Tech				
Semester	IV	ME			
Course Type	Core				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. G Sarat Raju , Assistant Professor				

I COURSE OVERVIEW:

The Fluid Mechanics and hydraulic machines Laboratory is intended to observe the properties of fluids and to conduct experiments involving both incompressible and compressible flow. This course enables to apply the laws of fluid mechanicsand hydraulic machines , the means by which the energy transfer is carried out in the turbomachinery. It includes the flow measuring devices, study of performance characteristic curves of equipment and techniques of fluid mechanics to know how the fluid is going to move or operate.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME003	III	Thermodynamics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Mechanics of Fluids and Hydraulic Machines Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

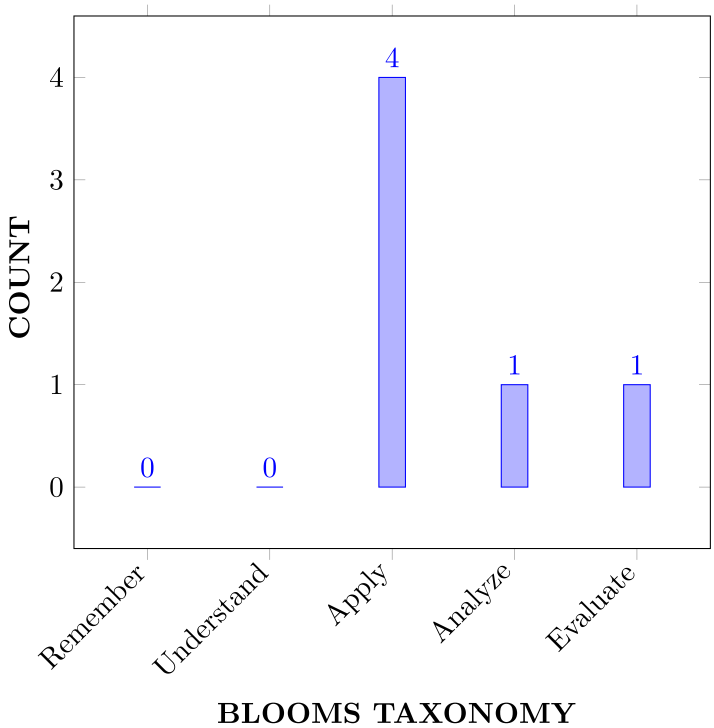
I	The types of fluids, properties and behaviour under static and dynamic conditions of closed conduit and external flow systems.
II	The operating principle of various turbo machinery and analyze their performance characteristics under various operating conditions.
III	The measurement of flow rate through various internal and external flow systems.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Utilize** the concept of calibrating Orifice and Venturi meter to reduce the uncertainty in the discharge coefficient.	Apply
CO 2	**Make use of** the pipe friction apparatus, determine the coefficient of friction interpreting data from Moody's diagram to identify, name, and characterize flow patterns and regimes.	Apply
CO 3	**Apply** the statement of Bernoulli's equation in real fluids to demonstrate whether the total energy of flow is constant.	Apply
CO 4	**Distinguish** the performance characteristics of turbo machinery for various operating conditions.	Analyze
CO 5	**Demonstrate** Performance characteristics of pumps for various operating conditions.	Understand
CO 6	**Determine** the impact of jet on various types of vanes to run the turbine efficiently.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises/CIA/SEE

PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Lab Exercises/CIA/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Utilize the concept of calibration to a considerable extent appreciate (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the **principles of Mathematics and Engineering**	3
	PO 2	Understand the (given **problem statement**) calibration procedure for (provided **information and data**) in reaching substantiated conclusions by the interpretation of results	3
	PSO 3	Apply (**knowledge**) properties, various types and patterns of fluid flow configurations (apply) for solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 2	PO 1	Explain (understanding) various effects of viscosity in flow through pipes and apply Newtons law of viscosity, in calculating energy loss by applying **principles of Mathematics, Science and Engineering**	3
	PO 5	Understand the (given **problem statement**) effects of viscosity, and capillary rise for the bodies immersed in fluids. (from the provided **information**) in solving analysis problems.	2

	PSO 3	Apply (**knowledge**) Newtons law of viscosity (understanding) in body, under different inlet conditions in (apply) solving flow through pipes by applying the principles of **Mathematics, Science and Engineering**	3
CO 3	PO 1	Summarize (**knowledge**) the concept of pressure measuring devices applications and effect of buoyancy on submerged bodies (understanding) their importance and applicability (apply) in solving (complex) fluid flow engineering problems by applying the textbfprinciples of Mathematics, Science and Engineering	3
	PO 3	Understand the given **problem statement** and formulate (complex) of pressure measuring devices applications and effect of buoyancy on submerged bodies (understanding) their importance and applicability (apply) in solving (**complex**) fluid flow engineering problems from the provided information and substantiate with the **interpretation** of variations in the **results**.	3
	PSO 3	Apply (knowledge) various effects of viscosity, static pressure, surface tension, Newton's law of viscosity, pressure difference and capillary rise (apply) in solving aircraft analysis problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 4	PO 1	Recognize (knowledge) the importance and application (apply) of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the **principles of Mathematics, Science and Engineering**	3
	PO 5	Understand the given **problem statement and formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern fluid systems in designing prototypes devices	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 5	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics.	3
	PO 3	Understand the given **problem statement** and formulate (complex) fluid flow engineering phenomena and system for deriving various governing equations of fluid mechanics from the provided information and substantiate with the **interpretation** of variations in the results.	2

	PO 5	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of fluid mechanics.	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 6	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** principles to understand the Bernoulli Equation for real flows and its applications	2
	PO 3	Using Euler equation of motion derive the Bernoulli equation to analyze complex fluid flow problems using **principles of mathematics and engineering sciences.**	3

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES			PSO'S
	PO 1	PO 3	PO 5	PSO 3
CO 1	2	3		3
CO 2	2		2	3
CO 3	2	3		3
CO 4	2		2	3
CO 5	2	3	2	3
CO 6	2	3		

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**DETERMINATION OF COEFFICIENT OF DISCHARGE OF VENTURI METER**
WEEK II	**DETERMINATION OF COEFFICIENT OF DISCHARGE OF ORIFICE METER**
WEEK III	**DETERMINATION OF FRICTION FACTOR**
WEEK IV	**VERIFICATION OF BERNOULLIS THEOREM**
WEEK V	**PERFORMANCE TEST ON PELTON WHEEL TURBINE**
WEEK VI	**PERFORMANCE TEST ON FRANCIS TURBINE**
WEEK VII	**PERFORMANCE TEST ON KAPLANTURBINE**
WEEK VIII	**PERFORMANCE TEST ON RECIPROCATING PUMP**
WEEK IX	**PERFORMANCE TEST ON CENTRIFUGAL PUMP**
WEEK X	**IMPACT OF JET ON VANES**
WEEK XI	**PERFORMANCE TEST ON MULTI STAGE CENTRIFUGAL PUMP**
WEEK XII	**LOSS OF HEAD DUE TO SUDDEN CONTRACTION**

TEXTBOOKS

1. H Modi, Seth, Hydraulics, Fluid Mechanics and Hydraulic Machinery, Rajsons, Publications, 21st Edition, 2017.
2. D. Rama Durgaiah, "Fluid Mechanics and Machinery", New Age International, 1st Edition, 2002.

REFERENCE BOOKS:

1. Dr. R K Bansal, A Text Book of Fluid Mechanics and Hydraulic Machines, Laxmi Publications, 9th Edition, 2015.
2. Banga, Sharma, "Hydraulic Machines", Khanna Publishers, 6th Edition, 2001.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Determination of coefficient of discharge (Cd) and generation of various characteristic curves for water flowing through Venturi meter.	CO 1, CO 2	T1:7.10
2	Determination of coefficient of discharge (Cd) and generation of various characteristic curves for water flowing through Orifice meter.	CO 1, CO 2	T1:7.10
3	Determination of friction factor for a given pipe line.	CO 1, CO 2	T1:11.5
4	Verification of Bernoulli's theorem.	CO 3	T1:7.7
5	Performance test on Pelton wheel and generate various characteristic curves.	CO 5, CO 6	T1:21.5

6	Performance test on Francis turbine and generate various characteristic curves.	CO 4, CO 5	T1:21.12
7	Performance test on Kaplan turbine and generate various characteristic curves.	CO 4, CO 5	T1:21.12
8	Performance test on reciprocating pump and generate various characteristic curves.	CO 4, CO 6	T1:23.2
9	Performance test on centrifugal Pumps and generate various characteristic curves.	CO 4, CO 6	T1:24.3
10	Determine the coefficient of impact on flat and curved vane.	CO 6	R2:2.6
11	Determine the effiicency of Multi-stage centrifugal Pumps.	CO 5, CO 6	T2:3.18
12	Determine the loss of head due to sudden contraction in pipe flow.	CO 5, CO 6	T2:3.18

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Draft Tube:** Demonstration of draft tube and calculation of Thoma's cavitation factor.
2	**Flow Pattern:** Demonstration of streamline at different angle of attack and calculation of separation point for different Reynolds number.
3	**Reaction Turbines:** Design of Kaplan and Francis turbines prototype models to understand various geometrical parameters and shapes.
4	**Pumps:** Model a centrifugal pump and calculate the difference of pressure in the impeller.
5	**Flow through pipes:** Encourage students to design and analyze flow through pipes using ANSYS

Signature of Course Coordinator **HOD, ME**
Mr. G.Sarat Raju, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**MACHINE TOOLS AND METROLOGY**				
Course Code	AME010				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr C. Labesh Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME006	IV	Production Technology

II COURSE OVERVIEW:

Machine Tools and Metrology is an instructional program that prepares individuals to shape metal parts on machines such as lathes, grinders, drill presses, milling machines and shapers. This program includes instruction in safety, making computations related to work dimensions testing feeds and speeds of machines using precision measuring instruments. Metrology is highly valuable for the students and practitioners, specifically from mechanical and allied engineering stream. This course is designed to impart the knowledge about the various machining processes like turning, shaping, planning, drilling, milling and grinding and to develop measurement procedures, conduct metrological experiments.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Machine Tools and Metrology	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
70%	Understand
20%	Apply
%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

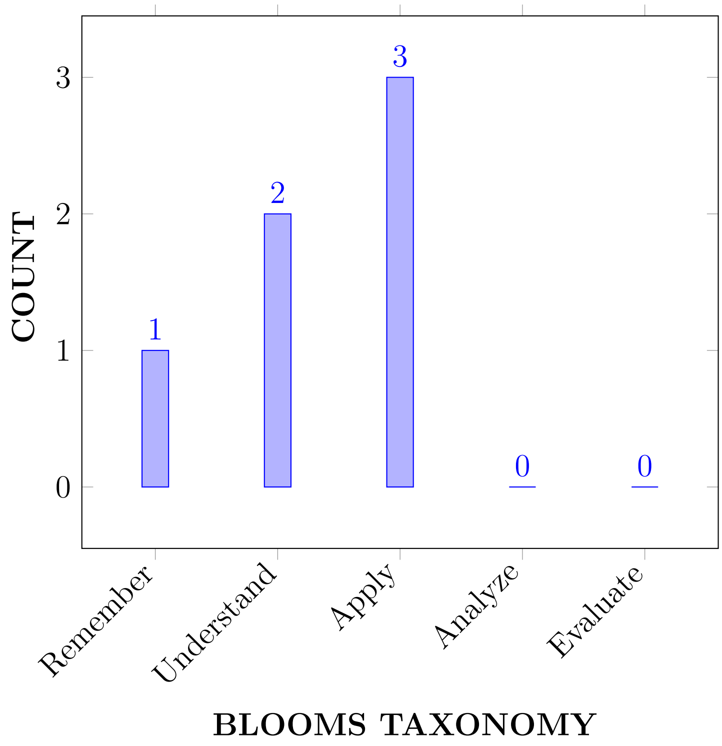
I	The fundamental concepts of the metal cutting principles to study the behavior of various machining processes.
II	The importance of tool materials, cutting parameters, cutting fluids and tool wear mechanisms for optimized machining.
III	The principles of linear and angular measuring instruments for accurate measurement of a given component
IV	The mechanics of machining process and optimization of various significant parameters in order to yield the optimum machining.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Recognize** the importance of geometry of cutting tools, coolants and tool materials for the analysis of material behavior during manufacturing processes.	Remember
CO 2	**Explain** the operational principles of different lathe machines and various reciprocating machines for quality machining.	Understand
CO 3	**Explain** the working principles of Milling, drilling and surface grinding machines for manufacturing the components of their requirement.	Understand
CO 4	**Apply** the principles of limits, fits and tolerance while designing and manufacturing the components of their requirement.	Apply
CO 5	**Choose** an appropriate measuring instrument for accurate inspection of the dimensional and geometric features of a given component.	Apply
CO 6	**Apply** the various methods for the measurements of screw threads, surface roughness parameters and the working of optical measuring instruments.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIA/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIA/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIA/Quiz/AAT
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.	1	CIA/Quiz/AAT
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	CIA/Quiz/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	1	CIA/Quiz/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	CIA/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing	3	AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	✓	✓	✓	-	-	-	-	✓	-	-	-
CO 4	✓	-	-	-		-	-	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	✓-	-	-
CO 6	✓	✓	-	-		-	-	-	-	-	-	-	✓	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recognize (knowledge) the importance of geometry of cutting tool, Tool life, coolants and tool materials to analyze material behaviour during manufacturing processes by applying the principles of **mathematics, science and Manufacturing fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Apply the operational principles of different lathe machines and various reciprocating machines for quality machining by applying the **the knowledge of mathematics, science and engineering fundamentals**	3
CO 3	PO 1	Explain (Understand) the working principles of Milling, drilling and surface grinding machines for solving (complex) manufacturing problems by applying the principles of **mathematics, science and engineering fundamentals**	3
	PO 2	Understand the given **problem statement and formulate** formulate the design (complex) engineering problems for working processes of machine tools from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results.**	4
	PSO 1	**Analysing** the metal cutting process in various machine tools to anable them to design, analyse and fabricate **complex designs.**	2
CO 4	PO 1	Identify (knowledge) the principles of limits, fits and tolerance while designing to get accurate and precision measurement of the manufactured components by using acquired knowledge in **mathematics and science** (physics and engineering).	2
	PO 2	Application of the principles of limits, fits and tolerance while designing can be used for **identifying, formulating, and analysing complex problems.**	3
	PSO 1	Ability to **apply** the principle of limits, fits and tolerance while designing and manufacturing help them to design, analyse and fabricate **complex designs.**	2
CO 5	PO 1	Ability to select, calibrate and use appropriate measuring equipment requires identification of measurend, selection of equipment by referring standard available equipment, and analysing the results using reference values are carried out by applying the **knowledge of mathematics, science and metrology engineering fundamentals**	3
	PO 3	A good **knowledge** in **measuring equipment.**and an ability to calibrate, equip them to **design solutions to complex engineering Problems** by measuring various parameters which are affecting them.	3
	PSO 1	Ability to **apply** the principle of limits, fits and tolerance while designing and manufacturing help them to design, analyse and fabricate **complex designs.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	Ability to select and use various methods for the measurements of screw threads, surface roughness parameters and the working of optical measuring instruments for proper analysis of results to reach actual conclusion requires some research based **knowledge of mathematics, science and metrology engineering fundamentals.**	3
	PSO 1	Ability to **apply** the principle of limits, fits and tolerance while designing and manufacturing help them to design, analyse and fabricate **complex designs.**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	3	3	3	-	-	-	-	3	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	40	100	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	40	-	-	100	100	100	-	-	-	-	100	-	-	-
CO 4	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 6	100	40	-	-	-	-	-	-	-	-	-	-	40	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	3	3	3	-	-	-	-	3	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
TOTAL	18	6	3	-	3	3	3	-	-	-	-	3	5	-	-
AVERAGE	3	2	3	-	3	3	3	-	-	-	-	3	2.5	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams		SEE Exams		Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 4	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**BASIC MECHANISM OF METAL CUTTING**
	Elementary treatment of metal cutting theory,element of cutting process, geometry of single point tool and angles chip formation and types of chips,built up edge and its effects, chip breakers: Mechanics of orthogonal cutting, Merchant'sforcediagram, cutting forces, cutting speeds, feed, depth of cut,tool life, coolants, machinability, tool materials.
MODULE II	**MACHINE TOOL - I**
	Engine lathe, Principle, specification, types, work and tool holding devices, Automatic lathes, classification: Single spindle and multi-spindle automatic lathes and its tool layouts; Shaping, slotting and planning machines, Principles of working, specification, operations performed, Kinematic scheme.
MODULE III	**MACHINE TOOL - II**
	Milling machine, classifications, specifications, working principles of milling machines; Geometry of milling cutters, methods of indexing, kinematic scheme of milling machines. Drilling and boring machines, principles of working, specifications, types, operations performed, twist drill; Kinematics scheme of the drilling and boring machines.

MODULE IV	GEOMETRICAL DIMENSIONING AND TOLERANCES
	Systems of Limits and Fits: Introduction, normal size, tolerance limits, deviations, allowance, fits and their types, unilateral and bilateral tolerance system, hole and shaft basis systems, Interchangeability and selective assembly; Linear Measurement: Slip gauges, dial indicator, micrometers; Measurement of angles and tapers: Bevel protractor, angle slip gauges, spirit levels, sine bar.
MODULE V	MEASURING INSTRUMENTS
	Design requirements and selection, performance evaluation and assessment, space environment on the selection of materials for rockets and spacecraft, material selection for specific requirements, advance materials, super alloys and composite materials, qualification of rocket and missile systems, types of testing and evaluation of design and function

TEXTBOOKS

1. Dr. R. Kesavan, Dr. R. Kesavan, "Machine Tools" Laxmi publications, 2nd Edition, 2016.
2. N. K Mehta, "Metal Cutting and Design of Cutting Tools, Jigs and Fixtures", McGrawHill Education, 1st Edition,2014.
3. T. L. Chaudhary, "Metal Cutting and Mechanical Tool Engineering", Khanna Publishers, 5th Edition, 2013.
4. R. K. Jain, Engineering Metrology, Khanna Publishers, 1st Edition, 2013.4. R. K. Jain, Engineering Metrology, Khanna Publishers, 1st Edition, 2013.

REFERENCE BOOKS:

1. Yuan S W, “Foundations of fluid Mechanics”, Prentice-Hall, 2nd Edition, 1987.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on CO and PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Introduction of Manufacturing and Machine tools	CO 1	T2: 1.1-1.5, T1: 4.1
3	Types of metal cutting processes and nomenclature of single point cutting tool	CO 1	T2: 1.1-1.5, T1: 4.1

4	Mechanism of chip formation in machining	CO 1	T2: 1.1-1.5, T1: 4.1
5	Mechanics of orthogonal cutting	CO 1	T2: 1.1-1.5, T1: 4.1
6	Merchant theory- Orthogonal Cutting forces	CO 1	T2: 1.1-1.5, T1: 4.1
7	Sources and causes of Heat generation in machining process	CO 1	T2: 1.1-1.5, T1: 4.1
8	Classification of cutting tools and tool materials	CO 1	T2: 1.1-1.5, T1: 4.1
9	Tool life based on Taylors equation	CO 1	T2: 1.1-1.5, T1: 4.1
10	Cutting fluids and Machinability	CO 1	T2: 1.1-1.5, T1: 4.1
11	Introduction of Lathe and uses of their parts	CO 2	T2: 1.1-1.5, T1: 4.1
12	Types of Lathes and work holding devices	CO 2	T2: 1.1-1.5, T1: 4.1
13	Lathe operations	CO 2	T2: 1.1-1.5, T1: 4.1
14	Semi-automatic and Automatic Lathes	CO 2	T2: 1.1-1.5, T1: 4.1
15	Introduction of reciprocating machines – Shaping machine	CO 3	T2: 1.1-1.5, T1: 4.1
16	Classifications of Shaping machines	CO 3	T2: 1.1-1.5, T1: 4.1
17	Reciprocating Mechanisms	CO 3	T2: 1.1-1.5, T1: 4.1
18	Introduction of Planning machine and uses of their parts	CO 3	T2: 1.1-1.5, T1: 4.1
19	Classifications of planning machines	CO 3	T2: 1.1-1.5, T1: 4.1

20	Introduction of slotting machine and uses of their parts	CO 3	T2: 1.1-1.5, T1: 4.1
21	Introduction of milling machine and its working principle	CO 4	T2: 1.1-1.5, T1: 4.1
22	Classifications of Milling machines	CO 4	T2: 1.1-1.5, T1: 4.1
23	Milling operations	CO 4	T2: 1.1-1.5, T1: 4.1
24	Work holding devices of milling machines	CO 4	T2: 1.1-1.5, T1: 4.1
25	Nomenclature of milling cutters and their types	CO 4	T2: 1.1-1.5, T1: 4.1
26	Introduction of drilling machines and their types	CO 4	T2: 1.1-1.5, T1: 4.1
27	Drilling operations	CO 4	T2: 1.1-1.5, T1: 4.1
28	Nomenclature of drill bits and their types	CO 4	T2: 1.1-1.5, T1: 4.1
29	Introduction of drilling machines and their types	CO 4	T2: 1.1-1.5, T1: 4.1
30	Introduction of Limit, Fits and Tolerances	CO 5	T2: 1.1-1.5, T1: 4.1
31	Terminology for fits and tolerances	CO 5	T2: 1.1-1.5, T1: 4.1
32	Types of Fits – Hole/shaft base systems	CO 5	T2: 1.1-1.5, T1: 4.1
33	Types of Assemblies	CO 5	T2: 1.1-1.5, T1: 4.1
34	Working principles of Linear measuring Instruments – Slip gauges, Micrometers	CO 5	T2: 1.1-1.5, T1: 4.1
35	Working principles of Angular measuring Instruments – bevel protractor, sine bar	CO 5	T2: 1.1-1.5, T1: 4.1

36	Working principles of Dial indicator, angular slip gauges	CO 6	T2: 1.1-1.5, T1: 4.1
37	Working principles of Tool maker's microscope and its uses	CO 6	T2: 1.1-1.5, T1: 4.1
38	Working principles of optical projector, interferometer and their uses	CO 6	T2: 1.1-1.5, T1: 4.1
39	Screw thread measurement: Element of measurement, errors in screw threads	CO 6	T2: 1.1-1.5, T1: 4.1
40	Surface roughness measurement: Numerical assessment of surface finish	CO 6	T2: 1.1-1.5, T1: 4.1
41	Methods of measurement of surface finish	CO 6	T2: 1.1-1.5, T1: 4.1
PROBLEM SOLVING/ CASE STUDIES			
1	The useful tool life of HSS tool machinery mild steel at 18m/min is 3 hrs. calculate the tool life when the tool operates at 24m/min.	CO 1	T2: 1.1-1.5, T1: 4.1
2	In an orthogonal cutting operation on a work piece of width 2.5mm, the uncut chip thickness was 0.25mm and 25 degree. It was observed that the chip thickness was 1.25mm.The cutting force was measured to be 900N and the thrust force was found to be 810 N. (a) Find the shear angle. (b) If the coefficient of friction between the chip and the tool, was 0.5, what is the machining constant Cm	CO 1	T1: 1.1-1.5, T2 : 4.1
3	The Taylor's tool life equation for machining C-40 steel with a 18-4-1 HSS cutting tool at a feed of 0.8 m/min and a depth of cut 4mm. The following V and T observation have been noted. Calculate n, C and also recommended the cutting speed for a desire tool life of 60min V (m/min) 35, 25 and T (min) 80,30.	CO 1	T1: 1.1-1.5, T2 : 4.1
4	Estimate the machine time to turn a MS bar of 50mm diameter down to 65mm for a length of 250mm in a single cut. Assume cutting as 20 m/min and feed as 0.3 mm/rev.	CO 2	T2: 1.1-1.5, T1: 4.1
5	Determine the machining time to turn the dimensions. The material is mild steel, the cutting speed with HSS tool being 100 m/min and feed is 0.9 mm rev.	CO 2	T2: 1.1-1.5, T1: 4.1
6	A CI flange of 200mm OD has a bore of 80 mm. This is to be faced on a lathe. Calculate the machining time to face the part, given the feed 0.9 mm/rev and cutting speed of 70 m/min	CO 2	T2: 1.1-1.5, T1: 4.1

7	A 9 cm thick laminated plate consists of a 7cm thick brass and a 2cm thick mild steel plate. A 20 mm diameter hale is to be drilled through the plate. Estimate the total time taken for drilling if Cutting speed of brass = 44 m/min Cutting speed for mild steel = 30 m/min Feed of 20mm drill for brass = 0.26 mm/rev	CO 3	T2: 1.1-1.5, T1: 4.1
8	Find the time required to drill 5 holes in a CI flange of 40mm depth, if the hole diameter is 30mm. Assume cutting speed as 24.9 m/min and feed as.06 cm/rev.	CO 3	T2: 1.1-1.5, T1: 4.1
9	How long will it take a 12.7 mm to drill a hole 50mm deep is brass. Take cutting speed as 75 m/min and feed as 0.175 mm/rev. Take A=0.8D for through hole.	CO 3	T2: 1.1-1.5, T1: 4.1
10	In an assembly of two parts 50mm nominal diameter the lower deviation of the hole is zero and the higher is 4 microns; while that of shaft is -4 and -8 microns respectively. Estimate the allowance and state the type of fit of the assembly	CO 4	T2: 1.1-1.5, T1: 4.1
11	Between mating parts of 100mm basic size, the actual interference fit is to be from 0.05mm to 0.12mm. tolerance for the hole is the same as the tolerance for the shaft. Find the size of both the shaft and the hole on a) hole basis unilateral system and b) shaft basis unilateral system.	CO 4	T2: 1.1-1.5, T1: 4.1
12	A 200mm sine bar is to be set up to an angle of 25 Degrees. Determine the slip gauges needed from 87 pieces set.	CO 4	T2: 1.1-1.5, T1: 4.1
13	Calculate the CLA(Ra) value of a surface for which the sampling length was 0.8mm. The graph was drawn to a vertical magnification of 10,000 and a horizontal magnification of 100, and the areas above and below the datum line were: Above: 150 80 170 40mm2 Below: 80 60 150 120mm2	CO 5, CO 6	T2: 1.1-1.5, T1: 4.1
14	In the measurement of surface roughness heights of 20 successive peaks and troughs were measured from a datum and were 35, 25, 40, 22, 35, 18, 42, 25, 35, 22, 36, 18, 42, 22, 32, 21, 37, 18, 35, 20 microns. If these measurements were obtained on 20mm length, determine CLA and RMS values of rough surface.	CO 5, CO 6	T2: 1.1-1.5, T1: 4.1
15	How Tomlinson surface recorded and Talysurf machine work? What are their relative merits?	CO 5, CO 6	T2: 1.1-1.5, T1: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Elementary treatment of metal cutting theory, element of cutting process, geometry of single point tool and angles chip formation and types of chips, built up edge and its effects, chip breakers: Mechanics of orthogonal cutting, Merchant's force diagram, cutting forces, cutting speeds, feed, depth of cut, tool life, coolants, machinability, tool materials.	CO 1	R4:2.1

2	Engine lathe, Principle, specification, types, work and tool holding devices, Automatic lathes, classification: Single spindle and multi-spindle automatic lathes and its tool layouts; Shaping, slotting and planning machines, Principles of working, specification, operations performed, Kinematic scheme.	CO 2	R4:2.1
3	Milling machine, classifications, specifications, working principles of milling machines; Geometry of milling cutters, methods of indexing, kinematic scheme of milling machines. Drilling and boring machines, principles of working, specifications, types, operations performed, twist drill; Kinematics scheme of the drilling and boring machines.	CO 3, CO 4	R4:2.1
4	Systems of Limits and Fits: Introduction, normal size, tolerance limits, deviations, allowance, fits and their types, unilateral and bilateral tolerance system, hole and shaft basis systems, Interchangeability and selective assembly; Linear Measurement: Slip gauges, dial indicator, micrometers; Measurement of angles and tapers: Bevel protractor, angle slip gauges, spirit levels, sine bar.	CO 5	R4:2.1
5	Optical measuring instruments: Tool maker's microscope and its uses, collimators, optical projector, interferometer; Screw thread measurement: Element of measurement, errors in screw threads, measurement of effective diameter, angle of thread and thread pitch, profile thread gauges; Surface roughness measurement: Numerical assessment of surface finish: CLA, R.M.S Values, Rz values, methods of measurement of surface finish: profilograph, talysurf - ISI symbol for indication of surface finish.	CO 6	R4:2.1
DISCUSSION OF QUESTION BANK			
1	Merchant theory- Orthogonal Cutting forces	CO 1	R4:2.1
2	Tool life based on Taylors new equation	CO 2	T4:7.3
3	Estimation of machine time on lathe operation	CO 3,4	R4:5.1
4	Estimation of machine time on shaper operation	CO 5	T1:7.5
5	Numerical assessment on fits and tolerances	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Dynamics of Machinery**				
Course Code	AME011				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr K. Viswanath Allamraju, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB002	II	Engineering Mechanics
B.Tech	AMEB001	II	Engineering Drawing

II COURSE OVERVIEW:

This course focuses on mechanical devices that are designed to have mobility to perform certain functions. In this process they are subjected to some forces. The study of Dynamics of machinery leads us to design machines by understanding the relationship between the movement of various parts of machine and the different forces that are acting on them. This course will provide the knowledge on how to analyze the motions of mechanisms and design mechanisms to give required strength. This includes relative static and dynamic force analysis and consideration of gyroscopic effects on aero planes, ships, automobiles like two wheelers and four wheelers.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Kinematics of Machines	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
25 %	Understand
50 %	Apply
25 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

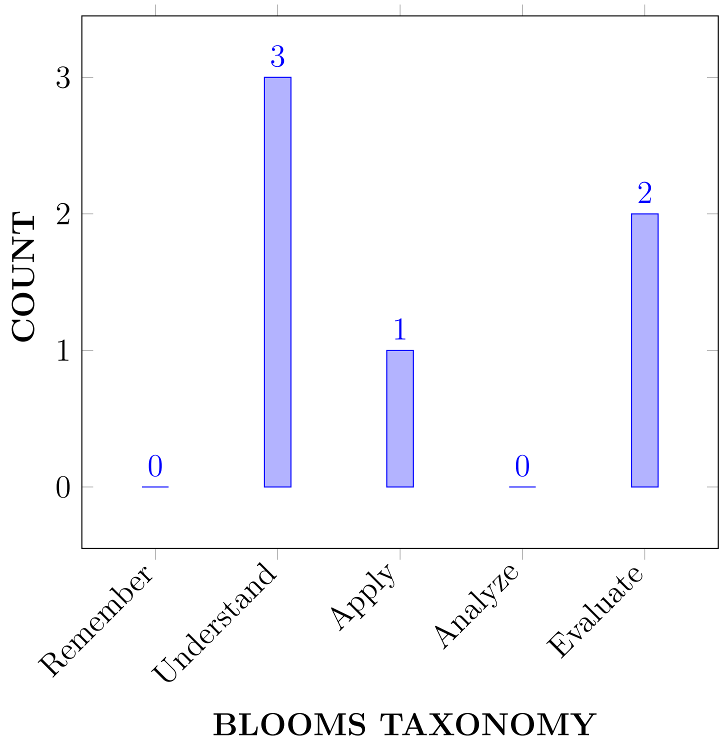
I	The concepts of precision, static and dynamic forces of planer mechanisms by neglecting friction of aero planes, sea vessels, auto mobiles and various force members.
II	The knowledge of engineering mechanics for identifying the coefficient of friction and engine speed of the various contact bodies (Clutches and Brakes) and speed controlled devices, variations of torques and fluctuation of speeds of IC engines.
III	The magnitude and direction of balanced mass for unbalanced rotary and reciprocating engines with the fundamentals of applied physics.
IV	Mathematical modeling of various degree of freedom systems to interpret the various vibration parameters.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Discuss** the Gyroscopes, effect of precession motion on the stability of moving vehicles such as motor car, motor cycle, aero-planes and ships.	Understand
CO 2	**Determine** the angle of heel to avoid upside down of a two wheeler vehicle while taking in left and right turns.	Evaluate
CO 3	**Illustrate** the static and dynamic force analysis of two and three force members by graphical super position method.	Understand
CO 4	**Apply** the laws of friction on clutches, brakes and dynamometers to reduce the power losses for the effective torque transmission.	Apply
CO 5	**Justify** the importance of torque and fluctuation of speeds for single and multi cylindered engines and governors to increase the mechanical efficiency.	Evaluate
CO 6	**Determine** the balanced mass and natural frequency for unbalanced rotary and reciprocating engines by analytical and graphical methods and equations of motion	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/Quiz/AAT
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	CIE/Quiz/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	CIE/Quiz/AAT
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	CIE/Quiz/AAT
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2	CIE/Quiz/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Quiz
PSO 3	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining.	2	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	✓	-		-	-	-
CO 2	✓	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 3	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 4	✓	✓	✓	-	-	-	-	-	-	-	-		-	-	-
CO 5	✓	-	-	-	-	-	-	✓	-	-	✓	-	✓	-	-
CO 6	✓	-	-	✓	-	-	-	-	-	-	-	✓	-	-	✓

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to find the gyroscopic effect	3
	PO 2	**Identify the problem statement dentify the problem statement, formulation , data collection ,validation and interpretation** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	5
	PO 10	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and determine the coefficient of friction of various clutches at different conditions	3
	PO 2	Illustrate the performance parameters of four bar mechanisms **first principles of Mathematics and engineering sciences and identify the problem statement, formulation , data collection ,validation and interpretation.**	5
	PO 5	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to clutches	1
CO 3	PO 1	Identify the speed of governors **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 7	**Identify the problem statement, socio economic and environmental** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to governors	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PO 1	Justify the knowledge of different forces (**scientific Principles and mathematical principles**) for governors and describe different performance parameters.	3
	PO 2	Determine the condition for correct steering **and also identify the problem statement, formulation , data collection ,validation and interpretation** of various steering mechanisms	5
	PO 3	**Identify the customer needs, investigate, innovate** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to engines	5
CO 5	PO 1	Develop the fundamentals of engineering and science in identifying the unbalanced mass **using the fundamentals of engineering and mathematical equations**	3
	PO 8	**Identify the problem statement and apply ethics to** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to unbalanced masses	2
	PO 11	**Identify the problem statement for quality, budget, schedule** (mission requirement), to select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to unbalanced machines	6
	PS O1	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	1
CO 6	PO 1	Formulate the problem statement and model the system for getting the solution of cams to regulate the speed of machines**using fundamentals of science &and engineering fundamentals.**	3
	PO 4	Understand the technical concepts of vibration and interpret the equilibrium conditions for various applications for **complex engineering problems.**	5
	PO 12	Investigate and define a problem and identify constraints of mechanisms **environmental and sustainability limitations, health and safety and risk assessment issues** when dealing with performance of followers and their application on real world problems	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 3	**Identify the problem statement** (mission requirement), select the appropriate system required foroptimu performance by reviewing the literature (information and data collection) suitable to mechanisms	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	5	-	-	-	-	-	-	-	2	-		-	-	-
CO 2	3	5	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 4	3	5	5	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	2	-	-	6	-	1	-	-
CO 6	3	-	-	5	-	-	-	-	-	-	-	4	-	-	1

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	50	-	-	-	-	-	-	-	50	-		-	-	-
CO 2	100	50	-	-	50	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	50	-	-	-	-	-	-	-	-
CO 4	100	50	50	-	-	-	-	-	-	-	-		-	-	-
CO 5	100	-	-	-	-	-	-	50	-	-	50	-	100	-	-
CO 6	100	-	-	50	-	-	-	-	-	-	-	50	-	-	50

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	2	-		-	-	-
CO 2	3	2	-	-	3	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 4	3	2	2	-	-	-	-	-	-	-	-		-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	3	-	-	-	-	-	-	2	-	-	2	-	3	-	-
CO 6	3	-	-	2	-	-	-	-	-	-	-	2	-	-	2
TOTAL	18	6	2	2	3	-	2	2	-	2	2	-	3	-	2
AVERAGE	3	2	2	2	3	-	2	2	-	2	2	-	3	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams		SEE Exams		Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	-
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**PRECESION, STATIC AND DYNAMIC FORCE ANALYSIS OF PLANAR MECHANISMS**
	Precession: Gyroscopes, effect of processional motion on the stability of moving vehicles such as motor car, motor cycle, aero-planes and ships, static and dynamic force analysis of planar mechanisms: Introduction to free body diagrams, conditions of equilibrium, two and three force members, inertia forces and D-Alembert's principle, planar rotation about a fixed centre.
MODULE II	**CLUTCHES, BRAKES AND DYNAMOMETERS**
	Clutches: Friction clutches, Single disc or plate clutch, multiple disc clutches, cone clutch and centrifugal clutch; Brakes and dynamometers: Simple block brakes, internal expanding brake, band brake of vehicle; Dynamometers absorption and transmission types, general description and method of operation.
MODULE III	**TURNING MOMENT AND GOVERNORS**
	Turning moment diagrams and flywheels: turning moment: Inertia torque, angular velocity and acceleration of connecting rod, crank effort and torque diagrams, fluctuation of energy; Design of flywheels. Governors
MODULE IV	**BALANCING OF ROTATORY AND RECIPROCATING MASSES**
	Balancing: Balancing of rotating masses, single and multiple-single and different planes-balancing of reciprocating masses, primary and secondary balancing-analytical and graphical methods; unbalanced forces and couples: Balancing of V-engines, multi cylinder, inline and radial engines for primary, secondary balancing and locomotive balancing.

MODULE V	**MECHANICAL VIBRATIONS**
	Vibrations: Free vibration of mass attached to a vertical spring, simple problems on forced damped vibration; Vibration isolation and transmissibility, whirling of shafts, critical speeds, torsional vibrations,two and three rotor systems.

TEXTBOOKS

1. Amithab Ghosh, Asok Kumar Malik, "Theory of Mechanisms and machines", East West Press Pvt Ltd, 2001.
2. S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 4th Edition, 2014
3. R. L. Norton, "Kinematics and Dynamics of Machinery", McGraw-Hill, 1st Edition, 2009.
4. P.L. Balleny, "Theory of Machines and Mechanisms", Khanna publishers, 2013.

REFERENCE BOOKS:

1. J. S. Rao, R.V. Dukkipati, "Mechanism and Machine Theory", New Age Publication, 1st Edition, 2013.
2. Uiker, Penock, Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition,2013.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
1	Introduction to Gyroscopes, angular motion, precession.	CO1	T2 17.2
2	Determination of Gyroscopic couple, problems.	CO2	T2 17.1
3	Effect of gyroscopic couple on stability of moving car.	CO2	T2 17.8
4	Effect of gyroscopic couple on stability of moving motorcycle.	CO2	T2 17.6
5	Effect of gyroscopic couple on stability of aero-plane.	CO1	T2 17.3
	CONTENT DELIVERY (THEORY)		
6	Effect of gyroscopic couple on stability of moving ship.	CO2	T2 17.4
7	Static and dynamic force analysis of planar mechanisms.	CO3	T2 12.1
8	Free body diagrams, problems.	CO3	T2 12.6
9	Friction circle, Boundary friction.	CO3	T2 8.2
10	Introduction to Clutches, types.	CO4	T2 8.9
11	Introduction to Brakes, classification.	CO4	T2 15.1
12	Introduction to dynamometers, types.	CO4	T2 15.8
13	Methods of operation of dynamometers power, Performance test.	CO4	T2 15.9
14	Calculation of brake torque, problems.	CO5	T2 15.13
15	Turning moment diagrams explanation.	CO5	T2 13.12
16	Inertia torque calculation for connecting rod.	CO5	T2 13.11
17	Problems on inertia torque calculation for connecting rod.	CO5	T2 13.7
18	Fluctuation of energy.	CO5	T2 13.13

19	Flywheel and its function.	CO5	R3 16.12
20	Flywheel design	CO5	R3 16.18
21	Problems on flywheel	CO5	R3 16.21
22	Introduction to governors and their classification	CO6	T2:16.1
23	Watt governor and Porter governor	CO6	T2 16.3,4
24	Proell governor, Hartnell and Hartung governors	CO6	T2:16.5,6
25	Problems on governors	CO6	T2:16.14
26	sensitiveness, isochronisms and hunting, effort and power of governors	CO6	R318.12
27	Balancing of rotating masses	CO5	T2:21.2
28	Problems on balancing of rotating masses.	CO5	T2:21.1
29	Primary balancing of reciprocating masses.	CO5	T2:22.1
30	Secondary balancing of reciprocating masses.	CO5	T2:22.2
31	Higher balancing of reciprocating masses.	CO5	R3 22.10
32	Locomotive balancing.	CO5	R322.4
33	Graphical method of calculating forces and couples.	CO5	R3 22.3
34	Balancing of Multi cylinder and V- Engines.	CO5	R3 22.13
35	Balancing of radial engines.	CO5	R3 22.12
36	Introduction to vibrations and their classification.	CO6	T2.18.1
37	Free vibrations of mass attached to vertical springs.	CO6	T2 18.6
38	Transverse vibrations-Problems.	CO6	R3 23.9
39	Frequency of transverse vibration for concentrated and distributed loads	CO6	R3 23.11
40	Dunkerley's method for calculating frequency.	CO6	R3 23.4
41	Raleigh's method for frequency calculations.	CO6	R3 23.5
42	Critical speeds, Whirling of shafts, problems.	CO6	R3 23.12
43	Torsional vibrations- one rotor system.	CO6	R3 24.4
44	Torsional vibrations- two rotor system.	CO6	R3 24.5
45	Torsional vibrations- three rotor system.	CO6	R3 24.6
PROBLEM SOLVING/ CASE STUDIES			
46	Problems on Gyroscope.	CO6	R3 24.4
47	Problems on gyroscope of two wheeler	CO6	R3 23.18
48	Problems on gyroscope of four wheeler	CO6	R3 23.18
49	Problems on gyroscope of four wheeler with forward rotation of the wheel	CO6	R323.23
50	Problems on clutches	CO6	R3 23.14
51	Balancing of rotating masses	CO5	T2:21.2
52	Problems on balancing of rotating masses.	CO5	T2:21.1
53	Primary balancing of reciprocating masses.	CO5	T2:22.1
54	Secondary balancing of reciprocating masses.	CO5	T2:22.2
55	Higher balancing of reciprocating masses.	CO5	R3 22.10
56	Locomotive balancing.	CO5	R322.4
57	Graphical method of calculating forces and couples.	CO5	R3 22.3
58	Balancing of Multi cylinder and V- Engines.	CO5	R3 22.13

59	Balancing of radial engines.	CO5	R3 22.12
DISCUSSION OF DEFINITION AND TERMINOLOGY			
60	Precissional motion	CO5	T2 13.12
63	Clutches and Brakes	CO5	T2 13.11
64	Unbalancing	CO5	T2 13.7
65	Governors	CO5	T2 13.13
66	Vibrations	CO5	R3 16.12
DISCUSSION OF QUESTION BANK			
1	Precissional motion	CO 1	R4:2.1
2	Clutches and Brakes	CO 2	T4:7.3
3	Unbalancing of rotary and reciprocatory motion of masses	CO 3	R4:5.1
4	Governors	CO 4	T1:7.5
5	Vibrations of damoed, undamped and critical damped structures	CO 5,6	T1: 4.1

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTOR

Department	**MECHANICAL ENGINEERING**				
Course Title	**DESIGN OF MACHINE MEMBERS**				
Course Code	AME012				
Program	B.Tech.				
Semester	V				
Course Type	CORE				
Regulation	IARE -R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	–	–
Course Coordinator	Mr.B.Vijaya Krishna , Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC05	III	Solids Mechanics

II COURSE OVERVIEW:

Machine design emphasizes for influence the failsafe design in the mechanical systems using different theories of failure modes. The design of machine members focuses mainly on design of machine elements subjected to various types of loads and components include joints; Riveted, Welded, threaded joints, shafts and springs using Design standards, B.I.S codes of steels. The Design philosophy is based on strength, stiffness and material selection for manufacture of machine elements.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Design of Machine Elements	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	✓	Videos
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	MOOC
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
40%	Understand
40%	Apply
10%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

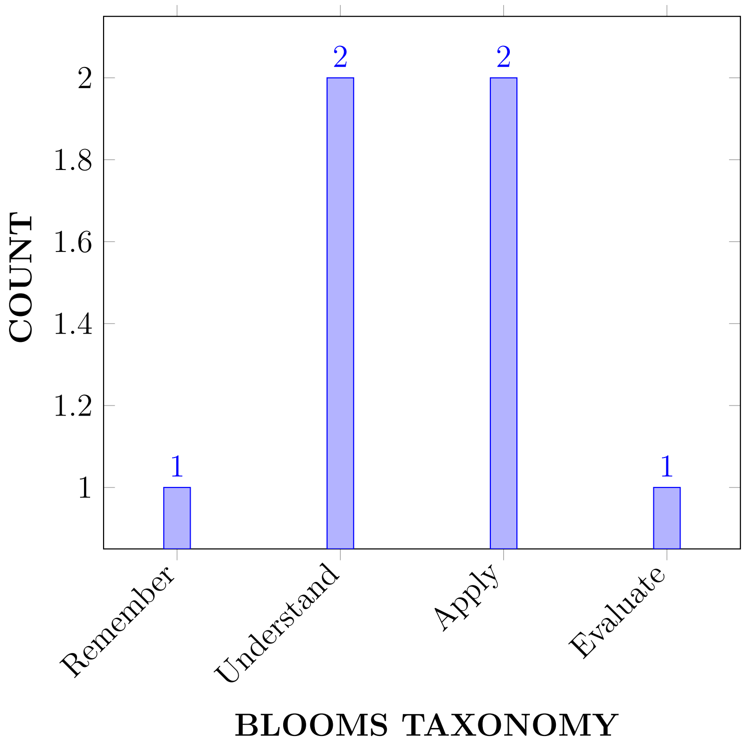
I	The machine element design process that achieves desired constraints for strength, rigidity and reliability
II	The nature of loading for the application of theories of failure for mechanical machine elements under different loading conditions.
III	The various permanent and temporary joints in engineering applications subjected to various loading conditions.
IV	The design procedure for the various power transmission elements on the basis of strength and rigidity

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO1	**Outline** the knowledge of design process and design standards, theories of failures, analyses the stresses and strainsfor various machine elements.	Understand
CO2	**Develop** the Design procedure of riveted joints and welded joints for engineering applications like boilers, pressure vessels, ships and trusses.	Apply
CO3	**Classify** various types of keys and cotter joints used to employee secure to gears, pulleys, disc applications.	Understand
CO4	**Develop** the design procedures of knuckle joint for different loading conditions in propeller applications.	Apply
CO5	**Select** appropriate design procedures on the basis of strength, torsional rigidity for shafts and Couplings.	Remember
CO6	**Evaluate** the natural frequency, energy storage, stresses and deflections of helical springs for static and fatigue loadings.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIA/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIA/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE/CIA/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Research papers / Industry exposure
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	3	Research papers / Industry exposure

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	-	✓	-	-	-	-	-	-	-	-	-	✓	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	-	✓	-	-	-	-	-	-	-	-	-	✓	-	-
CO 5	✓	-	✓	-	-	-	-	-	-	-	-	-	✓	-	✓
CO 6	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	✓

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Explain the importance of design process and theories failues solving through the scientific principles of **mathematics** and **science.**	2
CO 2	PO 1	Identify suitable permanent joints (Rivets, Welds) in engineering applications by applying the principles of **mathematics** and **engineering fundamentals.**	2
	PO 3	**Design Procedures** of **Riveted and Welded joint problems** with **various real time applications.**	3
	PSO 1	**Formulate** and **evaluate** engineering concepts of joints design to provide solutions for **various applications.**	3
CO 3	PO 1	Classify the different types of keys employed to various applications by applying the principles of **mathematics, sciece** and **engineering fundamentals.**	3
	PO 2	Apply the procedure of various loading on different cotter joints for **analyze** and **deriving related equations** from the provided information and substantiate with **interpretation** of **variations in the results**	4
CO 4	PO 1	Develop the theory, phenomena of Knucle joint for engineering applications by applying the principles of **mathematics, science** and **engineering fundamentals** to perform high efficiency.	3
	PO 3	**Design solutions** of **Knuckle joint problems** and **various loading conditions of each components** for different applications. .	4
	PSO 1	**Formulate** and **evaluate** engineering concepts of design to provide solutions for technology aspects in digital manufacturing.	2
CO 5	PO 1	Select the suitable shafts and couplings for numeraous engineering applications by applying the principles of **mathematics, science** and **engineering fundamentals** of design of machine elements.	3
	PO 3	**Design procedures** of **shafts** and **different strength conditions of** for various applications.	4
	PSO 1	**Formulate** and **evaluate** engineering concepts of shaft design to provide solutions for numerous applications.	2
	PSO 3	Make use of various **design tools** for**higher studies**in the field of design.	2
CO 6	PO 1	**Explain** the working principles of various springs and applying the principles of **mathematics, science** and **engineering fundamentals.** for derive the stress and deflection equations for helical and torsion springs	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Determine the given **spring problem statement** and**formulate** the deflection and energy storing capability for deriving related equations from the provided information and **interpretation** of **results.**	4
	PSO 1	**Formulate** and **evaluate** engineering concepts of torsion and helical springs design to provide solutions for technology aspects in digital manufacturing.	2
	PSO 3	Make use of various **design tools** for**higher studies**in the field of design.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	-	3	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	4	-		-	-	-	-	-	-		2	-	-
CO 5	3	-	4	-	-	-	-	-	-	-	-	-	2	-	2
CO 6	3	4	-	-	-	-	-	-	-	-	-	-	2	-	2

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.6	-	30	-	-	-	-	-	-	-	-	-	100	-	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	-	40	-		-	-	-	-	-	-	-	100	-	-
CO 5	100	-	40	-	-	-	-	-	-	-	-	-	100	-	100
CO 6	100	40	-	-		-	-	-	-	-	-		100	-	100

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	-	3	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	4	-		-	-	-	-	-	-		2	-	-
CO 5	3	-	4	-	-	-	-	-	-	-	-	-	2	-	2
CO 6	3	4	-	-	-	-	-	-	-	-	-		2	-	2
TOTAL	16	8	11	-	-	-	-	-	-	-	-	-	9	-	4
AVERAGE	2.66	4	3.66	-	-	-	-	-	-	-	-	-	2.25	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1, PO 2, PO3, PSO 1, PSO 3	SEE Exams	PO 1, PO 2, PO3, PSO 1, PSO 3	Seminars	PO 1, PO 2, PO3
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 1, PO 2, PO3	Open Ended Experiments	-
Assignments	PO 1, PO 2, PO3				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO THEORY OF FAILURES**
	Introduction: General considerations in the design of engineering materials and their properties, selection, manufacturing consideration in design, tolerances and fits, BIS codes of steels; Theories of failures, factor of safety design for strength and rigidity, preferred number; Fatigue loading : Stress concentration, theoretical stress concentration factor, fatigue stress concentration factor, notch sensitivity, design for fluctuating stresses, endurance limit, estimation of endurance strength, Goodman's life, Soderberg's line.
MODULE II	**DESIGN OF FASTENERS**
	Design of fasteners: Riveted joints, methods of failure of riveted joints, strength equations, efficiency of riveted joints, eccentrically loaded riveted joints; Welded Joints: Design of fillet welds, axial loads, circular fillet welds, bending, bolts of uniform strength.
MODULE III	**DESIGN OF KEYS AND JOINTS**
	Keys, cotters and knuckle joints: Design of keys, stress in keys, cotter joints, spigot and socket. Sleeve and cotter, jib and cotter joints, Knuckle joints

MODULE IV	**DESIGN OF SHAFTS**
	Design of Shafts: Design of solid and hollow shafts for strength and rigidity, design of shafts for complex loads, Shaft sizes, BIS code, design of shafts for gear and belt drives; Shaft couplings: Rigid couplings, muff, Split muff and flange couplings, flexible couplings, pin, bush coupling.
MODULE V	**DESIGN OF SPRINGS**
	Mechanical Springs: Stresses and deflections of helical springs, extension compression springs, springs for static and fatigue loading, natural frequency of helical springs, energy storage capacity, helical torsion springs, co-axial springs.

TEXTBOOKS

1. P. Kannaiah, "Machine Design", 2nd Edition, Scitech Publications India Pvt. Ltd, New Delhi, 2012 .

2. V.B. Bandari, "A Text Book of Design of Machine Elements", 3rd edition, Tata McGraw Hill, 2011.

REFERENCE BOOKS:

1. Richard G. Budynas, J. Keith Nisbett, "Shiegly's Mechanical Engineering Design", 10th Edition, 2014.

2. R.L. Norton, "Machine Design An Integrated approach", Person Publisher, 2nd Edition, 2006.

3. U.C. Jindal, "Machine Design", Pearson, 1st Edition, 2010.

4. R.S. Khurmi, A. K. Gupta,"Machine Design", S. Chand & Co, New Delhi, 1st Edition, 2014.

WEB REFERENCES:

1. http://nptel.ac.in/courses/Webcourse contents/IIT % 20 Kharagpur/Machine % 20design1/New index1.html

2. http://nptel.ac.in/downloads/112105125/

3. http:/alljntuworld.in/download/design machine members 1 dmm 1materials notes/

4. http:/scoopworld.in/2015/03/design of machine members dmm mech.html

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to Outcome Based Education		
CONTENT DELIVERY (THEORY)			
1	Introduction, General considerations in the design	CO 1	R4:1.5
2-3	Identify Engineering Materials and their properties. Tolerances and fits BIS codes of steels.	CO 1	T1:3.1 R3:3.16
4	Explain theories of failure	CO 1	T1:7.59

5-7	Explain Reversed Stresses	CO 1	T2:5.11
8	Explain Factor of safety, Design for strength and rigidity, preferred numbers	CO 1	T2:7.3 R3:3.21
9	Understand Stress concentration Theoretical stress Concentration factor Fatigue stress concentration factor Notch Sensitivity	CO 1	T1:7.63 R3:6.11
10-11	Explanation and problems on stress concentration. Endurance limit – Estimation of Endurance strength	CO 1	T1:7.89 R4:6.4
12-15	Explain Goodman's life – Soderberg's line. Solutions of problems on various types of loading.	CO 1	T1:7.9 R3:6.20
16-17	Compare Fasteners methods	CO 2	T1:11.2 R3:11.6
18	Explanation about Lap and but joints and various parameters involved in design of riveted joints.	CO 2	T1:9.2 R3:9.8
19	Understand efficiency of riveted joints Calculate stress induced in rivets	CO 2	T1:9.5 R3:9.14
20-21	Analyze Eccentrically loaded riveted joints. Problems in design of riveted joints.	CO 2	T2:8.3 R4:9.21
22-23	Understand design of fillet welds-axial loads-circular fillet welds	CO 2	T1:106 R4:10.17
24	Analyze Bending-bolts of uniform strength Construction design and proportions of bolts	CO 3	T1:11.9 R4:11.16
25	Explanation of various stresses induced in bolted joints and solution of problems in various applications	CO 3	T2:11.5 R4:11.10
26	Explanation of the procedure for finding size of bolts	CO 3	T2:11.9 R1:11.12
27	Bolted joints and associated parts for locking purpose	CO 3	T2:11.21 R1:11.7
28	Sketches for keys, cotters, knuckle joints and explanation of the purpose of each joint	CO 4	T1:12.1
29	Estimate Design of Keys, stress in keys	CO 7	T1:12.15 R3:12.7
30	Describe Cotter joints, Spigot and socket	CO 4	T2:9.9 R3:13.8
31-33	Compare Jib and cotter joints, knuckle joint	CO 4	T1:12:10 R3:12.4
34	Solution of problems under application load	CO 4	T1:12.16
35	Sketches of different couplings and various parameters to be explained	CO 4	T2:15.1 R3:14.16
36	Rigid couplings Muff, Split muff and Flange couplings	CO 4	T2:15.2. R2: 12.6
37	PIN-Bush coupling.	CO 4	T2:9.24 R2: 12.8
38	Problems of different couplings	CO 4	T2:9.30
39-41	Apply Formulas for determining size of both hollow and solid shafts and various conditions of loading for strength and Rigidity criteria	CO 5	T1:13.2 R3:14.6

42	Analyze Design of shafts for complex loads	CO 5	T1:13.8, R3:14.11
43-44	Distinguish Shaft size BIS codes. Applications and solution of problems for transmission of power by shafts loaded with belt and gear drives	CO 5	T1:13.9 R3:14:13
45	Sketches of different springs with relevant parameters Stresses and deflections of helical springs	CO 6	T2:16.2 R3:23.8
46	Extension compression springs-springs for static and fatigue loading	CO 6	T2:10.3 R4:23.18
47	Natural frequency of helical springs- energy storage capacity	CO 6	T2:10.5
48-49	Helical torsion springs	CO 6	T2:10.10
50-51	Co-axial springs.	CO 6	T1:10.15
52	Design of Helical Torsional Springs	CO 6	T2:10.21
PROBLEM SOLVING/ CASE STUDIES			
1	Problem Manufacutring Considerations	CO 1	R2:7.5
2	Problems on Theories of Failure	CO 1	R2:7.5
3	Problems on Factor of Safety	CO 1	R2:7.5
4	Problems on Notch Sensitivity	CO 1	R2:7.5
5	Problems on Rivit Efficiency	CO 2	R2:7.5
6	Problems on Soderberg's Line	CO 2	R2:7.5
7	Problems on Bolt Efficiency	CO 2	R2:7.5
8	Problems on Keys Strength	CO 3	R2:7.5
9	Problems on Cotter Joints	CO 3	R2:7.5
10	Problems on Knuckle Joint	CO 3	R2:7.5
11	Problems on Shaft	CO 4	R2:7.5
12	Problems on Couplings	CO 5	R2:7.5
13	Problems on Flange Couplings	CO 5	R2:7.5
14	Problems on Spring Strength	CO 6	R2:7.5
15	Problems on Torsional Springs	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definition and Terminology of Theory of Failures	CO 1	R4:2.1
2	Definition and Terminology of Various Fasternes	CO 2	R4:2.1
3	Definition and Terminology of Keys and Cotters	CO 3	R4:2.1
4	Definition and Terminology of Shafts	CO 4,5	R4:2.1
5	Definition and Terminology of Springs	CO 6	R4:2.1
DISCUSSION OF QUESTION BANK			
1	Discussion on Question Bank of Theory of Failures	CO 1	R4:2.1
2	Discussion on Question Bank of Various Fasternes	CO 2	R4:2.1
3	Discussion on Question Bank of Keys and Cotters	CO 3	R4:2.1
4	Discussion on Question Bank ofShafts	CO 4,5	R4:2.1
5	Discussion on Question Bank of Springs	CO 6	R4:2.1

Signature of Course Coordinator **HOD,ME**
Mr.B.Vijay Krishna, Assistant Professor

I A R E

EDUCATION FOR LIBERATION

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**THERMAL ENGINEERING**				
Course Code	AME013				
Program	B. Tech				
Semester	V				
Course Type	Professional Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. S Srikrishnan, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB04	IV	Thermodynamics I
B.Tech	AMEB09	IV	Applied Thermodynamics I

II COURSE OVERVIEW:

Thermal Engineering is the applications of thermodynamics. The objective of the course is to introduce the mechanical engineering students an understanding of the performance of Rankine cycle, parameters to improve the performance like reheating, regenerating and also Gas turbines and rocket engines and their performance. The knowledge of thermal engineering helps us in improving and designing the various parts of machine elements. The course content is designed in such a way that efficiencies of different turbines could be achieved by the calculation of different empirical values.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Fluid Dynamics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
18.18%	Remember
63.63 %	Understand
18.18%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

I	The usage of fundamental knowledge on thermodynamic cycles and fluid dynamics phenomena present in turbomachinery and combustion for producing electric and mechanical energy/power.
II	The operational concepts, principles, features, procedures and detailed thermodynamic analyses related to components of power cycles, rocket propulsion as well as steam and power generators.
III	The designing approaches for developing governing equations and correlations related to intricate parts of turbomachinery and their components with due consideration of effect on the performance.
IV	A wealth of real world engineering problems and examples towards gaining the experience for designing and developing power generating systems in engineering practice.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Recall** Recall the thermodynamic processes, working and analyses of combustion, vapor power cycles for producing electrical and mechanical power electrical and mechanical power.	Remember
CO 2	**Interpret** various concepts, principles of operation, theories and phenomena related to theboilers and nozzles	Understand
CO 3	**Execute** the performance parameters of the steam turbine and reaction turbine for maximum efficiency, thermodynamic analysis of a stage, degree of reaction, velocity diagram.	Apply
CO 4	**Describe** the principles of operation, classification, working, accessories and mountings of various steam generators and condensers.	Analyze
CO 5	**Apply** the working principles and analyses of combustion, gas power cycles for producing electrical and mechanical power.	Analyze
CO 6	**Discuss** the principles, methodologies and variations in the configurations of thermal gas turbomachinery and rocket propulsion based on the availability of resources.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIE/SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	CIE/SEE
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	3	CIE/SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	CIE/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3	CIE/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	3	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	✓	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 3	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 4	✓	✓	✓	-	-	✓	-	-			-		-	-	-
CO 5	✓		-	-	-	-	-	-		-	-	✓	-	✓	-
CO 6	✓	-	-	✓	-	-	-	-	-	-	-	✓	-	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall the thermodynamic properties and applications of various laws of thermodynamics in the advanced machines like steam engines, gas turbines and **rockets using the knowledge of mathematics, science and engineering fundamental.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Analyze the relationship of turbomachinery and power production to discern **problems and identify solutions**. Balance the equation using fundamental laws and internal energy to **develop solution** in real world problems.	1
	PSO 2	Formulate and Evaluate concepts of **Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.**	2
CO 2	PO 1	Recall the thermodynamic properties and applications of various laws of thermodynamics in the advanced machines like steam engines, gas turbines and **rockets using the knowledge of mathematics, science and engineering fundamental.**	3
	PO 2	Analyze the relationship of turbomachinery and power production to discern **problems and identify solutions**. Balance the equation using fundamental laws and internal energy to **develop solution** in real world problems.	1
	PSO 2	Formulate and Evaluate concepts of **Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.**	2
CO 3	PO 1	Understand the working principles of boilers, gas turbines, jet propulsion and rocketery **using the knowledge of engineering fundamentals and mathematics.**	3
	PO 7	**Individual** Understand the impact of the professional engineering solutions in **societal and environmental contexts** and **demonstrate the knowledge** and demonstrate the knowledge of, and need for sustainable development.	3
	PO 10	Communicate clearly in form of **writing** assignments, preparing **subject matter** in form of Tech Talk and 5 Minute video and maintain a profound **speaking style**	1
CO 4	PO 1	Analyze the various turbomachinery performance and characteristics with relevant **mathematical equations.**	2
	PO 2	Analyze the relationship of turbomachinery and power production to discern **problems and identify solutions**. Balance the equation using fundamental laws and internal energy to **develop solution** in real world problems.	3
	PO 3	Understand the **customer requirement, identify the cost** to correlate the properties of pure substances and steam to emit relevant inlet and exit conditions of thermodynamic **work bearing systems used in various day to day applications**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 6	Apply reasoning informed by the contextual knowledge to assess **societal, health, safety, legal and cultural issues and the consequent responsibilities**relevant to the professional engineering practice.	3
CO 5	PO 1	Categorize the various vapor and gas power cycles to select the relevant cycle for specific application using the fundamentals of engineering, science and mathematics	3
	PSO 2	Formulate and Evaluate concepts of **Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.**	2
CO 6	PO 1	Illustrate the various systems using **engineering fundamentals** to describe the functionality of steam generators and condensers and derive the relationship between them using basic **mathematical equations**	3
	PO 4	Use research-based knowledge and research methods including design of **experiments, analysis and interpretation of data,** and synthesis of the information to provide valid conclusions.	3
	PO 12	Recognize the need for, and have the preparation and **ability to engage in independent**and life-long learning in the broadest context of technological change. 3	
	PSO 2	Formulate and Evaluate concepts of **Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 3	3	-	-	-	-	-	1	-	-	-	-	-	-	-	-
CO 4	3	1	1	-	-	1	-	-	-	-	-		-	-	-
CO 5	3	-	-	1	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	-	-	1	-	-	-	-	-	-	-	1	-	2	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	25	60	-	-	-	-	-
CO 2	100	-	-	-	-	-	-	-	25	60	-	-	50.0	-	-
CO 3	100	-	-	-	-	-	-	-	25	60	-	-	50.0	-	-
CO 4	100	100	-	-	-	-	-	-	25	60	-	-	50.0	-	-
CO 5	100	100	-	-	-	-	-	-	25	60	-	-	50.0	-	-
CO 6	100	100	-	-	-	-	-	-	25	60	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 3	3	-	-	-	-	-	1	-	-	-	-	-	-	-	-
CO 4	3	2	2	-	-	3	-	-	-	-	-		-	-	-
CO 5	3	-	-	2	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	-	-	3	-	-	-	-	-	-	-	2	-	2	-
TOTAL	18	8	2	5	-	3	-	-	-	-	-	-	-	10	-
AVERAGE	3.0	2.6	2	2.5	-	3	-	-	-	-	-	2	-	2.5	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**BASIC CONCEPTS**
	Rankine cycle schematic layout, thermodynamic analysis, concept of mean temperature of heat addition, methods to improve cycle performance, regeneration and reheating. Combustion: fuels and combustion, adiabatic flame temperature, stoichiometry, exhaust gas analysis.
MODULE II	**BOILERS AND STEAM NOZZLES**
	Boilers: Classification, working principles with sketches, boilers mountings and accessories, working principles.; Basics of compressible flow, Isentropic flow of a perfect gas through nozzle, subsonic, supersonic and choked flow-normal shocks-ideal gas tables for isentropic and normal shock flow, flow of steam and refrigerant through nozzles, thermodynamic analysis of nozzle
MODULE III	**STEAM TURBINES AND STEAM CONDENSERS**
	Steam Turbines: Classification, Impulse turbine-velocity diagrams, pressure and velocity compounding .Reaction turbine-principle of operation, thermodynamic analysis of a stage, degree of reaction, velocity diagrams.Steam Condensers: Requirements of steam condensing plant, classification of condensers, working principle of different types.
MODULE IV	**GAS TURBINES**
	Gas turbines: Simple gas turbine plant, ideal cycle, essential components, parameters of performance, actual cycle, regeneration, inter cooling and reheating, closed and Semi-closed cycles, merits and demerits, brief concepts of combustion chambers of gas turbine plant.

MODULE V	**JET PROPULSION AND ROCKETS**
	Jet propulsion: Principle of operation, classification of jet propulsive engines, working Principles with schematic diagrams and representation on T-S diagram, thrust, thrust power and propulsion efficiency, turbo jet engines, needs and demands met by turbo jet, schematic diagram, thermodynamic cycle, performance evaluation; Rockets: Application, working Principle, classification, propellant type, thrust, propulsive efficiency, specific impulse, solid and liquid propellant rocket engines.

TEXTBOOKS

1. 1. R. K. Rajput, "Thermal Engineering", Lakshmi Publications, 8th Edition, 2015.

2. 2. V. Ganeshan "Gas turbines", Tata McGraw-Hill, 3rd Edition, 2010.

REFERENCE BOOKS:

1. 1. P. Khajuria, S. P Dubey, "Gas Turbines and Propulsive systems", Dhanpat Rai Publishers., 1st Edition, 2012

2. 2. Ballaney, "Thermal Engineering", Khanna Publishers, 1st Edition, 2012.

WEB REFERENCES:

1. https://onlinecourses.nptel.ac.in/noc21_me119/preview

COURSE WEB PAGE:

https://www.iare.ac.in/?q=pages/btech-course-descriptions-iare-r18-7

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	**Topics to be covered**	**CO's**	**Reference T1: 4.1**
OBE DISCUSSION			
1	Discussion on Outcome based education		
CONTENT DELIVERY (THEORY)			
1	Rankine cycle - Schematic layout	CO 1	T1 1.1
2-3	Thermodynamic Analysis,	CO 1	T1 1.2
4-6	Concept of Mean Temperature of Heat addition	CO 1	T1 1.3
7	Methods to improve	CO 3	T1 1.4
8-9	Regeneration and reheating	CO 2	T1 1.5
10-11	Combustion: fuels and combustion	CO 1	T1 1.6
12	adiabatic flame temperature	CO 2	T1 1.7 R2
13	stoichiometry	CO 3	T1 1.8, R1
14	flue gas analysis	CO 3	T1 1.8, R1
15-17	BOILERS : Classification – Working principles	CO 3	T1 2.1, R1
18-19	with sketches including H.P.Boilers	CO 4	T1 2.2, R1

20	Function of nozzle – applications- types	CO 4	T1 2.3, R2
21	Flow through nozzles	CO 4	T1 2.4, R1
22	thermodynamic analysis	CO 5	T1 2.5, R1
23	STEAM TURBINES: Classification	CO 5	T1 3.1, R2
24	Impulse turbine; Mechanical details	CO 5	T1 3.2, R2
25	Velocity diagram – effect of friction – power developed, axial thrust, blade or diagram efficiency	CO 5	T1 3.2, R2
26	condition for maximum efficiency	CO 6	T1 3.3, R2
27	Reaction Turbine: Mechanical details – principle of operation	CO 6	T1 3.4, R2
28	thermodynamic analysis of a stage, degree of reaction	CO 6	T1 3.5, R2
29	velocity diagram Parson's reaction turbine – condition for maximum efficiency	CO 6	T1 3.5,R2
30	STEAM CONDENSERS : Requirements of steam condensing plant —	CO 6	T1 3.6, R1
31	Classification of condensers working principle of different types	CO 6	T1 3.7, R1
32	GAS TURBINES : Simple gas turbine plant – Ideal cycle, essential components – parameters of performance – actual cycle	CO 5	T1 4.1, R3
33	regeneration, inter cooling and reheating	CO 5	T1 4.2, R3
34	Closed and Semi-closed cycles – merits and demerits.	CO 5	T1 4.3, R3
35-36	JET PROPULSION: Principle of Operation –Classification of jet propulsive engines – Working Principles with schematic diagrams and representation on T-S diagram	CO 5	T1 4.4, R3
36	Thrust, Thrust Power and Propulsion Efficiency	CO 6	T1 4.5, R3
37	Turbo jet engines – Needs and Demands met by Turbo jet – Schematic Diagram, Thermodynamic Cycle, and Performance Evaluation Thrust Augmentation – Methods.	CO 6	T1 4.7, R3
38-39	ROCKETS: Application – Working Principle – Classification – Propellant Type – Thrust, Propulsive Efficiency – Specific Impulse –Engines.	CO 6	T1 4.9, R3
40-41	Solid and Liquid propellant Rocket Engines.	CO 6	T1 4.11, R3
PROBLEM SOLVING/ CASE STUDIES			
42	Basic concepts,Rankine cycle	CO 1	T1 1.1 ,
43	Methods to improve cycle performance	CO 1	T1 1.2
44	Regeneration and reheating	CO 1	T1 1.3

45	Isentropic flow of a perfect gas through nozzle	CO 3	T1 1.4
46	Choked flow- normal shocks-ideal gas tables for isentropic	CO 2	T1 1.5
47	Refrigerant through nozzles, thermodynamic analysis of nozzle.	CO 2	T1 1.5
48	Reaction turbine-principle of operation, thermodynamic analysis of a stage	CO 2	T1 1.5
49	Degree of reaction, velocity diagrams.	CO 2	T1 1.5
50	Parameters of performance, actual cycle, regeneration, inter cooling and reheating	CO 2	T1 1.5
52	Cosed and Semi-closed cycles	CO 2	T1 1.5
53	Combustion chambers of gas turbine plant.	CO 2	T1 1.5
54	Flow of steam and refrigerant through nozzles	CO 2	T1 1.5
55	Thermodynamic analysis of nozzle	CO 2	T1 1.5
56	Jet propulsion and rockets	CO 2	T1 1.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Basic concepts,Rankine cycle	CO 1	T1 1.1 ,
58	Boilers and steam nozzles	CO 1	T1 1.2
59	Steam turbines and steam condensers	CO 1	T1 1.3
60	Gas turbines: Simple gas turbine plant	CO 3	T1 1.4
61	Jet propulsion and rockets	CO 2	T1 1.5
DISCUSSION OF QUESTION BANK			
62	Basic concepts,Rankine cycle	CO 1	T1 1.1 ,
63	Boilers and steam nozzles	CO 1	T1 1.2
64	Steam turbines and steam condensers	CO 1	T1 1.3
65	Gas turbines: Simple gas turbine plant	CO 3	T1 1.4
66	Jet propulsion and rockets	CO 2	T1 1.5

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**BUSINESS ECONOMICS AND FINANCIAL ANALYSIS**				
Course Code	AHS015				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. S. Sivasankara Rao, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

II COURSE OVERVIEW:

The present course is designed in such a way that it gives an overview of concepts of Economics. Managerial Economics enables students to understand micro environment in which markets operate how price determination is done under different kinds of competitions. Financial Analysis gives clear idea about concepts, conventions and accounting procedures along with introducing students to fundamentals of ratio analysis and interpretation of financial statements. Break Even Analysis is very helpful to the Business Concern for Decision Making, controlling and forward Strategic Planning. Ratio analysis gives an idea about financial forecasting, financial planning, controlling the business and decision making.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
BEFA	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

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The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
16%	Remember
17%	Understand
17%	Apply
50%	Analyze
0%	Evaluate
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

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This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

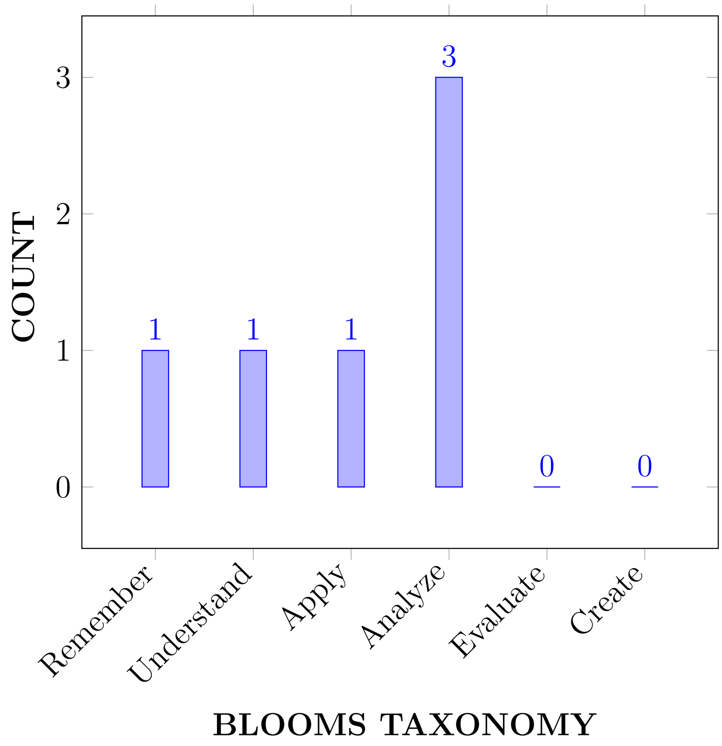
I	The concepts of business economics and demand analysis helps in optimal decision making in business environment
II	The functional relationship between Production and factors of production and able to compute breakeven point to illustrate the various uses of breakeven analysis.
III	The features, merits and demerits of different forms of business organizations existing in the modern business environment and market structures.
IV	The concept of capital budgeting and allocations of the resources through capital budgeting methods and compute simple problems for project management.
V	Various accounting concepts and different types of financial ratios for knowing financial positions of business concern.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**List** the basic concepts of managerial economics and analysis, measurement of demand and its forecasting to know the current status of goods and services.	Remember
CO 2	**Examine** to know the current status of goods and services. to know the economies and diseconomies of scale in manufacturing sector.	Analyze
CO 3	**Summarize** the four basic market models like perfect competition, monopoly, monopolistic competition, and oligopoly to know the price and quantity are determined in each model.	Understand
CO 4	**Compare** various types of business organizations and discuss their implications for resource allocation to strengthen the market environment.	Analyze
CO 5	**Analyze** different project proposals by applying capital budgeting techniques to interpret the solutions for real time problems in various business projects.	Analyze
CO 6	**Develop** the ability to use a basic accounting system along with the application of ratios to create (record, classify, and summarize) the data needed to know the financial position of the organization.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Build Embedded Software and Digital Circuit Development platform for Robotics, Embedded Systems and Signal Processing Applications.	-	-
PSO 2	Focus on the Application Specific Integrated Circuit (ASIC) Prototype designs, Virtual Instrumentation and System on Chip (SOC) designs.	-	-
PSO 3	Make use of High Frequency Structure Simulator (HFSS) for modeling and evaluating the Patch and Smart Antennas for Wired and Wireless Communication Applications.	-	-

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	✓	✓	-	✓	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	✓	✓	-	✓	-	-	-	-
CO 3	-	-	-	-	-	-	-	✓	✓	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	✓	✓	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-	-
CO 6	-	✓	-	-	-	-	-	-	-	-	✓	-	-	-	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Recall** (knowledge) the scientific fundamentals of economic activities performed by the businessmen in the business for profit earning.	2
	PO 2	**Interpret** and identify the demand and its analysis with the mathematical and natural principles of demand forecasting methods.	6
	PO 8	**Define** (knowledge) the responsibilities of the engineering practices by knowing the best economical practices.	1
	PO 9	**Match** (knowledge) the economical implication to effectively function as a team member, and as a member or leader in diverse teams.	5
	PO 11	**Relate** (knowledge) the knowledge and understanding of the economic principles and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	6
CO 2	PO 1	**Recall** (Knowledge) the knowledge of mathematics, science in the production function through Different Combination of variable inputs with Economies of Scale.	2
	PO 2	**Demonstrate** the different cost concepts and determine the significance of Break Even Analysis.	5
	PO 8	**Relate** (Knowledge) (Knowledge) the ethical principles and commit to professional ethics and responsibilities and norms of the production management	2
	PO 9	**Show** (Fundamentals) the production function implications for effective implementation of gang compositions in a team work and in multidisciplinary settings.	6
	PO 11	**Define** the economies of scale in production function and Break Even Analysis knowledge applied in one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	5
CO 3	PO 8	**List** (Knowledge) (Knowledge) different structures of market and how price is determined under different market structures commit to professional ethics and responsibilities and norms of the engineering practice.	2
	PO 9	**Match** the market structures and the market entry strategies as an individual, and as a member in diverse teams.	6
CO 4	PO 8	**Categorize** the ethical principles and commit to professional ethics and responsibilities belongs to different forms of business organizations existing in the modern business.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 9	**Classify** various business organizations and their functioning as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	6
CO 5	PO 1	**Explain** the ethical issues involved in the allocation of funds under the concept of capital budgeting.	1
	PO 11	**Summarize** the concept of capital budgeting and allocations of the resources through capital budgeting methods of the management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	8
CO 6	PO 2	**Explain** the GAAP principles and ratios to analyse complex engineering problems reaching substantiated conclusions using first principles of accounts and profitability and efficiency of the organization.	6
	PO 11	**Illustrate**the accounting methods and procedures and accounting principles to manage the financial aspects in a project.	8

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	6	-	-	-	-	-	1	5	-	6	-	-	-	-
CO 2	2	5	-	-	-	-	-	2	6	-	5	-	-	-	-
CO 3	-	-	-	-	-	-	-	2	6	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	2	6	-	-	-	-	-	-
CO 5	1	-	-	-	-	-	-	-	-	-	8	-	-	-	-
CO 6	-	2	-	-	-	-	-	-	-	-	8	-	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	60.0	-	-	-	-	-	33.3	41.6	-	50.0	-	-	-	-
CO 2	66.7	50.0	-	-	-	-	-	66.7	50.0	-	41.6	-	-	-	-
CO 3	-	-	-	-	-	-	-	66.7	50.0	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	66.7	50.0	-	-	-	-	-	-
CO 5	33.3	-	-	-	-	-	-	-	-	-	75.0	-	-	-	-
CO 6	-	20.0	-	-	-	-	-	-	-	-	75.0	-	-	-	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 - $5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	-	-	1	2	-	2	-	-	-	-
CO 2	3	2	-	-	-	-	-	3	2	-	2	-	-	-	-
CO 3	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-
CO 5	1	-	-	-	-	-	-	-	-	-	3	-	-	-	-
CO 6	-	1	-	-	-	-	-	-	-	-	3	-	-	-	-
TOTAL	7	7	-	-	-	-	-	10	8	-	-	-	-	-	-
AVERAGE	2.3	2.3	-	-	-	-	-	2.5	2	-	2.5	-	-	-	-

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1, PO 2, PO 8,PO 9 PO 11	SEE Exams	PO 1, PO 2, PO 8,PO 9 PO 11	Seminars	PO8
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 1, PO 2, PO 8,PO 9 PO 11	Open Ended Experiments	-
Assignments	PO 9				

XVI ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII SYLLABUS:

MODULE I	**INTRODUCTION&DEMAND ANALYSIS**
	Introduction to Business Economics: Definition, Nature and Scope of Managerial Economics – Demand Analysis: Demand Determinants, Law of Demand and its exceptions. Elasticity of Demand: Definition, Types, Measurement and Significance of Elasticity of Demand. Demand Forecasting, Factors governing demand forecasting, methods of demand forecasting

MODULE II	**PRODUCTION & COST ANALYSIS**
	Theory of Production and Cost Analysis: Production Function – Iso-quants and Iso-costs, MRTS, Least Cost Combination of Inputs, Cobb-Douglas Production function, Laws of Returns, Internal and External Economies of Scale. Cost Analysis: Cost concepts; Break-even analysis, Determination of Break – Even point (Simple Problems) , Managerial Significance of BEA.
MODULE III	**MARKETS & NEW ECONOMIC ENVIRONMENT**
	LMarket structures: Types of competition, Features of perfect competition, Monopoly and monopolistic competition. Price determination & Price Statistics: Price Output determination in case of perfect competition and monopoly. Features and evaluation of different forms of Business organization: Sole proprietorship, partnership, Joint Stock Company, public enterprises and their types.
MODULE IV	**CAPITAL BUDGETING**
	Capital and its significance, types of capital, estimation of fixed and working capital requirements, methods and sources of raising capital- Trading Forecast, Capital budget, Cash Budget. Features of capital budgeting proposals, methods of capital budgeting – payback method, Accounting rate of return(ARR), Net Present Value Method (simple problems).
MODULE V	**INTRODUCTION TO FINANCIAL ACCOUNTING AND FINANCIAL ANALYSIS**
	Financial accounting objectives, functions, importance; Accounting concepts and accounting conventions - double-entry book keeping, journal, ledger, trial balance; Final accounts: Trading account, profit and loss account and balance sheet with simple adjustments; Financial analysis: Analysis and interpretation of liquidity ratios, activity ratios, capital structure ratios and profitability ratios (simple problems), Du Pont chart.

TEXTBOOKS

1. Aryasri, “Managerial Economics and Financial Analysis”, TMH publications, 4thEdition,2012.
2. M. KasiReddy, Saraswathi, “Managerial Economics and Financial Analysis”, PHI Publications, New Delhi, 2ndEdition,2012.
3. Varshney, Maheswari, “Managerial Economics”, Sultan Chand Publications, 11thEdition,2009.

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1. D.N. Dwivedi, “Managerial Economics”, Vikas Publication House Pvt.Ltd, 2ndEdition,2012.
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3. R.NarayanaSwamy, “Financial Accounting- A managerial Perspective”, Pearson publications, 1stIndian Reprint Edition,2012.

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8. https://www.iedunote.com/write-accounting-ledger
9. https://opentextbc.ca/principlesofaccountingv1openstax/chapter/prepare-a-trial-balance/
10. https://caknowledge.com/how-to-prepare-final-accounts/
11. https://corporatefinanceinstitute.com/resources/knowledge/finance/ratio-analysis/

COURSE WEB PAGE:

https://lms.iare.ac.in/index?route=publicprofile&id=5201

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
1	Discussion on Course Outcomes and how these COs mapped with POs and PSOs.		
	CONTENT DELIVERY (THEORY)		
2-3	Explain about managerial economics according to the business	CO 1	T1- 1.3-1.8 R1-1.5-1.7
4-5	Describe about demand analysis, the Law of Demand and Demand Function.	CO 1	T1-2.2-2.11 R1-3.3-3.20
6-7	Understand elasticity of the demand of the product, different types, Measurement of Elasticity of Demand and Factors influencing on Elasticity of Demand.	CO 1	T1-3.3-3.20 R1- 5.29-6.8
8	State different methods of Demand Forecasting and the factors governing Demand Forecasting.	CO 1	T1-4.6-4.19
9-10	Demonstrate the Production function, features of Iso-Quants and Iso-Costs, different types of Internal Economies, External Economies and Law of Returns.	CO 2	T1- 5.3-5.18 R1- 5.29-6.8
11-13	Different types of Internal Economies, External Economies ad Law of Returns with appropriate examples.	CO 2	T1- 5.3-5.18
14-15	Illustrate different types of costs	CO 2	T1- 5.29-6.8
16-17	Explain the Significance and Limitations of Break-Even Analysis	CO 2	T1- 7.13-7.14
18-19	Calculate Break-Even Point (Simple Problems)	CO 2	T1- 7.1-7.12

20-21	Illustrate the features, price-output determination under Perfect Competition, Monopoly and Monopolistic competition Markets.	CO 3	T1- 8.4-8.16 R2- 5.29-6.8
22-24	Demonstrate the Objectives, Policies and Methods of Pricing Strategies and Price Methods.	CO 3	T1- 8.21-8.25
25-26	Describe Features of business, Definitions of Various forms of Business Units.	CO 4	T1-9.3-9.15
27-30	State the Merits & Demerits of Different types of Public Enterprises and Changing Business Environment to Post Liberalization Scenario.	CO 4	T1-9.2-10.23 R1- 8.21-8.25
31-32	Explain the significance and classification of capital, Methods and Sources of Raising Finance.	CO 6	T1-9.2-10.23
33-34	Demonstrate the concept of capital budgeting and allocations of the resources through capital budgeting methods and compute simple problems.	CO 6	T1-11.3-11.5 R2-12.3-12.5
35-37	Illustrate the Significance of Financial Accounting, Double Entry, Accounts, Accounting Concepts and Conventions	CO 6	T1-12.1-12.26
38-40	Explain the meaning, advantages and Limitations of the Journal, Ledger and Trial Balance and Final Accounts and Solve simple Problems.	CO 6	T1-13.4-13.15 R2-11.3-11.5
41-42	Describe Meaning, Definitions and Limitations of Ratio Analysis	CO 6	T1-13.4-13.15 R2-11.7-11.8
43-45	Compute different types of Financial Ratios (Problems)	CO 6	T1-13.5-13.68
PROBLEM SOLVING/ CASE STUDIES			
46	Problems relating to Demand elasticty measurement and Forecasting	CO 1	T1: 1.1 - 2.8, R1:2.1
47	Problems relation to Break Even Point	CO 2	T2: 3.0 to 3.6, 5.0 to5.5 , R2:4.4
48	Problems in determining the price in different types of markets	CO 3,4	T3: 6.0 to 6.4, R1:5.1
49	Problems relating to Capital Budgeting Decisions	CO 5	R2:7.5
50	Problems relating to Final Accounts and Calculation of Ratios	CO 6	R3: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
51	Introduction and Demand Analysis	CO 1	T1: 1.1 - 2.8, R1:2.1
52	Production and Cost Analysis	CO 2	T2: 3.0 to 3.6, 5.0 to5.5 , R2:4.4
53	Markets and New Environment	CO 3,4	T3: 6.0 to 6.4, R1:5.1
54	Capital Budgeting	CO 5	R2:7.5
55	Introduciton to Financial Accounting and Financial Analysis	CO 6	R3: 4.1

DISCUSSION OF QUESTION BANK			
56	Introduction and Demand Analysis	CO 1	T1: 1.1 - 2.8, R1:2.1
57	Production and Cost Analysis	CO 2	T2: 3.0 to 3.6, 5.0 to5.5 , R2:4.4
58	Markets and New Environment	CO 3,4	T3: 6.0 to 6.4, R1:5.1
59	Capital Budgeting	CO 5	R2:7.5
60	Introduciton to Financial Accounting and Financial Analysis	CO 6	R3: 4.1

Signature of Course Coordinator **HOD,ECE**
Dr. S. Sivasankara Rao, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Unconventional Machining Processes**				
Course Code	AME507				
Program	B.Tech				
Semester	V				
Course Type	Elective				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	0	0
Course Coordinator	Mr. M Sunil Kumar, Assistant Professor.				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME010	V	Machine Tools and Metrology

II COURSE OVERVIEW:

This course focuses on the various unconventional machining processes, the process parameters associated with them. Selection of an appropriate machining process for a particular application, properties of the work material and shape to be machined, process capability and economic considerations of these processes.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Unconventional Machining Processes	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
70 %	Understand
20%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

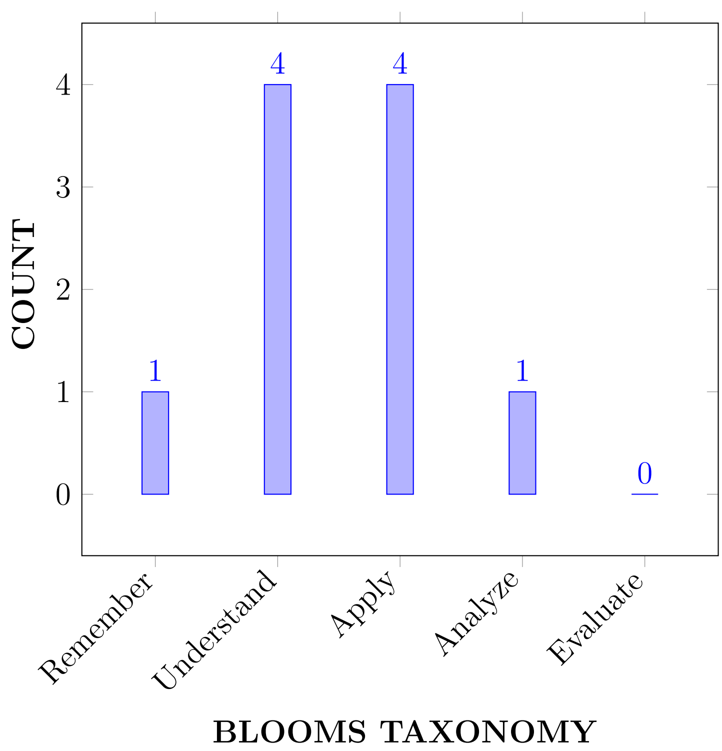
I	Understand the need and importance of non-traditional machining methods and process selection.
II	Gain the knowledge to remove material by thermal evaporation, mechanical energy process.
III	Apply the knowledge to remove material by chemical and electro chemical methods.
IV	Analyze various material removal applications by unconventional machining process.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Compare** Conventional and Non-Conventional machining and analyze the different elements.	Understand
CO 2	**Summarize** the principle and processes of abrasive jet machining of Ultrasonic Machining and its applications.	Understand
CO 3	**Illustrate** different parameters of Electrical Discharge Machining drilling for micro in the nozzle.	Understand
CO 4	**Identify** the principles, processes and applications of wire-EBM wire-EBM for aerospace and automotive parts.	Apply
CO 5	**Organize** various industrial problems in advanced machining processes using EBM and LBM.	Understand
CO 6	**Explain** the process and mechanism in Plasma Arc Machining for Profile cutting of metals, especially of these metals and alloys, has been the common prominent commercial application.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Quiz, Assignments.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE, CIE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIE, SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	3	Quiz, Assignment
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	1	Quiz, Assignment

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	✓	-	-	-	-		✓	✓	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	✓	-
CO 3	✓	✓	✓	-	-	-	✓	-	-	-	-	✓	✓	✓	-
CO 4	✓	✓	✓	-	-	✓	-	✓	-	-	-		✓	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 6	✓	✓	✓	-	-	-	✓	-	-	-	-	✓	✓	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recognize (knowledge) the importance of need for non-traditional machining methods and application to recent developments**mathematics**, **science** and Manufacturing fundamentals.	3
	PO2	Recognize (knowledge) the importance of need for non-traditional machining methods and application to recent developments **mathematics**, **science** and **Manufacturing fundamentals.**	3
	PSO1	Analysing the selection of high speed machining. complex designs.	2
CO 2	PO 1	Apply the operational principles of different metal removal process the knowledge of **mathematics**, **science** and **engineering fundamentals.**	3
	PO 2	Identify (knowledge) the electron beam machining for thermal features, speed depth of cut. **mathematics and science (physics and engineering)**.	2
	PSO1	Analysing the selection of high speed machining. complex designs.	2
CO 3	PO 1	Explain (Understand) the thermal removal process by EDM, **mathematics**, **science** and **engineering fundamentals.**	3
	PO 2	Understand the given problem statement and formulate formulate the design (complex) **engineering problems** for EDM information and data in reaching substantiated conclusions by the **interpretation of results.**	3
	PSO1	**Analysing** the selection of high speed machining. **complex designs.**	2
CO 4	PO 1	**Identify (knowledge)** the electron beam machining for thermal features, speed depth of cut. **mathematics and science (physics and engineering).**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Application of the **identifying, formulating**, and **analysing complex problems**.	3
	PO 3	**Ability to principle and applications** of laser beam machining. apply the principle of concentration of beam energy help them to design, analyse and fabricate complex designs.	3
	PSO 1	Ability to apply the generation and control of electron beam to **design, analyse and fabricate complex designs**.	3
CO 5	PO 1	**Application of plasma for machining**, metal removal mechanism of results to reach actual conclusion requires some research based **knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	**Ability to apply the principle** of chemical machining. while designing and manufacturing help them to design, **analyse** and fabricate maskant **complex designs**.	3
CO 6	PO 1	Application of plasma for machining, metal removal mechanism of results to reach actual conclusion requires some research based knowledge of **mathematics, science and engineering fundamentals.**	2
	PSO 1	Ability to apply the principle of chemical machining. while **designing and manufacturing help them to design**, **analyse and fabricate maskant complex designs.**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	3	-	-	-	-	-	2	2	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	3	2	-
CO 3	3	3	3	-	-	-	3	-	-	-	-	-	2	3	-
CO 4	3	3	3	-	-	2	-	2	-	-	-	3	2	-	-
CO 5	3	3	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	3	3	-	-	-	3	-	-	-	-	2	2	2	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	50	-	-	-	-	-	100	100	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	100	50	-
CO 3	100	50	50	-	-	-	50	-	-	-	-	-	50	50	-
CO 4	100	50	50	-	-	50	-	100	-	-	-	-	100	-	-
CO 5	100	40	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 6	100	40	50	-		-	50	-	-	-	-		50	50	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	2	-	-	-	-	-	3	3	
CO 2	2	2	-	-	-	-	-	-	-	-	-	-	3	2	-
CO 3	3	2	2	-	-	-	2	-	-	-	-	-	2	2	-
CO 4	3	2	2	-	-	2	-	3	-	-	-	-	3	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 6	3	2	2	-	-	-	2	-	-	-	-	-	2	2	-
TOTAL	18	10	6	-	-	2.0	6.0	3.0	-	-	-	-	13	12	-
AVERAGE	3.0	2.0	2.0	-	-	2.0	2.0	3.0	-	-	-	-	2.6	2.4	3

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓			Seminars	-
Assignments	-				
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE-I	**INTRODUCTION**
	Need for non-traditional machining methods, classifications of modern machining processes, considerations in process selection, materials application, Ultrasonic machining: Elements of the process, mechanics of metal removal, process parameters, economic considerations, application and limitations, recent developments.
MODULE II	**ABRASIVE JET MACHINING**
	Abrasive jet machining, water jet machining and abrasive water jet machining: basic principles, equipments process variables, mechanics of metal removal, MRR, applications and limitations; Electro chemical processes: Fundamentals of electro chemical machining, electro chemical grinding, electro chemical honing and deburring process, metal removal rate in ECM, tool design, surface finish and accuracy, economic aspect of ECM, simple problem for estimation of metal removal rate
MODULE-III	**THERMAL METAL REMOVAL PROCESSES**
	General principle and applications of Electric discharge machining, electric discharge grinding, electric discharge wire cutting processes, power circuits in EDM, mechanism of metal removal in EDM, process parameters. Selection of tool electrodes and dielectric fluids, surface finish and accuracy, characteristics of spark eroded surface and machine tool selection, wire EDM principle and applications.
MODULE-IV	**ELECTRON BEAM MACHINING**
	Generation and control of electron beam for machining, theory of electron beam machining, comparison of thermal and non thermal processes, general principle and applications of laser beam machining, thermal features, cutting speed and accuracy of cut.
MODULE-V	**PLASMA MACHINING**
	Application of plasma for machining, metal removal mechanism, process parameters, accuracy and surface finish and other applications of plasma in manufacturing industries; Chemical machining principle, maskants, etchants, applications.

TEXT BOOKS

1. V. K. Jain, “Advanced Machining Processes”, Allied Publishers, 1st Edition,2018.
2. Pandey P. C., Shah H.S., “Modern Machining Processes”, Tata McGraw-Hill, 1st Edition, 2019.

REFERENCE BOOKS:

1. Bhattacherya A, “New Technology”, The Institute for Engineers, 1stEdition, 2018.
2. C. Elanchezhian, B. Vijaya Ramnath, M. Vijayan, “Unconventional Machining processes”, Anuradha Publication, 1st Edition, 2019.
3. M. K. Singh, “Unconventional Machining processes”, New Age International Publishers, 1st Edition, 2018.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	OBE Discussion on outcome based education		
CONTENT DELIVERY (THEORY)			
2	Need for non-traditional machining methods,	CO1	R4:5.1
3	Need for non-traditional machining methods	CO1	R4:5.1
4	Classifications of modern machining processes,	CO1	T1:1.1
5	considerations in process selection.	CO1	T1:1.2
6	materials application	CO1	T2:1.3
7	Ultrasonic machining: Elements of the process, mechanics of metal removal	CO1	T1:1.3
8	process parameters.	CO1	T1:1.3
9	economic considerations, application and limitations, recent developments.	CO1	T2:1.5
10	Abrasive jet machining, water jet machining and abrasive	CO1	T2:1.3
11	water jet machining: basic principles,	CO1	T1:1.3
12	equipment's process Variables.	CO1	T1:1.6
13	Mechanics of metal removal, MRR, applications and limitations;	CO1	T2:1.3
14	Electro chemical processes: Fundamentals of electro chemical machining.	CO2	T1:1.8, R1:1.9
15	Electro-chemical grinding.	CO2	
	electro chemical honing and deburring process,	CO2	T1:1.8, R1:1.9
16	Metal removal rate in ECM	CO2	T1:2.0, R2:2.0
17	tool design	CO2	T1:2.2, R2:2.2
18	surface finish and accuracy.	CO2	T1:2.3, R2:2.4
19	economic aspect of ECM, simple problem for estimation of metal removal rate.	CO2	T1:2.3, R2:2.4
20	General principle and applications of Electric discharge machining.	CO3	T1:2.5
21	electric discharge grinding.	CO3	T1:2.6
22	electric discharge wire cutting processes.	CO3	T1:2.8
23	Power circuits in EDM.	CO3	T1:2.9, R2:2.6
24	Mechanism of metal removal in EDM.	CO3	T1:2.9, R2:2.6
25	Process parameters.	CO3	T2:3.0, R2:2.7
26	Selection of tool electrodes and dielectric fluids.	CO3	T2:3.0, R2:2.7

27	Surface finish and accuracy.	CO3	T2:3.2, R2:2.9
28	characteristics of spark eroded surface and machine tool selection.	CO4	T2:3.3, R2:3.0
29	wire EDM principle and applications.	CO4	T2:3.4, R2:3.0
30	Generation and control of electron beam for machining.	T1:4.0	CO4
31	theory of electron beam machining.	CO4	T1:5.0
32	comparison of thermal and non thermal processes, general	CO4	T2:5.2
33	principle and applications of laser beam machining.	CO4	T1:4.2
34	thermal features, cutting speed and accuracy of cut.	CO4	T2:5.2
35	Application of plasma for machining, metal removal mechanism.	CO4	T1:4.3, R2:5.5
36	process parameters, accuracy and surface finish.	CO5	T2:5.8, R2:5.6
37	other applications of plasma in manufacturing industries.	CO5 T2:6.0	R2:5.7
38	Chemical machining principle, maskants, etchants, applications.	CO5	T2:6.2, R2:5.8
39	Abrasive jet machining, water jet machining and abrasive	CO5	T2:6.2, R2:7.2
40	water jet machining: basic principles,	CO5	T1:6.3, R2:7.5
41	equipment's process Variables.	CO5	T1:6.5, R2:7.6
42	Mechanics of metal removal, MRR, applications and limitations;	CO5	T1:6.8, R2:7.9
43	Electro chemical processes: Fundamentals of electro chemical machining.	CO6	T1:8.1, R1:9.1
44	Electro-chemical grinding.	CO6	T1:8.2, R1:9.3
45	electro chemical honing and deburring process,	CO6	T1:8.3, R1:9.2
46	Metal removal rate in ECM, ,	CO6	T1:8.3, R1:9.2
47	tool design	CO6	T2:8.4, R2:9.5
48	surface finish and accuracy.	CO6	T2:8.5, R2:9.6
49	economic aspect of ECM, simple problem for estimation of metal removal rate.	CO6	T2:8.6, R2:9.7
50	General principle and applications of Electric discharge machining.	CO6	T2:8.7, R2:9.7
PROBLEM SOLVING/ CASE STUDIES			
51	Module I:Mechanics of metal removal in ultrasonic machining.	CO 1	R3:2.1

52	Module II:Mechanics of metal removal in abraive jet machining.	CO 2	T4:7.3
53	Module III:Mechanism of metal removal in EDM	CO 3, CO4	R2:5.1
54	Module IV:Generation and control of electron beam for machining	CO 5	T1:7.5
55	Module V: Application of maskant in Printed circuit board.	CO 6	T1: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Module I:INTRODUCTION	CO 1	R3:2.1
57	Module II:ABRASIVE JET MACHINING	CO 2	T2:7.3
58	Module III:THERMAL METAL REMOVAL PROCESSES	CO 3, CO4	R3:5.1
59	Module IV:ELECTRON BEAM MACHINING	CO 5	T1:7.5
60	Module V:PLASMA MACHINING	CO 6	T1: 4.1
DISCUSSION OF QUESTION BANK			
61	Module I:INTRODUCTION	CO 1	R3:2.1
62	Module II:ABRASIVE JET MACHINING	CO 2	T4:7.3
63	Module III:THERMAL METAL REMOVAL PROCESSES	CO 3, CO4	R3:5.1
64	Module IV:ELECTRON BEAM MACHINING	CO 5	T1:7.5
65	Module V:PLASMA MACHINING	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Tool Design**				
Course Code	AME509				
Program	B.Tech				
Semester	V				
Course Type	Professional Elective				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3		
Course Coordinator	Dr.CH. Sandeep, ME				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AME004	III	Mechanics of Solids
UG	AME005	III	Metallurgy and material science

II COURSE OVERVIEW:

The primary objective of this course is to introduce the concept of tool design technology selection of tooling materials for cutting operations with the help of various processes widely employed in industries. To design Jigs and Fixtures and selection of drills for various operations are studies in this course. The course consists of tool material, design of cutting tools, design of jigs and fixtures, design of sheet metal forming-I and design of sheet metal forming- II.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Tool Design	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50%	Understand
40%	Apply

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

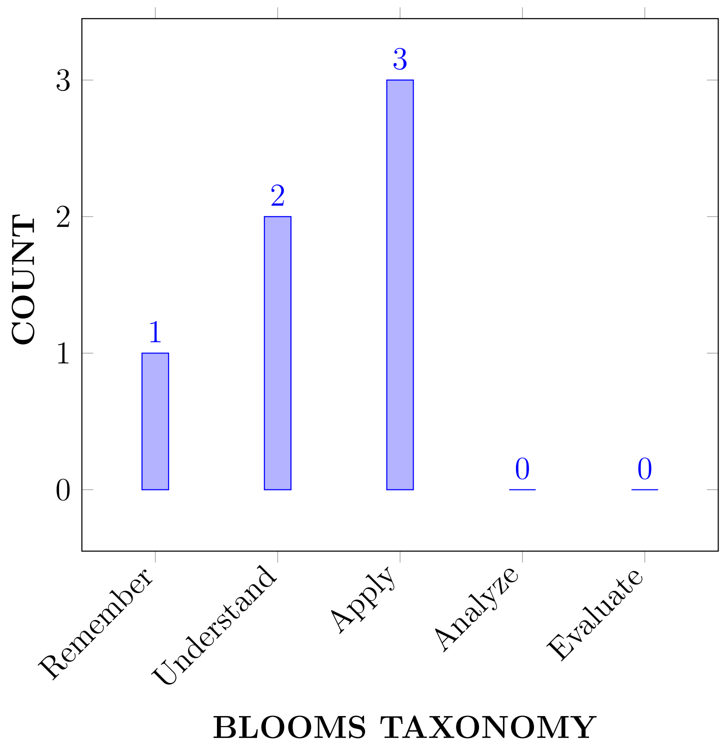
I	Compare the characteristics of various tool materials for cutting operations.
II	Demonstrate the design of cutting tools and its importance in manufacturing industry.
III	Understand the design of jigs and fixtures for holding the different components.
II	llustrate the design for sheet metal forming-I in the field of design aspects.
III	Compare the design for sheet metal forming-II in the manufacturing industry.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	Recall the different tool materials used in various industries.	Remember
CO 2	Explain the design of different cutting tools: Milling, Drilling and selection of carbide tool steels for cutting operations.	Understand
CO 3	Illustate the basic principles of location and clamping methods for Jigs and Fixres	Understand
CO 4	Develop design of drill jigs ,drill bushing and various types of fixtures	Apply
CO 5	Construct the design of sheet metal balnking and piecrcing dies.	Apply
CO 6	Develop design of sheet metal bending, drawng and forming dies..	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Seminar/ conferences/ Research papers
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Discussion on Innovations/ Presentation

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	-	Research papers/ Industry exposure
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications	-	Research papers/ Industry exposure -
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies..	1	Research papers/ Industry exposure

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	✓
CO 2	✓	✓	-	-	-	✓	-	-	-	-	-	✓	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	-	✓	-		-	-	-	-	-	-		-	-	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall (knowledge) the different tool material and their characteristic used in various industries (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	3
	PSO3	Identify the characteristics of different tool materials and their composition	1
CO 2	PO 1	Identify suitable techniquies involved in design,cutting tools to achieve error free components using in solving (complex) engineering problems by applying the principles of mathematics and engineering fundamentals.	3
	PO 2	Understand the design of cutting tools and determine the iinsert thickness for carbide tools for various manufacturing applications. .	2
	PO 6	Understand the need for high level of professional and ethical conduct in design of cutting tools .	1
	PO 12	Ability to engage in independent and life -long learning in design of cutting tools .	1
CO 3	PO 1	identify basic principles of location and clamping methods for Jigs and Fixtures using Scientic Principles of Methodology and engineering fundamentals	3
CO 4	PO2	Identify the general conditions for design of jigs and fixtures to solve complex engineering problems.	2
CO 5	PO 1	Apply the knowledge of mathematics and engineering fundamentals to design of sheet metal blanking and piercing dies	3
	PO3	Understand the given problem statement related to their working principle and type of sheet metal forming processes.	2
CO 6	PO 1	Apply the basic engineering knowledge, mathematics and scientific proncples to sheet metal bending	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Understand the working principle used in design of sheet metal bending,forming and drawing dies by mathematics and Engineering Sciences.	2
	PSO3	Identify the design principle involved in design of sheet metal bending, forming and drawing dies.	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	1
CO 2	3	2	-	-	-	1	-	-	-	-	-	1	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	2	-		-	-	-	-	-	-		-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	1

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	50
CO 2	100	20	-	-	-	20	-	-	-	-	-	8	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	-	20	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	20	-	-	-	-	-	-	-	-	-	-	-	-	50

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 2	3	1	-	-	-	1	-	-	-	-	-	1	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO5	3	-	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-	-	-	-	2
TOTAL	15	3	1	-	-	1	-	-	-	-	-	1	-	-	4
AVERAGE	3	1	1	-	-	1	-	-	-	-	-	1	-	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	TOOL MATERIAL
	Tool materials: Properties of materials: Tools steels, Cast Iron, Mild or low carbon steels, Non metallic and nonferrous materials, Heat treating.
MODULE II	DESIGN OF CUTTING TOOLS
	Design of cutting tools: Point cutting tools: Milling cutters, drills, selection of carbide steels, determination of shank size for single point carbide tools, determining the insert thickness for carbide tools.
MODULE III	DESIGN OF JIGS AND FIXTURES
	Welding: Inert gas welding, TIG welding, MIG welding, friction welding, induction pressure welding, Design of jigs and fixtures: Basic principles of location and clamping; Locating methods and devices, jigs, definition types. General considerations in the design of drill jigs, drill bushing, methods of construction; Fixtures, vice fixtures, milling, boring lathe grinding fixtures.
MODULE IV	DESIGN FOR SHEET METAL FORMING – I
	Design of sheet metal blanking and piercing dies: Fundamentals of die cutting operation, power press types, general press information, materials handling equipment, cutting action in punch and die operations, die clearance, types of die construction, die design fundamentals, banking and piercing die construction, pilots, stripper and pressure pads presswork material, strip layout, short run tooling for piercing.
MODULE V	DESIGN FOR SHEET METAL FORMING – II
	Design of sheet metal bending, forming and drawing dies: Bending dies, drawing dies, forming dies, drawing operations, variables that effect metal flow during drawing, determination of blank size, drawing force, single and double action draw dies

TEXTBOOKS

1. Donaldson, “Tool Design”, Tata McGraw-Hill, 1stEdition, 2013..
2. HMT, “Production Technology”, Tata McGraw-Hill, 1st Edition, 2012

REFERENCE BOOKS:

1. George F Dieter, “Mechanical Metallurgy”, Tata McGraw-Hill, 1stEdition, 2015
2. C. Elanchezhian, M.Vijayan, “Machine Tools”, Anuradha Publications, 1stEdition, 2010

WEB REFERENCES:

1. https://nptel.ac.in/courses/112/107/112107144/

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
	Discussion on outcome based education		
CONTENT DELIVERY (THEORY)			
1-4	Define principle of tool materials	CO 1	T2:2.3
5-7	Examine various types of tool materials	CO 1	R1:2.6
8-10	Relate various types of Non metallic and non ferrous materials and heat treatment process	CO 1	T1:2.6
11-14	Describe the design of cutting tools	CO 2	T2:2.7 R1:2.18
15-16	Compare various cutting operations	CO 2	T2:2.22
17-20	Explain the selection of carbide tools	CO 2	T2:2.25
21-23	Explain jigs and fixtures	CO 3	T2:2.26 R1:2.55
24-26	Discuss various types of clamping	CO 3	T2:2.16 R1:2.61
27-28	Define the location methods of jigs	CO 3	T2:2.30 R1:2.58
29-30	Describe the considerations of drill jigs and bushing	CO 4	T2:3.6 R1:4.29
31-32	Describe the methods of constructions	CO 4	T2:3.14 R1:4.31
33-34	Discuss the sheet metal design.	CO 5	T2:3.14 R1:4.33
35	Compare different types of cutting operations and material handling equipments	CO 5	R1:4.36
36-37	Die constructions	CO 5	T2:3.18 R1:4.64

38	Explain Blanking and piercing processes	CO 5	T2:3.18 R1:4.64
39	Discuss stripper and pressure work	CO 5	T2:3.22
40-41	Discuss tooling for piercing	CO 5	T2:3.28 R1:4.67
42	Explain the design of sheet metal bending	CO 6	T2:4.2
43-44	Discuss forming and drawing	CO 6	T2:4.3 R1:4.71
45	Explain various types of dies	CO 6	T1:4.8 R2:4.68
46	Explain the drawing process and its effects	CO 6	T2:4.15 R1:5.74
47-48	Describes the design of blank size	CO 6	T1:4.12 R2:5.75
49-50	Explanation of blanking and piercing operations	CO 6	T1:4.8 R1:5.72
PROBLEM SOLVING/ CASE STUDIES			
1	What is meant by the general term heat treating	CO 1	T2:2.3
2	What are the major elements in cast nonferrous cutting tools	CO 1	T2:4.3
3	Why are the properties of a elesticity and stiffness infortant to the design of cutting tools.	CO 1	T1:2.3
4	How blacklas eliminated on modern milling machines	CO 2	T1:2.3
5	When selecting a milling cutter, why is it important to keep the cutter diameter as small as possible.	CO 2	T2:2.3
6	What are possible causes of over size holes when drilling?	CO 2	T2:2.3
7	What are major factors that determines how the a workpiece will be located?	CO 3	T2:2.3
8	What are the common methods of locating from circular surfaces?	CO 3	T2:2.3
9	What are the four essential requirements of clamps and clamping devices?	CO 3	T2:2.3
10	What is meant by built-up construction of a jig, and what is the advantage?	CO 4	T2:2.3
11	What is difference between a drill jig and a fixture?	CO 4	T2:2.3
12	What are the economic aspects of the use of a fixture?	CO 4	T2:2.3
13	In sheet metal piercing and blaking what is meant by penetration?	CO 5	T2:2.3
14	What factors contribute to the amount of force needed to strip material from punches?	CO 6	T2:2.3
15	How is the bend radius formed when using wiping dies?	CO 6	T2:2.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	TOOL MATERIAL	CO 1	T2:2.3
2	DESIGN OF CUTTING TOOLS	CO 2	T2:2.3
3	DESIGN OF JIGS AND FIXTURES	CO 3	R2:5.1
4	DESIGN FOR SHEET METAL FORMING – I	CO 4	T1:7.5
5	DESIGN FOR SHEET METAL FORMING – II	CO 5	T1: 4.1

DISCUSSION OF QUESTION BANK			
1	TOOL MATERIAL	CO 1	T2:7.3
2	DESIGN OF CUTTING TOOLS	CO 2	T2:7.3
3	DESIGN OF JIGS AND FIXTURES	CO 3	R2:5.1
4	DESIGN FOR SHEET METAL FORMING – I	CO 4	T1:7.5
5	DESIGN FOR SHEET METAL FORMING – II	CO 5	T1: 4.1

Signature of Course Coordinator **HOD,ME**

Dr.CH. Sandeep, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTOR

Department	**MECHANICAL ENGINEERING**				
Course Title	**ENGINEERING OPTIMIZATION**				
Course Code	AME516				
Program	B.Tech				
Semester	V				
Course Type	ELECTIVE				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mrs. T Vanaja, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS011	IV	Mathematical Transformation Techniques

II COURSE OVERVIEW:

Optimization is one of the most powerful tools in process integration. Optimization involves the selection of the "best" solution from among the set of candidate solutions. The degree of goodness of the solution is quantified using an objective function (e.g., cost) which is to be minimized or maximized. The search process is undertaken subject to the system model and restrictions which are termed constraints. Hence, the purpose of optimization is to maximize (or minimize) the value of a function (called objective function) subject to a number of restrictions (called constraints). These constraints are in the form of equality and inequality expressions.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Engineering Optimization	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
16.6%	Remember
50%	Understand
33.4%	Apply

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

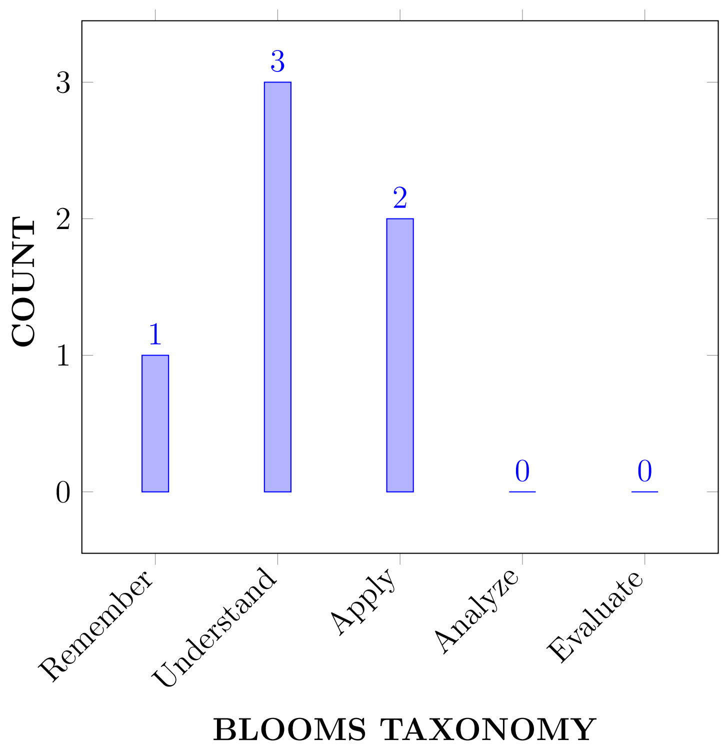
I	Understand the theory of optimization methods and algorithms developed for solving various types of optimization problems .
II	Develop and promote research interest in applying optimization techniques in problems of Engineering and Technology.
III	Apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Define and use** optimization terminology and concepts, and understand how to classify an optimization problem.	Remember
CO 2	**Outline** optimization methods to engineering problems, including developing a model, defining an optimization problem, applying optimization methods, exploring the solution, and interpreting results.	Understand
CO 3	**Explain** multi variable unconstrained optimization theory for Univariate, Hooke Jeeve's and Simplex methods.	Understand
CO 4	**Apply** unconstrained optimization theory for continuous problems,such as: Steepest descent, Conjugate gradient, and Variable metric methods.	Apply
CO 5	**Illustrate** methods for computing derivatives such as:Lagrangian method, Inequaliteis ,Kuhn-Tucker necessary and sufficient conditions.	Understand
CO 6	**Identify** constrained and unconstrained optimization problems, including posynomials, arithmetic, Geometric programming and Gomary cutting plane algorithm.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentation on real-world problems
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Seminar
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Assignment

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining	1	Seminar
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications..	-	-
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies..	-	-

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		✓	-	-
CO 2	-	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-		-	-	-	-	-	-		✓	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall the basic optimization algorithms in a minima/maxima problem and identify the optimization techniques using **mathematical knowledge, science and engineering fundamentals.**	3
	PO 2	Apply optimization methods, to determine the **robust design** through optimization methods, exploring the solution, and **interpreting results.**	2
	PSO 1	Implement basic optimization algorithms and apply existing optimization techniques to **solve engineering** and **application problems.**	2
CO 2	PO 2	**Solve the mathematical translation** of the verbal formulation of an optimization problem , measure the performance and **validate the results** of an algorithm.	2
	PO 4	Employing optimization techniques that are appropriate for **solving realistic engineering research problems** and **interpret the outputs**	2
CO 3	PO 1	Identify the optimization algorithms using **mathematical knowledge, science and engineering fundamentals**.	3
	PO 2	Demonstrate the Hook Jeeves method, identify and **solve problems** the individual functions and **validate the results.**	2
	PO 4	Study and Solve the individual functions of **optimization technique research oriented problems** and **validate the outputs through analysis.**	2
CO 4	PO 1	Recollect the Feasibility study for solving an optimization problems using the **mathematical knowledge, science and engineering fundamentals.**	3
	PO 2	Identify, define the gradient methods and interpreting the outputs to **real time applications** to enumerate the various problems and **effective solutions** that can be proposed.	2
	PSO 1	Implement basic optimization algorithms and apply existing optimization techniques to **solve engineering** and **application problems.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 5	PO 1	Recollect the Feasibility study for solving an optimization problems using the **mathematical knowledge, science and engineering fundamentals.**	3
	PO 2	Identify Kuhn Tucker methods and interpreting the outputs to **real time applications** to enumerate the various problems and **effective solutions** that can be proposed.	2
	PSO 1	Study and Solve the individual functions of optimization technique **real time application** problems and validate the outputs through analysis.	1
CO 6	PO 1	Understand the significance of nonlinear problem through its linear approximation using the **mathematical knowledge, science and engineering fundamentals.**	3
	PO 2	Identify, define and **solve problems** in optimal estimation for environmental engineering to be used in real world applications and Enumerate the interior-point methods and **effective solutions** that can be proposed.	2
	PSO 1	Discuss Geometric programming problems possible to **real world applications** and provide **solutions through recent optimisation techniques.**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-		2	-	-
CO 2	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-		-	-	-	-	-	-		2	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	20	-	-	-	-	-	-	-	-	-		100	-	-
CO 2	-	20	-	18.2	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20	-	18.2	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	20	-	-		-	-	-	-	-	-		100	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	100	20	-	-	-	-	-	-	-	-	-	-	50	-	-
CO 6	100	20	-	-	-	-	-	-	-	-	-	-	100	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\ \% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	3	-	
CO 2	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
TOTAL	15	6	-	2	-	-	-	-	-	-	-	-	11	-	-
AVERAGE	3	1	-	1	-	-	-	-	-	-	-	-	2.75	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	INTRODUCTION TO OPTIMIZATION
	Introduction: Optimal problem formulation, design variables, constraints, objective function, variable bounds; engineering optimization problems: Classification and Some examples (just theory and discussion): truss structure, ammonia structure, transit schedule and car suspension.

MODULE II	**SINGLE VARIABLE OPTIMIZATION**
	Single variable non-linear optimization problems: Local minimum global minimum and inflection point, necessary and sufficient conditions theorems, some problems based on this; Numerical methods: Exhaustive search methods, Fibonacci method, golden section method and comparison, interpolation methods: quadratic.
MODULE III	**MULTI VARIABLE UNCONSTRAINED OPTIMIZATION**
	Multivariable unconstrained non-linear optimization problems: Numerical methods direct search methods: Univariate method, Pattern Search methods: Powell, Hook-Jeeve's, Rosen Brock's search and Simplex methods, multivariable unconstrained non-linear optimization problems. Gradient methods: Gradient of a function, importance, gradient direction search based methods: Steepest descent/ascent method, conjugate gradient method and variable metric method
MODULE IV	**MULTI VARIABLE CONSTRAINED OPTIMIZATION**
	Multivariable constrained non-linear optimization problems classical optimization techniques: Constraints equations, Lagrangian method, inequalities-Kuhn-Tucker necessary and sufficient conditions, quadratic problem, Statement, Wolfe's and Beale's methods.
MODULE V	**GEOMETRIC AND INTEGER PROGRAMMING**
	Geometric programming: posynomials, arithmetic, geometric inequality, unconstrained G.P, constrained G.P($\leq$ type only) integer Programming; Introduction, formulation, Gomory cutting plane algorithm, branch and bound method.

TEXTBOOKS

1. Kalyanmoy Deb, "Optimization for Engineering Design", Prentice-Hall of India (Pvt) Ltd, New Delhi, 1 st Edition, 2005.
   2. S. D. Sharma, "Operations Research", Kedar Nath and Ran Nath Co., New Delhi, 1st Edition, 2013.

REFERENCE BOOKS:

1. Beveridge, Schechter, "Optimization Theory and Practice, McGraw-Hill, 1st Edition, 2010.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	**Topics to be covered**	**CO's**	**Reference T1: 4.1**
OBE DISCUSSION			
1	Introduction to Outcome Based Education		
CONTENT DELIVERY (THEORY)			
1	Introduction to Optimal problem formulation, design variables, constraints, objective function, variable bounds	CO 1	T2:2.3
2	Review on engineering optimization problems	CO 1	R1:2.6

3	Discuss the examples (just theory and discussion): truss structure, ammonia structure	CO 1	T1:2.6
4	Describe the transit schedule and car suspension	CO 1	T2:2.7 R1:2.18
5	Describe the Single variable non-linear optimization problems	CO 2	T2:2.22
6	Discuss Numerical methods: Exhaustive search methods	CO 2	T2:2.26 R1:2.55
7	Discuss Local minimum global minimum and inflection point, necessary and sufficient conditions theorems	CO 2	T2:2.25
8	Discuss Fibonacci method, golden section method and comparison	CO 2	T2:2.16 R1:2.61
9	Discuss the interpolation methods: quadratic.	CO 2	T2:2.30 R1:2.58
10	Introduction to Multivariable unconstrained non-linear optimization problems: Numerical methods direct search methods: Univariate method, Pattern Search methods	CO 3	T2:3.6 R1:4.29
11	Classifying Powell, Hook-Jeeve's, Rosen Brock's search and Simplex methods	CO 3	T2:3.14 R1:4.31
12	Discuss Powell, Hook-Jeeve's, Rosen Brock's search and Simplex methods	CO 3	T2:3.14 R1:4.33
13	Discuss Powell, Hook-Jeeve's, Rosen Brock's search and Simplex methods	CO 3	R1:4.36
14	Comparison multivariable unconstrained non-linear optimization problems. Gradient methods	CO 3	T2:3.18 R1:4.64
15	Introduction Gradient of a function, importance, gradient direction search based methods	CO 4	T2:3.22
16	Demonstration Steepest descent/ascent method, conjugate gradient method and variable metric method	CO 4	T2:3.28 R1:4.67
17	Demonstration Steepest descent/ascent method, conjugate gradient method and variable metric method	CO 4	T2:4.2
18	Demonstration Steepest descent/ascent method, conjugate gradient method and variable metric method	CO 4	T2:4.3 R1:4.71
19	Introduction to Multivariable constrained non-linear optimization problems classical optimization techniques	CO 5	T1:4.8 R2:4.68
20-21	Demonstration of Multivariable constrained non-linear optimization problems classical optimization techniques	CO 5	T2:4.15 R1:5.74
22	Discuss classical optimization techniques	CO 5	T1:4.12 R2:5.75
23-24	Discuss inequalities-Kuhn-Tucker necessary and sufficient conditions	CO 5	T1:5.14 R1:6.78
25	Explain inequalities-Kuhn-Tucker necessary and sufficient conditions	CO 5	T2:5.19 R1:6.81
26-27	Explain inequalities-Kuhn-Tucker necessary and sufficient conditions	CO 5	T1:6.4 R2:6.8
28	Describe quadratic problem, Statement, Wolfe's and Beale's methods.	CO 5	T2:7.7 R1:7.74

29-30	Describe quadratic problem, Statement, Wolfe's and Beale's methods.	CO 5	T1:7.12 R2:8.75
31	Describe quadratic problem, Statement, Wolfe's and Beale's methods.	CO 5	T1:7.8 R1:8.72
32-33	Explanation of Constraints equations	CO 5	T1:4.8 R1:5.72
34	Introduction to Lagrangian method	CO 5	T1:5.8 R1:5.73
35	Explain Geometric programming: posynomials, arithmetic, geometric inequality	CO 6	T1:8.8 R1:8.73
36	Discuss unconstrained G.P, constrained G.P($\leq$ type only)	CO 6	T1:9.14 R1:10.78
37-38	Describe integer Programming	CO 6	T2:9.19 R1:10.814
39-40	Describe formulation, Gomory cutting plane algorithm	CO 6	T1:10.4 R2:11.68
41-43	Discuss branch and bound method	CO 6	T2:10.7 R1:12.74
44-45	Discuss branch and bound method.	CO 6	T1:11.12 R2:12.75
PROBLEM SOLVING/ CASE STUDIES			
1	A company produces two types of hats. Each hat of first type requires twice as much as labour time as second type. If all hats are of the second type only, the company can produce a total of 500 hats a day. The market limits daily sales of the first and second type to 150 and 250 hats. Assuming that the profits per hat are Rs.8 for type A and Rs.5 for type B formulate.	CO1	T1:2.9
2	Let us consider a company making single product. The estimated demand for the product for the next four months is 1000,800,1200,900 respectively. The company has a regular time capacity of 800 per month and an overtime capacity of 200 per month. The cost of regular time production is Rs.20 per unit and the cost of overtime production is Rs.25 per unit. The company can carry inventory to the next month and the holding cost is Rs.3/unit/month the demand has to be met every month. Formulate a linear programming problem for the above situation	CO1	T2:2.9
3	Formulate the problem as a mathematical programming problem assuming that the cross-sectional dimensions of the beam are restricted as $x_1 \leq x_2$, 0.04m $\leq x_1 \leq$ 0.12m, and 0.06m $\leq x_2 \leq$ 0.20 m.	CO1	T2:2.10
4	There are two different sites, each with four possible targets (or depths) to drill an oil well. The preparation cost for each site and the cost of drilling at site i to target j are given below: Drilling cost to target j Site i 1 2 3 4 Preparation cost 1 4 1 9 7 11 2 7 9 5 2 13 Formulate the problem of determining the best site for each target so that the total cost is minimized. Find (i) k (ii) $p(X < 3)$ (iii) $p(X \geq 5)$	CO1	T2:2.11

5	An oil refinery produces four grades of motor oil in three process plants. The refinery incurs a penalty for not meeting the demand of any particular grade of motor oil. The capacities of the plants, the production costs, the demands of the various grades of motor oil, and the penalties are given in the following table: Production cost ($/day) to manufacture motor oil of grade: Process Capacity of the plant plant (kgal/day) 1 2 3 4 1 100 750 900 1000 1200 2 150 800 950 1100 1400 3 200 900 1000 1200 1600 Demand (kgal/day) 50 150 100 75 Penalty (per each kilogallon shortage) $10 $12 $16 $20 Formulate the problem of minimizing the overall cost as an LP problem	CO2	T2:2.32
6	Write an algorithm for exhaustive search method in solving single variable problems.	CO2	T2:2.35
7	Derive the one-dimensional minimization problem for the following case: Minimize f (X) = (1 - x_2) 2 + (1 - x_1) 2 (E1) from the starting point X_1 = [-2 -2]along the search direction S = [1.00 0.25]	CO2	T2:2.38
8	Consider the following function f(x) = x_2+54/x, with initial interval (0,5) and solve using fibonacci search method.	CO2	T2:2.38
9	Minimize f (x) = 0.65 - [0.75/(1 + x_2)] - 0.65x tan $^{-1}$ (1/x) in the interval [0,3] by the Fibonacci method using n = 6	CO2	T2:2.41
10	Find the minimum of f = x(x - 1.5) in the interval (0.0, 1.0) using Simplex methods?	CO3	T2:2.56
11	Minimize the function f(x) = 10-x_1+x_1x_2+x_2^2, use (0,2), (0,0) and (1,1) as the initial simplex of three points. complete two iterations of nelder mead's simplex search algorithm to find new simplex. Assume $\beta = 0.5$ and $\gamma = 2$.	CO3	T2:3.58
12	Minimize the function f(x) = f(x_1,x_2) = $(x_1^2+x_2-11)^2$ $+(x_1+x_2^2-7)^2$ using steepest descent method.	CO4	T2:3.58
13	Solve the following problem by using the method of lagrangian multipliers. Minimize Z = x_1 ^{2}+x_2 ^{2}+x_3^2, subject to the constraints i) $x_1+x_2+3x_3 = 2$,ii) $5x_1+2x_2+x_3 = 5$, and $x_1,x_2 \geq 0$	CO4	T2:3.71
14	Use the Kuhn-tucker conditions to solve QPP Max Z = $-2x_2^2+3x_1+4x_2$ subject to $x_1+2x_2 \leq 4$; $x_1+x_2 \leq 2$; x_1, $x_2 \geq 0$.	CO4	T2:3.74
15	Slove the following LPP using Gomory's cutting plane method Max Z = x_1+x_2 subject to $3x_1+2x_2 \leq 5$; $x_2 \leq 2$; x_1, $x_2 \geq 0$, are integers.	CO5	T2:3.88
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Introduction to Optimization	CO1	T1:3.3
2	Single Variable Optimization	CO2	T1:4.7
3	Multi Variable Unconstrained Optimization	CO3,CO4	T2:2.69
4	Multi Variable Constrained Optimization	CO5	T2:2.86
5	Geometric and Integer Programming	CO6	T2:2.98
DISCUSSION OF QUESTION BANK			
1	Introduction to Optimization	CO1	T1:2.41
2	Single Variable Optimization	CO2	T2:2.57
3	Multi Variable Unconstrained Optimization	CO3,CO4	T2:2.71

4	Multi Variable Constrained Optimization	CO5	T2:2.84
5	Geometric and Integer Programming	CO6	T2:2.102

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">THERMAL ENGINEERING LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">AME109</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>V</td><td colspan="4">ME</td></tr>
<tr><td>Course Type</td><td>Core</td><td colspan="4"></td></tr>
<tr><td>Regulation</td><td>IARE - R16</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>3</td><td>2</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Ms. N Santhisree, Assistant Professor</td></tr>
</table>

I COURSE OVERVIEW:

In this laboratory, students will have the opportunity to study the working principle of IC engines (both SI and CI engines), performance and characteristics in terms of heat balancing, economical speed variations, air fuel ratio influence on the engine to reinforce classroom theory by having the student perform required tests, analyze subsequent data, and present the results in a professionally prepared report.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME007	IV	Applied Thermodynamics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Thermal Engineering Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

I	Visualize the cycle timings of S.I and C.I engines.
II	Determine performance characteristics of C.I and S.I engines.
III	Differentiate between water tube and fire tube boilers.
IV	Estimate the importance of multi-staging of air compressors.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** the functionality of the major components of the IC engines and effects of operating conditions on their performance.	Understand

CO 2	**Identify** the different parts of petrol and diesel engines, and to draw valve timing diagrams.	Apply
CO 3	**Evaluating** the performance characteristics of petrol and diesel engine at different loads.	Evaluate
CO 4	**Understand** the Performance Test on CI engine and air compressor unit.	Understand
CO 5	**Develop** the process to extract the different data from the test rig.	Apply
CO 6	**Explain** the principle of working of steam boilers and their accessories and mountings.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises/CIA
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Exercises/CIA

PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Lab Exercises/CIA
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Lab Exercises/CIA
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Lab Exercises/CIA

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Utilize the concept of the IC Engines and effects of operating conditions on their performance using the principles of**mathematics, science and engineering knowledge**.	3
	PO 9	Understand the working principle and major components of the IC Engines effectively as an **individual**, and as a member or **leader** in diverse **teams**.	3
	PO 12	Recognize the major components of the IC Engines and ability to take part in **independent** and **life- long learning** in the broadest context of technological change.	2
	PSO 2	Formulate and Evaluate the performance of IC Engines using the concept of **Thermo-Fluid Systems** to provide solutions for Inter Disciplinary **Engineering Applications**.	2
CO 2	PO 1	Explain the different parts of petrol and diesel engines using the principles of **mathematics, science and engineering knowledge**	3
	PO 2	Analyze the different parts of petrol and diesel engines to discern **problems** and identify **solutions**.	2

	PO 9	Identify the different parts of petrol and diesel engines effectively as an **individual**, and as a member or **leader** in diverse **teams**.	3
CO 3	PO 1	Evaluate the performance characteristics of petrol and diesel engine using the principles of **mathematics, science and engineering knowledge**.	3
	PO 9	Identify the performance characteristics of petrol and diesel engine effectively as an **individual**, and as a member or **leader** in diverse **teams**.	3
	PSO 2	Formulate and Evaluate the performance characteristics of petrol and diesel engine using the concept of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary Engineering Applications**.	3
CO 4	PO 1	Explain the performance test on CI engine and air compressor unit using the principles of**mathematics, science and engineering knowledge**.	3
	PO 2	Analyze the performance on CI engine to discern **problems** and identify **solutions**.	2
	PO 4	Analyze the performance test on CI engine using **research-based knowledge** and research methods including **design of experiments, analysis and interpretation of data**, and synthesis of the information to provide **valid conclusions**.	3
	PO 9	Identify the performance test on CI engine and air compressor unit effectively as an **individual**, and as a member or **leader** in diverse teams.	2
	PSO 2	Formulate and Evaluate the performance test on CI engine and air compressor unit using the concept of **Thermo-Fluid Systems** to provide solutions for Inter Disciplinary **Engineering Applications**.	2
CO 5	PO 1	Identify the process to extract the different data from the IC Engine test rig using the principles of **mathematics, science and engineering knowledge**.	3
	PO 4	Analyze the different process involved in IC Engine using **research-based knowledge** and research methods including **design of experiments, analysis and interpretation of data**, and synthesis of the information to provide **valid conclusions**.	3
	PO 9	Explain the different process involved in IC Engine effectively as an **individual**, and as a member or **leader** in diverse **teams**.	3
CO 6	PO 1	Explain the principle of working of steam boilers using the principles of**mathematics, science and engineering knowledge**.	3
	PO 2	Analyze the working principle of steam boilers and their accessories and mountings to discern **problems** and identify **solutions**.	2

	PO 9	Explain the principle of working of steam boilers effectively as an **individual**, and as a member or **leader** in diverse **teams**.	3

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE	PROGRAM OUTCOMES			PSO'S		
OUTCOMES	PO 1	PO 2	PO 4	PO 9	PO 12	PSO 2
CO 1	3	-	-	3	2	2
CO 2	3	2	-	3	-	-
CO 3	3	-	-	3	-	3
CO 4	3	2	3	2	-	2
CO 5	3	-	3	3	-	-
CO 6	3	2	-	3	-	-

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**IC Engines Valve/Port Timing Diagram**
	Drawing valve and port timing diagram for 4-stroke diesel and 2-stroke petrol engine respectively.
WEEK II	**IC Engine performance test for 4-stroke SI Engine**
	Performance test for 4-stroke SI engine and draw performance curves.
WEEK III	**IC Engine performance test for 2-stroke SI Engine**
	Determination of volumetric efficiency and break thermal efficiency.
WEEK IV	**IC Engines Morse, retardation and motoring test**
	Determination of frictional power of IC engine.
WEEK V	**IC Engines heat balance-CI/SI engines**
	Balancing of heat losses and heat input in SI/CI engines.
WEEK VI	**IC Engines economical speed test on SI Engine**
	Performance Test on SI engine with speed as a parameter.

WEEK VII	**IC Engines effect of Air/Fuel ration in a SI engine**
	Calculating air/fuel ratio of a 4-stroke SI Engine.
WEEK VIII	**Performance test on Variable Compression Ratio(VCR) engine**
	Performance Test on CI engine when the compression ratio is changing.
WEEK IX	**IC Engine performance test on 4-Stroke CI engine**
	Performance Test on 4-stroke CI engine and to draw the performance curves.
WEEK X	**Volumetric Efficiency of Reciprocating Air compressor unit**
	Performance of air compressor unit.
WEEK XI	**Disassembly/Assembly of Engines**
	Awareness of components of given IC engine and assembling /disassembling of parts.
WEEK XII	**Study of Boilers**
	To study the working operation of different types of boilers.

TEXTBOOKS

1. V. Ganesan, —Internal combustion engines, Tata McGraw-Hill, 3rd Edition, New Delhi, India. 2011.

2. B. John Heywood, —Internal combustion engine fundamentals, Tata McGraw-Hill, 2nd Edition, New Delhi. 2011.

3. R. K. Rajput, —Thermal Engineering, Lakshmi Publications, 18th Edition, 2011.

REFERENCE BOOKS:

1. Mathur, M., and Sharma, R.P., —Gas Turbines and Jet and Rocket Propulsion, Standard Publishers, New Delhi 1998

2. Cornelisse, J.W., Rocket Propulsion and Space Dynamics, J.W., Freeman & Co. Ltd., London, 1982.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Understand the concept of Drawing valve and port timing diagram for 4-stroke diesel and 2-stroke petrol engine respectively.	CO 1	T2:26.3
2	Know the Performance test for 4-stroke SI engine and draw performance curves.	CO 2	R2: 3.5
3	Understand Basic fundamentals and Determination of volumetric efficiency and break thermal efficiency.	CO 3	T2:26.6
4	Understand fundamentals and Determination of frictional power of IC engine.	CO 4	T2:26.7
5	Performance of Machining practice on Balancing of heat losses and heat input in SI/CI engines.	CO 5	T2:155-160
6	Performance Test on SI engine with speed as a parameter.	CO 6	T2:161-174
7	Calculating air/fuel ratio of a 4- stroke SI Engine.	CO 6	T2:175-208

8	Understand the Performance Test on CI engine when the compression ratio is changing.	CO 6	T2:224-226
9	Performance Test on 4-stroke CI-engine and to draw the performance curves.	CO 6	T1:321-353
10	Understand the Performance of air compressor unit.	CO 7	T2:368-390
11	Awareness of components of given IC engine and assembling/disassembling of parts.	CO 7	T1:368-390
12	To study the working operation of different types of boilers.	CO 7	T2:321-353

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Performance test of an IC Engine using electrical break dynamometer.
2	Performance test of a multi cylinder petrol engine by Morse method.
3	Performance test of an IC Engine using mechanical rope break dynamometer.
4	Investigate the cooling system of petrol engine with dual fuel.
5	Investigate the lubrication system of EFI petrol engine.

Signature of Course Coordinator **HOD, ME**
Ms. N Santhisree, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**MACHINE TOOLS AND METROLOGY LABORATORY**				
Course Code	AME110				
Program	B.Tech				
Semester	V	ME			
Course Type	CORE				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Dr. K Ch Apparao, Associate Professor				

I COURSE OVERVIEW:

Manufacturing is the production of goods through the use of labour, machinery and tools. This course introduces the mechanism of metal cutting of different geometrical shapes using wide variety of cutting tools. This emphasizes on the development/ demand of the newer materials with cutting edge technology tools. It is designed to impart the practical knowledge about the various machining processes like turning, shaping, planning, drilling, milling and grinding to produce desired shape of a product. This course introduces the metrological equipment to measure form and positional accuracy of manufactured/machined components and to interpret the results.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AMEB16	III	Manufacturing Technology

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
MACHINE TOOLS AND METROLOGY LABORATORY	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Probing Further Experiments (last)	✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day-to-day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the principal from the panel of experts recommended by Chairman, BOS.
The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		**Strength**	**Proficiency Assessed by**
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises/CIA/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Lab Exercises/CIA/SEE

PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises/CIA/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Lab Exercises/CIA/SEE
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

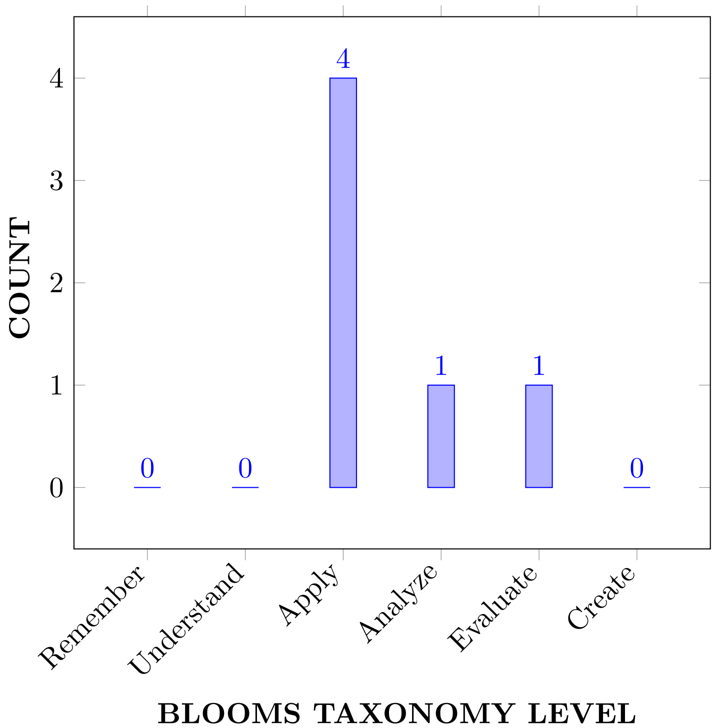
I	The empirical knowledge on machine tools so that they can identify, manipulate and control various process parameters during machining processes in the manufacturing industry.
II	The details related to thermal aspects during machining for defect free manufacturing components.
III	The mechanics of machining process and significance of various process parameters in order to yield the optimum machining.
IV	The principles of linear and angular measuring instruments for accurate measurement of a given component.

IX COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Apply** the appropriate cutting parameters for prismatic operations and their critical tool development/selection of Lathe, Milling, drilling, slotting shaping and surface grinding machines for manufacturing the components of their requirement	Apply
CO 2	**Apply** surface grinding operations to improve the quality of the surface with desired dimensions by removing uneven spots on the surface	Apply
CO 3	**Analyze** the chip formation mechanism by measuring the cutting forces during the chip formation process	Analyze
CO 4	**Estimate** machining times for machining operations at specified levels of cutting parameters of machine tools	Evaluate
CO 5	**Apply** the principles of limits, fits and tolerance while designing and manufacturing the components of their requirement to get form and position	Apply
CO 6	**Apply** equipment's like Surface Roughness tester, and Tool makers Microscope to find out parameters of gear, thread, tool and surface roughness	Apply

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Selection of operations which have to be carried out using machine tools for a specific application, need the knowledge of science and **engineering fundamentals and engineering fundamentals.**	3
	PO 2	**Explain**(Understand) the machining mechanism by measuring the cutting forces during the machining process in developing (complex) desired products by **opportunity identification**, **problem statement**, **model translation**, **solution development and experimentation** using **mathematics and engineering fundamentals**	5
	PO 5	Select, and apply machining operations, resources, and modern **engineering machine tools** including prediction and modeling to complex engineering activities with an understanding of the limitations.	1
	PO 9	Will be **able work** in a **group** with **Maturity**, **independence** and **self direction** to **understand** and **evaluating** work drawings to get the **demonstrated ability** and thereby develop a product after machining using different machine tools	8
CO 2	PO 1	Apply the operational principles of different lathe, milling, drilling machines and various reciprocating machines for quality machining by applying the **knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	**Explain**(Understand) the machining mechanism by measuring the cutting forces during the machining process in developing (complex) desired products by **opportunity identification**, **problem statement**, **model translation**, **solution development and experimentation** using **mathematics and engineering fundamentals**	5
CO 3	PO 1	Apply the operational principles of different grinding machines for quality machining by applying the **knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	**Explain**(Understand) the machining mechanism by measuring the cutting forces during the machining process in developing (complex) desired products by **opportunity identification**, **problem statement**, **model translation**, **solution development and experimentation** using **mathematics and engineering fundamentals**	5

	PO 9	Will be **able work** in a **group** with **Maturity**, **independence** and **self direction** to **understand** and **evaluating** work drawings to get the **demonstrated ability** and thereby develop a product after machining using different machine tools	8
CO 4	PO 2	**Explain**(Understand) the machining mechanism by measuring the cutting forces during the machining process in developing (complex) desired products by **opportunity identification**, **problem statement**, **model translation**, **solution development and experimentation** using **mathematics and engineering fundamentals**	5
	PO 9	Design and develop the product manufacturing process effectively as an **individual**, and as a **group member** in **diverse teams, and in multidisciplinary settings** with **Maturity**, **independence** and **self direction** with the **demonstrated ability** for machining effectively in building of product.	8
	PSO 1	Students can apply the knowledge of **Additive manufacturing**, **simulation** and **high speed machining** to implement different machine tools processes for developing a product.	3
CO 5	PO 1	Ability to select and use various Limits and tolerances for proper analysis of design to reach actual conclusion requires some research-based **knowledge of mathematics, science and metrology engineering fundamentals**	3
CO 6	PO 1	Ability to select and use various methods for the measurements of screw threads, surface roughness parameters and the working of optical measuring instruments for proper analysis of results to reach actual conclusion requires some research-based **knowledge of mathematics, science and metrology engineering fundamentals**	3
	PO 9	Design and develop the product manufacturing process effectively as an **individual**, and as a **group member** in **diverse teams, and in multidisciplinary settings** with **Maturity**, **independence** and **self direction** with the **demonstrated ability** for machining effectively in building of product.	8
	PO 12	Students **recognise** the **need for** self-study and importance of **earning skills** in manufacturing technology through **lifelong learning**	3
	PSO 1	Students can apply the knowledge of **Additive manufacturing**, **simulation** and **high speed machining** to implement different machine tools processes for developing a product.	3

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES					PSO'S
	PO 1	PO 2	PO 5	PO 9	PO 12	PSO 1
CO 1	3	2	3	3		
CO 2	3	2				
CO 3	3	2		3		
CO 4		2		3		2
CO 5	3					
CO 6	3			3	2	2

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-	Mini projects	-		

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK 1	**LATHE MACHINE**
	Step turning, taper turning, Thread cutting and knurling using lathe machine
WEEK 2	**DRILLING AND STEP BORING**
	Drilling, tapping and step boring using drilling machine.
WEEK 3	**PLANNING AND SHAPING**
	Shaping of V-groove using shaper
WEEK 4	**SLOTTING**
	Slotting of a keyway using slotter machine.
WEEK 5	**MILLING AND SURFACE GRINDING**
	Milling of gear and surface grinding.
WEEK 6	**VERNIER CALIPERS AND MICROMETER**

	Length, depth, diameter measuring using vernier calipers and micrometer.
WEEK 7	**SCREW THREAD MEASUREMENT**
	Screw thread measurement by three wire method.
WEEK 8	**SURFACE ROUGHNESS MEASUREMENT**
	Surface roughness by talysurf
WEEK 9	**BORE GAUGE**
	Bore measurement using bore gauge.
WEEK 10	**GEAR TEETH CALIPER/MICROMETER**
	Use of gear teeth caliper for checking the chordal addendum and chordal height of spur gear.
WEEK 11	**ANGLE MEASUREMENTS**
	Tool angle measurements using bevel protractor, sine bar, slip gauges
WEEK 12	**TAPER MEASUREMENTS**
	Taper measurements using Tool Maker‘s microscope.
WEEK 13	**REVIEW**
	Spare session for additional repetitions and review.
WEEK 14	**EXAMINATIONS**

TEXTBOOKS

1. R. K. Jain, "Production Technology", Khanna Publishers, 18th Edition, 2013.
2. B. S. Raghu Vamshi, ―Workshop Technology Vol – II‖, 9th Edition, Dhanpat Rai Publishers, New Delhi, India. 2010.

REFERENCE BOOKS:

1. B.L. Juneja, G.S. Sekhon, Nitin Seth "Fundamentals of Metal Cutting and Machine Tools ", New Age Publishers, 2nd Edition,2014.
2. Geofrey, "Fundamentals of metal machining and machine tools", Tata McGraw Hill Education, 1st Edition, 2013.
3. M Mahajan "A Textbook of Metrology ", Dhanpatrai and Co, 2nd Edition, 2013

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Plain turning, Step turning and Grooving	CO1, CO 2	T1:2.1.5 T2:2.3
2	Step Turning and Taper Turning	CO1,CO 2	T2:2.1.5 R1:2.6
3	Thread cutting and Knurling	CO 2, CO 5, CO 9	T1:2.6 R3:3.6.5
4	Drilling and Tapping	CO 2, CO 5	T2:2.7 R2:2.18
5	Milling Machine	CO 2, CO 9	T2:2.22 R3:3.1.1
6	Surface Grinding	CO 2, CO 4	T1:2.5.1 T2:2.25
7	Shaping Operations	CO 1, CO 12	T2:2.26 R3:2.55
8	Vernier calipers	CO 9	T2:2.3 R3:2.6

9	Inside micrometer	CO 5	T2:2.3 R1:2.6
10	Dial bore indicator	CO 5, CO 9	T1:2.6
11	Spirit level	CO 5, CO 12	T2:2.7 R1:2.18
12	Optical bevel protractor	CO 5, CO 9	T2:2.22
13	Sine bar	CO 5, CO 9	T2:2.25

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Twin vortex formation:** Perform the experimental work with positive zero and negative rake angle for the development of chip mechanism on ductile and brittle material.
2	Optimization of Milling Process parameters for optimal tool life using a Design of Experiments approach.
3	Design and Development of Lathe Machine Cutting Tools Attached with nano Coolant Systems .
4	Design and develop spline hub by using indexing compound mechanism by Slotting Machine.
5	Design and develop of spur gear by universal milling machine.
6	Design and develop a Stir Processing Machine Tool for stir processing on Milling Machine

Prepared by: **HOD,ME**
Dr. K. Ch Apparao, Associate professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**Finite Element Modeling**					
Course Code	AME014					
Program	B.Tech					
Semester	VI	ME				
Course Type	Core					
Regulation	IARE - R16					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	1	4	-	-	
Course Coordinator	Mr. M Prashanth Reddy, Assistant Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME004	III	Mechanics of Solid

II COURSE OVERVIEW:

The finite element analysis (FEA) is a numerical method widely used for modeling and analyzing structures. This course introduces the mathematical modeling concepts of the Finite Element Method for solving structural, thermal and dynamics problems that are too complicated to be solved by analytical methods.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Finite Elements Methods	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
70 %	Understand
20 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

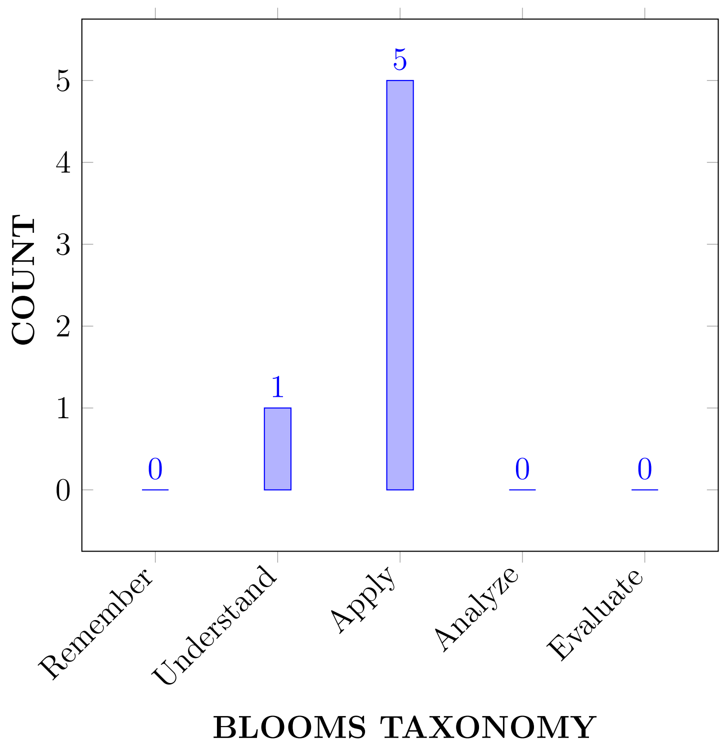
I	The basic concepts of Finite Element methods and its applications to complex engineering problems.
II	The characteristics and selection of different finite elements used in finite element methods.
III	The equilibrium equations and stress-strain relations for different boundary conditions encountered in structural and heat transfer continuum problems.
IV	The application of the FEM technique to dynamic problems and validate the solutions through simulation software for real time applications.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the discretization concepts and shape functions of structural members for computing displacements and stresses.	Understand
CO 2	**Make use of** shape functions of truss and beam elements for obtaining stiffness matrix and load vector to compute nodal displacement, stresses.	Apply
CO 3	**Apply** the discreet models of CST element for estimating displacement and stress.	Apply
CO 4	**Make use of** axi-symmetric modelling concepts to solids of revolution for stress approximation.	Apply
CO 5	**Apply** numerical techniques for heat transfer problems to compute the temperature gradients under various thermal boundary conditions.	Apply
CO 6	**Develop** the governing equations for the dynamic systems to estimate circular frequency and mode shapes, in correlation with modern tools.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:**Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Program Outcomes	
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE/AAT
PO 2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/SEE/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIE/SEE/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/SEE/AAT

PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1	CIE/SEE/AAT
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	1	Research papers/ Group discussion/ Short term courses
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	1	Research papers/ Group discussion/ Short term courses

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	✓	-
CO 6	✓	✓	✓	✓-	✓	-	-	-	-	-	-	✓	-	-	✓

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	**Recall engineering knowledge** of potential energy concepts or variational methods for solving complex structural geometries of different fields by using the principles of **mathematics and sciences.**	3
	PO 2	Understand the **problem statement and formulate** stiffness matrix, load vector by using the shape functions.	2
CO 2	PO 1	Apply the **engineering knowledge** of shape functions in truss and beam elements for developing stiffness matrix and load vector by using **principles of mathematics and sciences.**	3
	PO 2	**Identify the problem** of 2D elements and utilize shape functions to **formulate** for obtaining stiffness matrix and load vector for truss and beam elements strains in reaching substantiated conclusions by the **interpretation of results.**	2
	PO 12	Apply the **Personal continuing education efforts** of shape functions in truss and beam elements for developing stiffness matrix and load vector	1
CO 3	PO 1	Identify the **mathematical** model for two dimensional elements for obtaining stiffness matrix and load vector by using principles of **engineering and sciences.**	3
	PO 2	Understand the given **problem and formulate** it by using finite element method to obtain the shape functions of triangular, axi-symmetric and four noded elements.	2
	PO 12	Apply the **Personal continuing education efforts** stiffness matrix and load vector by using principles of engineering and sciences.	1
CO 4	PO 1	Understand the **engineering** concepts of shapes functions to obtain stiffness matrix and load vector for two dimensional elements by using the **principles of mathematics and sciences.**	3
	PO 2	**Identify the problem, formulate** stiffness matrix and load vector for two dimensional elements **for solution development** in reaching substantiated conclusions by the **interpretation of results.**	3
	PO 12	Apply the **Personal continuing education efforts** axisimetric solids and trangular elements.	1
CO 5	PO 1	Illustrate the basics of heat transfer for developing **mathematical models** by using **engineering and sciences.**	3

	PO 2	Recognize the **problem** of heat transfer and formulate thermal stiffness matrix, thermal load vector by applying numerical methods to get the **solution for interpretation of results.**	4
	PO 12	Apply the **Personal continuing education efforts** heat conduction analysis of plates etc.	1
	PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications	1
CO 6	PO 1	Create a model for finding displacements, stresses and strains of structural and thermal problems by using **principles of engineering, sciences and mathematics.**	3
	PO 2	Identify the **problem statement** of different structural and thermal problems and **formulate** it to obtain displacements, stresses and strains for **solving** complex engineering problems in reaching substantiated conclusions by **interpretation of results.**	2
	PO 3	**Use creativity to establish innovative solutions** for dyanmic systems and **Manage the design process and evaluate outcomes**	2
	PO 4	**Identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques** for dynamic system to estimate frequency and mode shapes	2
	PO 5	Make use of **modern tools, create and analyse**mathematical model problems for finding the mechanical and thermal properties of elements.	1
	PO 12	Understand the usage of modern tools like ANSYS, Hyper mesh and NASTRAN to engage in independent and **life-long learning** in the broadest context of **technological change**.	2
	PSO 3	Use of **computational and experimental tools for creating mathematical model** problems in the fields of mechanical, aeronautical and civil.	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 4	3	3	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 5	3	4	-	-	-	-	-	-	-	-	-	1	-	1	-
CO 6	3	2	2	2	1	-	-	-	-	-	-	2	-	-	1

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	20	-	-	-	-	-	-	-	-	-	12.5	-	-	-
CO 3	100	20	-	-	-	-	-	-	-	-	-	12.5	-	-	-
CO 4	100	30	-	-	-	-	-	-	-	-	-	12.5	-	-	-
CO 5	100	40	-	-	-	-	-	-	-	-	-	12.5	-	50	-
CO 6	100	20	20	18	100	-	-	-	-	-	-	25	-	-	50

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C < 5\%$ – No correlation
1 - $5\ \% \leq C < 40\%$– Low/ Slight
2 - $40\ \% \leq C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	1	-	2	-
CO 6	3	1	1	1	3	-	-	-	-	-	-	1	-	-	2
TOTAL	18	7	1	1	3	-	-	-	-	-	-	5	-	2	2
AVERAGE	3.0	1.1	1	1	3	-	-	-	-	-	-	1	-	2	2

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	-	Tech Talk	-	Projects	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO FEM**
	Introduction to FEM for solving field problems. Basic equations of elasticity, Stress–Strain and strain-displacement relations for 2D-3D elastic problems. Boundary conditions. One Dimensional problem: Finite element modeling coordinates and shape functions. Assembly of Global stiffness matrix and load vector. Finite element equations - Quadratic shape functions.
MODULE II	**ANALYSIS OF TRUSSES AND BEAMS**
	Analysis of Trusses Stiffness matrix for plane Truss Elements, stress calculations and problems Analysis of beams: Element stiffness matrix for two nodes, two degrees of freedom per node beam element and simple problems. Problems.
MODULE III	**2-D ANALYSIS**
	Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions. Estimation of load Vector, stresses; Finite element modeling of Axisymmetric solids subjected to Axisymmetric loading with triangular elements. Two dimensional four nodded isoparametric elements.
MODULE IV	**STEADY STATE HEAT TRANSFER ANALYSIS**
	Steady state Heat Transfer Analysis: 1-D Heat conduction of slab 1D fin elements, 2D heat conduction - analysis of thin plates, Analysis of a uniform shaft subjected to torsion- problems.
MODULE V	**DYNAMIC ANALYSIS**
	Dynamic Analysis: Dynamic equations, lumped and consistent mass matrices, eigen Values and Eigen Vectors for a stepped bar, beam; Finite element, formulation to 3D problems in stress analysis, convergence requirements, mesh generation, techniques such as semi-automatic AND fully automatic use of software such as ANSYS, NISA, NASTRAN.

TEXTBOOKS

1. Tirupathi K. Chandrupatla and Ashok D. Belagundu, “Introduction to Finite Elements in Engineering”, Pearson, 4th Edition, 2011.
2. S. Rao, “The Finite Element Methods in Engineering”, Elsevier, 4th Edition 2009.
3. J. N. Reddy, “An Introduction to Finite Element Methods”, McGraw Hill, 4th Edition 2009.

REFERENCE BOOKS:

1. O.C. Zienkowitz, “The Finite Element Method in Engineering Science”, McGraw Hill. 4th Edition, 2009.
2. Robert Cook, “Concepts and Applications of Finite Element Analysis”, Wiley, 4th Edition, 2010.
3. S.Md.Jalaludeen, “Introduction of Finite Element Analysis” Anuradha publications, 4th Edition, 2010

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference T1: 4.1
	OBE DISCUSSION		
1	Introduction to outcome based education		
	CONTENT DELIVERY (THEORY)		
2	Introduction to Finite Element Method for solving field problems, Stress and Equilibrium	CO 1	T1:1.5 R1:2.4
3-4	Boundary conditions, Stress-strain relations for 2-D and3-D elastic problems, strain displacement relations.	CO 1	T2:2.5 R1:2.5
5	One Dimensional Problem: Finite element modeling coordinates and shape functions	CO 1	T1:2.5 R2:2.6
6-7	Assembly of Global stiffness matrix and load vector. Finite element equations – Treatment of boundary conditions	CO 1	T1:22.7
8	Quadratic shape functions	CO 1	T2:6.3 R1:5.3
9-10	Analysis of Trusses: Stiffness matrix for plane Truss Elements	CO 2	T1:6.6 R1:5.3.6
11-12	Stiffness matrix for plane Truss Elements, stress calculations and problems	CO 2	R3:6
13-14	Analysis of beams: Element stiffness matrix for two noded, two degrees of freedom per node beam element	CO 2	T1:7.5 R1:6.3
15-16	Element stiffness matrix for two noded, two degrees of freedom per node beam element	CO 2	T1:8.5 R3:6.8
17-18	Problems on beams and trusses.	CO 3	T1:12.2 R1:13.1

19-20	Finite element modeling of two dimensional stress analysis with constant strain triangles	CO 3	T3:12.3 R1:13.2
21-22	Two dimensional stress analysis with constant strain triangles and treatment of boundary conditions	CO 3	T1:12.10 R1:13.7
23-24	Estimation of load vector and stresses	CO 3	T1:11.2 R1:10.2
25	Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular Elements	CO 4	T1:11.5 R2:10.3
26	Two dimensional four noded iso parametric elements	CO 4	T1:11.12 R1:11.9
27-28	Problems on two dimensional elements	CO 4	T1:11.8 R1:11.5
29-30	Steady state Heat Transfer Analysis: one dimensional analysis of slab	CO 5	T1:9.9
31-32	Fin and two-dimensional analysis of thin plate Analysis of a uniform shaft subjected to torsion	CO 5	T1:12.1-12.2
33-34	Dynamic Analysis: Formulation of finite element model	CO 6	T3:11.3 T2:16.13
35-36	Mass matrices for bar, beam and truss	CO 6	T3:12.3 R1:11.3
37-38	evaluation of Eigen values and Eigen Vectors for a stepped bar, truss	CO 6	T1:1.5 R1:2.4
39-40	Finite element-formulation to 3D problems in stress analysis	CO 6	T2:2.5 R1:2.5
41-42	Finite element-formulation to 3D problems in stress analysis, convergence requirements	CO 6	T1:2.5 R2:2.6
43-50	Techniques such as semi-automatic and fully automatic use of software such as ANSYS, NISA, NASTRAN	CO 6	T1:22.7
PROBLEM SOLVING/ CASE STUDIES			
1	Boundary conditions, Stress-strain relations for 2-D and3-D elastic problems, strain displacement relations.	CO 1	T2:2.5 R1:2.5
2	One Dimensional Problem: Finite element modeling coordinates and shape functions	CO 1	T1:2.5 R2:2.6
3	Assembly of Global stiffness matrix and load vector. Finite element equations – Treatment of boundary conditions	CO 1	T1:22.7
4	Quadratic shape functions	CO 1	T2:6.3 R1:5.3
5	Analysis of Trusses: Stiffness matrix for plane Truss Elements	CO 2	T1:6.6 R1:5.3.6
6	Stiffness matrix for plane Truss Elements, stress calculations and problems	CO 2	R3:6
7	Analysis of beams: Element stiffness matrix for two noded, two degrees of freedom per node beam element	CO 2	T1:7.5 R1:6.3
8	Two dimensional four noded iso parametric elements	CO 4	T1:11.12 R1:11.9

9	Problems on two dimensional elements	CO 4	T1:11.8 R1:11.5
10	Steady state Heat Transfer Analysis: one dimensional analysis of slab	CO 5	T1:9.9
11	Fin and two-dimensional analysis of thin plate Analysis of a uniform shaft subjected to torsion	CO 5	T1:12.1-12.2
12	Dynamic Analysis: Formulation of finite element model	CO 6	T3:11.3 T2:16.13
13	Mass matrices for bar, beam and truss	CO 6	T3:12.3 R1:11.3
14	evaluation of Eigen values and Eigen Vectors for a stepped bar, truss	CO 6	T1:1.5 R1:2.4
15	Finite element-formulation to 3D problems in stress analysis	CO 6	T2:2.5 R1:2.5
41-42	Finite element-formulation to 3D problems in stress analysis, convergence requirements	CO 6	T1:2.5 R2:2.6
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module I	CO 1	R4:2.1
2	Module II	CO 2	T4:7.3
3	Module III	CO 3,4	R4:5.1
4	Module IV	CO 5	T1:7.5
5	Module V	CO 6	T1: 4.1
DISCUSSION OF QUESTION BANK			
1	Module I	CO 1	R4:2.1
2	Module II	CO 2	T4:7.3
3	Module III	CO 3,4	R4:5.1
4	Module IV	CO 5	T1:7.5
5	Module V	CO 6	T1: 4.1

Signature of Course Coordinator **HOD, ME**
Mr M. Prashanth Reddy Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**MACHINE DESIGN**				
Course Code	AME015				
Program	B.Tech				
Semester	VI	ME			
Course Type	CORE				
Regulation	IARE-R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. GVR Seshagiri Rao, Associate Professor				

I COURSE OVERVIEW:

The Machine design focus mainly on design of power transmitting elements like gears, connecting rod, crankpin, crankshafts, pistons, cylinders, bearings, belts, ropes, chain's, pulleys, Power screws and nuts. Design basis is strength and stiffness of the parts and selection of material for manufacture of machine elements.
Mechanical design is creating new devices or improving existing ones in an attempt to provide the "best" or "optimum "design. In other words, mechanical design may be de need as an iterative decision-making process that has as its objective the creation and optimization of a new or improved mechanical engineering system or device for the fulfillment of a human need or desire, with due regard for conservation of resources and environmental impact.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME002	III	Engineering Mechanics
B.Tech	AME005	III	Mechanics of solids
B.Tech	AME013	V	Design of Machine Members

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
MACHINE DESIGN	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10 %	Remember
50 %	Understand
25%	Apply
15%	Analyze
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

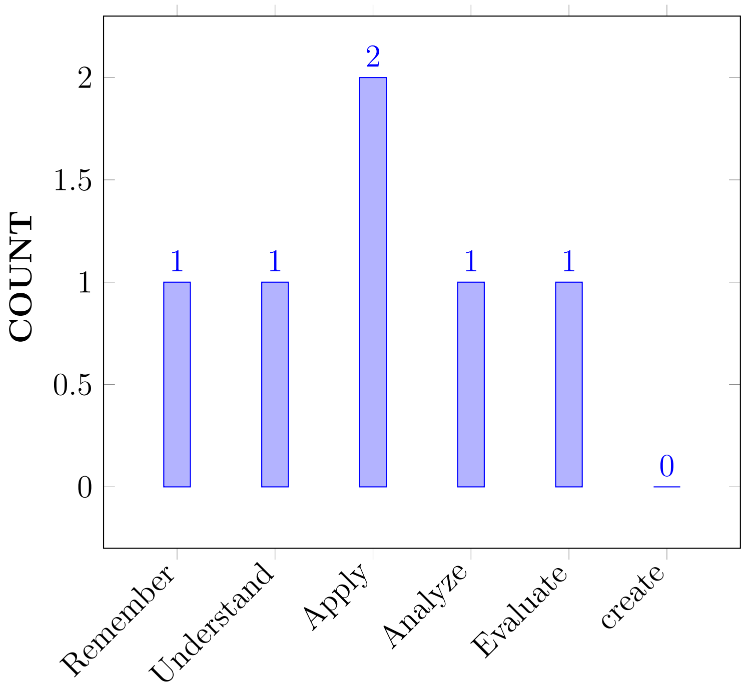
I	To build a system, component, or process that meets desired needs within realistic design constraints for safety, manufacturability and sustainability.
II	To make use of design data hand books to understand the design standards for introducing empirical design data process applicable for mechanical standard elements.
III	To analyze the design parameters for performance evaluation for mechanical transmission elements including bearings, gears and power screw transmission systems.
IV	To elaborate different design criteria and their procedure to carry out the required design steps for application of beam strength criteria for power transmissions in mechanical and allied engineering optimization.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Outline**the various surface contact bearings and their basic features, terminology and limitations for low speed applications.	Remember
CO 2	**Understand** basic modes of hydrodynamic lubrication applicable to sliding contact bearings using Petroff's equation todetermine the frictional torque.	Understand
CO 3	**Apply** the design procedures to sliding and rolling contact bearings for static and dynamic loading for calculation the bearing life.	Apply
CO 4	**Implement** the design methodology for critical automobile components like connecting rod, crank shaft for combined loading for feasible solution.	Apply
CO 5	**Design** of internal combustion engine component (piston) by applying the structural and thermal loadsto meet the input design specifications using equilibrium equation.	Analyse
CO 6	**Select** the kinematic synthesis for power transmission systems and their scope of application.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	3	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	2	AAT
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	AAT

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	✓	-	-	-	-	-	-	-	-	-		✓	-	-

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply knowledge of **science, engineering** fundamentals to understand the various surface contact bearings and their basic features, in order to **mathematically** relate the performance of bearing systems.	3
	PO 2	**Recognize** the basic components of bearings and **Understand** the function of each component and **interpret** which **design** is appropriate.	4
CO 2	PO 1	**Identify and compare** the processes of supplying lubrication supply to different types of engines and **analyse** the various components in fuel supply system.	3
CO 3	PO 1	**Apply** the knowledge of science, engineering fundamentals to **demonstrat**e the working and operation process of various types of cooling systems utilized in automobile.	3

	PO2	**Compare** the different ignition systems and **interpret** the performance of characteristics of SI and CI engines by **stating the limitations.**	4
CO 4	PO 1	**Apply** the knowledge of engineering fundamentals and science to **illustrate** starting motor, Horn and Wiper and electric circuits.	2
	PO 3	**Apply** the fundamentals ofIC engines **Demonstrate** the different types of power transmission system.	2
CO 5	PO 2	**Identify, formulate and analyse** how power is transmitted from engine to wheels by using engineering fundamentals.	3
	PSO 1	**Analyse and compare** different power transmitting systems in automobile engineering.	2
CO 6	PO 1	**Apply** the knowledge of science and engineering fundamentals to **Illustrate** the importance of suspension system.	2
	PSO 1	**Interpret** the failure of suspension system by **applying** the basic concepts of spring mass systems.	2

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	2	-	-	-	-		1	-	-
CO 5	-	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 6	2	-	-	-	-	-	-	-	-	-	-		2	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	40	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	-	30	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 6	66.6	-	-	-	-	-	-	-	-	-	-		100	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - $40\ \% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	3	-	-	-	-	-	-		-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-		3	-	-
TOTAL	33	10	4	-	-	-	-	-	-	-	-	-	15	-	9
AVERAGE	3.0	1.0	1	-	-	-	-	-	-	-	-	-	3 -	-	3

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	P	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 1,PO2	Open Ended Experiments	-
Assignments	✓				

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVII SYLLABUS:

MODULE I	**BEARINGS**
	Bearings: Types of journal bearings, basic modes of lubrication, bearing modulus, full and partial bearings, Clearance ratio, Heat dissipation of bearings, bearing materials, Journal bearing design. Ball and roller bearing, Static load- dynamic load, equivalent radial load-design and selection of ball and roller bearings.

MODULE II	**DESIGN OF IC ENGINE PARTS**
	Connecting rod: thrust in connecting rod-stress due to whipping action on connecting rod ends-cranks and crank shafts, strength and proportions of over hung and center cranks-crank pins, crank shafts, piston, forces acting on piston-construction design and proportions of piston..
MODULE III	**POWER TRANSMISSION SYSTEMS, PULLEYS**
	Transmission of power by belt and rope drives, transmission efficiencies, Belts-Flat and V belts-ropes-pulleys for belt and rope drives, materials-chain drives.
MODULE IV	**SPUR GEAR**
	Load concentration factor-dynamic load factor, surface compressive strength-bending strength-design analysis of spur gear, check for plastic deformation, check for dynamic and wear considerations. Helical and Bevel Gear Drives: Load concentration factor-dynamic load factor, Analysis of helical and bevel gears, check for plastic deformation, check for dynamic and wear considerations. Design of Worm gears: worm gear-properties of worm gears-selections of materials-strength and wear rating of worm gears-force analysis-friction in worm gears-thermal considerations
MODULE V	**DESIGN OF POWER SCREWS**
	Design of screw, design of nut, compound screw, differential screw, ball screw-possible failures

TEXTBOOKS

1. P. Kannaiah, Machine Design, 2nd Edition, Scitech Publications India Pvt. Ltd, New Delhi, 2012.
2. V.B. Bandari, A Text Book of Design of Machine Elements, 3rd edition, Tata McGraw hill, 2011.

REFERENCE BOOKS:

1. Shigley, J.E, (2011), Mechanical Engineering Design, 9th Edition, Tata McGraw-Hill, New Delhi, India.
2. S. M.D. Jalaludin, (2011), Machine Design, 3rd Edition, Anuradha Publishers, Kumbakonam, Chennai, India
3. R. L. Norton (2006), Machine Design (An Integrated approach), 2nd edition, Pearson Publishers, Chennai, India.

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
	OBE DISCUSSION		
1	Discussion on Outcome Based Education		

CONTENT DELIVERY (THEORY)			
1	Types of journal bearings	CO 1	T1:1.2 R4:1.5
2-3	Basic modes of lubrication	CO 1	T1:3.1 R3:3.16
4	Bearing modulus-full and partial bearings,	CO 1	T1:7.59
5-7	Clearance ratio	CO 2	T2:5.11
8	Heat dissipation in bearing	CO 2	T2:7.3 R3:3.21
9	Bearing materials, Journal bearing design	CO 3	T1:7.63 R3:6.11
10-11	Types of rolling contact bearings	CO 4	T1:7.89 R4:6.4
12-15	Selection of bearing type	CO 4	T1:7.9 R3:6.20
16-17	Static and dynamic loading of ball and roller bearings	CO 5	T1:11.2 R3:11.6
18	Transmission of power by belt drives	CO 5	T1:9.2 R3:9.8
19	Construction of rope drives	CO 6	T1:9.5 R3:9.14
20-21	Transmission efficiencies.	CO 4	T2:8.3 R4:9.21
22-23	Belts-Flat and V belts	CO 4	T1:106 R4:10.17
24	Pulleys for belt and rope drives, materials	CO 4	T1:11.9 R4:11.16
25	Design of Chain drives	CO 4	T2:11.5 R4:11.10
26	Thrust in Connecting Rod	CO 5	T2:11.9 R1:11.12
27	Stress due to Whipping action on Connecting rod ends.	CO 5	T2:11.21 R1:11.7
28	Cranks and crankshafts, Strength and proportions of crankshafts	CO 5	T1:12.1
29	Design of Piston, Forces acting on piston	CO 5	T2:9.9 R3:13.8
30-32	Construction design and proportions of piston	CO 5	T1:12:10 R3:12.4
33	Spur Gear Drives: Design of spur gears	CO 5	T1:12.15 R3:12.7
34	Load concentration factor-dynamic load factor	CO 5	T1:12.16
35-36	Surface compressive strength-bending strength	CO 5	T1:13.2 R3:14.6

37	Design analysis of spur gear	CO 5	T1:13.8, R3:14.11
38-39	Estimation of center distance, module and face width, check for plastic deformation	CO 5	T1:13.9 R3:14:13
40	Check for dynamic and wear considerations	CO 5	T2:15.1 R3:14.16
41-42	Helical and Bevel Gear Drives: Load concentration factor-dynamic factor	CO 6	T2:15.2. R2: 12.6
43	Design analysis of Helical and Bevel gear	CO 6	T2:9.24 R2: 12.8
44	Check considerations for dynamic strength	CO 6	T2:9.30
45	Design of Worm gears: worm gear- properties of worm gears-selections of materials	CO 6	T2:16.2 R3:23.8
46	Strength and wear rating of worm gears- force analysis	CO 6	T2:10.3 R4:23.18
47	Friction in worm gears-thermal considerations	CO 6	T2:10.5
48-49	Design of power screws : Design of screw	CO 6	T2:10.10
50-51	Square, ACME, Buttress screws	CO 6	T1:10.15
52	Design of nut	CO 6	T2:10.21
PROBLEM SOLVING/ CASE STUDIES			
1	15 problem solving classes	CO 1	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	5 classes	CO 1,2, 3	R4:2.1
DISCUSSION OF QUESTION BANK			
1	Module I	CO 1	R4:3.2
2	Module II	CO 2,	T4:7.3
3	Module III	CO 3,4	R4:5.1
4	Module IV	CO 5	T1:7.5
5	Module V	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	Mechanical Engineering				
Course Title	HEAT TRANSFER				
Course Code	AME016				
Program	B. Tech				
Semester	VI				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr. K. Ch Apparao, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME003	III	Thermodynamics
B.Tech	AME008	IV	Mechanics of fluids and Hydraulic Machines

II COURSE OVERVIEW:

Heat transfer is the flow of thermal energy due to temperature gradient and the subsequent distribution changes commonly measured as heat flux. This course focuses on heat transfer modes viz. Conduction, convection and radiation with different boundary conditions under steady and transient conditions, and heat exchangers applied to modern electric and electronic plants require efficient dissipation of thermal losses. Thus there is great relevance for this course in modeling heat exchangers, heat treatment of fins and complex mechanical systems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Heat Transfer	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos

V EVALUATION METHODOLOGY:

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40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

I	The governing equations and performance relations of various modes of heat transfer using the three types of coordinate systems.
II	The concepts for validating heat transfer parameters during internal and external flows based on non-dimensional numbers and convective mode heat transfer.
III	The performance and analysis of heat exchangers for real-time applications using logarithmic mean temperature difference and number of transfer unit methods.
IV	The design methodologies for enhancing heat transfer among a wide variety of practical engineering problems.

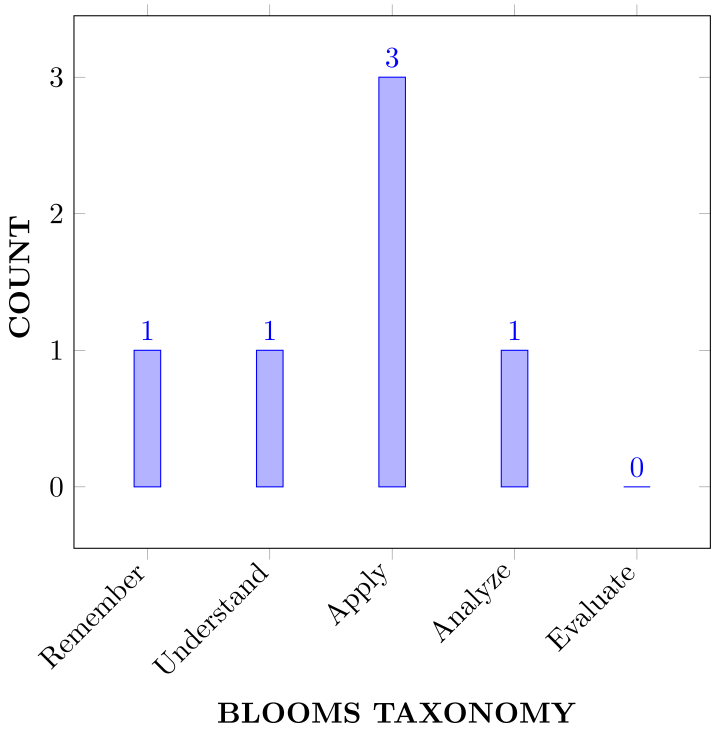
VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Recall** the basic concepts of heat transfer mechanisms and general heat conduction equation in Cartesian, Cylindrical and Spherical Coordinate System for various measures of heat transfer rate.	Remember
CO 2	**Solve** problems involving steady state heat conduction with and without heat generation in simple geometries.	Apply

CO 3	**Make use of** the concept of Boundary layer theory for the derivation of empirical relations related to the characteristics of Boundary layer.	Apply
CO 4	**Utilize** the principles associated with convective heat transfer to formulate and solve the heat transfer coefficients for various cross section areas	Apply
CO 5	**Explain** the physical mechanisms involved in radiation heat transfer, boiling and condensation to give various correlations applied to heat exchangers, boilers, heat engines, etc.	Understand
CO 6	**Analyze** LMTD and NTU techniques for tackling real time problems with thermal analysis, simulation (mathematical model) and cost optimization of heat exchangers.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

Program Outcomes	
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIA
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE/CIA
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE/CIA
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE/CIA

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	SEE/CIA
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	SEE/CIA

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Formulate and evaluate concepts of thermo-fluid systems to provide solutions for inter disciplinary engineering applications sustainable designs for new generation automotive systems.	3	SEE/CIA

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-
CO 4	✓	-	✓	-	-	✓	✓	-	-	-	-	-	-	-	
CO 5	✓	-	✓	-	-	-	✓	-	-	-	-	-	-	✓	-
CO 6	-	✓	-	✓	-	✓	✓	-	-	-	-		-	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall (knowledge) the basic concepts of heat transfer and temperature gradients for various measures of heat transfer rate using **scientific principles** of Methodology, **mathematical principles** and **engineering fundamentals.**	3
CO 2	PO 1	Identify (knowledge) suitable mechanisms for solving the one-dimensional problems with different surfaces and geometries (fins) for which the temperature distribution and heat flow rates are calculated using **mathematical principles** and **engineering fundamentals.**	2

	PO 2	problem analysis based on first **principles of mathematics** and **engineering sciences** is essential to analyze complex engineering problems based on **data collection** which is related to steady state heat conduction with and without heat generation for **validating** the **experimental design solution**	5
CO 3	PO 2	Make use of the concept of Boundary layer theory for the **Design, Model Creation** and **Validation** of **experimental design** of heat transfer geometries by **Problem Analysis**	5
	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **heat transfer process.**	2
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for new generation heat exchangers, boilers and heat pipes.	2
CO 4	PO 1	Recall (knowledge) the principles associated with convective heat transfer to understand the dynamics of temperature field in fluid flow using **scientific principles** of Methodology, **mathematical principles** and **engineering fundamentals.**	3
	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **heat transfer process.**	2
	PO 6	Gained **Knowledge and understanding** of commercial and economic context of various convection problems will help the students to develop heat transfer equipment which is beneficial for the **society**.	2
	PO 7	Students can develop **socio economic** products in a sustainable manner by understanding the impact of the convection heat transfer solutions in **societal** and **environmental** contexts.	3
CO 5	PO 1	recall (knowledge) the physical mechanisms involved in radiation heat transfer and boiling and condensation phenomena to give various correlations using **mathematical principles** and **engineering fundamentals**.	2
	PO 3	Identify the various properties of boiling and condensation phenomena to heat engines using **Design, analytical** and **mathematical process.**	3
	PO 7	Students can develop **socio economic** products in a sustainable manner by understanding the impact of the radiation heat transfer solutions along with boiling concept in **societal** and **environmental contexts.**	3
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for new generation heat exchangers, boilers.	2

CO 6	PO 2	Make use of LMTD and NTU techniques used in heat exchangers and fins for the **design, model translation** and **validate** the system and **interpret** the results to get good **experimental design**	5
	PO 4	LMTD and NTU techniques are required to solve problems involving heat transfer rates in heat exchanger and fins based on **experimental data** to **understanding of and ability to apply a systems approach to engineering problems.**	2
	PO 6	**Gained Knowledge** and **understanding** of commercial and economic context of various convection problems will help the students to develop heat exchangers which are beneficial for the **society.**	2
	PO 7	Students can develop **socio economic** products in a sustainable manner by understanding the impact of the heat exchanging solutions in **societal** and **environmental** contexts.	3
	PSO 2	Formulate and evaluate concepts of thermo-fluid systems to **provide solutions** for inter disciplinary **engineering applications** for sustainable designs for new generation heat exchangers, boilers and heat pipes.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

	PROGRAM OUTCOMES												PSO'S		
COURSE OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	5	2	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	-	2	-	-	2	3	-	-	-	-		-	-	-
CO 5	2	-	3	-	-	-	3	-	-	-	-	-	-	3	-
CO 6	-	5	-	2	-	2	3	-	-	-	-		-	3	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

	PROGRAM OUTCOMES												PSO'S		
COURSE OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	50	20	-	-	-	-	-	-	-	-	-	-	100	-
CO 4	100	-	20	-	-	40	66.7	-	-	-	-		-	-	-
CO 5	66.7	-	30	-	-	-	66.7	-	-	-	-	-	-	100	-
CO 6	-	50	-	18.1	-	40	66.7	-	-	-	-		-	100	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	2	1	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	-	1	-	-	2	3	-	-	-	-		-	-	-
CO 5	3	-	1	-	-	-	3	-	-	-	-	-	-	3	-
CO 6	-	2	-	1	-	2	3	-	-	-	-		-	3	-
TOTAL	12	6	3	1	-	4	9	-	-	-	-	-	-	9	-
AVERAGE	3	2	1	1	-	2	3	-	-	-	-	-	-	3	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓	-	-	-	

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO HEAT TRANSFER**
	Classification of launch vehicles and missiles, rocket systems, airframe components, forces and moments acting on a rocket, propulsion, aerodynamics, gravity, inertial and non-inertial frames, coordinate transformation, equations of motion for three-dimensional motion through atmosphere and vacuum, earth's atmosphere, numerical problems
MODULE II	**CONDUCTION HEAT TRANSFER**
	One dimensional steady state conduction heat transfer: Homogeneous slabs, hollow cylinders and spheres, overall heat transfer coefficient, electrical analogy, Critical radius of insulation; one dimensional steady state conduction; heat transfer: with variable thermal conductivity, extended surfaces (Fins) long, short and insulated tips; significance of Biot and Fourier numbers, chart solutions of transient conduction systems.

MODULE III	**CONVECTIVE HEAT TRANSFER**
	Buckingham Pi Theorem and method, application for developing semi, empirical non-dimensional correlation for convection heat transfer, significance of non-dimension numbers, concepts of continuity, momentum and energy equations; free convection: Development of hydrodynamic and thermal boundary layer along a vertical plate, use of empirical relations for vertical plates and pipes. Forced convection: external flows: Concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer, flat plates and cylinders; Internal flows, Concepts about Hydrodynamic and thermal entry lengths, division of internal flows based on this, use of empirical correlations for horizontal pipe flow and annulus flow
MODULE IV	**RADIATION AND PHASE CHANGE**
	Emission characteristics, laws of black-body radiation, Irradiation, total and Monochromatic quantities, laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann, heat exchange between two black bodies, concepts of shape factor, emissivity, heat exchange between grey bodies, radiation shields, electrical analogy for radiation networks. Boiling: Pool boiling-regimes Calculations on Nucleate boiling, Critical heat flux, Film boiling; Condensation: Film wise and drop wise condensation, Nussels theory of condensation on a vertical plate Film condensation on vertical and horizontal cylinders using empirical correlations.
MODULE V	**HEAT EXCHANGERS**
	Classification of heat exchangers, overall heat transfer Coefficient and fouling factor, Concepts of LMTD and NTU methods, Problems using LMTD and NTU methods.

TEXTBOOKS

1. Holman, —Heat Transfer, Tata McGraw-Hill education, 10th Edition, 2011.
2. P. S. Ghoshdastidar, —Heat Transfer, Oxford University Press, 2nd Edition, 2012.

REFERENCE BOOKS:

1. Jindal, "Strength of Materials", Pearson Education, 1st Edition, 2012.
2. Vazirani, Ratwani, "Analysis of Structures", Khanna Publishers, 19th Edition, 2014.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112/101/112101097/

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=pages/btech-lecture-notes-iare-r18-7

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to Outcome Based Education	-	-
CONTENT DELIVERY (THEORY)			
2	Modes and mechanisms of heat transfer, Basic laws of heat transfer, Applications of heat transfer	CO 1	T2:2.3, R1:2.6
3-4	Fourier Equation, General heat conduction equations in Cartesian, Cylindrical and Spherical coordinates.	CO 2	T1:2.6
5	Simplification and forms of the field equation, steady and unsteady and periodic heat transfer.	CO 3	T2:2.7, R1:2.18

6	Transient heat transfer, Initial and boundary conditions	CO 3	T2:2.22
7-9	One dimensional steady state heat conduction heat transfer Homogeneous slabs, hollow cylinders and spheres.	CO 3	T2:2.25
10	Overall heat transfer coefficient, Electrical analogy,	CO 4	T2:2.26 R1:2.55
11-13	One dimensional steady state heat conduction heat transfer: systems with variable thermal conductivity and Systems with internal heat generation.	CO 4	T2:2.16 R1:2.61
14	Extended surfaces (Fins), Long, Short and insulated tips.	CO 5	T2:2.30 R1:2.58
18	Systems with negligible internal resistance, of different geometries.	CO 5	T2:3.14 R1:4.31
20	Significance of Biot and Fourier umbers,	CO 6	T2:3.14 R1:4.33
21-22	Chart solutions of transient conduction systems.	CO 6	R1:4.36
23-24	Classification of systems based on causation flow ,condition of flow, configuration of flow and medium flow	CO 7	T2:3.18 R1:4.64
25-27	Dimensional analysis as a tool for experimental investigation-Buckingham pi theorem Dimensional analysis-Application for developing non-dimensional correlation for convective heat transfer.	CO 7	T2:3.22 R1:4.67
28	Concepts of Continuity, Momentum and Energy Equations.	CO 7	T2:3.28 R1:4.67
29	External Flows Concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for Flat plates.	CO 7	T2:4.2 R1:4.67
30	Critical heat flux and film boiling	CO 7	T2:4.3 R1:4.71
31	Development of Hydrodynamic and thermal boundary layer along a vertical	CO 8	T1:4.8 R2:4.68
32	Use of empirical relations for Vertical plates and pipes.	CO 8	T2:4.15 R1:5.74
33	Regimes of Pool boiling and Flow boiling, Critical heat flux, Calculations on Nucleate Boiling	CO 8	T1:4.12 R2:5.75
34	Critical heat flux and film boiling	CO 9	T1:4.8 R2:5.72
35	Condensation, Film wise and drop wise condensation, Nusselts theory of condensation on a vertical plate.	CO 9	T1:5.8 R1:5.73
36	Film condensation on vertical and horizontal cylinders using empirical correlations	CO 9	T1:5.14 R1:6.78
37	Black-body radiation, Irradiation, Total and monochromatic quantities, Laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann.	CO 10	T2:5.19 R1:6.81
38	Heat exchange between grey bodies, Concepts of shape factor	CO 10	T2:7.7 R1:7.74
39	Comparison of thermal and non -thermal processes, Classification of heat exchangers	CO 12	T1:7.8 R1:8.72
40	Overall heat transfer Coefficient and fouling factor, Concepts of LMTD and NTU methods	CO 12	T2:9.19 R1:10.814
PROBLEM SOLVING/ CASE STUDIES			

41	Problems on heat transfer modes	CO 1,CO 2,	T2:2.3, R1:2.6
42	Problems on Conduction	CO 1,CO 2,	T2:2.7, R1:2.18
43	Problems on Composite slabs	CO 1,CO 2	T2:2.16 R1:2.61
44	Problems on Composite Cylinders and spheres	CO 1,CO 2, CO3	T2:2.16 R1:2.61
45	Problems on Critical radious of Insulation	CO 1,CO 2, CO3	R1:2.61
46	Problems on Long, Short and insulated tips Fins	CO 1,CO 2, CO3	T2:2.30 R1:2.58
47	Problems on Forced Convection	CO 4,CO 5, CO 6	T2:3.22 R1:4.67
48	Problems on Overall heat transfer coefficient	CO 7, CO 9, CO 8	T1:2.6
49	Problems on forced convection	CO 10,CO 11	T1:4.8 R2:4.68
50	Problems on Natural convection	CO11, CO12	T1:4.8 R2:4.7
51	Problems on configuration of flow and medium flow	CO 7, CO 9, CO 8	T2:4.2 R1:4.67
52	Problems on shape factor	CO 10,CO 11	T2:3.28 R1:4.67
53	Problems on Critical heat flux and film boiling	CO11, CO12	T1:4.8 R2:4.68
54	Problems on LMTD and NTU methods	CO 10,CO 11	T2:9.19 R1:10.814
55	Problems on heat exchangers	CO11, CO12	T2:9.19 R1:10.814
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Module: I: Introduction to Heat Transfer	CO 1,CO 2, CO3	T2:2.3, R1:2.6
57	Module: II: Conduction Heat Transfer	CO 4,CO 5, CO 6	T2:2.16 R1:2.61
58	Module: III: Convection Heat Transfer	CO 7, CO 9, CO 8	T1:4.8 R2:4.7
59	Module: IV: Radiation Heat Transfer	CO 10, CO 11	T2:3.28 R1:4.67
60	Module: V: Heat Exchangers and Phase change	CO 11, CO 12	T2:9.19 R1:10.814
DISCUSSION OF QUESTION BANK			
61	Module: I: Introduction to Heat Transfer	CO 1, CO 2, CO3	R1:2.6
62	Module: II: Conduction Heat Transfer	CO 4, CO 5, CO 6	T2:2.16 R1:2.61
63	Module: III: Convection Heat Transfer	CO 7, CO 9, CO 8	T1:4.8 R2:4.7

64	Module: IV: Radiation Heat Transfer	CO 10, CO 11	T1:5.2 R2:5.7
65	Module: V: Heat Exchangers and Phase change	CO11, CO12	T2:9.19 R1:10.814

Signature of Course Coordinator **HOD, ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Solar Energy Systems**				
Course Code	AME525				
Program	B.Tech				
Semester	VI				
Course Type	Elective				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	0	0
Course Coordinator	Mr. M Sunil Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME013	V	Thermal Engineering

II COURSE OVERVIEW:

This course will helps the students to develop an understanding of the physical and technological principles of photovoltaic energy systems. It will address the solar energy resource, and assessment and measurement techniques for the available insolation. The components in a PV system, with a particular focus on the module will be central topic.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Solar Energy Systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
70 %	Understand
20%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

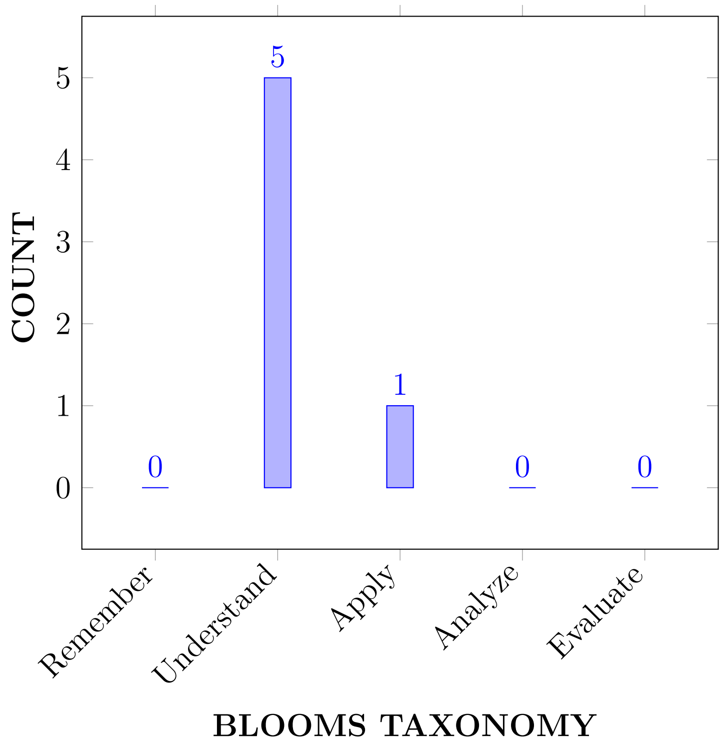
I	Understand the concept related various laws in solar engineering.
II	Outline the basic idea of solar energy collecting as well as energy storagedevices.
III	Development of solar cells and photo voltaic cells.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Construct** a practical knowledge on various devices of solar PV systems and trying with an assortment of parameters.	Apply
CO 2	**Explain** the various characteristics of the solar cell under local climatic working conditions for performance of the Solar PV cell under various specified operating temperature ranges and will be able to relate it with nominal values.	Understand
CO 3	**Explain** the performance of the solar PV cell under various specified operating temperature ranges and will be able to relate it with nominal values.	Understand
CO 4	**Interpret** in depth knowledge of about solar cells, thermal energy storage and electrical energy storages.	Apply
CO 5	**Illustrate** various types of energy storage devices and perform the selection based on techno-economic view point..	Understand
CO 6	**Outline** the concept and the diverse materials used in solar devices for concentration of solar energy.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Quiz, Assignments.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE, CIE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIE, SEE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	1	Quiz, Assignment

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	✓	-	-	-	-		-	✓	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-
CO 3	✓	✓	✓	-	-	-	✓	-	-	-	-	-	-	✓	-
CO 4	✓	✓	✓	-	-	✓	-	✓	-	-	-		-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	✓	✓	-	-	-	✓	-	-	-	-	✓	-	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recognize (knowledge) the importance of solar systems processes by applying the principles of **mathematics, science and Manufacturing fundamentals.**	3
	PO2	Apply the operational principles of different solar tracking by applying the the knowledge of **mathematics, science** and **engineering fundamentals.**	3
	PSO2	**Analysing** the solar cells photo voltaic to an able them to **design, analyse** and fabricate complex designs.	2
CO 2	PO 1	Apply the operational principles of different metal removal process the knowledge of **mathematics**, **science** and **engineering fundamentals.**	3
	PO 2	Explain (Understand) the solar radiation, thermal applications by applying the principles of **mathematics, science** and **engineering fundamentals.**	2
	PSO2	**Analysing** the solar cells photo voltaic to an able them to **design, analyse** and fabricate complex designs.	2
CO 3	PO 1	Explain (Understand) the thermal removal process by EDM, **mathematics**, **science** and **engineering fundamentals.**	3
	PO 2	Understand the given **problem statement and formulate the design (complex) engineering problems** for organic cells information and data in reaching substantiated **conclusions by the interpretation of results.**	3
	PSO2	**Analysing** the solar cells photo voltaic to an able them to **design, analyse** and fabricate complex designs.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PO 1	**Identify (knowledge)** the principles of solar radiation, solar radiation components by using acquired knowledge in **mathematics** and **science (physics and engineering).**	3
	PO 2	Application of the **identifying, formulating**, and **analysing complex problems**.	3
	PO 3	**Ability to principle and applications** of laser beam machining. apply the principle of concentration of beam energy help them to design, analyse and fabricate complex designs.	3
	PSO 2	**Ability to apply** the principle of concentration of solar energy help them to **design, analyse and fabricate complex designs.**	3
CO 5	PO 1	Ability to select, calibrate and use appropriate measuring equipment requires **identification of measured, selection of equipment by referring standard available equipment**, and analysing the results using reference values are carried out by applying the **knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	A **good knowledge in energy storage equipment** and an ability to calibrate, equip them to **design solutions to complex engineering Problems** by measuring various parameters which are affecting them.	3
CO 6	PO 1	Ability to select and **use various methods for concentration** of solar energy systems for proper analysis of results to reach actual conclusion requires some research based **knowledge of mathematics, science and engineering fundamentals.**	2
	PSO2	Ability to **apply** the principle of chemical energy storage. while designing and manufacturing help them to design, analyse and fabricate**complex designs.**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	3	-	-	-	-	-	2	2	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	3	2	-
CO 3	3	3	3	-	-	-	3	-	-	-	-	-	2	3	-
CO 4	3	3	3	-	-	2	-	2	-	-	-	3	2	-	-
CO 5	3	3	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	3	3	-	-	-	3	-	-	-	-	2	2	2	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	50	-	-	-	-	-	100	100	-
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	100	50	-
CO 3	100	50	50	-	-	-	50	-	-	-	-	-	50	50	-
CO 4	100	50	50	-	-	50	-	100	-	-	-	-	100	-	-
CO 5	100	40	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 6	100	40	50	-		-	50	-	-	-	-		50	50	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	2	-	-	-	-	-	3	3	
CO 2	2	2	-	-	-	-	-	-	-	-	-	-	3	2	-
CO 3	3	2	2	-	-	-	2	-	-	-	-	-	2	2	-
CO 4	3	2	2	-	-	2	-	3	-	-	-	-	3	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 6	3	2	2	-	-	-	2	-	-	-	-	-	2	2	-
TOTAL	18	10	6	-	-	2.0	6.0	3.0	-	-	-	-	13	12	-
AVERAGE	3.0	2.0	2.0	-	-	2.0	2.0	3.0	-	-	-	-	2.6	2.4	3

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓			Seminars	-
Assignments	-				
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE-I	**INTRODUCTION TO SOLAR ENERGY**
	Basics of solar energy, brief history of solar energy utilization, various approaches of utilizing solar energy, blackbody radiation, relation between radiation field energy density and radiation spectrum, Planck's formula in energy unit, maximum spectral density ; Planck's formula in wavelength unit , Wien displacement law, Stefan- Boltzmann law; Photoelectric effect , Einstein's theory of photons, Einstein's derivation of the black body formula
MODULE II	**ORIGIN OF SOLAR ENERGY,TRACKING SUNLIGHT AND ATMOSPHERIC INTERACTION**
	Basic parameters of the sun, measurement of the solar constant, the structure of the Sun, the origin of solar energy, rotation and orbital motion of the earth around the sun; solar time, sidereal time, universal standard time, local standard time, equation of time, intensity of sunlight on an arbitrary surface at any time, interaction with the atmosphere, absorption of the molecules, air mass, rayleigh scattering, direct and scattered sunlight.
MODULE-III	**SOLAR CELLS, PHOTOVOLTAIC BASICS**
	Formation of a p-n junction, space charge and internal field, quasi Fermi levels, the Shockley diode equation, structure of a solar cell , the solar cell equation, fill factor and maximum power, various electron hole pair recombination mechanisms, crystalline silicon solar cells; Thin film solar cells: CIGS, cite and a silicon Tandem solar cells, dye sensitized solar cells, organic solar cells. Structure and working of Solar Cells, types, electrical properties and behavior of Solar cells, cell properties and design, PV cell interconnection and module fabrication, PV modules and arrays, basics of load estimation.
MODULE-IV	**SOLAR ENERGY**
	Solar radiation at the earth's surface, solar radiation measurements, estimation of average solar radiation , solar thermal flat plate collectors , concentrating collectors, solar thermal application, heating, cooling, desalination, drying, cooking etc.,solar thermal electric power plant , principle of photovoltaic conversion of solar energy, types of solar cells; photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc, solar PV power plant, net metering concept
MODULE-V	**CONCENTRATION OF SOLAR ENERGY, ENERGY STORAGE**
	Three types of imaging optics: trough or linear collectors, central receiver with heliostats, and parabolic dish concentrator with on axis tracking, solar thermal electricity using stirling engine or ranking engine, solar photovoltaic's with concentration; necessity of storage for solar energy, chemical energy storage, thermal energy storage, thermal flywheels, compressed air, rechargeable batteries.

TEXT BOOKS

1. Duffie, J.A., Beckman, W.A. , "Solar Energy Thermal Process", John Wiley and Sons, 2018.
2. Jui Sheng Hsieh, "Solar Energy Engineering", Prentice-Hall, 1st Edition, 2019.
3. M. Stix, "The Sun, An Introduction", Springer, 2nd Edition, 2018.
4. G. D. Rai, "Solar Energy Utilization", Khanna Publishers, 1st Edition, 2010.

5. B. G. Streetman, S.Banerjee, "Solid state Electronic Devices", Prentice Hall, 6th Edition, 2006.
6. S.P. Sukhatme, "Solar Energy", Tata McGraw-Hill, 1st Edition, 1984.

REFERENCE BOOKS:

1. C S Solanki, "Solar Photovotaics–Fundamentals, Technologies and Applications", PHI Learning Pvt. Ltd., 2011.
2. Solar Energy International, "Photovoltaics: Design and Installation Manual", Solar Energy International, 1st Edition, 2010

WEB REFERENCES:

1. www.nptel.ac.in/courses/112105051
2. www.freevideolectures.com Mechanical IIT Kharagpur

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
2	Basics of solar energy.	CO1	T4:1.7
3	brief history of solar energy utilization.	CO1	T1:1.1
4	various approaches of utilizing solar energy.	CO1	T1:1.1, R1:1.1
5	blackbody radiation.	CO1	T1:1.2
6	relation between radiation field energy density and radiation spectrum.	CO1	R1:1.2
7	Plancks formula in energy unit.	CO1	T2:1.3
8	maximum spectral density.	CO1	T1:1.5
9	Plancks formula in wavelength unit.	CO1	T1:1.6 R2:2.1
10	Wien displacement law.	CO1	T1:1.7
11	Stefan- Boltzmann law.	CO1	T1:1.8
12	Photoelectric effect.	CO1	T1:1.9
13	Einsteins theory of photons.	CO1	T1:2.0
14	Einsteins derivation of the black body formula.	CO1	T1:2.1
15	Basic parameters of the sun.	CO2	T1:2.2
16	measurement of the solar constant.	CO2	T1:2.3
17	the structure of the Sun.	CO2	T1:2.4
18	the origin of solar energy.	CO2	T1:2.5
19	rotation and orbital motion of the earth around the sun.	CO2	T1:2.6
20	solar time, sidereal time	CO2	T1:2.7
21	universal standard time.	CO2	T1:2.8

22	local standard time.	CO2	T1:2.9
23	equation of time.	CO2	T1:3.0
24	intensity of sunlight on an arbitrary surface at any time.	CO2	T1:3.1
25	interaction with the atmosphere.	CO2	T1:3.3
26	absorption of the molecules.	CO2	T1:3.4
27	air mass.	CO2	T1:3.5
28	rayleigh scattering.	CO2	T1:3.6
29	direct and scattered sunlight.	CO2	T1:3.7 R2:4.2
30	Formation of a p-n junction.	CO3	T1:3.8
31	space charge and internal field.	CO3	T1:3.9
32	quasi Fermi levels.	CO3	T1:4.0
33	the Shockley diode equation.	CO3	T1:4.1
34	structure of a solar cell.	CO3	T1:4.2
35	the solar cell equation.	CO3	T1:4.3
36	fill factor and maximum power.	CO3	T1:4.4
37	various electron hole pair recombination mechanisms.	CO3	T1:4.5
38	crystalline silicon solar cells	CO3	T1:4.6
39	Thin film solar cells.	CO4	T1:5.1
40	CIGS.	CO4	T1:5.2
41	cite and a silicon Tandem solar cells.	CO4	T1:5.3
42	dye sensitized solar cells.	CO4	T1:5.4
43	organic solar cells.	CO4	T1:5.5
44	Structure and working of Solar Cells.	CO4	T1:5.6
45	working of Solar Cells, types.	CO4	T1:5.7
46	electrical properties and behavior of Solar cells.	CO4	T1:5.8
47	cell properties and design.	CO4	T1:5.9
48	PV cell interconnection and module fabrication.	CO4	T1:6.1
49	PV modules and arrays.	CO4	T1:6.2
50	basics of load estimation	CO4	T1:6.3
51	Solar radiation at the earths surface.	CO5	T1:6.4
52	solar radiation measurements.	CO5	T1:6.5
53	estimation of average solar radiation.	CO5	T1:6.6
54	solar thermal flat plate collectors.	CO5	T1:6.7
55	concentrating collectors.	CO5	T1:6.8
56	solar thermal application heating, cooling, desalination, drying, cooking etc.	CO5	T1:6.9
57	solar thermal electric power plant.	CO5	T1:7.0
58	principle of photovoltaic conversion of solar energy.	CO5	T1:7.1
59	types of solar cells.	CO5	T1:7.2
60	photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc,	CO5	T1:7.3
61	solar PV power plant, net metering concept.	CO5	T1:7.4
62	Three types of imaging optics: trough or linear collectors.	CO6	T1:7.5

63	central receiver with heliostats.	CO6	T1:7.6
64	and parabolic dish concentrator with on axis tracking.	CO6	T1:7.7
65	solar thermal electricity using stirling engine or ranking engine.	CO6	T1:7.8
66	solar photovoltaics with concentration.	CO6	T1:7.9
67	necessity of storage for solar energy	CO6	T1:8.0
68	chemical energy storage	CO6	T1:8.1
69	thermal energy storage	CO6	T1:8.2
70	thermal flywheels	CO6	T1:8.3
71	compressed air, rechargeable batteries.	CO6	T1:8.5
PROBLEM SOLVING/ CASE STUDIES			
72	Module I:Einstein'sderivation of the black body formula.	CO 1	R3:2.1
73	Module II:rotation and orbital motion of the earth around the sun.	CO 2	T4:7.3
74	Module III:organic solar cells.	CO 3, CO4	R2:5.1
75	Module IV:solar PV power plant.	CO 5	T1:7.5
76	Module V: solar thermal electricity using stirling engine or ranking engine.	CO 6	T1: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
77	Module I:Introduction to solar energy	CO 1	R3:2.1
78	Module II: origin of solar energy, tracking sunlight and atmospheric interatcion.	CO 2	T2:7.3
79	Module III: Solar cells, photo volatic basics.	CO4	R3:5.1
80	Module IV:Solar energy.	CO 5	T1:7.5
81	Module V:Concentration of solar energy, energy storage.	CO 6	T1: 4.1
DISCUSSION OF QUESTION BANK			
82	Module I:Introduction to solar energy	CO 1	R3:2.1
83	Module II:origin of solar energy, tracking sunlight and atmospheric interatcion.	CO 2	T4:7.3
84	Module III:Solar cells, photo volatic basics.	CO 3, CO4	R3:5.1
85	Module IV:Solar energy.	CO 5	T1:7.5
86	Module V:Concentration of solar energy, energy storage.	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**					
Course Title	**NON DESTRUCTIVE TESTING**					
Course Code	AME526					
Program	B.Tech					
Semester	VI					
Course Type	ELECTIVE					
Regulation	R-16					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	-	3	-	-	
Course Coordinator	Mr A. Venu Prasad, Assistant Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB05	III	Manufacturing Processes

II COURSE OVERVIEW:

on-destructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system. In other words, when the inspection or test is completed the part can still be used..

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
ADDITIVE MANUFACTURING PROCESS	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
20%	Remember
40 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 2), with 20 marks for continuous internal examination (CIE), 05 marks for quiz and 05 marks for alternative assessment tool

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 17th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams
Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.
Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Open Ended Experiment
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

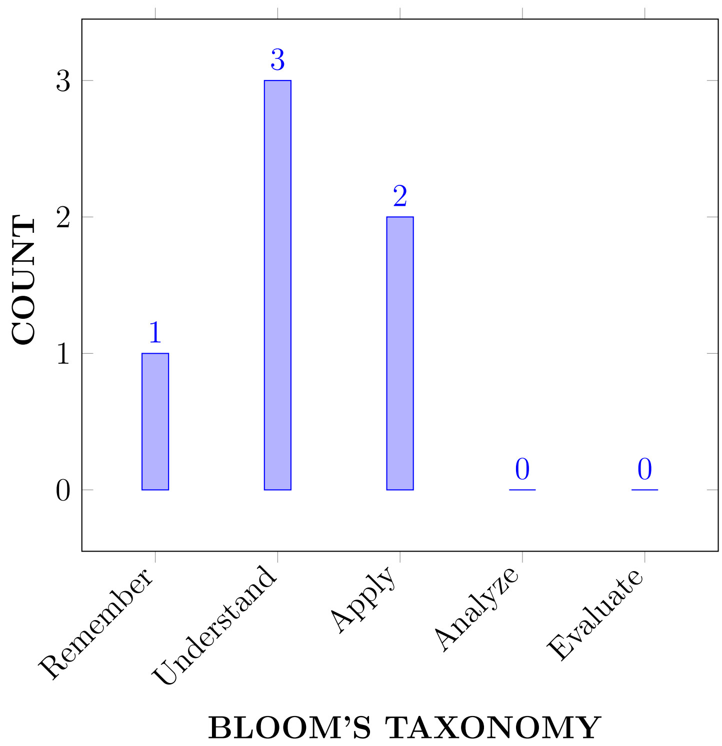
I	Apply the techniques of surface non destructive techniques testing methods.
II	The knowledge in relevant non-destructive testing methods for various engineering practice.
III	Apply the acoustic emission inspection method principle and understand its various applications.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Memorise** testing techniques for Visual examination, direct and indirect methods, liquid penetrant and magnetic particle testing for the surface methods. Non Destructive Testing and Testing methods understand for defects and characterization of industrial components	Remember
CO 2	**Discuss** the Principle of ultrasonic testing, methods, equipment, evaluation, interpretation and applications of non destructive testing methods to obtaining the evaluation of testing result.	Understand
CO 3	**Describe** the principles, films, radiography equipment, variables to examine the internal structure of manufactured components identifying any flaws or defects.	Understand
CO 4	**Describe** the process of radiographic image quality and it's techniques and safety to inspecting the characteristics of contrast, Optical density, image detail and distortion.	Understand
CO 5	**Execute** the advanced Non destructive methods of phase array and special radiographic techniques for evaluate the properties of a material or product.	Apply
CO 6	**Execute** the principles acoustic, emission inspection and industrial computed tomography to evaluate the properties of a material., component or system without causing damage.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Program Outcomes	
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	CIE/Quiz/AAT, AAT, QUIZ
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	CIE/Quiz/AAT, AAT, QUIZ

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change		

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing. standards	2	SEE/CIE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	✓	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	✓	-	-	-	-	-	-	-	-	-	-	✓	-	✓	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles**of Methodology using mathematics and physics and**engineering fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Identify (knowledge) in suitable methods involved in design, casting to achieve error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals.**	3
	PO 2	Understand the given **problem statement** and **apply data validation techniques** to **solve** (complex) specific engineering problems related to design.	2
CO 3	PO 4	Investigate prototype models based on constraint including **Environmental sustainability, Health and safety risks assessment issues** and define specific problem	2
CO 4	PO 3	**Identify** the various properties of Bonding techniques using **analytical and mathematical process.**	3
CO 5	PO 2	Make use of the metal forming techniques used in **Design, Model Creation** and **Validation of component** Parts by **Problem Analysis.**	4
	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **Additive manufacturing process.**	2
CO 6	PO 1	Apply the basic **mathematical principles** used in formulation of **engineering problems.**	2
	PO 2	Understand the working principle used in liquid, solid and powder based 3D Printing Process by **Natural Science and Engineering Sciences.**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	3	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	2	-	2	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	66.7	-	-	100	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 4	100	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	-	-	-	-	-	-	-	-	-	-	66.7	-	66.7	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - $40\ \% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	3	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	2	-	2	-
TOTAL	18	5	-	-	3	-	3	-	-	-	-	-	-	2	-
AVERAGE	3	1.6	-	-	3	-	3	-	-	-	-	2	-	2	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1,PO 2	SEE Exams	PO 1,PO 2, PO 7	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 5	Open Ended Experiments	PO12
Assignments	PO 1, PO 2, PO 5, PO 7				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**SURFACE NDE METHODS**
	Visual examination, direct and indirect methods, equipment, codes and standards, liquid penetrant testing, variables, interpretation and evaluation of test results, applicable codes and standards, magnetic particle testing, principle, equipment, advantages and limitations.
MODULE II	**ULTRASONIC TESTING**
	Principle of ultrasonic testing, methods, equipment, evaluation, interpretation, applications.
MODULE III	**RADIOGRAPHIC TESTING**
	Principles, films, radiography equipment, variables, radiographic image quality, techniques, safety.
MODULE IV	**ADVANCED NDE TECHNIQUES-I**
	Principle of phase array, technique, equipment, verification of flow existence and position, reporting, application, special radiographic techniques and interpretation of radiography, advantages and limitations.
MODULE V	**ADVANCED NDE TECHNIQUES-II**
	Acoustic, emission inspection, principles and applications, leak testing, principles and applications, industrial computed tomography principles and applications.

TEXTBOOKS

1. ASM, ―Non–destructive examination and quality control‖, ASM International, volume17, 9th Edition, 1989.

2. J. Prasad, C.G.K Nair, ―Non-destructive Test and Evaluation of materials‖, Tata McGraw-Hill, 2nd Edition, 2011.

REFERENCE BOOKS:

1. B. Raj, T. Jayakumar, M. Thavasinumuthu, Practical Non-destructive Testing‖, Alpha science International Limited, 3rd Edition, 2002.

WEB REFERENCES:

1. 1. http://www.nptel.kmeacollege.ac.in/syllabus/125106002/ 2. http://www.nptel.ac.in/courses/125106002/

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
	Discussion on Outcome Based Education		
CONTENT DELIVERY (THEORY)			
1	Introduction to non destructive techniques testing methods	CO 1	T2:2.3
2	Introduction to non destructive techniques testing method	CO 1	R1:2.6
3	Visual examination	CO 1	T1:2.6
4	direct and indirect methods, equipment	CO 1	T2:2.7 R1:2.18
5	codes and standards	CO 1	T2:2.22
6	liquid penetrant testing, variable	CO 1	T2:2.25
7	interpretation and evaluation of test results	CO 2	T2:2.26 R1:2.55
8	applicable codes and standards	CO 2	T2:2.16 R1:2.61
9	magnetic particle testing, principle	CO 2	T2:2.30 R1:2.58
10	equipment	CO 3	T2:3.6 R1:4.29
11	advantages and limitations of NDT	CO 3	T2:3.14 R1:4.31
12	Principle of ultrasonic testing	CO 3	T2:3.14 R1:4.33
13	Principle of ultrasonic testing	CO 3	R1:4.36
14	Principle of ultrasonic testing, methods, equipment	CO 4	T2:3.18 R1:4.64
15	evaluation, interpretation, applications.	CO 4	T2:3.22
16	Principle of ultrasonic testing, methods, equipment, evaluation, interpretation, applications	CO 4	T2:3.28 R1:4.67
17	APrinciples, films	CO 4	T2:4.2
18	radiography equipment, variables	CO 4	T2:4.3 R1:4.71
19	radiographic image quality, techniques, safety.	CO 5	T1:4.8 R2:4.68
20-21	radiographic image quality, techniques, safety.	CO 4	T2:4.15 R1:5.74
22	Principles, films, radiography equipment, variables, radiographic image quality, techniques, safety	CO 4	T1:4.12 R2:5.75

23-24	Principle of phase array	CO 4	T1:4.8 R1:5.72
25	technique, equipment,	CO 4	T1:5.8 R1:5.73
26-27	verification of flow existence and position,	CO 4	T1:5.14 R1:6.78
28	reporting, application	CO 56	T2:5.19 R1:6.81
29-30	reporting, application	CO 5	T1:6.4 R2:6.8
31	special radiographic techniques	CO 5	T2:7.7 R1:7.74
32-33	special radiographic techniques	CO 5	T1:7.12 R2:8.75
34	special radiographic techniques	CO 5	T1:7.8 R1:8.72
35	interpretation of radiography, advantages and limitations	CO 6	T1:8.8 R1:8.73
36	Acoustic, emission inspection	CO 6	T1:9.14 R1:10.78
37-38	principles and applications, leak testing,	CO 6	T2:9.19 R1:10.814
39-40	ADVANCED NDE TECHNIQUES-II principles and applications	CO 6	T1:10.4 R2:11.68
41-43	industrial computed tomography principles and applications. .	CO 6	T2:10.7 R1:12.74
44-45	industrial computed tomography principles and applications	CO 6	T1:11.12 R2:12.75

Signature of Course Coordinator **HOD,ME**
Mr. A. Venu Prasad Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**DISASTER MANAGEMENT**				
Course Code	ACE551				
Program	B.Tech				
Semester	VI				
Course Type	Open Elective-I				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. S Selva Prakash, Assistant Professor				

I COURSE OVERVIEW:

The course of Structural Engineering comprises a set of fundamental theorems of mechanics that obey physical laws required to study and predict the behavior of structures for computation of deformations, internal forces and stresses. This course mainly discusses the energy, force and displacement methods for the analysis of arches, determinate and indeterminate beams and trusses. This course also includes the effects of rolling loads on bridge girders and truss girders. Through this course content engineers can analyze the response of various structural members under different loading conditions for design, safety and serviceability.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Disaster Management	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	x	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
70 %	Understand
20 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

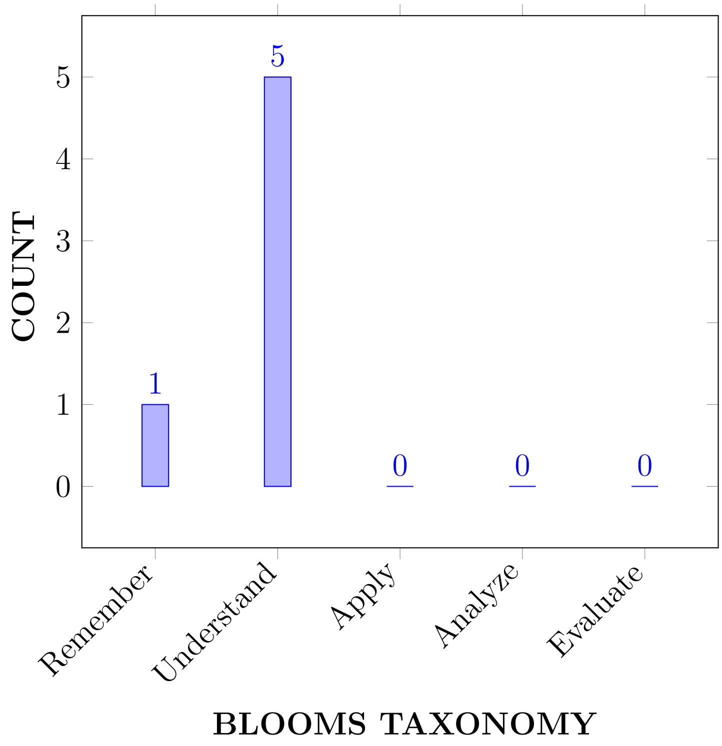
I	The concept of environmental hazards, disasters and various approaches dealing with the mitigation of disasters.
II	The knowledge on various types of environmental disasters and their impacts on human beings and nature.
III	The Different types of endogenous and exogenous hazards and their influence on human life and nature.
IV	The immediate response and damage assessment with information reporting and monitoring tools.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Classify** Environmental hazards for developing modern disaster management system.	Understand
CO 2	**Explain** various approaches for reducing the level of risk associated with Disasters.	Understand
CO 3	**Compare** natural and manmade disasters for finding out intensity of damage loss occurred by them.	Understand
CO 4	**List** various hazards and their effects for evaluating their impact on society and Environment.	Remember
CO 5	**Explain** human adjustments and perception towards hazards for mitigation of disasters.	Understand
CO 6	**Summarize** disaster phenomenon and its different contextual aspects for implementing the Disaster Risk Reduction Strategy.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	CIE/SEE/AAT
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	CIE/SEE/AAT
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	1	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
-	-	-	-

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	✓	-	-	-	-	-	-	-	-
CO 2	✓	-	-	-	-	✓	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	✓	✓	-	-	-	-	-	-	-	-
CO 4	-	-	-	-	-	✓	✓	-	-	-	-	-	-	-	-
CO 5	✓	-	-	-	-	✓	-	-	-	-	-	-	-	-	-
CO 6	✓	-	-	-	-	✓	-	-	-	-	-	-	-	-	-

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the knowledge of **science** and **Engineering fundamentals** to differentiate hazards and disasters and to develop a modern disaster management system	2
	PO 7	Understand the disaster management by considering **Environmental** impacts on the livelihood and their effect on **Socio economic** issues for sustainable development.	2
CO 2	PO 1	Apply the knowledge on various disaster mitigation approaches in **engineering disciplines** and use their application in geographical researches.	1
	PO 6	Apply the engineering knowledge in disaster management to **promote sustainable development** and build **Awareness on health**, safety, and risk issues associated with Disasters.	2
CO 3	PO 6	Identify **engineering activities including personnel, health, safety, and risk and effective disaster management strategies** for implementing, analyzing disaster impacts on human life and environment.	2

	PO 7	Understand intensity of disasters and their impact on **environment** and influence on **socio economic** parameter for assessment of intensity of risk.	2
CO 4	PO 6	Identify **engineering activities including personnel, health, safety, and risk** for analyzing hazard impacts on environment.	1
	PO 7	Identify the impact of various hazards in **socio economic and environmental** aspects for developing modern disaster management system.	2
CO 5	PO 1	Understand the **methodology and scientific principal towards** hazards for human adjustments and perception by sharing technological knowledge from **other engineering branches**.	2
	PO 6	Understanding of the need for a **high level of professional and ethical conduct in engineering** for human adjustments, perception with effective **management strategies** for disaster mitigation.	2
CO 6	PO 1	Understand the **knowledge of scientific principal and methodology** in disaster phenomenon for minimizing impact by implementing the Disaster Risk Reduction Strategy.	1
	PO 6	**Appropriate management strategies** are to be applied to reduce the level of risk in disaster mitigation.	1

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	2	-	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 2	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-
CO 4	-	-	-	-	-	1	2	-	-	-	-		-	-	-
CO 5	2	-	-	-	-	2	-	-	-	-	-	-	-	-	-
CO 6	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	66.6	-	-	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 2	33.3	-	-	-	-	40	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	40	66.6	-	-	-	-	-	-	-	-
CO 4	-	-	-	-	-	20	66.6	-	-	-	-		-	-	-
CO 5	33.3	-	-	-	-	40	-	-	-	-	-	-	-	-	-
CO 6	33.3	-	-	-	-	20	-	-	-	-	-	-	-	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - 0≤ C≤ 5% – No correlation
2 - 40 % <C < 60% –Moderate
1-5 <C≤ 40% – Low/ Slight
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	3	-	-	-	-		-	-	-
CO 2	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-
CO 4	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-
CO 5	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-
CO 6	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-
TOTAL	6	-	-	-	-	5	9	-	-	-	-	-	-	-	-
AVERAGE	2	-	-	-	-	1	3	-	-	-	-	-	-	-	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	-	-	-	-	

XVI ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVII SYLLABUS:

MODULE I	**ENVIRONMENTAL HAZARDS AND DISASTERS**
	Environmental hazards and disasters: meaning of environmental hazards, environmental disasters and environmental stress; concept of environmental hazards, environmental stress and environmental disasters, different approaches and relation with human ecology, landscape approach, ecosystem approach, perception approach, human ecology and its application in geographical researches.
MODULE II	**TYPES OF ENVIRONMENTAL HAZARDS AND DISASTERS**
	Types of environmental hazards and disasters: Natural hazards and disasters, man induced hazards and disasters, natural hazards, planetary hazards/ disasters, extra planetary hazards/ disasters, planetary hazards, endogenous hazards, exogenous hazards.
MODULE III	**ENDOGENOUS HAZARDS**
	Endogenous hazards, volcanic eruption, earthquakes, landslides, volcanic hazards/ disasters, causes and distribution of volcanoes, hazardous effects of volcanic eruptions, environmental impacts of volcanic eruptions. Earthquake hazards/ disasters, causes of earthquakes, distribution of earthquakes, hazardous effects of, earthquakes, earthquake hazards in India, human adjustment, perception and mitigation of earthquake.
MODULE IV	**EXOGENOUS HAZARDS**
	Exogenous hazards/ disasters, infrequent events, cumulative atmospheric hazards/ disasters; Infrequent events: Cyclones , lightning , hailstorms; Cyclones: Tropical cyclones and local storms, destruction by tropical cyclones and local storms (causes, distribution human adjustment, perception and mitigation); Cumulative atmospheric hazards/ disasters: Floods, droughts, cold waves, heat waves floods; Causes of floods, flood hazards India, flood control measures (human adjustment, perception and mitigation); Droughts: Impacts of droughts, drought hazards in India, drought control measures, extra planetary hazards/ disasters, man induced hazards /disasters, physical hazards/ disasters, soil erosion, Soil erosion: Mechanics and forms of soil erosion, factors and causes of soil erosion, conservation measures of soil erosion; Chemical hazards/ disasters: Release of toxic chemicals, nuclear explosion, sedimentation processes; Sedimentation processes: Global sedimentation problems regional sedimentation problems, sedimentation and environmental problems, corrective measures of erosion and sedimentation, biological hazards/ disasters, population explosion.

MODULE V	**EMERGING APPROACHES IN DISASTER MANAGEMENT**
	Emerging approaches in Disaster Management, Three Stages 1. Pre, disaster stage(preparedness) 2. Emergency Stage 3. Post Disaster stage, Rehabilitation.

TEXTBOOKS:

1. PardeepSahni, "Disaster Mitigation: Experiences and Reflections", PHI Learning Pvt. Ltd., 1 st Edition, 2001.
2. J.Glynn, GaryW.HeinKe, "Environmental Science and Engineering",Prentice Hall Publishers, 2 nd Edition, 1996.

REFERENCE BOOKS:

1. R.B.Singh (Ed), "Environmental Geography", 2nd Edition, 1990.
2. R.B. Singh (Ed), "Disaster Management", 2nd Edition, 2006.
3. Donald Hyndman "Natural Hazards and Disasters" - 5th edition, 2017.

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Introduction to outcome based education		
CONTENT DELIVERY (THEORY)			
1	Classify Environmental Hazards & Disasters	CO 1	T2:26.3 R2: 3.1
2	Understand the Meaning of Environmental Hazards	CO 1	T2:2.2.2
3	Understand Environmental Stress	CO 1	T2:2.2.2 R3:3.7
4	Understand Environmental stress.	CO 2	T2:2.2.2
5-6	Obtain knowledge on Concept of Environmental Hazards	CO 2	T1:8.1
7	Capacity to analyze Environmental stress & Environmental Disasters	CO 2	T1:7.1 R2: 1.2
8	Capacity to analyze Ecology concept	CO 2	T2:3.2.3 R2: 1.3
9	Understand Different Approaches	CO 3	T2:4.2.3
10	Understand Landscape Approach -.	CO 3	T2:4.5.2
11	Explain Ecosystem approach -Perception approach.	CO 3	T2:4.7.9
12-13	Understand Human ecology & its application in geographical researches	CO 4	T2:5.2.1 R2: 6.4

14	Understand Types of Environmental hazards & Disasters	CO 4	T2:5.4
15-16	Capacity to analyze and evaluate Natural hazards and Disasters	CO 5	T2:5.5.3
17-18	Understand Man induced hazards & Disasters	CO 5	T2:6.2.2
19-20	Obtain knowledge on Natural Hazards- Planetary Hazards/ Disasters	CO 5	R1:2.5 R2: 8.2
21-22	Analyze the Planetary Hazards-Endogenous Hazards - Exogenous Hazards	CO 5	R2:2.2.5 R2: 9.2
23-24	Understand Volcanic Eruption – Earthquakes – Landslides	CO 5	R3:5.4.8 R2: 9.6
25-26	Volcanic Hazards/Disasters- Causes and distribution of Volcanoes	CO 5	T2:8.1.2
27-28	Analyze the Hazardous effects of volcanic eruptions	CO 6	T2:8.3.5 R2: 5.3
29-30	Understand Environmental impacts of volcanic eruptions - Earthquake Hazards/ disasters - Causes of Earthquakes	CO 6	T2:8.5
31	Distribution of earthquakes - Hazardous effects of - earthquakes - Earthquake Hazards in India	CO 6	T2:8.9.2
32-33	Analyze the Exogenous hazards/ disasters - Infrequent events- Cumulative atmospheric hazards/ disasters	CO 6	T2:9.2 R3: 4.6
34-35	Understand the Infrequent events: Cyclones, Lightning, Hailstorms, Cyclones: Earthquake Hazards in India	CO 6	T2:9.5.3
36-37	Analyze the Tropical cyclones and Local storms	CO 6	T2:9.6.2 R3: 8.5
38	Understand the Destruction by tropical cyclones and local storms (causes, distribution human adjustment, perception and mitigation)	CO 6	T2:9.7.5 R3: 8.12
39-40	Analyze the Cumulative atmospheric hazards/ disasters : Floods, Droughts, Cold waves, Heat waves Floods	CO 6	T2:9.5.4
41-42	Identification of Flood control measures (Human adjustment, perception and mitigation),	CO 6	T2:9.5.4
43-44	Explain the Droughts: Impacts of droughts, Drought hazards in India	CO 6	T2:9.5.5
45	Understand Extra Planetary Hazards/ Disasters- Man induced Hazards /Disasters	CO 6	T2:9.5.6

Signature of Course Coordinator **HOD, ME**
Mr. S Selva Prakash, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**THEORY OF MACHINES LABORATORY**					
Course Code	AME111					
Program	B.Tech					
Semester	V	ME				
Course Type	CORE					
Regulation	IARE - R16					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	-	-	-	3	2	
Course Coordinator	Ms.V.Lakshmi prasanna, Assistant Professor					

I COURSE OVERVIEW:

Theory of machines is defined as that branch of engineering science, which deals with the study of relative motion between various parts of a machine and forces which acts on them. The knowledge is very essential for engineer in designing Various parts of a machine.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEB11	IV	Materials and Mechanics of Solids	1.5

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
THEORY OF MACHINES LABORATORY	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Probing Further Experiments (last)	✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day-to-day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the principal from the panel of experts recommended by Chairman, BOS.

The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

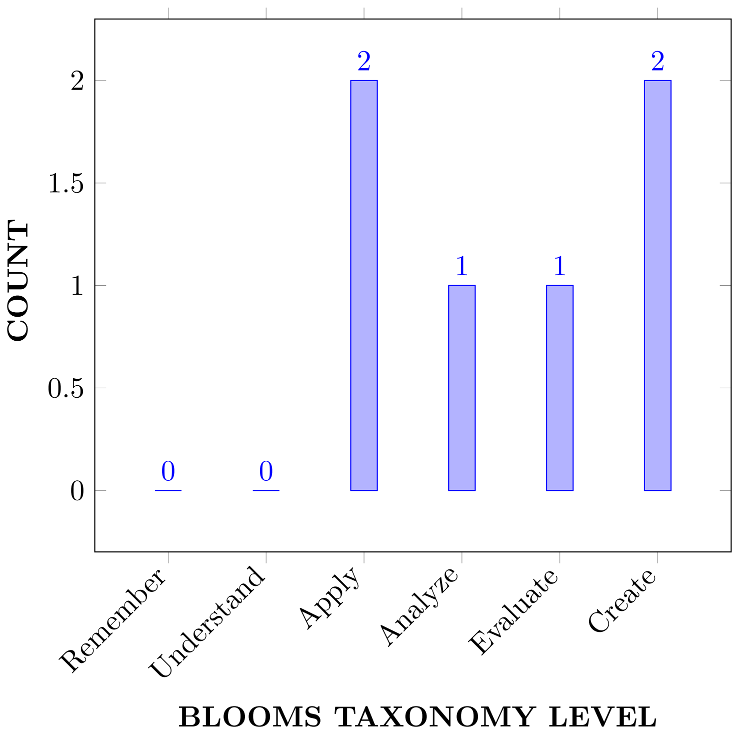
I	The Importance of theory of machines and mechanism involved in the day-to-day life, and study of basic mechanisms and inversion mechanisms to form a machine.
II	The information related design and analysis of mechanisms for a specific type of motion in a machine.
III	The developmental use of rigid bodies motions and forces for transmission system, machine kinematics.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO1	**Identify** the gyroscopic effect for the real time applications of ships, aero planes .	Apply
CO2	**Examine** the life expectancy for ball bearing and their real time application.	Analyze
CO3	**Select** the appropriate journal bearing for balancing of machine components such as shafts.	Apply
CO4	**Build** out the inversion mechanism for 4-bar mechanism to form different mechanical compoenents.	Evaluate
CO5	**Design** the shafts material for calculate the critical speed of shafts	Create
CO6	**Choose** the balancing techniques for effective balancing of machines and structures.	Create

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises/CIA/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Lab Exercises/CIA/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises/CIA/SEE
PO 9	**Individual and team work:**Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and engineering fundamentals.	2

	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to making of governors	3
CO 2	PO 1	Identify (knowledge) in suitable methods involved during welding for error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals**	2
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to welding in identification of process adoption for the specially develop component.	3
CO 3	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2
	PO 5	Create, select, and apply metal forming techniques, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	2
CO 4	PO 1	Recall (knowledge) the basic molding processes uses plastics and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 5	PO 1	Identify (knowledge) in suitable methods involved in design, casting to achieve error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals**	2
	PO 5	Design the ball bearing and estimation of life, and **modern engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	2
	PO 9	Design and develop the journal bearing effectively as an individual, and as a member in **diverse teams, and in multidisciplinary** settings for different lubricant effectively in building of product.	2
CO 6	PO 1	Recall (knowledge) the basic concepts of manufacturing processes and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals** for better solution.	2

	PO 5	Create, select, and apply appropriate mechanisms parameters, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations for effective optimization of prototype / products.	2
	PSO 3	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES				Program Specific Outcomes
	PO 1	PO 2	PO 5	PO 9	PSO 3
CO 1	2	3			
CO 2	2	3			
CO 3	2		2		
CO 4	2				2
CO 5	2		2	2	
CO 6	2		2		2

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 2	SEE Exams	PO 1, PO 2, PO 5, PO 9 PSO 3	Seminars	-
Laboratory Practices	PO 1, PO 2, PO 5, PO 9	Student Viva	PO 1,PO 2, PO 5,PO 9	Certification	-
Assignments	PO 5, PO 9, PO 3	Mini projects	-		

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK 1	**GOVERNOR**
	To study the function of a Governor
WEEK 2	**GYROSCOPE**
	To determine the Gyroscope couple.
WEEK 3	**STATIC FORCE ANALYSIS**
	To draw free body diagram and determine forces under static condition.
WEEK 4	**DYNAMIC FORCE ANALYSIS**
	To draw free body diagram and determine forces under dynamic condition.
WEEK 5	**BALANCING**
	To determine balancing forces and reciprocating masses.
WEEK 6	**JOURNAL BEARING**
	To determine the bearing life.
WEEK 7	**UNIVERSAL VIBRATION**
	To determine the longitudinal and transfer vibration.
WEEK 8	**WHIRLING OF SHAFT**
	To determine critical speed of a shaft.
WEEK 9	**MECHANISMS**
	To design various mechanism and their inversions.
WEEK 10	**DIFFERENTIAL GEAR BOX**
	To study automobile differential gear box.
WEEK 11	**Indexing**
	To study various intermittent mechanism.
WEEK 12	**BEYOND SYLLABUS**
	To study various intermittent mechanism
WEEK 13	**EXAMINATIONS**

TEXTBOOKS

1. Thomas Bevan, "Theory of Machines", Pearson Education, 3rd Edition, 2009.
2. . S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 4th Edition, 2014.

REFERENCE BOOKS:

1. J. S. Rao, R.V. Dukkipati, "Mechanism and Machine Theory", New Age Publication, 1st Edition, 2013.
2. Uiker, Penock, Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition, 2013.
3. R.S. Khurmi, Guptha, "Theory of Machines", S.Chand & Co, New Delhi, 14th Edition, 2013.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Governor	CO1, CO 5	T1:2.1.5 T2:2.3
2	Gyroscope	CO1, CO 5	T2:2.1.5 R1:2.6
3	Static Force Analysis	CO 1, CO 4, CO 5, CO 6	T1:2.6 R3:3.6.5
4	Dynamic Force Analysis	CO 2, CO 6	T2:2.7 R2:2.18
5	Balancing	CO 2, CO 6	T2:2.22 R3:3.1.1
6	Journal Bearing	CO 2, CO 6	T1:2.5.1 T2:2.25
7	Universal Vibration	CO 3, CO 6	T2:2.26 R3:2.55
8	Whirling of Shaft	CO 3, CO 6	T2:2.3 R3:2.6
9	Mechanisms	CO 3, CO 6	T2:2.3 R1:2.6
10	Differential Gear Box	CO 4, CO 6	T1:2.6
11	Indexing	CO 4, CO 6	T2:2.7 R1:2.18

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design of flywheel for I.C engine and punch press.
2	Design of journal bearing using different lubrication oils and different speeds.
3	Design of ball bearing for different loads and estimation of life.
4	Design of differential gear box for automobile I.C Engine.
5	Design of inversion four bar mechanism.

Prepared by:
Ms.V.Lakshmi Prasanna,, Assistant professor

HOD,ME

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**HEAT TRANSFER LABORATORY**					
Course Code	AME112					
Program	B. Tech					
Semester	SIX					
Course Type	Core					
Regulation	IARE-R16					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	-	-	-	3	2	
Course Coordinator	Dr.K.China Apparao, Assistant Professor					

I COURSE OVERVIEW:

Heat transfer laboratory is intended to enhance the learning experience of the student about the flow of thermal energy due to temperature difference and the subsequent temperature distribution changes. This laboratory focuses on heat transfer modes, boundary conditions, one dimensional steady and unsteady state condition and heat exchangers applied to modern electric and electronic plants require efficient dissipation of thermal losses. Students are expected to gain experience in hands on training as well as knowledge to model heat exchangers, heat treatment of fins and complex mechanical systems.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEB13	IV	Fluid Machinery and IC Engines lab	2

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Heat Transfer Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing Further Experiments

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day-to-day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the principal from the panel of experts recommended by Chairman, BOS.

The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component	**Laboratory**		Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

A. Experiment Based

Objective	**Analysis**	**Design**	**Conclusion**	**Viva**	**Total**
2	2	2	2	2	10

B. Programming Based

Purpose	**Algorithm**	**Program**	**Conclusion**	**Viva**	**Total**
2	2	2	2	2	10

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Experiments/CIE/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Experiments/CIE/SEE
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	Lab Experiments/CIE/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Experiments/CIE/SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency Assessed by
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

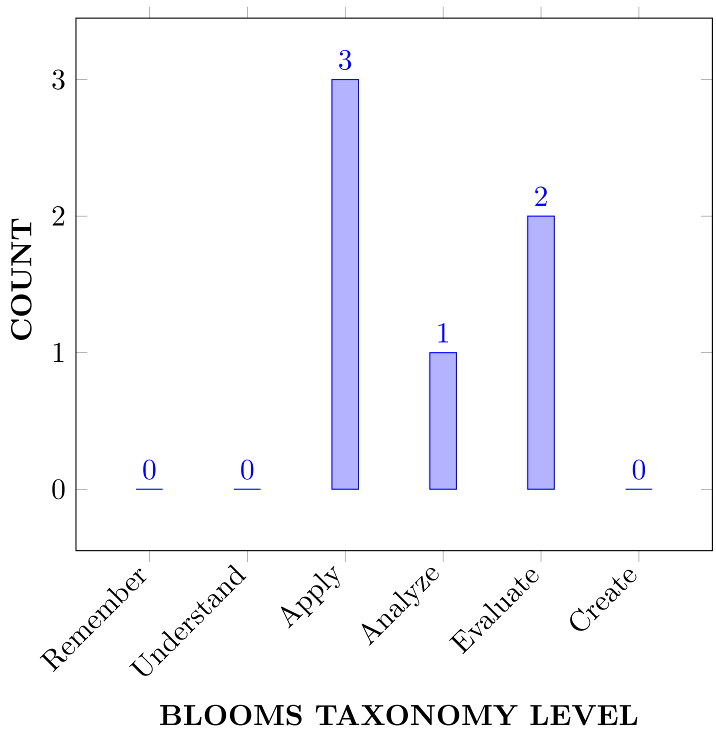
I	The information for validating heat transfer parameters during internal and external flows based on non-dimensional numbers and convective mode heat transfer.
II	Enhance the performance and analysis of heat exchangers for real-time applications using logarithmic mean temperature difference and number of transfer unit methods.
III	Compare experimental results with theoretical to improve the design for improving the efficiency of heat transfer rate.

IX COURSE OUTCOMES:

After successful completion of the course, students should be able to:

Course Outcomes		Knowledge Level (Bloom's Taxonomy)
CO 1	**Identify** the steps involved with different surfaces and geometries for which the temperature distribution and heat flow rates are calculated for automotive industry components like radiators, engine blocks.	Apply
CO 2	**Examine** the principles associated with convective heat transfer to formulate and calculate the dynamics of temperature field in fluid flow for real time applications.	Analyze
CO 3	**Select** the appropriate convection equations for solving heat transfer rate in cylinders and spheres.	Apply
CO 4	**Build** the phenomena of boiling and condensation to give various correlations applied to heat exchangers, boilers, heat engines, etc.	Evaluate
CO 5	**Select** the appropriate expression for overall heat transfer coefficient for modelling heat exchanger to achieve defect/error free components.	Evaluate
CO 6	**Identify** the appropriate parameters for enhancing heat transfer rates in heat exchangers.	Apply

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing of a product and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	2
	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to pin fin for heat transfer enhancement.	2
CO 2	PO 1	Identify (knowledge) in suitable methods involved during heat exchangers using in solving (complex) engineering problems by applying the principles of mathematics and engineering fundamentals	2
	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to convection in identification of process adoption to special develop of a component.	2
CO 3	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing of a product and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	2
	PO 5	Create, select, and apply convection, radiation resources, and modern engineering tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2
CO 4	PO 1	Recall (knowledge) the basic mechanisms and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	2
	PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 5	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing of a product and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	2
	PO 5	Create, select, and apply convection, radiation resources, and modern engineering tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2

	PO 9	Design and develop the heat exchangers effectively as an individual, and as a member in diverse teams, and in multidisciplinary settings for designing of modern heat exchagers.	2
CO 6	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing of a product and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and engineering fundamentals.	2
	PO 5	Create, select, and apply convection, radiation resources, and modern engineering tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2
	PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES				Program Specific Outcomes
	PO 1	PO 2	PO 5	PO 9	PSO 3
CO 1	2	2			
CO 2	2	2			
CO 3	2		2		
CO 4	2				2
CO 5	2		2	2	
CO 6	2		2		2

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	✓	Mini projects	-		

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK 1	**Composite slab apparatus-Overall heat transfer coefficient**
	Calculating the overall heat transfer coefficient for a composite slab.
WEEK 2	**Heat transfer through lagged pipe**
	Determination of thermal conductivity.
WEEK 3	**Heat transfer through concentric sphere**
	Determination of thermal conductivity.
WEEK 4	**Thermal conductivity of given metal rod**
	Determination of thermal conductivity.
WEEK 5	**Heat transfer in Pin fin apparatus**
	Calculate the effectiveness and efficiency of pin fin.
WEEK 6	**Experiment on transient heat conduction**
	Determination of thermal conductivity in transient mode.
WEEK 7	**Heat transfer in forced convection apparatus**
	Calculating convective heat transfer coefficient.
WEEK 8	**Heat transfer in natural convection apparatus**
	Calculating convective heat transfer coefficient.
WEEK 9	**Parallel and counter flow heat exchangers**
	Calculate the effectiveness of heat exchangers both experimental and theoretical method.
WEEK 10	**Emissivity apparatus**
	Determination of emissivity of grey and black body.
WEEK 11	**Stefan Botlzman apparatus**
	Determination of Stefan Botlzman constant and compare its value.
WEEK 12	**Critical heat flux apparatus**
	Evaluate the critical heat flux value by studying different zones of boiling.
WEEK 13	**Study of heat pipe**
	Demonstration of heat pipe.
WEEK 14	**Film and drop wise condensation apparatus**
	Understanding different methods of condensation.

TEXTBOOKS

1. Yunus A. Cengel,Heat Transfer a Practical Approach, Tata McGraw hill education (P) Ltd, New Delhi, 4th Edition, 2012.
2. R. C. Sachdeva, Fundamentals of Engineering, Heat and Mass Transfer, New Age, New Delhi, India, 3rd Edition, 2012.

REFERENCE BOOKS:

1. Holman, Heat Transfer, Tata McGraw-Hill Education, 10th Edition, 2011.
2. P. S. Ghoshdastidar, Heat Transfer, Oxford University Press, 2nd Edition, 2012.
3. D. S. Kumar, Heat and Mass Transfer, S.K. Kataria & sons, 9th Edition 2015.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Composite slab apparatus-Overall heat transfer coefficient	CO1, CO 2	T2:2.3
2	Heat transfer through lagged pipe	CO1, CO 2	R1:2.6
3	Heat transfer through concentric sphere	CO 1, CO 2, CO 3, CO 4	T1:2.6
4	Thermal conductivity of given metal rod	CO 2, CO 3, CO 4	T2:2.7 R1:2.18
5	Heat transfer in Pin fin apparatus	CO 3, CO 4	T2:2.22
6	Experiment on transient heat conduction	CO 3, CO 5	T2:2.25
7	Heat transfer in forced convection apparatus	CO 4, CO 3	T2:2.26 R1:2.55
8	Heat transfer in natural convection apparatus	CO 3, CO 4	T2:2.3
9	Parallel and counter flow heat exchangers	CO 4 R1:2.6	
10	Emissivity apparatus	CO 5	T1:2.6
11	Stefan Botlzman apparatus	CO 5	T2:2.7 R1:2.18
12	Critical heat flux apparatus	CO 5, CO 6	T2:2.22

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design and development of Heat Exchangers for effective dissipation of heat from radiators.
2	Design of fin for constant base temperature under natural and force flow conditions
3	Design and development of emissivity measurement apparatus for the non – black surface and compare with the black body.
4	Design the convective and radiation heat transfer coefficient at each zone and compare them to decide the critical thickness of insulation
5	Design and development of forced convection apparatus for effective heat transfer through extended surfaces.

Prepared by: **HOD,ME**
Dr.K.China Apparao, Associate Professor

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MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**Fluid Thermal, Modelling and Simulation Laboratory**				
Course Code	AME113				
Program	B.Tech				
Semester	VI	ME			
Course Type	Practical				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Ms.N. Santhisree, Assistant Professor				

I COURSE OVERVIEW:

The ANSYS software has different modulus (Ansys, CFX, Fluent etc...). The Workbench environment is an intuitive up-front finite element analysis tool that is used in conjunction with CAD systems and/or Design Modeler. ANSYS Workbench is a software environment for performing structural, thermal, and fluid flow analyses. The laboratory sessions are focuses on geometry creation, meshing and how to apply the boundary conditions, attaching existing geometry, setting up the model, solving, and reviewing results. The lab sessions will describe how to create geometry, how to use the basic finite element simulation concepts, as well as Computational Fluid Dynamics concepts and how to do interpretation of results.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME108	IV	Mechanics of Fluid and Hydraulic Machine Laboratory
B.Tech	AME104	III	Metallurgy and Mechanics of Solids Laboratory Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Fluid Thermal, Modelling and Simulation Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

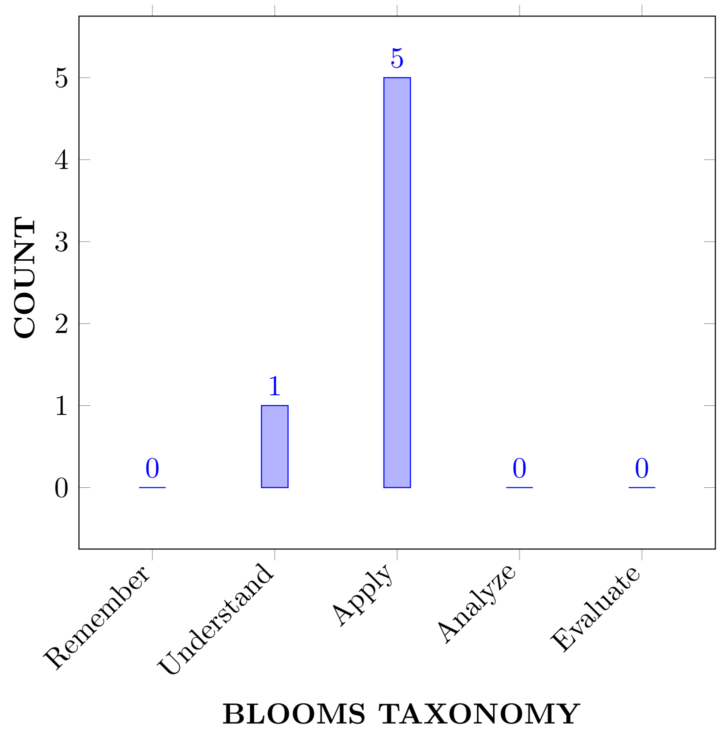
I	Analyze the Internal and External fluid flow problems.
II	Apply FEM techniques to fluid flow problems.
III	Evaluate the thermal stresses in real time problems.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Demonstrate** the application of finite element method for analyzing 2D fluid flow problems. .	Understand
CO 2	**Make use of** AnsysCFX or Solid Works Flow Simulation for analyzing simple fluid flow problems.	Apply
CO 3	**Develop** the Matlab code for analyzing 2D fluid flow problems.	Apply
CO 4	**Make use of** Ansys or Solid Works Flow Simulation for analyzing simple heat transfer problems.	Apply
CO 5	**Make use of** AnsysFluent for analyzing conjugate heat transfer.	Apply
CO 6	**Make use of** Ansys for analyzing thermal stress in piston.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcome		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lab Exercises/ CIE/ SEE

PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Lab Exercises/ CIE/ SEE
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	Lab Exercises/ CIE/ SEE
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Exercises/ CIE/ SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises/ CIE/ SEE
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	Lab Exercises/ CIE/ SEE
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	Lab Exercises/Projects
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises/ CIE/ SEE
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Lab Exercises/ CIE/ SEE
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2	Lab Exercises/Projects
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Lab Exercises/Projects

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Specific Program Outcome		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	3	Lab Exercises/ CIE/ SEE
PSO 3	Make use of Computational and Experimental tools for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	2	Lab Exercises/ CIE/ SEE

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply the **principles of Mathematics(differentiation an integration) and Engineering(FEM)** in solving fluid flow problems.	2
	PO 2	**Identify the problem** from the given **problem statement**, **formulate solution for the problem** by **collecting the appropriate data**, **implement the solution** and prepare **documentation** by the **interpretation of results**	7
	PO 3	**Understand the customer needs** of solving the complex flow problems, **use creativity to establish innovative solutions** in applying the FEM technique and **evaluate the outcomes** of such **investigations for the sustainable development** with the thorough **understanding of the requirements**.	5
	PO 4	Acquire the **Knowledge of characteristics of flow** through the review of **technical literature** and **understand which engineering knowledge can be applied** in different flow scenarios then **analyze engineering process** involving the flow with the **use of analytical FEM technique**.	5
	PO 5	**Use the modern technique** called FEM for the analysis of the flow problems.	1
	PO 6	**Understand the requirements** of flow characteristics **for sustainable development of engineering processes** with **high level of professional and ethical conduct**	3
	PO 8	Demonstrate **High degree of trust and integrity** in performing the analysis and **professional ethics** in documenting the results.	2
	PO 9	Perform the analysis **individually**, **help each other in teams** and demonstrate **ability to work with a team** as well as **ability to get along with other** in the class to be an effective **team member during the project**.	5

	PO 10	Communicate the results with **clarity** in writing with proper **grammar** and express the subject in**oral** during the viva sessions.	3
	PO 11	**Communicate** to the team the **plan of usage if human resource** in order to get **quality** results by following the planned **schedule** for the decided **breakdown Structure** of the work.	5
	PO 12	**Stay up with industry trends** with the **continued personal development** by **learning the FEM modelling and result analysis techniques** and even **begin work on advance degree** with these abilities.	4
	PSO 2	**Formulate and Evaluate the fluid flow problems** using the FEM technique.	2
CO 2	PO 1	Apply the **principles of Mathematics and Engineering** in solving fluid flow problems.	2
	PO 2	**Identify the problem** from the given **problem statement**, **formulate solution for the problem** by **collecting the appropriate data**, **implement the solution** and prepare **documentation** by the **interpretation of results**	7
	PO 3	**Understand the customer needs** of solving the complex flow problems, **use creativity to establish innovative solutions** in applying the FEM technique and **evaluate the outcomes** of such **investigations for the sustainable development** with the thorough **understanding of the requirements**.	5
	PO 4	Acquire the **Knowledge of characteristics of flow** through the review of **technical literature** and **understand which engineering knowledge can be applied** in different flow scenarios then **analyze engineering process** involving the flow with the **use of Ansys-CFX software**.	5
	PO 5	**Use the modern technique** called FEM for the analysis of the flow problems.	1
	PO 6	**Understand the requirements** of flow characteristics **for sustainable development of engineering processes** with **high level of professional and ethical conduct**	3
	PO 8	Demonstrate **High degree of trust and integrity** in performing the analysis and **professional ethics** in documenting the results.	2
	PO 9	Perform the analysis **individually**, **help each other in teams** and demonstrate **ability to work with a team** as well as **ability to get along with other** in the class to be an effective **team member during the project**.	5
	PO 10	Communicate the results with **clarity** in writing with proper **grammar** and express the subject in**oral** during the viva sessions.	3
	PO 11	**Communicate** to the team the **plan of usage if human resource** in order to get **quality** results by following the planned **schedule** for the decided **breakdown Structure** of the work.	5

	PO 12	**Stay up with industry trends** with the **continued personal development** by **learning the Ansys-CFX software and result analysis techniques** and even **begin work on advance degree** with these abilities.	4
	PSO 2	**Formulate and Evaluate the fluid flow problems** using the Ansys-CFX software.	2
	PSO 3	**Make use of Computational tool** Ansys-CFX for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1
CO 3	PO 1	Apply the **principles of Mathematics(differentiation an integration) and Engineering(FEM)** in solving fluid flow problems.	2
	PO 2	**Identify the problem** from the given **problem statement**, **formulate solution for the problem** by **collecting the appropriate data**, **implement the solution** and prepare **documentation** by the **interpretation of results**	7
	PO 3	**Understand the customer needs** of solving the complex flow problems, **use creativity to establish innovative solutions** in applying the FEM technique and **evaluate the outcomes** of such **investigations for the sustainable development** with the thorough **understanding of the requirements**.	5
	PO 4	Acquire the **Knowledge of characteristics of flow** through the review of **technical literature** and **understand which engineering knowledge can be applied** in different flow scenarios then **analyze engineering process** involving the flow with the **use of Matlab sofware**.	5
	PO 5	**Use the modern technique** called FEM for the analysis of the flow problems.	1
	PO 6	**Understand the requirements** of flow characteristics **for sustainable development of engineering processes** with **high level of professional and ethical conduct**	3
	PO 8	Demonstrate **High degree of trust and integrity** in performing the analysis and **professional ethics** in documenting the results.	2
	PO 9	Perform the analysis **individually**, **help each other in teams** and demonstrate **ability to work with a team** as well as **ability to get along with other** in the class to be an effective **team member during the project**.	5
	PO 10	Communicate the results with **clarity** in writing with proper **grammar** and express the subject in**oral** during the viva sessions.	3
	PO 11	**Communicate** to the team the **plan of usage if human resource** in order to get **quality** results by following the planned **schedule** for the decided **breakdown Structure** of the work.	5

	PO 12	**Stay up with industry trends** with the **continued personal development** by **learning the Matlab coding and result analysis techniques** and even **begin work on advance degree** with these abilities.	4
	PSO 2	**Formulate and Evaluate the fluid flow problems** using the Matlab coding.	2
	PSO 3	**Make use of Computational tool** Matlab for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1
CO 4	PO 1	Apply the **principles of Mathematics and Engineering** in solving Heat flow problems.	2
	PO 2	**Identify the problem** from the given **problem statement**, **formulate solution for the problem** by **collecting the appropriate data**, **implement the solution** and prepare **documentation** by the **interpretation of results**	7
	PO 3	**Understand the customer needs** of solving the complex heat flow problems, **use creativity to establish innovative solutions** using Ansys software and **evaluate the outcomes** of such **investigations for the sustainable development** with the thorough **understanding of the requirements**.	5
	PO 4	Acquire the **Knowledge of characteristics of Heat flow** through the review of **technical literature** and **understand which engineering knowledge can be applied** in different flow scenarios then **analyze engineering process** involving the heat transfer with the **use of Ansys software**.	5
	PO 5	**Use the modern tool** called Ansys software for the analysis of the heat flow problems.	1
	PO 6	**Understand the requirements** of flow characteristics **for sustainable development of engineering processes** with **high level of professional and ethical conduct**	3
	PO 8	Demonstrate **High degree of trust and integrity** in performing the analysis and **professional ethics** in documenting the results.	2
	PO 9	Perform the analysis **individually**, **help each other in teams** and demonstrate **ability to work with a team** as well as **ability to get along with other** in the class to be an effective **team member during the project**.	5
	PO 10	Communicate the results with **clarity** in writing with proper **grammar** and express the subject in**oral** during the viva sessions.	3
	PO 11	**Communicate** to the team the **plan of usage if human resource** in order to get **quality** results by following the planned **schedule** for the decided **breakdown Structure** of the work.	5

	PO 12	**Stay up with industry trends** with the **continued personal development** by **learning the Ansys software and result analysis techniques** and even **begin work on advance degree** with these abilities.	4
	PSO 2	**Formulate and Evaluate the heat transfer problems** using the Ansys software.	2
	PSO 3	**Make use of Computational tool** Ansys for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1
CO 5	PO 1	Apply the **principles of Mathematics and Engineering** in solving conjugate Heat flow problems.	2
	PO 2	**Identify the problem** from the given **problem statement**, **formulate solution for the problem** by **collecting the appropriate data**, **implement the solution** and prepare **documentation** by the **interpretation of results**	7
	PO 3	**Understand the customer needs** of solving the complex heat flow problems, **use creativity to establish innovative solutions** using Ansys-Fluent software and **evaluate the outcomes** of such **investigations for the sustainable development** with the thorough **understanding of the requirements**.	5
	PO 4	Acquire the **Knowledge of characteristics of Heat flow** through the review of **technical literature** and **understand which engineering knowledge can be applied** in different flow scenarios then **analyze engineering process** involving the conjugate heat transfer with the **use of Ansys-Fluent software**.	5
	PO 5	**Use the modern tool** called Ansys-Fluent software for the analysis of the conjugate heat flow problems.	1
	PO 6	**Understand the requirements** of flow characteristics **for sustainable development of engineering processes** with **high level of professional and ethical conduct**	3
	PO 8	Demonstrate **High degree of trust and integrity** in performing the analysis and **professional ethics** in documenting the results.	2
	PO 9	Perform the analysis **individually**, **help each other in teams** and demonstrate **ability to work with a team** as well as **ability to get along with other** in the class to be an effective **team member during the project**.	5
	PO 10	Communicate the results with **clarity** in writing with proper **grammar** and express the subject in**oral** during the viva sessions.	3
	PO 11	**Communicate** to the team the **plan of usage if human resource** in order to get **quality** results by following the planned **schedule** for the decided **breakdown Structure** of the work.	5

	PO 12	**Stay up with industry trends** with the **continued personal development** by **learning the Ansys-Fluent software and result analysis techniques** and even **begin work on advance degree** with these abilities.	4
	PSO 2	**Formulate and Evaluate the heat transfer problems** using the Ansys-Fluent software.	2
	PSO 3	**Make use of Computational tool** Ansys-Fluent for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1
CO 6	PO 1	Apply the **principles of Mathematics and Engineering** in solving thermal stress problems.	2
	PO 2	**Identify the problem** from the given **problem statement**, **formulate solution for the problem** by **collecting the appropriate data**, **implement the solution** and prepare **documentation** by the **interpretation of results**	7
	PO 3	**Understand the customer needs** of solving the complex heat flow problems, **use creativity to establish innovative solutions** using Ansys software and **evaluate the outcomes** of such **investigations for the sustainable development** with the thorough **understanding of the requirements**.	5
	PO 4	Acquire the **Knowledge of characteristics of thermal stresses** through the review of **technical literature** and **understand which engineering knowledge can be applied** in different flow scenarios then **analyze engineering process** involving the thermal stress with the **use of Ansys software**.	5
	PO 5	**Use the modern tool** called Ansys software for the analysis of the thermal stress analysis problems.	1
	PO 6	**Understand the requirements** of flow characteristics **for sustainable development of engineering processes** with **high level of professional and ethical conduct**	3
	PO 8	Demonstrate **High degree of trust and integrity** in performing the analysis and **professional ethics** in documenting the results.	2
	PO 9	Perform the analysis **individually**, **help each other in teams** and demonstrate **ability to work with a team** as well as **ability to get along with other** in the class to be an effective **team member during the project**.	5
	PO 10	Communicate the results with **clarity** in writing with proper **grammar** and express the subject in**oral** during the viva sessions.	3
	PO 11	**Communicate** to the team the **plan of usage if human resource** in order to get **quality** results by following the planned **schedule** for the decided **breakdown Structure** of the work.	5

	PO 12	**Stay up with industry trends** with the **continued personal development** by **learning the Ansys software and result analysis techniques** and even **begin work on advance degree** with these abilities.	4
	PSO 2	**Formulate and Evaluate the thermal stress analysis problems** using the Ansys software.	2
	PSO 3	**Make use of Computational tool** Ansys for Building Career Paths towards Innovation Startups, Employability and Higher Studies.	1

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COs	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	3	2	-	3	2	2	2	2	-	3	-
CO2	3	3	2	2	3	2	-	3	2	2	2	2	-	3	2
CO3	3	3	2	2	3	2	-	3	2	2	2	2	-	3	2
CO4	3	3	2	2	3	2	-	3	2	2	2	2	-	3	2
CO5	3	3	2	2	3	2	-	3	2	2	2	2	-	3	2
CO6	3	3	2	2	3	2	-	3	2	2	2	2	-	3	2

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**INTERNAL PIPE FLUID FLOW – FEM**
	Internal Pipe flow problem Using theoretical FEM.
WEEK II	**INTERNAL PIPE FLUID FLOW - ANSYS**
	Analyzing Flow in a System of Pipes using ANSYS.
WEEK III	**INTERNAL PIPE FLUID FLOW – MATLAB**
	Internal Pipe flow problem using MAT LAB.

WEEK IV	**EXTERNAL FLUID FLOW**
	to analyze fluid flowing over the surface of the plate using ANSYS CFX Simulation.
WEEK V	**FLOW THROUGH BALL VALVE**
	Flow of water through a ball valve assembly using ANSYS/ Solid Works Flow Simulation.
WEEK VI	**HEAT CONDUCTION**
	Heat Conduction within a Solid using ANSYS.
WEEK VII	**TEMPERATURE DISTRIBUTION**
	Temperature distribution in a fin cooled electronic component using ANSYS.
WEEK VIII	**3D HEAT CONDUCTION**
	3D Heat Conduction within a Solid-Cell Phone using ANSYS.
WEEK IX	**COUNTER FLOW HEAT EXCHANGER**
	Calculation of the efficiency of the counter flow heat exchanger using ANSYS/SolidWorks Flow Simulation. .
WEEK X	**CONJUGATE HEAT TRANSFER**
	Conjugate heat transfer problem using ANSYS/ Solid Works Flow Simulation.
WEEK XI	**3D THERMAL ANALYSIS**
	3D Thermal Analysis, Finned Pipe using ANSYS.
WEEK XII	**THERMAL STRESS ANALYSIS**
	Thermal stress analysis of piston.

TEXTBOOKS

1. Janna,W.S., “Design of Fluid Thermal Systems”, Cengage Learning” 3rd Edition, 2011.
2. Jaluria,Y.,” Design and Optimization of Thermal Systems”, McGraw-Hill, 2nd Edition, 2007.

REFERENCE BOOKS:

1. Suryanarayana, N.V. and Arici “Design and Simulation of Thermal Systems”, McGraw-Hill, 1st Edition, 2003.
2. McDonald, A.G., Magande, H.L ,“Thermo-Fluids Systems Design”, John Wiley, 1st Edition, 2012.
3. Robert Cook, “Concepts and Applications of Finite Element Analysis”, Wiley, 1st Edition, 2013.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
1	Internal Pipe flow problem Using theoretical FEM.	CO 1	T1: 1.4

2	Analyzing Flow in a System of Pipes using ANSYS .	CO 2	T2: 1.5
3	Internal Pipe flow problem using MAT LAB.	CO 3	T1: 2.5
4	External flow over Plate analysis using ANSYS.	CO 2	R1: 2.6
5	Flow of water through a ball valve assembly using ANSYS/ Solid-Works Flow Simulation.	CO 2	T2: 2.7
6	Heat Conduction within a Solid using ANSYS.	CO 4	R1: 5.3
7	Temperature distribution in a fin cooled electronic Component using ANSYS.	CO 4	T1: 7.5
8	3D Heat Conduction within a Solid-Cell Phone using ANSYS.	CO 4	R1: 6.8
9	Calculation of the efficiency of the counter flow heat exchanger using ANSYS/Solid-Works Flow Simulation.	CO 5	T1: 12.2
10	Conjugate heat transfer problem using ANSYS/Solid Works Flow Simulation .	CO 5	R1:13.2
11	3d thermal analysis.	CO 5	R2:13.7
12	Thermal stress analysis.	CO 6	R3:10.2

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design and analyse a heat exchanger for the given cold and hot fluid conditions.
2	Design and analyse the centrifugal pump for the given head and discharge.
3	Analyse different shapes of fins for finding the optimum fin shape for maximum heat transfer.
4	Analyse different aerofoil shapes to find the optimum shape for the desired lift and drag.
5	Analyse the heat transfer through the different materials to find the best for the given conditions.

Signature of Course Coordinator **HOD,ME**
Ms.N. Santhisree, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**REFRIGERATION AND AIR CONDITIONING**				
Course Code	AME017				
Program	B. Tech				
Semester	SEVEN				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. A Somaiah, & M.Prasanth Reddy Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME003	IV	Thermodynamics
B.Tech	AME013	V	Thermal Engineering

II COURSE OVERVIEW:

Refrigeration and air conditioning continues to grow in importance in every segment of our day-to-day living. The course covers various conventional refrigeration systems like aircraft refrigeration, vapour compression, vapour absorption and steam jet refrigeration systems, also describes some unconventional refrigeration systems; thermoelectric refrigeration, Hilsch tube, etc.. The course introduces the psychrometry, cooling load calculations, thermodynamics of human body, industrial and comfort air conditioning, equipment required for air conditioning systems and heat pump circuits.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Fluid Dynamics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with ”either” or ”choice” will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10 %	Remember
50 %	Understand
25%	Apply
15%	Analyze
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

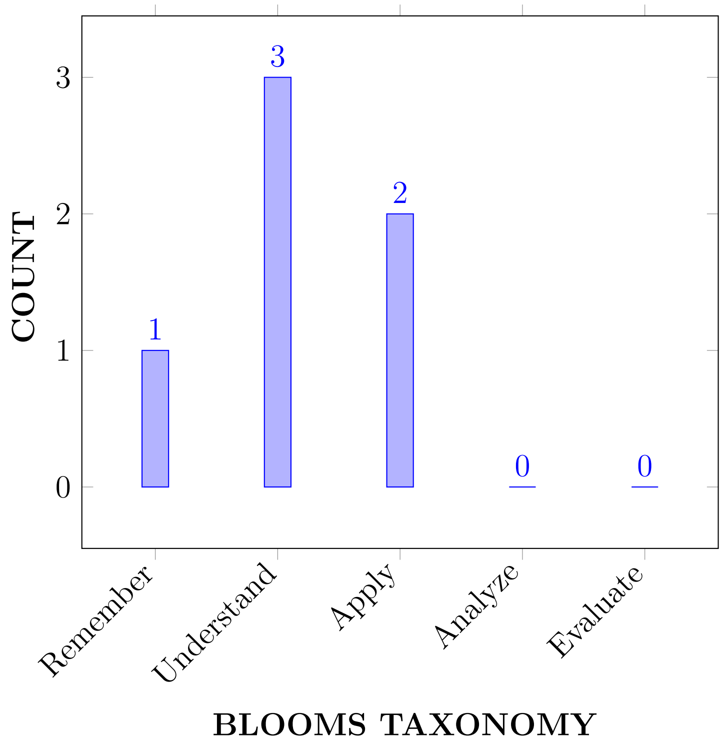
I	The principles of thermodynamics in refrigeration and air conditioning, analyze the methods of refrigeration, recognize the necessity and ideal cycle of refrigeration.
II	The nomenclature of refrigerants, realize the desirable properties of refrigerants to probe their ozone depleting and global warming potential.
III	The working principles, limitations, maintenance of refrigeration and air conditioning equipment and study their impact on the performance of the system.
IV	The psychrometric relations, processes, utilize their principles to resolve cooling load calculations and design of air conditioning systems.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** the modifications required in an impossible reversed Carnot cycle to convert it into practical cycle for refrigeration Applications.	Remember
CO 2	**Illustrate** the working principles, limitations of various refrigeration systems like practical aqua ammonia, LiBr-Water and Electrolux vapour absorption refrigeration systems.	Understand
CO 3	**Classify** the equipment used for the refrigeration, air conditioning purposes with suitable materials and refrigerant pairs.	Understand
CO 4	**Construct** the sensible heat factor lines, locate alignment circle and SHF scale on a psychrometric chart for the cooling load calculations of refrigeration systems.	Apply
CO 5	**Explain** thermal comfort conditions with respect to effective temperature, relative humidity, and their impact on human comfort, productivity and health.	Apply
CO 6	**Classify** the equipment required for air conditioning systems, study for operating principles, safety controls employed in air conditioning systems.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE / Quiz / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	3	CIE / Quiz / AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Seminar/ conferences / Research papers
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	Group discussion / Short term courses / AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	2	Research papers / Group discussion / Short term courses

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2 -	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	
CO 3	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Apply knowledge of science, engineering fundamentals to understand the principle of vapour compression refrigeration system and the working of principal components of a mechanical refrigeration system, in order to mathematically relate the performance of various vapour compression cycles.	2
	PO 2	Define the type of vapour compression cycle, identify various processes involved in the cycle, then formulate it for the determination of COP and interpret the results for the improvement of the system performance.	5
CO 2	PO 2	Analyse the reversed Carnot cycle to understand its practical impossibilities and identify modifications required to make it practical to apply in refrigeration purposes.	5
	PO 4	Use research-based knowledge including analysis and interpretation of data, and synthesis of the information to provide valid conclusions to make reversed Carnot cycle impractical to practical.	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 3	PO 1	Apply the knowledge of science, engineering fundamentals to demonstrate the working principles and determination of COP of the heat pump, heat engine and refrigerator.	2
CO 4	PO 1	Apply the knowledge of engineering fundamentals and science to illustrate lithium bromide – water absorption and Electrolux refrigeration systems.	1
CO 5	PO 1	Apply the knowledge of mathematics, science and engineering fundamentals to formulate and solve the problems in steam jet refrigeration system.	2
	PO 2	Identify, formulate and analyse theoritical and practical steam jet refrigeration cycles with T-S and P-h charts and interpret, stating merits, limitations, etc.	6
CO 6	PO 7	Understand the impact of ozone depleting substances like chlorine, fluorine, etc. in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2
CO 7	PO 1	Apply the knowledge of science and engineering fundamentals to classify the equipment used for the refrigeration and air conditioning purposes.	2
CO 8	PO 1	Construct the sensible heat factor lines, locate alignment circle, SHF scale on a psychrometric chart for the cooling load calculations of air conditioning systems by applying knowledge of science and engineering fundamentals.	3
	PO 2	Identify, formulate, and interpret the various psychrometric process by plotting a skeleton psychrometric chart and solve the problems related cooling load of air conditioning systems.	5
	PSO 1	Understand, formulate and design refrigeration and air conditioning systems for residential and public buildings, industrial applications, etc.	2
CO 9	PO 1	Apply the knowledge of mathematics and science to determine the thermal comfort conditions with respect to effective temperature, relative humidity, etc. and their impact on human comfort, productivity and health.	2
	PO 2	Identify, formulate and analyse human thermodynamic comfort conditions like effective temperature, relative humidity, etc., state the influence on health and productivity.	5
CO 10	PO 1	Apply the knowledge of science, engineering fundamentals to distinguish the equipment required for air conditioning systems, study the operating principles and safety controls employed in A.C systems.	2
CO 11	PO 1	Use the knowledge engineering fundamentals and mathematics to assess the principles of psychrometry to calculate and design the air conditioning systems for particular purpose.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Formulate and analyse the principles of psychrometry to calculate and design the air conditioning systems for particular purpose.	5
	PSO 1	Understand, analyse and design to calculate and design the air conditioning systems for residential and public buildings, industrial applications and for any particular purpose.	2
CO 12	PO 2	Identify, analyse and solve the various heat pump circuits for heating, cooling purposes with suitable industrial applications.	4
	PO 4	Use research based knowledge, analysis and interpret the data in design of heat pump circuits for different purposes.	5
	PSO 1	Formulate and evaluate engineering concepts of design and construction of heat pump circuits for residential and public buildings, industrial applications, etc.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	5	-	5	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	5	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 5	3	5	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	50	0	45.00	0	0	0	0	0	0	0	0	0	0	0
CO 2	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO 3	100	50	0	0	0	0	0	0	0	0	0	0	0	0	0
CO 4	100	50	0	0	0	0	0	0	0	0	0	0	0	66.6	0
CO 5	100	50	0	0	0	0	0	0	0	0	0	0	0	66.6	0
CO 6	100	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - 40 % $<$C $<$ 60% –Moderate
3 - 60% $\leq$ C $<$ 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	8		2										4	
AVERAGE	3	2		1.0										2.0	

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments	✓				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback
✓	Early Semester Feedback		Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO REFRIGERATION**
	Basic concepts: unit of refrigeration and COP, refrigerators, heat pump, Carnot refrigerator, applications of refrigerators, air refrigeration: Bell-Coleman cycle, open and dense air system, ideal and actual refrigeration, applications, vapor compression refrigeration, ideal cycle, effect of sub cooling of liquid, super heating of vapor, deviations of practical (actual cycle) from ideal cycle, construction and use of p-h chart problems.
MODULE II	**VAPOUR ABSORPTION REFRIGERATION AND AIR REFRIGERATION**
	Vapor absorption refrigeration: description, working of NH3-Water, Li Br–water system, calculation of HCOP, Principle and operation of three fluid vapor absorption refrigeration systems. Steam jet refrigeration system, working principle, basic operation; Refrigerants: Properties, nomenclature selection of refrigerants, effects of refrigerants on global warming, alternate refrigerants.

MODULE III	**REFRIGERATOR COMPONENTS**
	Compressors: classification, working, advantages and disadvantages; Condensers: classification, working Principles. Evaporators: classification, working Principles; Expansion devices: types, working principles.
MODULE IV	**INTRODUCTION TO AIR CONDITIONING**
	Psychometric properties and processes, sensible and latent heat loads, characterization, need for ventilation, consideration of Infiltration, load concepts of RSHF, ASHF, ESHF and ADP; concept of human comfort and effective temperature, comfort air conditioning, industrial air conditioning and requirements, air conditioning load calculations.
MODULE V	**AIR CONDITIONING SYSTEMS**
	Classification of equipment, cooling, heating humidification and dehumidification, filters, grills and registers, deodorants, fans and blowers, heat pump, heat sources, different heat pump circuits, applications.

TEXTBOOKS

1. Manohar Prasad, "Refrigeration and Air Conditioning‖ New Age International, 3rd Edition, 2015
2. S. C. Arora, Domkundwar, A Course in Refrigeration and Air-conditioning, Dhanpatrai Publications, Edition 2014.
3. S. N. Sapali, "Refrigeration and Air-conditioning", PHI Learning, 2nd Edition, 2011.

REFERENCE BOOKS:

1. C. P. Arora, Refrigeration and Air Conditioning‖ Tata McGraw-Hill, 17th Edition, 2006.
2. Ananthanarayanan, Basic Refrigeration and Air Conditioning‖, Tata McGraw-Hill, 2015.
3. R.K.Rajput, A text of Refrigeration and Air Conditioning‖ S. K. Kataria & Sons, 3rd Edition, 2009.
4. P. L. Ballaney, Refrigeration and Air Conditioning‖ Khanna Publishers, 16th Edition, 2015.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Discussion on Outcome based education and CO and PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Introduction to refrigeration and air conditioning.	CO 2	T2:2.3
2	Review of thermodynamics and define TR	CO 2	R1:2.6

3	Derive COP of heat pump, refrigerator and heat engine.	CO 1	T1:2.6
4	Numerical problems on heat pump, refrigerator and heat engine.	CO 1	T1:2.7
5	Describe the working of Carnot refrigerator and its applications.	CO 2	T2:2.7 R1:2.18
6	Air refrigeration: Bell-Coleman cycle, open and dense air system	CO 3	T3:3.6.5
7	Ideal, actual refrigeration and applications.	CO 2	T3:3.6.7
8	Describe the working of vapor compression refrigeration cycle and ideal cycle of refrigeration.	CO 1	T2:2.22
9	Discuss the effect of sub cooling	CO 1	T2:2.2
10	Discuss the effect of superheating	CO 1	T2:2.26 R1:2.55
11	Numerical problems on sub cooling and super heating.	CO 1	T3:4.162
12	Construction and description of PH chart & Solve the problems.	CO 1	T3:4.162
13	Introduction to vapor absorption refrigeration.	CO 3	T1:4.8 R2:4.68
14	Description and working of NH3-Water (actual and practical cycles).	CO 3	T1:4.8 R2:4.68
15	Illustrate Li Br–water system (two shell and four shell).	CO 3	T2:4.15 R1:5.74
16	Derivation for COP of a VARS and Numerical problems.	CO 3	T1:4.12 R2:5.75
17	Principle and operation of three fluid vapor absorption refrigeration systems.	CO 4	T1:4.8 R1:5.72
18	Introduction to steam jet refrigeration system and working principle.	CO 4	T3:2.3.5
19	Explain basic operation of SJRS.	CO 4	T3:2.3.5
20	Analysis of SJRS cycle and Numerical problems.	CO 4	T3:2.3.5sss
21	Introduction to refrigerants and discuss the properties of refrigerants.	CO 5	T3:5.4
22	Nomenclature and selection of refrigerants.	CO 5	T3:5.7
23	Discuss the effects of refrigerants on global warming.	CO 5	T3:5.13
24	Describe alternate refrigerants.	CO 5	T3:5.15
25	Introduction to compressors and classification.	CO 5	T2:3.14 R1:4.31
26-27	Working principles of compressors.	CO 5	T2:3.14 R1:4.31
28	Advantages and disadvantages of compressors.	CO 5	T2:3.14 R1:4.31
29	Classification and working principles of condensers.	CO 6	T2:3.18 R1:4.64
30	Advantages and disadvantages of condensers.	CO 6	T2:3.18 R1:4.64
31-32	Classification and working principles of expansion devices.	CO 4	T2:4.2

33	Advantages and disadvantages of expansion devices.	CO 4	T2:4.3 R1:4.71
34-35	Classification and working principles of evaporators.	CO 4	T2:3.28 R1:4.67
36	Advantages and disadvantages of evaporators.	CO 6	T2:3.28 R1:4.67
37-38	Describe psychometric properties.	CO 6	T3:8.2
39-40	Explain psychometric processes and solve numerical problems.	CO 6	T2:5.19 R1:6.81
41	Describe sensible, latent heat loads and characterization.	CO 6	T1:6.4 R2:6.8
42	Discuss need for ventilation and consideration of infiltration.	CO 5	T2:7.7 R1:7.74
43-44	Load concepts of RSHF, GSHF and ESHF, ADP and solve numerical problems.	CO 5	T3:9.18
45	Concept of human comfort and effective temperature.	CO 5	T3:9.4
46	Describe summer, winter and year round air conditioning systems.	CO 5	T3:9.19
47	Comfort air conditioning, industrial air conditioning and requirements,	CO 5	T1:8.8 R1:8.73
48	Air conditioning load calculations.	CO 5	T1:9.14 R1:10.78
49	Classification of equipment required for air conditioning.	CO 5	T2:9.19 R1:10.814
50-51	Equipment required for cooling, heating, humidification and dehumidification	CO 5	T2:9.19 R1:10.814
52	Describe various types of filters used in A.C systems.	CO 5	T1:10.4 R2:11.68
53	Discuss the functions of grills, registers and deodorants.	CO 5	T1:10.4 R2:11.68
54-55	Demonstrate various types of fans and blowers.	CO 5	T1:10.4 R2:11.68
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Introduction and working of a heat pump.	CO 6	T2:10.7 R1:12.7sss4
57	Discuss various types of heat sources required for heat pumps.	CO 6	T2:10.7 R1:12.74
58-59	Demonstrate different heat pump circuits.	CO 6	T1:11.12 R2:12.75
60	Discuss applications of heat pump circuits.	CO 6	T1:11.12 R2:12.75

DISCUSSION OF QUESTION BANK			
1	Module I	CO 1	R4:2.1
2	Module II	CO 2	T4:7.3
3	Module III	CO 3,4	R4:5.1
4	Module IV	CO 5	T1:7.5
5	Module V	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**CAD-CAM**				
Course Code	AME018				
Program	B.Tech				
Semester	VII				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. M Sunil Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME014	VI	Finite Element Modeling

II COURSE OVERVIEW:

Computer aided Design/ Computer aided Manufacturing (CAD/CAM) is a course primary important to mechanical engineering students. The aim is to impart the overview of computer applications or design and manufacturing the discrete engine components, assemblies and final product to meet the global competition. The course covers the life cycle of a product describes the product model generation, analysis structural, thermal, dynamic behaviours. This course also deals with creation of synthetic curves and surfaces. It imposes the knowledge o latest manufacturing techniques using CNC/DNC Machines centers with different CNC programming methods, Manufacturing processes, Group Technologies. It makes the student to understand the modern inspection methods and concepts of CIM.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
CAD-CAM	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
34%	Understand
66%	Apply
0%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

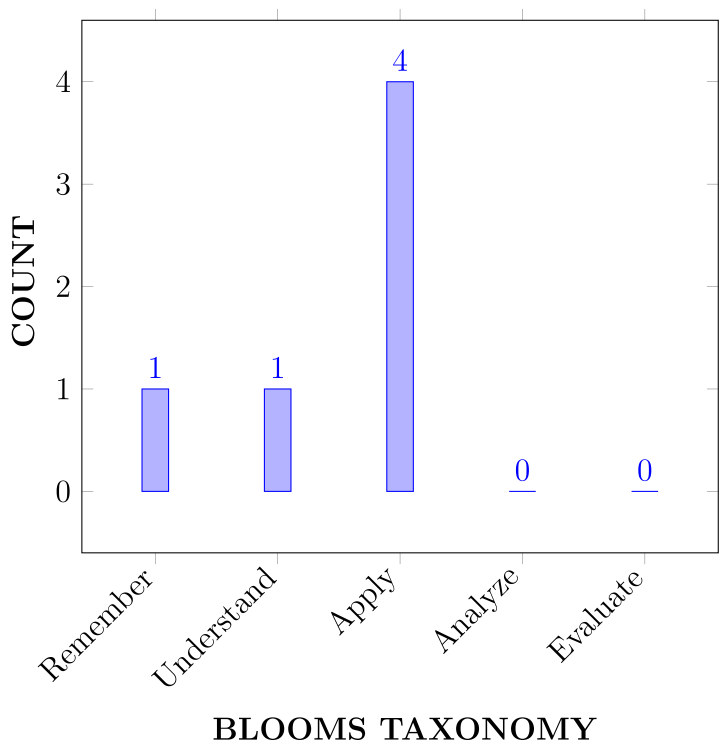
I	The product designs, manufacturing processes, and production plant as critical base for the interface and integration of CAD/CAM.
II	The assimilation of all product life cycle systems using computer controlled networks, integrated systems software and secondary information technologies
III	Implementation of computer aided design techniques, digital in seamless way in the manufacturing automation for product life management systems.
IV	Identify the quality parameters by adopting the contact and non-contact type of inspection techniques.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the integration of CAD, CAM and other systems with support of hardware and software for product life cycle management.	Understand
CO 2	**Make use of** geometric models, curve representation and surface representation to generate solid modelling.	Apply
CO 3	**Develop** NC part program data using manual data input (MDI) and automatically using standard commercial CAM package for manufacturing of required component using CNC milling or turning applications.	Apply
CO 4	**Compare** various computer controlled machine tools with respect to their functional capacity.	Apply
CO 5	**Recall** the different quality control methods and various contact and non-contact inspection methods used in various manufacturing systems.	Remember
CO 6	**Organize** the computer controlled monitoring and material handling management system for computer integrated manufacturing systems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
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PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
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PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	CIE/Quiz/AAT
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.	2	Assignments/ Discussion
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	Assignments/ Discussion
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2	Assignments/ Discussion
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	Research paper analysis/ Short term courses

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	2	Group discussion/ Short term courses

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		✓	-	-
CO 2	✓	-	-	-	-	-	-	-	-	-	-	✓	✓	-	-
CO 3	✓	-	✓	-	✓	-	-	-	-	-	-	✓	✓	-	-
CO 4	✓	✓	✓	-	-	-	✓	-	-	-	✓	✓	✓	-	-
CO 5	✓	✓	✓	-	-	-	-	-	-	-	✓	-	✓	-	-
CO 6	✓	✓	✓	-	-	-	✓	-	-	-	-		✓	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recollect (knowledge) the basic concept of static stability and to an extent appreciate (understand) the importance of longitudinal, lateral and directional modes of stabilityby applying the principles of **mathematics and science**.	3
	PSO 1	Extend the focus to understand the **fundamental knowledge of digital manufacturing**.	2
CO 2	PO 1	Describe (knowledge) in the field of computer aided design system and computer aided manufacturing **using computer graphics and synthetic entities using latest state of art technologies**.	3
	PO 12	**Make use of experimental tools for innovation** to assess high speed machining and rapid prototyping.	2
	PSO 1	Extend the focus to understand the **fundamental knowledge of digital manufacturing and limitations of Modern Tools.**	3
CO 3	PO 1	**Analyse complex mechanical designs usage** geometrical modelling techniques and PLM software's.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	Identify (knowledge) to compare NC/CNC machines with interpolations accuracy and their functions and applications with the **fundamentals of mathematics, science, and engineering fundamentals**.	2
	PO 5	**Use the mathematical model** to justify ABC Analysis and economic order quantities in manufacturing planning.	2
	PO 12	Use the retrieval and generative type process plans to minimize the ideal time to **minimize the shortest possible path**.	1
	PSO 1	**Make use of experimental tools for innovation** to assess high speed machining and rapid prototyping.	3
CO 4	PO 1	Identify (knowledge) to compare NC/CNC machines with interpolations accuracy and their functions and applications with the **fundamentals of mathematics, science, and engineering fundamentals**.	3
	PO 2	Apply (knowledge) to conduct the experimental work the appropriate using **analytical synthetic mathematical tools**.	2
	PO 3	Explain qualitatively about motion of CNC Machines in three-dimensions **using the principles of mathematics and engineering fundamentals**.	2
	PO7	Application of internet and intranet technologies for production, planning control and tractability by **using digital models available in the flexible manufacturing systems at the manufacturing environment.**	2
	PO11	Apply the concept of product life cycle management cycles at component level and sub assembly level of product using product life cycle systems useful for **effective project management**.	2
	PO 12	Apply the concept of adaption control techniques during the machining operation and optimise various machining parameters by **using CAD-CAM softwares** .	2
	PSO 1	**Focus on working digital manufacturing systems** on CNC vertical machining centre.	3
CO 5	PO 1	Develop the computer assisted knowledge base and suboptimal process plans to improve **the process capability using probability mathematical models**.	3
	PO 2	Use the retrieval and generative type process plans to minimize the ideal time to **minimize the shortest possible path**	2
	PO 3	Application of DNC for CNC machines which includes turning, milling and grinding centres for establishing **digital manufacturing environment**.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 11	Application of DNC for CNC machines which includes turning, milling and grinding centres for establishing **digital manufacturing environment**.	2
	PSO 1	Interpret **process models to justify digital manufacturing criteria** for unmanned control.	3
CO 6	PO 1	**Construct the mathematical model of manufacturing model** through computer machined tool cell system using design and manufacturing tools	3
	PO 2	**Make use of experimental tools for innovation** to assess high speed machining and rapid prototyping.	1
	PO 3	Overview of different programming techniques applied in the **CNC machines to generate part program for simple and complex geometrics**.	2
	PO 7	Apply the production and planning control technologies for **giving professional engineering solutions in societal and environmental context** .	2
	PSO 1	**Make use of experimental tools for innovation** to assess high speed machining and rapid prototyping.	3

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 2	3	-	-	-	1	-	-	-	-	-	-	2	3	-	-
CO 3	3	-	2	-	2	-	2	-	-	-	-	1	3	-	-
CO 4	3	2	2	-	-	-	2	-	-	-	2	2	3	-	-
CO 5	3	2	2	-	1	-	-	-	-	-	2	-	3	-	-
CO 6	3	1	2	-	-	-	2	-	-	-	-	-	3	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-	-	66	-	-
CO 2	100	-	-	-	33	-	-	-	-	-	-	66	100	-	-
CO 3	100	-	66	-	66	-	66	-	-	-	-	33	100	-	-
CO 4	100	66	66	-	-	-	66	-	-	-	66	66	100	-	-
CO 5	100	66	66	-	33	-	-	-	-	-	66	-	100	-	-
CO 6	100	33	66	-	-	-	66	-	-	-	-	-	100	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -5 $< C \leq 40\%$ – Low/ Slight
2 - 40 % $< C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 2	3	-	-	-	1	-	-	-	-	-	-	3	3	-	-
CO 3	3	-	3	-	3	-	2	-	-	-	-	1	3	-	-
CO 4	3	3	3	-	-	-	3	-	-	-	3	3	3	-	-
CO 5	3	3	3	-	1	-	-	-	-	-	3	-	3	-	-
CO 6	3	1	3	-	-	-	3	-	-	-	-	-	3	-	-
TOTAL	18	7	12	-	5	-	8	-	-	-	6	7	18	-	-
AVERAGE	3	1	2	-	1	-	1	-	-	-	1	1	3	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1,PO 2,PO 3	SEE Exams PO 1, PO 2 PO 3		Seminars	PO 5,PO 7,PO 11
Laboratory Practices	-	Student Viva	PO 12, PSO 1	Certification	-
Term Paper	-	5 Minutes Video	PO 12	Open Ended Experiments	-
Assignments	PO 1,PO 2,PO 3				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

UNIT I	**FUNDAMENTAL CONCEPTS IN CAD**
	Computers in Industrial Manufacturing, Product cycle, CAD / CAM Hardware, Basic structure, CPU,Memory types, input devices, display devices, hard copy devices, storage devices, raster scan graphicscoordinate system, database structure for graphics modeling, transformation of geometry, 3D transformations, mathematics of projections, clipping, hidden surface removal.
UNIT II	**GEOMETRICAL MODELLING AND DRAFTING SYSTEMS**

	Requirements, geometric models, geometric construction models, curve representation methods, surface representation methods, solid modeling, modeling facilities desired, Basic geometric commands, layers, display control commands, editing, dimensioning.
UNIT III	**COMPUTER AIDED MANUFACTURING**
	Numerical control: NC, NC modes, NC elements, NC machine tools, structure of CNC machine tools, features of machining center, turning center; CNC part programming: fundamentals, manual part programming methods, computer aided part programming.
UNIT IV	**GROUP TECHNOLOGY, CAPP AND CAQC**
	Group technology: Part family, coding and classification, production flow analysis, advantages and limitations, computer Aided Processes Planning, Retrieval type and generative type, terminology in quality control, the computer in QC, contact inspection methods, non-contact inspection methods, optical, computer aided testing, integration of CAQC with CAD/CAM.
UNIT V	**COMPUTER INTEGRATED MANUFACTURING SYSTEMS**
	Types of manufacturing systems, machine tools and related equipment, material handling systems,computer control systems, human labor in the manufacturing systems, CIMS benefits.

TEXTBOOKS

1. William M Neumann and Robert F.Sproull “Principles of Computer Graphics”, McGraw Hill Book Co., Singapore, 1989.

2. Ibrahim Zeid, “Mastering CAD/CAM”, McGraw Hill, International Edition, 2007.

3. K. Lalit Narayan, K. Mallikarjuna Rao and M.M.M. Sarcar, “Computer Aided Design Manufacturing”, PHI, 2008.

REFERENCE BOOKS:

1. Yoram Koren, “Computer Control of Manufacturing Systems”, McGraw Hill. 1983.

2. Groover, M. P. and Zimmers, E. W., “CAD/CAM: Computer Aided Design and Manufacturing”, Pearson Education India, 2006.

WEB REFERENCES:

1. http:// nptel.ac.in/courses/112102101/

2. http:// nptel.ac.in/courses/112102103/

3. https://ocw.mit.edu/courses/mechanical-engineering/2-007-design-and-manufacturing-i-spring- 009/lecturenotes/

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courseslist/72

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	CO 1,2,3,4,5,6	
CONTENT DELIVERY (THEORY)			
2	Computers in Industrial Manufacturing	CO 1	T2:1,T1:1
3	Product cycle	CO 1	T2: 23
4	CAD / CAM Hardware, Basic structure, CPU, Memory types, input devices, Display devices, hard copy devices, storage devices	CO 1	T2:3
5	Raster scan graphics coordinate system, database structure for graphics modeling	CO 1	T2:11
6	Transformation of geometry, 3D transformations	CO 1	T2:12
7	Mathematics of projections	CO 1	T2:13
8	Clipping	CO 1	T2:14
9	Hidden surface removal	CO 1	T2:14
10	Requirements, geometric models	CO 2	T2:5
11	Geometric construction models	CO 2	T2:5
12	Curve representation methods	CO 2	T2:6
13	Surface representation methods	CO 2	T2:7
14	Solid modeling	CO 2	T2:9
15	Solid modeling facilities desired	CO 2	T2:9
16	Basic geometric commands, layers, display control commands, editing, dimensioning	CO 2	T2:4
17	Numerical control: NC, NC modes, NC elements	CO 3	T2:22
18	NC machine tools	CO 3	T2:22
19	Structure of CNC machine tools	CO 3	T2:22
20	Features of machining center	CO 4	T2:22
21	Turning center	CO 3	T2:22
22	CNC part programming: fundamentals	CO 4	T2:22
23	Manual part programming methods	CO 4	T2:22
24	Computer aided part programming	CO 4	T2:22
25	Group technology: Part family, coding and classification	CO 5	T2:21
26	Production flow analysis, advantages and limitations	CO 5	T2:21
27	Computer Aided Processes Planning	CO 5	T2:21
28	Retrieval type and generative type CAPP	CO 5	T2:21
29	Terminology in quality control, the computer in QC	CO 5	T3:17
30	Contact inspection methods	CO 5	T3:17
31	Non-contact inspection methods	CO 5	T3:17

32	Optical inspection methods	CO 5	T3:17
33	Computer aided testing	CO 5	T3:17
34	Integration of CAQC with CAD/CAM	CO 5	T3:17
35	Types of manufacturing systems	CO 6	T3:21
36	Machine tools and related equipment	CO 6	T3:21
37	Material handling systems	CO 6	T3:21
38	Computer control systems	CO 6	T3:21
39	Human labor in the manufacturing systems	CO 6	T3:21
40	CIMS benefits	CO 6	T3:22
PROBLEM SOLVING/ CASE STUDIES			
41	Transformation of geometry	CO 1	T3:7
42	Mathematics of projections	CO 1	T3:7
43	Clipping	CO 1	T3:7
44	Geometric construction models	CO 2	T3:8
45	Synthetic Curves representation methods	CO 2	T3:8
46	Non Synthetic Curve Representation Methods	CO 2	T3:8
47	Surface representation methods	CO 2	T3:9
48	Solid Modeling I	CO 2	T3:10
49	Solid modeling-II	CO 2	T3:10
50	Manual part programming methods (Milling)	CO 4	T3:14
51	Computer aided part programming (Milling)	CO 4	T3:14
52	Manual part programming methods (Turning)	CO 4	T3:14
53	Computer aided part programming (Turning)	CO 4	T3:14
54	Group Technology	CO 5	T3:15
55	Computer Aided Process Planning	CO 5	T3:16
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Unit I: Fundamental concepts in CAD	CO 1	T1,T2,T3, R1,R2
57	Unit II: Geometrical modelling and drafting systems	CO 2	T1,T2,T3, R1,R2
58	Unit III: Computer Aided Manufacturing	CO 3,4	T1,T2,T3, R1,R2
59	Unit IV: Group Technology, CAPP and CAQC	CO 5	T1,T2,T3, R1,R2
60	Unit V: Computer Integrated Manufacturing Systems	CO 6	T1,T2,T3, R1,R2
DISCUSSION OF QUESTION BANK			
61	Unit I: Fundamental concepts in CAD	CO 1	T1,T2,T3, R1,R2
62	Unit II: Geometrical modelling and drafting systems	CO 2	T1,T2,T3, R1,R2
63	Unit III: Computer Aided Manufacturing	CO 3,4	T1,T2,T3, R1,R2
64	Unit IV: Group Technology, CAPP and CAQC	CO 5	T1,T2,T3, R1,R2

65	Unit V: Computer Integrated Manufacturing Systems	CO 6	T1,T2,T3, R1,R2

Signature of Course Coordinator **HOD,ME**
Mr. M Sunil Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Mechanical Engineering**
Course Title	**INSTRUMENTATION AND CONTROL SYSTEMS**
Course Code	AME019
Program	B.Tech
Semester	VII
Course Type	Elective
Regulation	R-16

	Theory			Practical	
Course Structure	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	3 -	-
Course Coordinator	M.Sunil Kumar				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME008	IV	Mechanics of Fluids and Hydraulic Machines
B.Tech	AMEB16	V	Manufacturing Technology

II COURSE OVERVIEW:

The Present course concentrates on developing basic understanding about various instruments that are involved in measuring. This course enables the student to understand the working of various measuring instruments. The course focuses on all principles, working, advantages, disadvantages and applications of various measuring instruments. In this course; students also will gain a broad understanding of the control systems. Student can learn in detail about how to measure displacement, temperature, pressure, level, flow, acceleration, vibration, strain, humidity, force, torque and power and their appropriate application.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
INSTRUMENTATION AND CONTROL SYSTEMS	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
%	Remember
%	Understand
%	Apply
%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

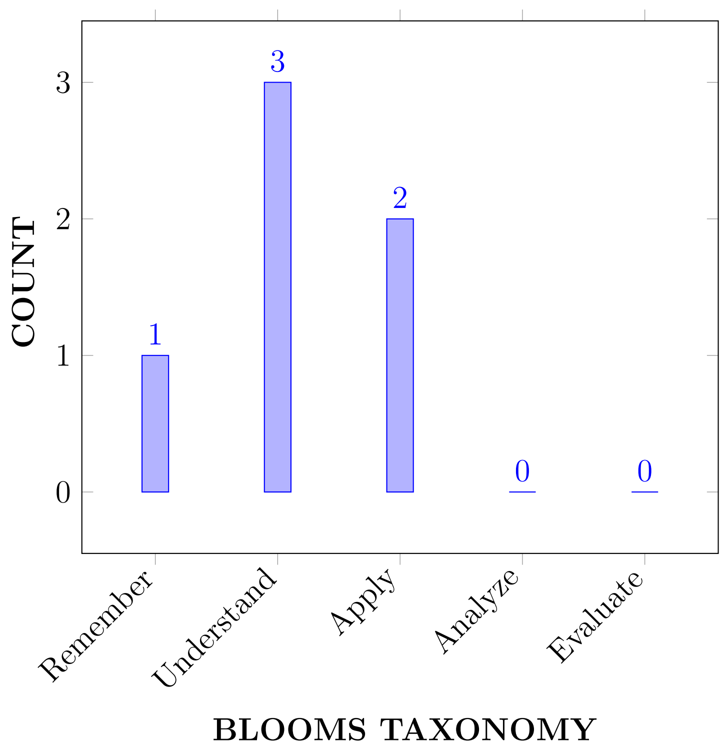
I	The fundamental knowledge of measuring principles, configuration and functional description of instruments with static, dynamic inputs and error control.
II	The concepts and working of instrumentation devices for displacement, flow, dynamic and other mechanical measurement applications.
III	Instrumentation practices and automatic control system for monitoring industrial real time processes within limits of parameter specifications.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Recognize** the importance of basic principles, configuration and functional description of measuring instruments.	Remember
CO 2	**Describe** performance characteristics of an instrument when the device is exposed to measure dynamic inputs and error control.	Understand
CO 3	**Categorize** the measuring instruments basedon the principle of working with the physical parameters such as displacement, temperature and pressure.	Understand
CO 4	**Demonstrate** working principle of level measuring devices for ascertaining liquid level and choose appropriate device for controlling fluid level in industrial applications.	Understand
CO 5	**Make use of** appropriate instrument for measuring Speed, Acceleration and Vibration by considering different aspects.	Apply
CO 6	**Apply** relevant control systems for speed, position and control processes in practical applications.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	AAT, CIE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIE
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	AAT, CIE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	✓	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	✓	-	✓	-	-	-	-	-	-	-	-	-
CO 4	✓	✓	-	-	-	✓	-	-	-	-	-	✓	✓	✓	-
CO 5	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-
CO 6	✓	✓	-	✓	-	✓	-	-	-	-	-	✓	-	✓	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recognize (knowledge) the importance of basic principles, configuration, appreciate (understanding) their importance and applicability (apply) in solving (complex) engineering problems of measurement by applying the **the scientific principles of mathematics and science.**	2
	PSO 2	Make use of **computational** and **experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 2	PO 1	Demonstrate (understand) performance characteristics of an instrument when the device is exposed to measure dynamic inputs and error control systems by applying the principles of **mathematics and engineering fundamentals.**	2
	PO 2	Analyze the performance parameters of meaasurements using **first principles of Mathematics and engineering sciences.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 3	PO 1	Categorize (understand) the measuring instruments based on the principles of working with the physical parameters such as displacement, temperature and pressure etc., in solving (complex) fluid flow engineering problems by applying the principles of mathematics, science and engineering fundamentals. **mathematics, science and engineering fundamentals.**	3
	PO 2	Analyze the performance parameters of meaasurements using **first principles of Mathematics and engineering sciences.**	2
CO 4	PO 1	Explain (understand) calibration of instrument for measurement of all types of mechanical parameters by applying the principles of mathematics, science and engineering fundamentals. (**mathematics, science and engineering fundamentals.**)	3
	PO 2	Understand the given **problem statement** and **formulate** (complex) engineering problems and choosing appropriate measuring device for calibration considering mechanical parameter and substantiate with **interpretation** of variation in the **results**.	4
	PSO 2	Make use of **computational** and **experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2
CO 5	PO 1	Demonstrate (understand) working principle of level measuring device for ascertaining parameter such as liquid level , in solving (complex) liquid level engineering problems by applying the applying the principles of **mathematics, science** and **engineering fundamentals** for controlling fluid level in industrial applications.	3
	PO 2	Understand the given **problem statement** and formulate (complex) fluid level engineering phenomena for deriving related equations from the provided information and substantiate with **interpretation** of variations in the results.	4
CO 6	PO 1	Explain (understand) the theory, phenomena and working of flow measuring instruments to solution of flow engineering problem by applying the principles of **mathematics**, **science** and **engineering fundamentals** to perform calibration for flow measuring devices.	3
	PO 2	Understand the given **problem statement** and **formulate**(complex) fluid flow engineering phenomena for deriving related equations from the provided information and substantiate with **interpretation** of variations in the **results**.	4

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-		-	3	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	2	-	-	-	-	-	-	-	-	-
CO 4	3	1	1	-	-	2	-	-	-	-	-	2	-	3	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	2	-	-	-
CO 6	3	1	1	-	-	2	-	-	-	-	-	2	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	100	-
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	50	-	-	-	50	-	-	-	-	-	-	-	-	-
CO 4	100	50	50	-	-	50	-	-	-	-	-	50	-	100	-
CO 5	100	40	-	-	-	-	-	-	-	-	-	50	-	-	-
CO 6	100	40	50	-	-	50	-	-	-	-	-	50	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	2	-	-	-	-	-	-	-	-	-
CO 4	3	1	1	-	-	2	-	-	-	-	-	2	-	3	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	2	-	-	-
CO 6	3	1	1	-	-	2	-	-	-	-	-	2	-	-	-
TOTAL	18	5	-	-	-	6	-	-	-	-	-	6	-	6	-
AVERAGE	3.0	1.0	1.0		-	2.0	-	-	-	-	-	3.0	-	3.0	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	✓	5 Minutes Video	✓	Open Ended Experiments	✓
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

x	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE-I	**PRINCIPLES OF MEASUREMENT**
	Definition, basic principles of measurement, measurement systems, generalized configuration and functional descriptions of measuring instruments examples, dynamic performance characteristics, sources of error, classification and elimination of error
MODULE-II	**MEASUREMENT OF DISPLACEMENT, TEMPERATURE, PRESSURE**
	Measurement of Displacement: Theory and construction of various transducers to measure displacement, peizo electric, inductive, capacitance, resistance, ionization and Photo electric transducers, Calibration procedures; Measurement of temperature: Classification ranges, various principles of measurement, expansion, electrical resistance, thermistor, thermocouple, pyrometers, temperature indicators; Measurement of pressure: MODULEs, classification, different principles used, manometers, piston, bourdon pressure gauges, bellows, diaphragm gauges. low pressure measurement, thermal conductivity gauges, ionization pressure gauges, Mcleod pressure gauge.
MODULE-III	**MEASUREMENT OF LEVEL, FLOW, SPEED, ACCELERATION AND VIBRATION**
	Measurement of Level: Direct method, indirect methods, capacitative, ultrasonic, magnetic, cryogenic fuel level indicators, bubler level indicators; Flow measurement: Rotameter, magnetic, ultrasonic, turbine flow meter, hot-wire anemometer, laser doppler anemometer (LDA); Measurement of Speed: Mechanical tachometers, electrical tachometers, stroboscope, noncontact type of tachometer; Measurement of Acceleration and Vibration: Different simple instruments, principles of seismic instruments, vibrometer and accelerometer using this principle.
MODULE-IV	**MEASUREMENT OF STRESS – STRAIN, HUMIDITY, FORCE, TORQUE AND POWER**
	Stress Strain Measurements: Various types of stress and strain measurements, electrical strain gauge, gauge factor method of usage of resistance strain gauge for bending compressive and tensile strains, usage for measuring torque, strain gauge rosette; Measurement of Humidity: Moisture content of gases, sling psychrometer, Absorption psychrometer, Dew point meter; Measurement of Force, Torque and Power:Elastic force meters, load cells, torsion meters, dynamometers

MODULE-V	**ELEMENTS OF CONTROL SYSTEMS**
	Elements of Control Systems: Introduction, importance, classification, open and closed systems, servomechanisms examples with block diagrams, temperature, speed and position control systems.

TEXTBOOKS

1. D. S. Kumar, "Measurement Systems: Applications and Design", Anuradha Agencies, 1st Edition, 2013.
2. C. Nakra, K. K. Choudhary, "Instrumentation, Measurement and Analysis", Tata McGraw-Hill, 1st Edition, 2013

REFERENCE BOOKS:

1. Chennakesava R Alavala, "Principles of Industrial Instrumentation and Control Systems", Cengage Learning, 1st Edition, 2013
2. S. Bhaskar, "Instrumentation and Control systems", Anuradha Agencies, 1st Edition, 2013.
3. Holman, "Experimental Methods for Engineers", McGraw-Hill, 8th Edition, 2013
4. R. K. Jain, "Mechanical and Industrial Measurements", Khanna Publishers, 1st Edition, 2013.
5. Sirohi, Radhakrishna, "Mechanical Measurements", New Age, 3rd Edition, 2015
6. A. K. Tayal, "Instrumentation and Mechanical Measurements", Galgotia Publications, 1st Edition, 2013.

WEB REFERENCES:

1. http://nptel.ac.in/courses/112106138

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
	OBE DISCUSSION		
1	Introduction to Outcome Based Education	-	-
	CONTENT DELIVERY (THEORY)		
1	Introduction, definition, fundamental measuring process.	CO 1	T1: 1.1-1.16
2	Basic principles of measurement, classification, measurement systems.	CO 1	T1: 1.1-1.16
3-4	generalized configuration and functional descriptions of measuring instruments – examples	CO 1	T2:26.7
5	Static performance characteristics.	CO 2	T1: 1.16,
6-7	Dynamic performance characteristics.	CO 2	T1: 1.16,
8	Sources of error, Classification of errors.	CO 2	T1: 1.16

9	Classification of errors, elimination of error and calibration.	CO 2	TT1: 1.16
10	Zero order, 1st order 2nd order systems.	CO 2	T1: 1.12-1.16
11-12	Classification of transducers, Theory and construction of LVDT, Resistance, Inductive transducer for measurement of displacement.	CO 3	T1: 14.1-14.2
13	Theory and construction of capacitance transducer formeasurement of displacement.	CO 3	T1: 14.1-14.2
14	Theory and construction of Piezo electric and photo electric transducer transducers for measurement of displacement.	CO 3	T1: 14.1-14.2
15	Theory and construction of Ionization and Photo electric transducer for measurement of displacement.	CO 3	T1: 14.1-14.2
16	Hall effect Transducer, LDR.	CO 3	T1: 14.1-14.2
17	Measurement of Temperature: Classification – Ranges.	CO 3	T1: 20.1-20.3
18	Various principles of measurement – Expansion, Electrical Resistance	CO 3	T1: 20.1-20.3
19	Resistance Temperature Detyector (RTD).	CO 3	T1: 20.1-20.3
20	Thermistor for temperature measurement.	CO 3	T1: 20.1-20.3
21	Thermocouple for temperature measurement.	CO 3	T1: 20.1-20.3
22	Pyrometers – Temperature Indicators.	CO 3	T1: 20.1-20.3
23	Measurement of Pressure: Units – classification – different principles used.	CO 4	T1: 18.1-18.3
24	Piston gauge, Manometers.	CO 4	T1: 18.1-18.3
25-26	Bourdon pressure gauges, Bellows – Diaphragm gauges. Low pressure measurement.	CO 4	T1: 18.1-18.3
27	Thermal conductivity gauges.	CO 4	T1: 18.1-18.3
28	Ionization pressure gauges, Mcleod pressure gauge	CO 4	R2:7.5
29	Measurement of Level: Direct method – Indirect methods	CO 5	T1: 24.1-24.2
30	Capacitive, ultrasonic level measurement.	CO 5	T1: 24.1-24.2
31	Magnetic, cryogenic fuel level indicator.	CO 5	T1: 24.1-24.2
32	Bubbler level indicatorss	CO 5	T1: 24.1-24.2
33	Flow Measurement: Rotameter, magnetic flow meter	CO 6	R2:7.5
34	Ultrasonic, Turbine flow meter	CO 6	T1: 21.1-21.2
35	Hot – wire anemometer, Laser Doppler Anemometer (LDA)	CO 6	R2:7.5

36	Measurement of Speed: Mechanical Tachometers	CO 6	R2:7.5
37	Electrical tachometers	CO 7	R2:7.5
38	Noncontact type of tachometer , Stroboscope.	CO 7	R2:7.5
39	Measurement of Acceleration and Vibration: Different simple instruments.	CO 7	R2:7.5
40	Principles of Seismic instruments	CO 7	R2:7.5
41-42	Vibrometer and accelerometer using this principle.	CO 7	R2:
43-44	Stress Strain Measurements: Various types of stress and strain measurements.	CO 7	R2:7.61
45	Electrical strain gauge.	CO 8	R2:7.63
46	gauge factor – method of usage of resistance strain gauge for bending compressive and tensile strains.	CO 10	R2:7.65
47	usage for measuring torque, Strain gauge Rosettes.	CO 10	R2:7.68
48	Measurement of Humidity: Moisture content of gases, sling psychrometer.	CO 10	R2:7.69
49	Absorption psychrometer, Dew point meter.	CO 10	R2:7.0
50	Measurement of Force , and Elastic force meters.	CO 10	R2:7.1
51	Measurement of Torque.	CO 10	R2:7.2
52	load cells, Torsion meters.	CO 10	R2:7.3
53-54	Measurement of Power, Dynamometers	CO 10	R2:7.5
55	Elements of Control Systems: Introduction, Importance, Classification.	CO 10	R2:7.5
PROBLEM SOLVING/ CASE STUDIES			
56	Module I:measuring instruments examples, dynamic performance characteristics	CO 1,2, 3	R4:2.1
57	Module II:Measurement of temperature: Classification ranges, various principles of measurement, expansion, electrical resistance, thermistor, thermocouple, pyrometers, temperature indicators;	CO 4,5	T4:7.3
58	Module III: Measurement of Speed: Mechanical tachometers, electrical tachometers, stroboscope	CO 6,7	R4:5.1
59	Module IV:Measurement of Humidity: Moisture content of gases, sling psychrometer.	CO 8,9	T1:7.5
60	Module V:Elements of Control Systems: Introduction, Importance, Classification.	CO 10	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
61	Module I:measuring instruments examples, dynamic performance characteristics	CO 1,2, 3	R4:2.1
62	Module II:Measurement of temperature: Classification ranges, various principles of measurement, expansion, electrical resistance, thermistor, thermocouple, pyrometers, temperature indicators;	CO 4,10	T4:7.3
63	Module III: Measurement of Speed: Mechanical tachometers, electrical tachometers, stroboscope	CO 6,7	R4:5.1
64	Module IV:Measurement of Humidity: Moisture content of gases, sling psychrometer.	CO 8,10	T1:7.5

65	Module V:Elements of Control Systems: Introduction, Importance, Classification.	CO 10	R2:7.5
DISCUSSION OF QUESTION BANK			
1	Module I:measuring instruments examples, dynamic performance characteristics	CO 1,2, 3	R4:2.1
2	Module II:Measurement of temperature: Classification ranges, various principles of measurement, expansion, electrical resistance, thermistor, thermocouple, pyrometers, temperature indicators;	CO 4,9	T4:7.3
3	Module III: Measurement of Speed: Mechanical tachometers, electrical tachometers, stroboscope	CO 6,7	R4:5.1
4	Module IV:Measurement of Humidity: Moisture content of gases, sling psychrometer.	CO 8,10	T1:7.5
5	Module V:Elements of Control Systems: Introduction, Importance, Classification.	CO 10	R2:7.5

Signature of Course Coordinator **HOD,ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**Additive Manufacturing Techniques**				
Course Code	AME510				
Program	B.Tech				
Semester	VII				
Course Type	ELECTIVE				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr A. Venu Prasad, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB05	III	Manufacturing Processes

II COURSE OVERVIEW:

The primary objective of this course is to build bridges between the gap of an idea and production. Rapid prototyping is a group of methods used to rapidly manufacture a scale model of a physical part or assembly using three-dimensional computer aided design (CAD), Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) data. Construction of the part or assembly is usually done using 3D printing technology. Rapid prototyping techniques are often referred to solid free; computer automated manufacturing, form fabrication. This course covers the knowledge of rapid prototyping systems and reduces to build the manufacturing lead time and it helps to visualizing the 3D intricate shapes.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
ADDITIVE MANUFACTURING PROCESS	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
20%	Remember
40 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 2), with 20 marks for continuous internal examination (CIE), 05 marks for quiz and 05 marks for alternative assessment tool

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 17th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Open Ended Experiment
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

I	The Importance of Additive manufacturing Technology in the day-to-day life, and study the basic 3D Printing processes and techniques used.
II	The knowledge in various materials and machines used for the development of prototypes..
III	Design features that make each of these Additive manufacturing process both harder, easier, assess design and manufacturing features on real products.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Outline** the steps involved in making a prototype with desired method for automotive and medical industry components like cylinder valves, micro actuators and dental prosthesis etc..	Understand
CO 2	**Develop** the CAD model in the system needed for rapid prototype, requirements to achieve defect/error free components	Apply
CO 3	**Categorize** various methods during liquid based additive manufacturing operation such as SLA, SGC and SOUP etc. for real time applications.	Analyze
CO 4	**Illustrate** the properties and bonding techniques of liquid based 3D printing and various printing techniques in micro and macro scales.	Understand
CO 5	**Recall** the process parameters and techniques for producing components using solid as a base material.	Remember
CO 6	**Describe** the working principle of various Powder based Rapid prototyping processes and their application in industries for making of commercial prototypes.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Program Outcomes	
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	CIE/Quiz/AAT, AAT, QUIZ

3 = High; 2 = Medium; 1 = Low

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	CIE/Quiz/AAT, AAT, QUIZ
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	CIE/Quiz/AAT, AAT, QUIZ
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	1	CIE/Quiz/AAT, AAT, QUIZ
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	CIE/Quiz/AAT, AAT, QUIZ
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	CIE/Quiz/AAT, AAT, QUIZ
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	3	CIE/Quiz/AAT, AAT, QUIZ
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2	CIE/Quiz/AAT, AAT, QUIZ

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing. standards	2	SEE/CIE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	-	-	-	-	-	-	-	✓	-		✓	-	-
CO 2	✓	✓	-	-	✓	-	-	-	-	-	-	-	✓	-	-
CO 3	✓	-	-	-	✓	-	✓	-	-	-	-	-	✓	-	-
CO 4	✓	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	-
CO 5	✓	-	-	-	-	-	-	✓	✓	-	✓	-	✓	-	-
CO 6	✓	-	-	✓	-	-	-	-	-	-	-	✓	✓	-	-

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

Course Outcomes	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key competencies matched.**
CO 1	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles**of Methodology using mathematics and physics and**engineering fundamentals.**	3
	PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in **digital manufacturing. standards**	2
CO 2	PO 1	Identify (knowledge) in suitable methods involved in design, casting to achieve error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals.**	3
	PO 2	Understand the given **problem statement** and **apply data validation techniques** to **solve** (complex) specific engineering problems related to design.	2
	PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in **digital manufacturing. standards**	2
CO 3	PO 4	Investigate prototype models based on constraint including **Environmental sustainability, Health and safety risks assessment issues** and define specific problem	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in **digital manufacturing. standards**	2
CO 4	PO 3	**Identify** the various properties of Bonding techniques using **analytical and mathematical process.**	3
	PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in **digital manufacturing. standards**	2
CO 5	PO 2	Make use of the metal forming techniques used in **Design, Model Creation** and **Validation of component** Parts by **Problem Analysis.**	4
	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **Additive manufacturing process.**	2
	PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in **digital manufacturing. standards**	2
CO 6	PO 1	Apply the basic **mathematical principles** used in formulation of **engineering problems.**	2
	PO 2	Understand the working principle used in liquid, solid and powder based 3D Printing Process by **Natural Science and Engineering Sciences.**	2
	PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in **digital manufacturing. standards**	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	2	-	-	3	-	-
CO 2	3	1	-	-	3	-	-	-	-	-	-	-	3	-	-
CO 3	3	-	-	-	3	-	2	-	-	-	-	-	3	-	-
CO 4	3	2	2	-	3	-	-	-	-	-	-	-	3	-	-
CO 5	3	-	-	-	-	-	-	2	2	-	3	-	3	-	-
CO 6	3	-	-	2	-	-	-	-	-	-	-	2	3	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	66.7	-	-	-	-	-	-	-	66.7	-	-	100	-	-
CO 2	100	66.7	-	-	100	-	-	-	-	-	-	-	100	-	-
CO 3	100	-	-	-	100	-	66.7	-	-	-	-	-	1003	-	-
CO 4	100	66.7	66.7	-	100	-	-	-	-	-	-	-	100	-	-
CO 5	100	-	-	-	-	-	-	66.7	66.7	-	100	-	100	-	-
CO 6	100	-	-	66.7	-	-	-	-	-	-	-	66.7	100	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation
2 - 40 % $< C < 60\%$ –Moderate
1-5 $< C \leq 40\%$ – Low/ Slight
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	2	-	-	3	-	-
CO 2	3	1	-	-	3	-	-	-	-	-	-	-	3	-	-
CO 3	3	-	-	-	3	-	2	-	-	-	-	-	3	-	-
CO 4	3	2	2	-	3	-	-	-	-	-	-	-	3	-	-
CO 5	3	-	-	-	-	-	-	2	2	-	3	-	3	-	-
CO 6	3	-	-	2	-	-	-	-	-	-	-	2	3	-	-
TOTAL	18	5	2	2	9	-	2	2	2	-	3	2	18	-	-
AVERAGE	3	1.6	2	2	3	-	2	2	2	-	3	2	3	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1,PO 2	SEE Exams	PO 1,PO 2, PO 4	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 4	Open Ended Experiments	PO4
Assignments	PO 1, PO 2, PO 3, PO 4				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO RAPID PROTOTYPING**
	Introduction: Prototype Fundamentals, Types and Roles of Prototype, Fundamentals of Rapid Prototyping, Phases of Development Leading to Rapid Prototyping, Advantages of Rapid Prototyping and Classifications of Rapid Prototyping System, Generic RP process. Rapid Product Development: An Overview virtual prototyping and testing technology, Physical Prototyping and Rapid Manufacturing technologies and Synergic Integration Technologies.
MODULE II	**LIQUID-BASED RAPID PROTOTYPING SYSTEMS**
	Liquid-Based Rapid Prototyping Systems: Principle, Process parameter, Process details, Advantages, Disadvantages and Applications of Stereolithography Apparatus (SLA), Solid Ground Curing (SGC), Solid Object Ultraviolet-Laser Printer (SOUP), Rapid Freeze Prototyping and Micro fabrication.
MODULE III	**SOLID-BASED RAPID PROTOTYPING SYSTEMS**
	Solid-Based Rapid Prototyping Systems: Principle, Process parameter, Process details, Advantages, Disadvantages and Applications of Laminated Object Manufacturing (LOM); Fused Deposition Modeling (FDM), Paper Lamination Technology (PLT), Multi-Jet Modeling System (MJM) and CAM-LEM.
MODULE IV	**POWDER-BASED RAPID PROTOTYPING SYSTEMS**
	Powder-Based Rapid Prototyping Systems: Principle, Process parameter, Process details, Advantages, Disadvantages and Applications of Selective Laser Sintering (SLS), Laser Engineered Net Shaping (LENS), Multiphase Jet Solidification (MJS), Electron Beam Melting (EBM) and Three-Dimensional Printing (3DP) – Hands on Session.
MODULE V	**RAPID TOOLING**
	Rapid Tooling: Introduction to rapid tooling (RT), Indirect rapid tooling methods: spray metal deposition, RTV epoxy tools, and 3D Keltool process, Direct rapid tooling methods: DTM Rapid Tool Process, EOS Direct Tool Process and Direct Metal Tooling using 3DP.

TEXTBOOKS

1. Chua C K, Leong K F, Chu S L, "Rapid Prototyping: Principles and Applications in Manufacturing", World Scientific, 3rd Edition, 2008.

2. Liou W L, Liou F W, "Rapid Prototyping and Engineering applications: A Tool Box for Prototype Development", CRC Press, 1st Edition, 2007.

REFERENCE BOOKS:

1. Gibson D W Rosen, Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 1st Edition, 2014.

2. Kamrani A K, Nasr E A, “Rapid Prototyping: Theory and practice”, Springer, 1st Edition, 2006.
3. Rafiq I. Noorani, “Rapid Prototyping: Principles and Applications”, John Wiley and Sons, 1st Edition, 2005.

WEB REFERENCES:

1. 1. https://nptel.ac.in/courses/112102103/16 2. https://nptel.ac.in/courses/112107078/37

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
	Discussion on Outcome Based Education		
CONTENT DELIVERY (THEORY)			
1	Introduction to prototype processes.	CO 1	T2:2.3
2	Types and Roles of Prototype	CO 1	R1:2.6
3	Fundamentals of Rapid Prototyping	CO 1	T1:2.6
4	Describe the solidification of casting	CO 1	T2:2.7 R1:2.18
5	Phases of Development Leading to Rapid Prototyping	CO 1	T2:2.22
6	Advantages of Rapid Prototyping	CO 1	T2:2.25
7	Classifications of Rapid Prototyping System	CO 2	T2:2.26 R1:2.55
8	Generic RP process.	CO 2	T2:2.16 R1:2.61
9	An Overview virtual prototyping and testing technology, Physical Prototyping and Rapid Manufacturing technologies and Synergic Integration Technologies.	CO 2	T2:2.30 R1:2.58
10	Principle, Process parameter, Process details of Stereo lithography Apparatus (SLA)	CO 3	T2:3.6 R1:4.29
11	Advantages, Disadvantages of Stereo lithography Apparatus (SLA)	CO 3	T2:3.14 R1:4.31
12	Applications of Stereo lithography Apparatus (SLA)	CO 3	T2:3.14 R1:4.33
13	Principle, Process parameter, Process details of Solid Ground Curing (SGC)	CO 3	R1:4.36
14	Advantages, Disadvantages of Solid Ground Curing (SGC)	CO 4	T2:3.18 R1:4.64
15	Applications of Solid Ground Curing (SGC)	CO 4	T2:3.22

16	Principle, Process parameter, Process details, Advantages, Disadvantages of Solid Object Ultraviolet-Laser Printer (SOUP)	CO 4	T2:3.28 R1:4.67
17	Applications of Solid Object Ultraviolet-Laser Printer (SOUP)	CO 4	T2:4.2
18	Rapid Freeze Prototyping and Micro fabrication	CO 4	T2:4.3 R1:4.71
19	Introduction to Solid based 3D printing	CO 5	T1:4.8 R2:4.68
20-21	Principle, Process parameter, Process details, Advantages, Disadvantages and applications of Laminated Object Manufacturing (LOM)	CO 5	T2:4.15 R1:5.74
22	Discuss Fused Deposition Modeling (FDM)	CO 5	T1:4.12 R2:5.75
23-24	Explanation of Paper Lamination Technology (PLT) operations	CO 5	T1:4.8 R1:5.72
25	Multi-Jet Modeling System (MJM).	CO 5	T1:5.8 R1:5.73
26-27	Principle, Process parameter, Process details, Advantages, Disadvantages and applications of CAD-LEM	CO 5	T1:5.14 R1:6.78
28	Principle, Process parameter, Process details, Advantages, Disadvantages and applications of Selective Laser Sintering (SLS)	CO 6	T2:5.19 R1:6.81
29-30	Discuss Laser Engineered Net Shaping(LENS)	CO 6	T1:6.4 R2:6.8
31	Advantages, Disadvantages and applications of LENS	CO 6	T2:7.7 R1:7.74
32-33	Discuss Multiphase Jet Solidification (MJS)	CO 6	T1:7.12 R2:8.75
34	Advantages, Disadvantages and applications of MJS	CO 6	T1:7.8 R1:8.72
35	Discuss Electron Beam Melting (EBM)	CO 6	T1:8.8 R1:8.73
36	Advantages, Disadvantages and applications of EBM	CO 6	T1:9.14 R1:10.78
37-38	Describe the importance of Introduction to rapid tooling (RT),	CO 6	T2:9.19 R1:10.814
39-40	Describe the importance of Indirect rapid tooling methods: spray metal deposition, RTV epoxy tools, and 3D Keltool process,	CO 6	T1:10.4 R2:11.68

41-43	Discuss the Direct rapid tooling methods: DTM Rapid Tool Process, EOS Direct Tool Process and Direct Metal Tooling using 3DP.	CO 6	T2:10.7 R1:12.74
44-45	Discuss various case studies related to Additive Manufacturing Technologies	CO 6	T1:11.12 R2:12.75

Signature of Course Coordinator **HOD,ME**
Mr. A. Venu Prasad Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Robotics**				
Course Code	AME533				
Program	B.Tech				
Semester	VII				
Course Type	Professional Elective				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	3	-	-
Course Coordinator	Mr. A. Anudeep Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS002	I	Linear Algebra and Ordinary Differential Equations
B.Tech	AME002	II	Engineering Mechanics

II OURSE OVERVIEW:

Robotics is recognized as one of the important aids of mechatronics systems and provides applications in the unmanned areas of industrial automation. The course emphasis on the design and developments of robot geometry, sensors and actuators to meet the kinematics requirements and trajectory planning of the manipulator. The overall applications in the manufacturing automation is to minimal elimination of human intervention.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Robotics	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	✓	Seminars	x	Mini Project	✓	Videos
✓	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
15%	Remember
50%	Understand
35%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

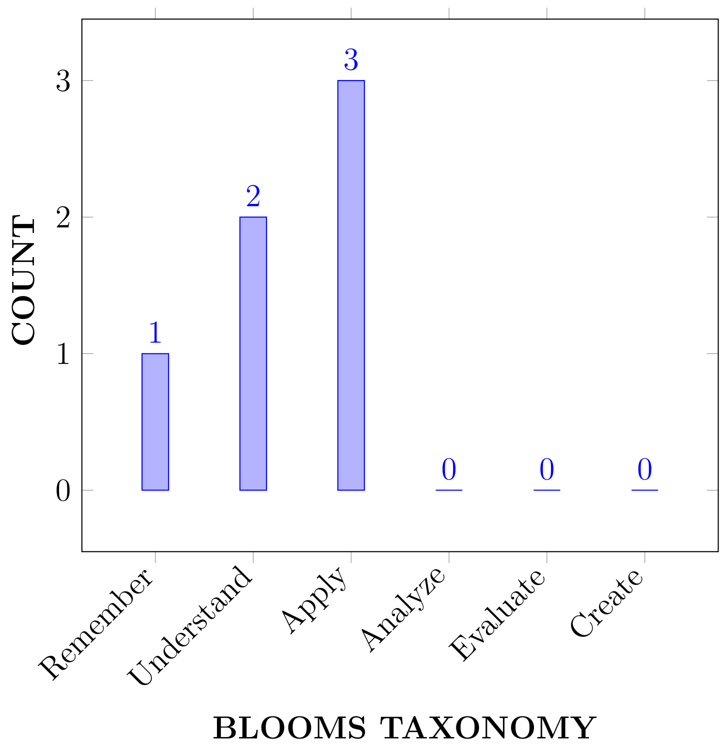
I	The fundamental concepts of various configurations of the robot manipulators and their working principles used in the industries.
II	The circuit design and operation for generation of high DC, AC and impulse voltages.
III	The path planning of a robot manipulator for given polynomial equation and how to avoid obstacles in its path.
IV	The performance of various feedback components like sensors and actuators and how they can be used according to the specifications of the manipulator.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Outline** the relationship between mechanical structures of industrial robots and their operational workspace characteristics.	Understand
CO 2	**Demonstrate** an ability to apply spatial transformation to obtain forward kinematics equation of robot manipulators.	Apply
CO 3	**Develop** the mechanism for solving forward and inverse kinematics of simple robot manipulators.	Apply
CO 4	**Develop** an ability to obtain the Jacobian matrix and use it to identify singularities.	Apply
CO 5	**Outline** the various motions of the manipulator and use it for trajectory.	Understand
CO 6	**Illustrate** the considerations of workspace for a given robot application.	Remember

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety,and the cultural, societal, and Environmental considerations
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings..
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	1	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety,and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT

PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 3	Make use of computational and experimental tools for building career paths towards innovative start-ups, employability and higher studies.	3	CIE/SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	✓		-	-	-	-	-	-	-	-	-	-
CO 4	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	✓
CO 6	✓	✓	✓	-	-	-	-	-	-	-	-		-	-	✓

XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUT COMES	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key Competencies**
CO 1	**PO 1**	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and physics and **engineering fundamentals**.	2

CO 2	**PO 1**	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	2
	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	3
CO 3	**PO 4**	Investigate prototype models based on constraint including Environmental sustainability, Health and safety risks assessment issues and define specific problem.	2
CO 4	**PO 3**	Design the solution for problems of voltage doublers and multiplier circuits	3
CO 5	**PO 2**	Make use of the metal forming techniques used in Design, Model Creation and Validation of component Parts by Problem Analysis.	4
	PO 3	Understand the given problem statement related to their working principle and based upon type of robotics.	2
	PSO 3	Build practical experience in building the real time products, using automation.	2
CO 6	**PO 1**	Apply the basic mathematical principles used in formulation of engineering problems.	2
	PO 2	Understand the working principle used in robotics for trajectory planning.	2
	PSO 3	Identify the principle involved in robot actutators for varied applications.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	**Program Outcomes/ No. of Key Competencies Matched**												**PSO'S**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	4	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	2	2	-	-	-	-	-	-	-	-	-	-	-	-	2

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	66.7	30.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	18.18	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	30.0	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	40.0	20.0	-	-	-	-	-	-	-	-	-	-	-	100.0
CO 6	66.7	20.0	-	-	-	-	-	-	-	-	-	-	-	-	100.0

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

2 - $40\ \% < C < 60\%$ –Moderate

1-5 $< C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	1	2	-	-	-	-	-	-	-	-	-	-	-	3
CO 6	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3
TOTAL	9	3	4	1	-	-	-	-	-	-	-	-	-	-	6
AVERAGE	3.0	1.0	2.0	1.0	-	-	-	-	-	-	-	-	-	-	3.0

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1,PO 2	SEE Exams	PO 1,PO 2, PO 3	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 1,PO 2 ,PO 4	Open Ended Experiments	-
Assignments	PO 1,PO 2, PO 3	Tech Talk	PO 4	-	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

X	Assessment of Mini Projects by Experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO AUTOMATION AND ROBOTICS**
	Introduction: Automation and robotic, an over view of robotics, classification by coordinate system and control systems, components of the industrial robotics: Degrees of freedom, end effectors: mechanical gripper, magnetic vacuum cup and other types of grippers, general consideration on gripper selection and design, robot actuator and sensors.
MODULE II	**MOTION ANALYSIS**
	Motion analysis: Basic rotation matrices, composite rotation matrices, equivalent angle and axis homogeneous transformation, problems; Manipulator kinematics: D-H notations, joint coordinates and world coordinates, forward and inverse kinematics, problems.
MODULE III	**DIFFERENTIAL KINEMATICS**
	Differential kinematics: Differential kinematics of planar and spherical manipulators, Jacobians problems. Robot dynamics: Lagrange, Euler formulations, Newton-Euler formulations, problems on planar two link manipulators.
MODULE IV	**TRAJECTORY PLANNING**
	Trajectory planning: Joint space scheme, cubic polynomial fit, avoidance of obstacles, types of motion: Slew motion, joint interpolated motion, straight line motion, problems, robot actuators and feedback components; actuators: pneumatic.
MODULE V	**ROBOTIC APPLICATIONS**
	Robot application in manufacturing: Material handling, assembly and inspection, work cell design.

TEXTBOOKS

1. M. P. Groover, "Industrial Robotics", Pearson, 2nd Edition, 2012.
2. J.J Criag, "Introduction to Robotic Mechanics and Control", Pearson, 3rd Edition, 2013.

REFERENCE BOOKS:

1. K.S Fu, "Robotics", McGraw-Hill, 1st Edition, 2013.
2. Richard, D. Klafter, Thomas A Chmielewski, Miachael Neigen, "Robotic Engineering An Integrated Approach", Prentice Hall, 1st Edition, 2013.
3. Asada, Slotine, "Robot Analysis and Intelligence", Wiley, 1st Edition, 2013.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
	Introduction to Outcome Based Education		
1	Introduction to Automation and Robotics.	CO 1	T1:1.1
2	Determination of Kinematics of robot.	CO 2	T1:2.2
3	Determination of Dynamics of robot.	CO 3	T1:3.1
4	Trajectory path of manipulator and its importance.	CO 4	T1:4.1
5	Applications of robot in industtries.	CO 6	T1:5.1
CONTENT DELIVERY (THEORY)			
S.No	**Topics to be covered**	**CO's**	**Reference**
6	Introduction to automation.	CO 1	T1:1.1
7	Classification of automation and its role.	CO 1	T1:1.1
8	Introduction to robotics.	CO 1	T1:1.2
9	Need of automation and robotics in manufacturing.	CO 1	T1:1.3
10	Degrees of freedom and its classification.	CO 1	T1:1.4
11	Classification of robots based on degrees of freedom and control.	CO 1	T1:1.5
12	Description of Robot Components.	CO 1	T1:1.6
13	Classification of robot end effectors.	CO 1	T1:1.7
14	Gripper force calculation.	CO 1	T1:1.8
15	Requirement of gripper selection features.	CO 1	T1:1.9
16	Classification of robot actuators.	CO 1	T1:1.10
17	Classification of robot sensors.	CO 1	T1:1.11
18	Introduction to robot motion analysis.	CO 2	T1:2.1
19	Manipulator rotational matrices.	CO 2	T1:2.2
20	Composite rotation matrices, equivalent angle .	CO 2	T1:2.3
21	Homogeneous transformations of the manipulator.	CO 2	T1:2.4
22	Joint space coordinates and world space coordinates.	CO 2	T1:2.5
23	Introduction to Manipulator kinematics.	CO 2	T1:2.6
PROBLEM SOLVING/ CASE STUDIES			
24	Forward kinematics of 2 D.O.F in 2D and 3D.	CO 2	T1:2.7
25	Forward kinematics of 3 D.O.F in 2D and 3D.	CO 2	T1:2.8
26	Inverse kinematics of 2 D.O.F in 2D and 3D.	CO 2	T2:2.9
27	Inverse kinematics of 3 D.O.F in 2D and 3D.	CO 2	T2:2.10
28	Denavit-Hartenberg notation of the manipulator.	CO 2	T2:2.11
29	Problems related to transformation of manipulator in various axes.	CO 2	T2:2.12
30	Derivation of Lagrange-Euler equation and solution of problems different configuration of robots	CO 3	R2:3.1
31	Derivation of Lagrange-Euler equation and solution of problems different configuration of robots	CO 3	R2:3.1

32	Derivation of Newton-Euler equation and solution of problems different configuration of robots.	CO 3	R2:3.2
33	Derivation of Newton-Euler equation and solution of problems different configuration of robots.	CO 3	R2:3.2
34	Problems on differential motion derivation of jacobian matrix for various configuration.	CO 3	R2:3.3
35	Problems on planar two link manipulators.	CO 4	R2:3.4
36	Introduction to trajectory planning.	CO 4	R2:4.1
37	Illustration of Joint space motion for both straight line and point to point.	CO 5	R2:4.2
38	Illustration of slew motion and interpolated motion.	CO 5	R2:4.3
39	Explanation of polynomial equation for various types of motion and solution of Problems in various types of trajectories.	CO 5	R2:4.4
40	Cubic polynomial fit of the trajectory.	CO 5	R2:4.5
41	Solving of problems on cubic polynomial fit.	CO 5	R2:4.6
42	Avoidance of obstacles in robot path.	CO 5	R2:4.7
DISCUSSION OF DEFINITION AND TERMINOLOGY			
43	Classification of robot actuators.	CO 5	R1:4.8
44	Description of Hydraulic actuators.	CO 5	R2:4.9
45	Description of Pneumatic actuators.	CO 5	R2:4.10
46	Description of Electric actuators.	CO 5	R2:4.11
47	Classification of feedback components.	CO 5	R2:4.12
48	Classification of feedback components.	CO 5	R2:4.13
49	Function wise description of various configuration of robots for different applications	CO 6	T1:5.1
50	Function wise description of various configuration of robots for different applications	CO 6	T1:5.2
51	Role of robots in material handling.	CO 6	T1:5.3
52	Role of robots in material handling.	CO 6	T1:5.4
53	Applications of robots in manufacturing.	CO 6	T1:5.5
54	Applications of robots in manufacturing.	CO 6	T1:5.6
DISCUSSION OF QUESTION BANK			
55	Description of robot work cell design of the robot.	CO 6	T1:5.7
56	Description of robot work cell design of the robot.	CO 6	T1:5.8
57	Palletizing by the robot.	CO 6	T1:5.9
58	Machine loading and unloading using the robot.	CO 6	T1:5.9
59	Part selection and transfer using the robot.	CO 6	T1:5.10
60	Robots in assembly operations.	CO 6	T1:5.11

Signature of Course Coordinator **HOD,MECH**
Mr.A. Anudeep Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**					
Course Title	ENERGY FROM WASTE					
Course Code	AEE551					
Program	B.Tech					
Semester	VII					
Course Type	Open Elective-II					
Regulation	IARE - R16					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	-	3	-	-	
Course Coordinator	Mr. Ch.Balakrishna, Assistant Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB07	II	Environmental Studies

II COURSE OVERVIEW:

The course is designed to create environmental awareness and consciousness among the present generation to become environmental responsible citizens. The course will discuss on the municipal solid waste composition, characteristics and to improve the methods to minimize municipal solid waste generation. This course deals with methods of disposal of solid waste by thermal biochemical processes and production of energy from different types of waste sand to know the environmental impacts of all types of municipal waste. This course will discuss the overall scenario of E-Waste management in India in comparison with other countries around the globe. This course will deals with E-waste legislation and government regulations on E-waste management.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Energy From Waste	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
20%	Remember
60%	Understand
20%	Apply
0%	Analyze
0%	Evaluate

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Open Ended Experiment
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

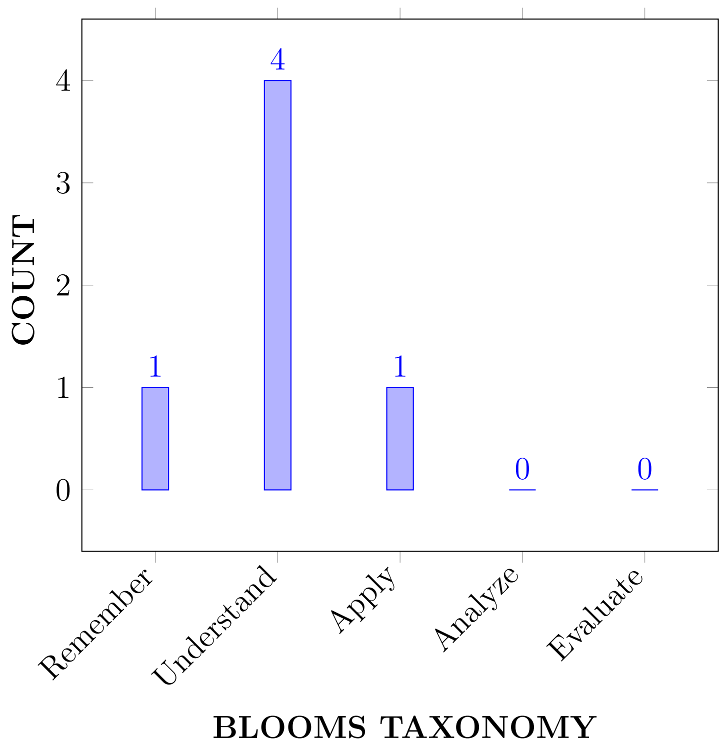
I	The principles of solid waste management in reducing and eliminating dangerous impacts of waste materials on human health and the environment to contribute economic development and superior quality of life.
II	The insight of the design and operations of a municipal solid waste landfill by collection, transfer and transportation of municipal solid waste for the final disposal.
III	The main operational challenges in operating thermal and biochemical energy from waste facilities and device processes involved in recovering energy from wastes.
IV	The scenario of E-Waste management in India and other countries around the globe and assess the impact of electronic waste on human, environment and society by informal recycling and management. The sustainable solution of E-Waste Management can be achieved by adopting modern techniques and Life-Cycle Analysis approach.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** the different sources, types of solid waste by the properties of municipal solid waste for segregation and collection of waste.	Remember
CO 2	**Understand** the Composition, characteristics of leachate and preliminary design considerations of landfill to control the emission of gases and monitoring the movement of landfill leachate.	Understand
CO 3	**Outline** the Biochemical conversion of biomass for energy generation by anaerobic digestion of solid waste.	Understand
CO 4	**Illustrate** the thermo-chemical conversion of solid waste by using Gasification and pyrolysisprocess for energy generation.	Understand
CO 5	**Identify** the need to stringent health safeguards and environmental protection laws of India for the effective disposal of E-waste.	Apply
CO 6	**Interpret** the global scenario of environmental concerns and health hazards by the generation of E- waste.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

Program Outcomes	
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/SEE/AAT
PO 3	**Design/development of solutions:** : Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	1	CIE/SEE/AAT
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	CIE/SEE/AAT
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	3	CIE/Quiz/AAT

PO 12	**Life-long learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 2	Focus on Improving Performance of Structures with reference to Safety, Serviceability and Sustainable Green Building Technology.	3	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	✓	-	-	✓	✓	-	-	-	-		-	-	-
CO 2	-	-	✓	-	-	✓	-	-	-	-	-	-	-	-	-
CO 3	✓	-	-	-	-	✓	✓	-	-	-	-	-	-	✓	-
CO 4	✓	-	✓	-	-	-	✓	-	-	-	-		-	-	-
CO 5	-	-	-	-	-	✓	-	-	-	-	-	✓	-	✓	-
CO 6	-	-	-	-	-	✓	-	-	-	-	-	✓	-	-	-

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key competencies matched.**
CO 1	PO 1	Apply the **Scientific principles** for energy generation by applying different technologies from waste management plants.	1
	PO 3	Identify the **constraints including environmental health and safety and risk assessment issues** of different methods of disposal of municipal solid waste by aerobic composting **to promote sustainable development.**	2
	PO 6	Apply the **knowledge of management techniques** by understanding the **requirement for engineering activities**of municipal solid waste for the **sustainable development**.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 7	Interpret the discarding of solid waste and their impact on **socio economic, environment** is considered and energy generation activities by aerobic composting of waste.	2
CO 2	PO 3	Identify **constraints including environmental and sustainability limitations, health and safety and risk assessment issues** for environmental monitoring system of land fill gases and composition of leachate and **Understanding commercial and economic context** of managing the land fill site	2
	PO 6	Understand the characteristics, generation and movement of leachate in landfills by the **management techniques** which uses for controlling the emission of gases in landfills **to promote sustainable development**	2
CO 3	PO 1	Explain the **Scientific principles** for Energy generation from waste bio-chemical conversion and **to integrate / support the engineering disciplines**	2
	PO 6	Apply the knowledge in planning and operations of waste to Energy plants **for sustainable development** by following **legal legislation** related to solid waste management for **high level of professional and ethical values.**	3
	PO 7	Identify the sources of energy generation by anaerobic digestion of sewage and municipal waste for **socio economic solutions** and direct combustion of municipal solid waste for environmental solutions.	2
	PSO 2	Identify the Energy generation processes from waste by bio-chemical conversion and help in **Sustainable** development and **Safety** of the public life.	2
CO 4	PO 1	Illustrate the methods of pyrolysis process by understanding **Scientific principles and methodology** and apply to **integrate / support study of their own engineering discipline** for solving environmental problems	2
	PO 3	Interpret thermo-chemical conversion sources of energy generation, gasification of waste and **identify constraints including environmental and sustainability limitations**	2
	PO 7	Understand the environmental benefits by using thermo-chemical process will decrease the emission of harmful gases and will attain **Environmental sustainability.**	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 5	PO 6	Define the global scenario of environmental concerns by the increase in the generation of E-waste worldwide causing the **personnel, health, safety, and risk (including environmental risk) issues** and the problem can solved by imposing strong legal regulation for disposing of E-waste and help in **sustainable development**	2
	PO 12	List out the health hazards by the generation of E-waste and their impact on environment will be solved by the proper management and formal disposal of E-waste and this can be achieved by long term learning process in **Professional certifications, advanced degree** for developing advanced technologies in recycling of E-waste.	2
	PSO 2	Apply strong environmental protection laws in India for the effective disposal of E-waste and constraints including environmental and **sustainability** development and while recycling the E-waste and problem including production, operation, maintenance and disposal with proper **safety**	2
CO 6	PO 6	Define the global scenario of environmental concerns by the increase in the generation of E-waste worldwide causing the **personnel, health, safety, and risk (including environmental risk) issues** and the problem can solved by imposing strong legal regulation for disposing of E-waste and help in **sustainable development**	2
	PO 12	List out the health hazards by the generation of E-waste and their impact on environment will be solved by the proper management and formal disposal of E-waste and this can be achieved by long term learning process in **Professional certifications, advanced degree** for developing advanced technologies in recycling of E-waste.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	-	2	-	-	3	2	-	-	-	-	-	-	-	-
CO 2	-	-	2	-	-	2	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	3	2	-	-	-	-	-	-	2	-
CO 4	2	-	2	-	-	-	1	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	-	2	-	-	-	-	-	2	-	2	-
CO 6	-	-	-	-	-	2	-	-	-	-	-	2	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	-	20.0	-	-	60.0	66.6	-	-	-	-	-	-	-	-
CO 2	-	-	20.0	-	-	40.0	-	-	-	-	-	-	-	-	-
CO 3	66.6	-	-	-	-	60.0	66.6	-	-	-	-	-	-	66.6	-
CO 4	66.6	-	20.0	-	-	-	33.3	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	-	40.0	-	-	-	-	-	25	-	66.6	-
CO 6	-	-	-	-	-	40.0	-	-	-	-	-	25	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation ***1*** -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	1	-	1	-	-	2	3	-	-	-	-		-	-	-
CO 2	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	2	3	-	-	-	-	-	-	3	-
CO 4	3	-	1	-	-	-	1	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	1	3	-	-	-	-	1	-	3	-
CO 6	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-
TOTAL	10	-	3	-	-	7	10	-	-	-	-	2	-	6	-
AVERAGE	3.0	-	1.0	-	-	1.0	3.0	-	-	-	-	1.0	-	3.0	

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	-	Tech talk	-	-	

XVII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

UNIT - I	**INTRODUCTION TO WASTE AND WASTE PROCESSING**
	Solid waste sources solid waste sources, types, composition, properties, global warming; Municipal solid waste: Physical, chemical and biological properties, waste collection and, transfer stations, waste minimization and recycling of municipal waste, segregation of waste, size reduction, managing waste, status of technologies for generation of energy from waste treatment and disposal aerobic composting, incineration, furnace type and design, medical waste / pharmaceutical waste treatment technologies, incineration, environmental impacts, measures to mitigate environmental effects due to incineration
UNIT - II	**WASTE TREATMENT AND DISPOSAL**
	Land fill method of solid waste disposal land fill classification, types, methods and sitting consideration; Layout and preliminary design of landfills: Composition, characteristics, generation, movement and control of landfill leachate and gases, environmental monitoring system for land fill gases.
UNIT - III	**BIO-CHEMICAL CONVERSION**
	Energy generation from waste bio-chemical conversion: Sources of energy generation, anaerobic digestion of sewage and municipal waste, direct combustion of MSW-refuse derived solid fuel. Industrial waste, agro residues and anaerobic digestion.
UNIT - IV	**THERMO-CHEMICAL CONVERSION**
	Biogas production, land fill gas generation and utilization, thermo-chemical conversion: Sources of energy generation, gasification of waste using gasifies briquetting, utilization and advantages of briquetting, environmental benefits of bio-chemical and thermo- chemical conversion

UNIT - V	**E-WASTE MANAGEMENT**
	E-waste: E-waste in the global context: Growth of electrical and electronics industry in India, environmental concerns and health hazards; Recycling e-waste: A thriving economy of the unorganized sector, global trade in hazardous waste, impact of hazardous e-waste in India; Management of e-waste: E-waste legislation, government regulations on e-waste management, international experience, need for stringent health safeguards and environmental protection laws of India.

TEXTBOOKS

1. Nicholas P Cheremisinoff, —Handbook of Solid Waste Management and Waste Minimization Technologie, An Imprint of Elsevier, New Delhi, 2003.
2. P AarneVesilind, William A Worrell and Debra R Reinhart, —Solid Waste Engineering, 2 nd edition 2002.
3. M Dutta , B P Parida, B K Guha and T R Surkrishnan, —Industrial Solid Waste Management and Landfilling practice, Reprint Edition New Delhi, 1999.
4. RajyaSabha Secretariat, —E-waste in India: Research unit, Reprint Edition, June, 2011.

REFERENCE BOOKS:

1. C Parker and T Roberts (Ed), —Energy from Waste, An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
2. KL Shah,"Basics of Solid and Hazardous Waste Management Technology", Prentice Hall, Reprint Edition, 2000.
3. M Datta, —"Waste Disposal in Engineered Landfill", Narosa Publishing House, 1997.

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference T1: 4.1
	OBE DISCUSSION		
1	Outcome Based Education, CO PO attainment and Blooms Taxonomy		
	CONTENT DELIVERY (THEORY)		
1	Sources of Municipal Solid waste	CO 1	T1:3.3, T2:1.2, R2: 2.2
2	Types of Municipal Solid waste	CO 1	T1:3.4, T2:1.4
3	Composition of Municipal Solid waste	CO 1	T1:3.5, R2:1.5
4	Effects of Global warming	CO 1	T1:3.7, R2:1.8
5	Segregation of waste, size reduction and managing waste	CO 1	T1: 3.9, R3: 1.10
6	Waste collection and transfer stations	CO 1	T1:5.5, T2:6.2, R3:4.8

7	Waste minimization and recycling of municipal waste	CO 1	T1:5.6, T2:6.3, R3:7.5
8	Properties of Municipal solid waste	CO 1	T1:4.3, T2:5.2, R2: 5.7
9	Incineration, furnace type and design	CO 1	T1: 4.4, R1:3.3
10	Measures to mitigate environmental effects due to incineration	CO 1	T1:4.5, T2: 5.4, R3: 7.3
11	Land fill methods and disposal of solid waste	CO 2	T1:4.6, T2:5.5
12	land fill classification	CO 2	T1: 4.5.2, T2: 5.6
13	Landfill sitting consideration	CO 2	T1:4.6, T2:5.5
14	Layout and preliminary design of landfills	CO 2	T1:4.6.2, T2:5.5.2
15	Characteristics and composition of landfill	CO 2	T1:4.7, T2:5.6
16	Movement and control of landfill leachate and gases	CO 2	T1:4.7, T2:5.8
17	Environmental monitoring system for land fill gases	CO 2	T1:4.7.2, T2:5.8.2
18	Energy generation from waste by bio-chemical conversion	CO 3	T1:4.8, T2:5.9
19	Sources of energy generation from bio solid waste	CO 3	T1:4.9, T2:5.7
20	Anaerobic digestion of sewage and municipal waste	CO 3	T1:6.2, T2:5.6
21	Direct combustion of MSW-refuse derived solid fuel	CO 3	T1:6.3, T2:5.7
22	Industrial waste, agro residues and anaerobic digestion	CO 3	T1:6.4, T2:5.8
23	Biogas production	CO 3	T1:6.5, T2:5.3
24	land fill gas generation and utilization	CO 3	T1:6..6, T2:5.2
25	Thermo-chemical conversion	CO 4	T1:6.7, T2:5.3
26	Sources of energy generation	CO 4	T1:6.5, T2:7.5
27	Gasification of waste using gasifies briquetting	CO 4	T1: 6.2, R2:7.9
28	Utilization and advantages of briquetting	CO 4	T1: 6.2
29	Environmental benefits of bio-chemical	CO 4	T1:6.2, T2:7.2
30	E-waste in the global context	CO 5	T1:6.3, T2:7.3
31	Growth of electrical and electronics industry in India	CO 5	T1:6.4, T2:7.5
32	Environmental concerns and health hazards	CO 5	T1: 6.2, T2: 5.6
33	Recycling e-waste	CO 5	T1:6.3, T2: 5.7
34	A thriving economy of the unorganized sector and global trade in hazardous waste	CO 5	T1:6.4, T2:5.8
35	Impact of hazardous e-waste in India	CO 5	T1:2.1, T2:9.1
36	Management of e-waste	CO 5	T1:2.2, T2:9.2

37	E-waste legislation	CO 5	T1: 2.1, R2: 9.1
38	Government regulations on e-waste management	CO 5	T1:2.6, R1:5.1
39	International experience in management of e-waste	CO 6	T1:2.7, R1:5.2
40	Need for stringent health safeguards and environmental protection laws of India.	CO 6	T1:2.8, R1:5.5
41	Summarize government regulations on E-waste management	CO 6	T1:2.1, R1:5.6
42	Outline international E-waste management and the guidelines imposed for formal disposal	CO 6	T1:2.2, R1:5.4
43	Explain the need for stringent health safeguards of human health and their effects	CO 6	T1:2.4,R1:5
44	Discuss the need for environmental protection laws and	CO 6	T1:2.4, R1:5.5
45	Outline environmental protection laws of India with respect to E-waste management.	CO 6	T1:2.4, R1:5.5
PROBLEM SOLVING/ CASE STUDIES			
1	Explain different Types of Municipal Solid waste	CO 1	T1:3.3, T2:1.2, R2: 2.2
2	Explain the Composition of Municipal Solid waste	CO 1	T1:3.4, T2:1.4
3	Effects of Global warming	CO 1	T1:3.5,R2:1.5
4	Illustrate the importance of Land fill classification	CO 2	T1:4.5, T2: 5.4, R3: 7.3
5	Landfill sitting consideration	CO 2	T1:4.6, T2:5.5
6	Layout and preliminary design of landfills	CO 2	T1: 4.5.2, T2: 5.6
7	Anaerobic digestion of sewage and municipal waste	CO 3	T1:4.6, T2:5.5
8	Direct combustion of MSW-refuse derived solid fuel	CO 3	T1:4.6.2, T2:5.5.2
9	Industrial waste, agro residues and anaerobic digestion	CO 3	T1:4.7, T2:5.6
10	Explain the Thermo-chemical conversion	CO 4	T1:4.7, T2:5.8
11	E-waste in the global context	CO 5	T1:4.7.2, T2:5.8.2
12	Growth of electrical and electronics industry in India	CO 5	T1:4.7.2, T2:5.8.2
13	E-waste legislation	CO 5	T1:4.8, T2:5.9
14	Government regulations on e-waste management	CO 6	T1:4.9, T2:5.7
15	International experience in management of e-waste	CO 6	T1:6.3, T2: 5.7

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Solid waste sources solid waste sources, types, composition, properties, Municipal solid waste: Physical, chemical and biological properties, waste collection and, transfer stations, waste minimization and recycling of municipal waste, environmental impacts, measures to mitigate environmental effects due to incineration	CO 1	T1:1.5, T2: 5.4, R3: 7.3
2	Land fill method of solid waste, classification, types, methods and sitting consideration; Layout and preliminary design of landfills: Composition, characteristics, generation, movement and control of landfill leachate and gases, environmental monitoring system for land fill gases.	CO 2	T1:4.5, T2: 5.4, R3: 7.2
3	Energy generation from waste bio-chemical conversion: Sources of energy generation, anaerobic digestion of sewage and municipal waste, direct combustion of MSW-refuse derived solid fuel. Industrial waste, agro residues and anaerobic digestion.	CO 3	T1:4.5, T2: 5.4, R3: 7.3
4	Biogas production, land fill gas generation and utilization, thermo-chemical conversion:gasification of waste using gasifies briquetting, utilization and advantages of briquetting, environmental benefits of bio-chemical and thermo- chemical conversion	CO 4	T1:4.5, T2: 5.4, R3: 7.3
5	E-waste in the global context: Growth of electrical and electronics industry in India, environmental concerns and health hazards; global trade in hazardous waste, Management of e-waste, legislation, government regulations on e-waste management, international experience and environmental protection laws of India	CO 5	T1:4.5, T2: 5.4, R3: 7.3
DISCUSSION OF QUESTION BANK			
1	Explain the composition of Municipal solid waste and various types of solid waste in detail.	CO 1	T1:3.3, T2:1.2, R2: 2.2
2	Explain the various phases of municipal solid waste decomposition in a closed landfill cell.	CO 2	T 1.4:7.3
3	Explain in-detail step by step procedure of bio-chemical conversion	CO 3	T1:6.2, T2:5.6
4	Discuss in detail the process of biogas production in thermo chemical conversion.	CO 4	T1:6.7, T2:5.3
5	Discuss in detail about regulations by government on e-waste management	CO 5, CO 6	T1:2.4, R1:5.5

Signature of Course Coordinator **HOD, ME**
Mr. Ch.Balakrishna, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	COMPUTER AIDED MODELLING AND ANALYSIS LABORATORY				
Course Code	AME114				
Program	B.Tech				
Semester	VII	ME			
Course Type	Lab				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. D.Atchuta Ramacharyulu, Assistant Professor				

I COURSE OVERVIEW:

In this laboratory the students learn the fundamentals of Computer Aided Modelling and analysis using CAD softwares. Prepare the 2-D and 3-D drawings unsing parametric solid software's as per industry template. Able to solve vector and scalar problems for structural and thermal field using analysis softwares.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME102	II	Computer Aided Engineering Drawing Practice

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computer Aided Modelling and Analysis Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

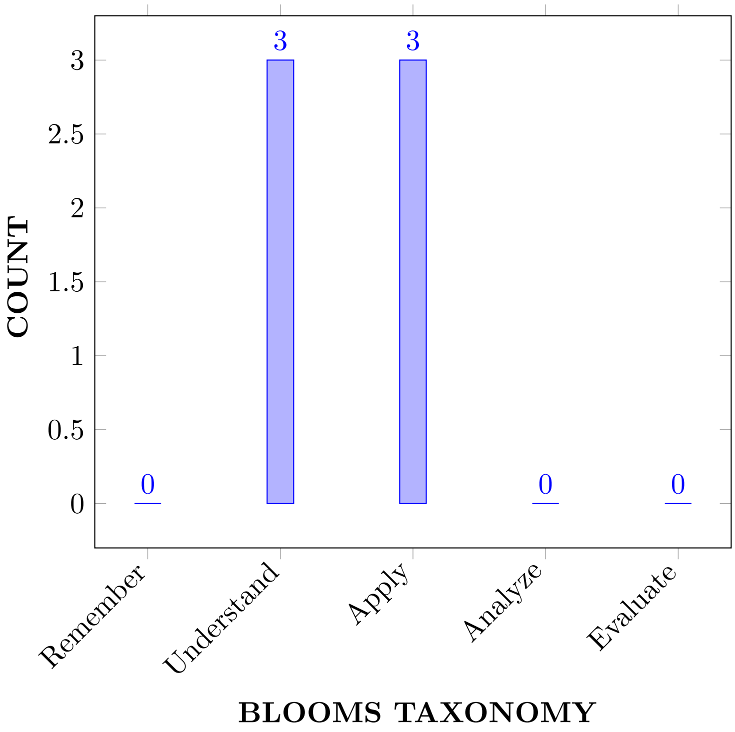
I	Understand code of drawing practice as per BIS conventions for mechanical elements using CAD software.
II	Prepare the 2-D and 3-D drawings using parametric solid software‘s as per industry templates.
III	Solve vector and scalar problems for structural and thermal fields using analysis software‘s.
IV	Summarize computer aided engineering results with real time problems.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Understand** the concept of using 2D drawing softwares using CATIA .	Apply
CO 2	**Understand** the generation of solid models in CATIA	Apply
CO 3	**Demonstrate** the creation of Solid modelling, Beams, Trusses, Shells structures in CTIA	Understand
CO 4	**Understand** the concept of unsing ANSYS for different strucures.	Understand
CO 5	**Demonstrate** various analysis of solid models, trusses and beams	Apply
CO 6	**Understand** production drawing and part drawing of objects using CATIA.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises

PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIA
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	**Justification for mapping (Students will be able to)**	No. of Key Competencies
CO 1	PO 1	Explain qualitatively about motion of CNC Machines in three-dimensions **using the principles of mathematics and engineering fundamentals.**	3
	PO 2	Application of synthetic and free form surfacengeneration equations to **create coon's surfaces on CNC machine centres and 2D contour surfaces on turning centres through simulation techniques.**	3
	PSO 3	Apply (**knowledge**) The application of high speed techniques by **using latest art of cutting tools technology for hard to machine components**	1
CO 2	PO 2	Use the retrieval and generative type process plans to minimize the ideal time to **minimize the shortest possible path.**	6
CO 3	PO 1	Use the mathematical model to justify ABC Analysis and economic order quantities in manufacturing planning	3
	PSO 1	**Make use of experimental tools for innovation** to assess high speed machining and rapid prototyping.	3
CO 4	PO 1	Recognize (knowledge) the importance and application (apply) of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the **principles of Mathematics, Science and Engineering**	3

	PO 5	Understand the given **problem statement and formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern fluid systems in designing prototypes devices	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 5	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics.	3
	PO 3	Understand the given **problem statement** and formulate (complex) fluid flow engineering phenomena and system for deriving various governing equations of fluid mechanics from the provided information and substantiate with the **interpretation** of variations in the results.	2
	PO 5	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of fluid mechanics.	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 6	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** principles to understand the Bernoulli Equation for real flows and its applications	2
	PO 3	Using Euler equation of motion derive the Bernoulli equation to analyze complex fluid flow problems using **principles of mathematics and engineering sciences.**	3
CO 7	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** for determining unit indicators, and performance of hydraulic machines such as speed, discharge and power numbers etc for designing the new equipment's as per the requirements	2
	PO 5	Using first **principles of Sciences and Engineering fundamentals** understand the concept of unit indicators, and performance of hydraulic machines such as speed, discharge and power numbers for designing desired equipment's.	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of hydraulic machine performance.	1

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES		PSO'S
	PO 1	PO 2	PSO 1
CO 1	3	3	1
CO 2		2	
CO 3	3		1
CO 4	3		1
CO 5		2	
CO 6		2	

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO1, PO2, PO4, PSO1	SEE Exams	PO1, PO2	Seminars	PO1, PO2
Laboratory Practices	PO 1, PO 2, PSO 1	Student Viva	PO 1, PO 2	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**INTRODUCTION TO CATIA**
	Familiarization and practicing of drawing and modifying commands, template creation, lettering, object snapping and sectioning
WEEK II	**DRAFTING OF SIMPLE 2D DRAWINGS**
	Prepare the 2D drawings using draw and modify commands for simple geometric assemblies, sectional views for part drawing and assemblies.
WEEK III	**SOLID MODELING**
	Preparing the 2D and 3D models (wire frame, surface and solid models) by using B-REP, CSG. Introduction of Boolean operations. Generation of 2D, 3D models through protrusion, revolve, sweep.

WEEK IV	**CREATING ORTHOGRAPHIC VIEWS FROM SOLID MODELS**
	Development of orthographic views for assembly drawings and preparation of bill of materials(IC engine components, Machine tool accessories, Jigs and Fixtures).
WEEK V	**INTRODUCTION TO ANSYS**
	Determination of deflection and stresses in bar.
WEEK VI	**TRUSSES AND BEAMS**
	Determination of deflection and stresses in 2D and 3D trusses and beams.
WEEK VII	**SHELL STRUCTURES**
	Determination of stresses in 3D and shell structures (one example in each case).
WEEK VIII	**HARMONIC ANALYSIS**
	Estimation of natural frequencies and mode shapes, harmonic responses of 2D beams.
WEEK IX	**HEAT TRANSFER ANALYSIS**
	Steady state heat transfer analysis of plane and axi-symmetric components.
WEEK X	**CONVENTIONAL REPRESENTATION OF MATERIALS**
	Conventional representation of parts screw joints, welded joints, springs, gears, electrical, hydraulic and pneumatic circuits, methods of indicating notes on drawings.
WEEK XI	**LIMITS, FITS AND TOLERANCES**
	Fundamentals of CNC programming, Part programming and interpolation techniques, Work piece setting methods, tool setting methods
WEEK XII	**FORM AND POSITIONAL TOLERANCES**
	Introduction and indication of form and position tolerances on drawings, types of run out, total run out and their indication.
WEEK XIII	**SURFACE ROUGHNESS AND ITS INDICATION**
	Definition, types of surface roughness indication surface roughness obtainable from various manufacturing processes, recommended surface roughness on mechanical components. Heat treatment and surface treatment symbols used on drawings
WEEK XIV	**DETAILED AND PART DRAWINGS**
	Drawing of parts from assembly drawings with indications of size, tolerances, roughness, form and position errors.
WEEK XV	**PRODUCTION DRAWING PRACTICE**
	Part drawings using computer aided drafting by CAD software.

TEXTBOOKS

1. K.L. Narayana, P. Kannaiah, —Production Drawing‖, New Age publishers, 3rd Edition, 2009.

2. Goutham Pohit, Goutham Ghosh, —Machine Drawing with Auto CAD‖, Pearson, 1st Edition, 2004.

3. James D. Meadows, —Geometric Dimensioning and Tolerancing‖, CRC Press, 1st Edition, 1995.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Familiarization and practicing of drawing and modifying commands, template creation, lettering, object snapping and sectioning.	CO 1	T21.2
2	Prepare the 2D drawings using draw and modify commands for simple geometric assemblies, sectional views for part drawing and assemblies.	CO 2	R2: 3.5
3	Preparing the 2D and 3D models (wire frame, surface and solid models) by using B-REP, CSG. Introduction of Boolean operations. Generation of 2D, 3D models through protrusion, revolve, sweep.	CO 3	R1: 3.4
4	Development of orthographic views for assembly drawings and preparation of bill of materials(IC engine components, Machine tool accessories, Jigs and Fixtures).	CO 4	R1: 2.2
5	Determination of deflection and stresses in bar.	CO 5	R1: 2.4
6	Determination of deflection and stresses in 2D and 3D trusses and beams	CO 6	R3: 4.5
7	Determination of stresses in 3D and shell structures (one example in each case).	CO 6	R3: 4.6
8	Estimation of natural frequencies and mode shapes, harmonic responses of 2D beams.	CO 6	R2: 5.1
9	Steady state heat transfer analysis of plane and axi-symmetric components.	CO 6	R2: 5.2
10	Conventional representation of parts screw joints, welded joints, springs, gears, electrical, hydraulic and pneumatic circuits, methods of indicating notes on drawings.	CO 6	R1: 7.1
11	Limits, Fits and Tolerances: Types of fits, exercises involving selection, interpretation of fits and estimation of limits from tables.	CO 6	R1:7.2
12	Introduction and indication of form and position tolerances on drawings, types of run out, total run out and their indication.	CO 6	R1:7.3
13	Definition, types of surface roughness indication surface roughness obtainable from various manufacturing processes, recommended surface roughness on mechanical components. Heat treatment and surface treatment symbols used on drawings.	CO 6	R1:7.3

14	Drawing of parts from assembly drawings with indications of size, tolerances, roughness, form and position errors.	CO 6	R1:7.3
15	Part drawings using computer aided drafting by CAD software.	CO 6	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**AUTOCAD:** Develop the drafting and design using AutoCAD.
2	**CAD Modeling Software:** Develop the design and drafting using CATIA.
3	**ANSYS:** Analyse the deisgn unsing ANSYS.

Signature of Course Coordinator **HOD,ME**
Mr D.Atchuta Ramacharyulu, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**COMPUTER AIDED NUMERICAL CONTROL LABORATORY**				
Course Code	AME115				
Program	B.Tech				
Semester	VII	ME			
Course Type	Lab				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr M Prashanth Reddy, Assistant Professor				

I COURSE OVERVIEW:

In this laboratory the students learn the fundamentals of numerical control (NC) technology, programming of computer numerical control (CNC) machines in NC codes and APT language and with CAD/CAM systems. Students also gain experience in NC postprocessors and distributed numerical control, operation of CNC lathe and milling machines, and programming and machining complex engineering parts.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME010	V	Machine Tools and Metrology Lab

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computer Aided Numerical Control Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

I	Understand the features and specifications of CNC and 3D printing machines.
II	Develop the process planning sheets and tool layouts.
III	Use the CAM software and prepare CNC part programs.

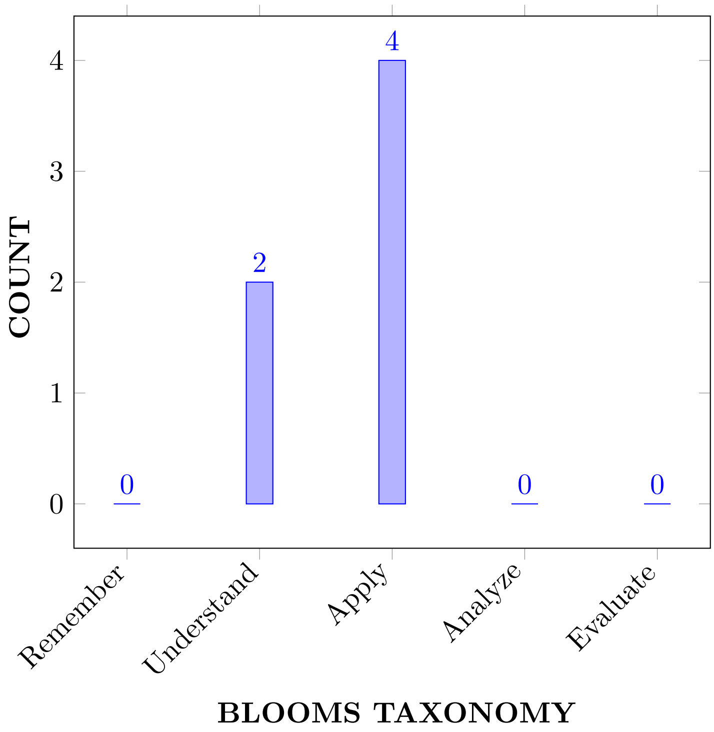
VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Understand** the concept of numerical control and advantages of CNC machine tools. .	Apply
CO 2	**Understand** Basic fundamentals of CNC milling and familiarization of machine control panel.	Apply

CO 3	**Demonstrate** fundamentals of CNC programming, Part programming and interpolation techniques	Understand
CO 4	**Generate** part programming through CAM software.	Apply
CO 5	**Understand** various Work piece setting methods and tool setting methods.	Apply
CO 6	**Understand** CNC programming and execution on milling and turning machines.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIA

PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 3	Make use of multi physics, computational fluid dynamics and flight simulation tools for building career paths towards innovative startups, employability and higher studies.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Explain qualitatively about motion of CNC Machines in three-dimensions **using the principles of mathematics and engineering fundamentals.**	3
	PO 2	Application of synthetic and free form surfacengeneration equations to **create coon's surfaces on CNC machine centres and 2D contour surfaces on turning centres through simulation techniques.**	3
	PSO 3	Apply (**knowledge**) The application of high speed techniques by **using latest art of cutting tools technology for hard to machine components**	1
CO 2	PO 2	Use the retrieval and generative type process plans to minimize the ideal time to **minimize the shortest possible path.**	6
CO 3	PO 1	Use the mathematical model to justify ABC Analysis and economic order quantities in manufacturing planning	3
	PSO 1	**Make use of experimental tools for innovation** to assess high speed machining and rapid prototyping.	3
CO 4	PO 1	Recognize (knowledge) the importance and application (apply) of dimensions, units and dimensional homogeneity in solving (complex) engineering problems with specific emphasis to fluid mechanics by applying the **principles of Mathematics, Science and Engineering**	3
	PO 5	Understand the given **problem statement and formulate** the dimensional analysis and similarity parameters for predicting physical parameters that govern fluid systems in designing prototypes devices	2

	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 5	PO 1	Apply the basic conservation laws of science for various phenomena of fluid systems and use **mathematical principles** for deriving (complex) fluid flow engineering equations by understanding the appropriate parametric assumptions and limitations based on **engineering fundamentals** of fluid mechanics.	3
	PO 3	Understand the given **problem statement** and formulate (complex) fluid flow engineering phenomena and system for deriving various governing equations of fluid mechanics from the provided information and substantiate with the **interpretation** of variations in the results.	2
	PO 5	Make use of **computational and experimental tools** for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of fluid mechanics.	2
	PSO 3	Apply (knowledge) concept of dimensional analysis and similarity parameters for predicting physical parameters (understanding) for the fluid flow analysis used in designing prototypes devices (apply) solving design problems by applying the **principles of Mathematics, Science and Engineering**	3
CO 6	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** principles to understand the Bernoulli Equation for real flows and its applications	2
	PO 3	Using Euler equation of motion derive the Bernoulli equation to analyze complex fluid flow problems using **principles of mathematics and engineering sciences.**	3
CO 7	PO 1	Apply the knowledge of **Mathematics and Engineering fundamentals** for determining unit indicators, and performance of hydraulic machines such as speed, discharge and power numbers etc for designing the new equipment's as per the requirements	2
	PO 5	Using first **principles of Sciences and Engineering fundamentals** understand the concept of unit indicators, and performance of hydraulic machines such as speed, discharge and power numbers for designing desired equipment's.	2
	PSO 3	Extend the focus to **understand the innovative and dynamic challenges** involves in evaluation of hydraulic machine performance.	1

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES		PSO'S
	PO 1	PO 2	PSO 1
CO 1	3	3	1
CO 2		2	
CO 3	3		1
CO 4	3		1
CO 5		2	
CO 6		2	
CO 7		2	

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO1, PO2, PO4, PSO1	SEE Exams	PO1, PO2	Seminars	PO1, PO2
Laboratory Practices	PO 1, PO 2, PSO 1	Student Viva	PO 1, PO 2	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK I	**INTRODUCTION TO CATIA**
	Familiarization and practicing of drawing and modifying commands, template creation, lettering, object snapping and sectioning
WEEK II	**DRAFTING OF SIMPLE 2D DRAWINGS**
	Prepare the 2D drawings using draw and modify commands for simple geometric assemblies, sectional views for part drawing and assemblies.
WEEK III	**SOLID MODELING**
	Preparing the 2D and 3D models (wire frame, surface and solid models) by using B-REP, CSG. Introduction of Boolean operations. Generation of 2D, 3D models through protrusion, revolve, sweep.
WEEK IV	**CREATING ORTHOGRAPHIC VIEWS FROM SOLID MODELS**
	Development of orthographic views for assembly drawings and preparation of bill of materials(IC engine components, Machine tool accessories, Jigs and Fixtures).

WEEK V	**INTRODUCTION TO ANSYS**
	Determination of deflection and stresses in bar.
WEEK VI	**TRUSSES AND BEAMS**
	Determination of deflection and stresses in 2D and 3D trusses and beams.
WEEK VII	**SHELL STRUCTURES**
	Determination of stresses in 3D and shell structures (one example in each case).
WEEK VIII	**HARMONIC ANALYSIS**
	Estimation of natural frequencies and mode shapes, harmonic responses of 2D beams.
WEEK IX	**HEAT TRANSFER ANALYSIS**
	Steady state heat transfer analysis of plane and axi-symmetric components.
WEEK X	**INTRODUCTION TO COMPUTER NUMERICAL CONTROL**
	Numerical control, functions of a machine tool, concept of numerical control, historical development, definition, advantages of CNC machine tools. Evolution of CNC, advantages of CNC, limitations of CNC, features of CNC, machine control MODULE (MCU) for CNC, classification of CNC machine tools; CNC machining centers: classification, features of CNC machining centers.
WEEK XI	**CNC TURNING**
	Fundamentals of CNC programming, Part programming and interpolation techniques, Work piece setting methods, tool setting methods
WEEK XII	**CNC MILLING**
	Fundamentals of CNC programming, Part programming and interpolation techniques, Machining practice on CNC milling

TEXTBOOKS

1. Kundra T. K., Rao P. N. and Tewari M. K., —Numerical Control and Computer Aided Manufacturing‖, Tata McGraw-Hill, 1st Edition, 1999

2. Groover M.P., —Automation, Production Systems and Computer Integrated Manufacturing.‖, Prentice Hall, 1st Edition, 1989

3. Elanchezhian C, Selwyn Sunder T, Shanmuga Sundar G., —Computer Aided Manufacturing‖, Laxmi Publications, New Delhi, 1st Edition, 2006

4. Rao P N., —CAD/CAM Principles and Applications‖, Tata McGraw-Hill, 1st Edition, 2006

REFERENCE BOOKS:

1. FANUC and SIEMENS part programming manuals.

2. 3D printing manual – ULTIMAKE

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
1	Understand Numerical control, its function and advantages.	CO 1	T21.2
2	Understand Evolution of CNC and classification of CNC machine tools	CO 2	R2: 3.5
3	Understand Basic fundamentals of CNC milling, familiarization of machine control panel.	CO 3	R1: 3.4
4	Fundamentals of CNC programming, Part programming and interpolation techniques.	CO 4	R1: 2.2
5	Machining practice on CNC milling.	CO 5	R1: 2.4
6	Generation of part programming through CAM software package.	CO 6	R3: 4.5
7	CAM-CNC programming and execution.	CO 6	R3: 4.6
8	Work piece setting methods, tool setting methods.	CO 6	R2: 5.1
9	Practice on CNC turning and exercises on machine.	CO 6	R2: 5.2
10	Generation of part programming through the CAM software package, CAM-CNC programming and execution on milling and turning machines.	CO 7	R1: 7.1
11	Prepare simple prototype models.	CO 7	R1:7.2
12	Practice session at industry	CO 7	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**NASS Test:** Develop the nass test model in CNC milling machine.
2	**NASS Test:** Develop the nass test model in CNC lathe machine.
3	**Prototyping:** Design and develop the turbine blade in 3D printer

Signature of Course Coordinator **HOD,ME**
Mr M Prashanth Reddy, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**INSTRUMENTATION AND CONTROL SYSTEM LABORATORY**				
Course Code	AME116				
Program	B.Tech				
Semester	VII	ME			
Course Type	CORE				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. M.Sunil Kumar, Assistant Professor				

I COURSE OVERVIEW:

The primary objective of this course is to study and calibrate measuring instruments used in engineering industry. Understanding the principles involved in various measuring transducers used in flow, linear, angular, speed, temperature, Pressure, Strain, Vibration and Selection of suitable measuring instrument for any process control applications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AME110	V	Machine Tools and Metrology laboratory	2

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Instrumentation and Control Systems Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Probing Further Experiments (last)	✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day-to-day performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the principal from the panel of experts recommended by Chairman, BOS.
The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program outcomes		**Strength**	**Proficiency Assessed by**
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Lab Exercises/CIA/SEE
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Lab Exercises/CIA/SEE

PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	Lab Exercises/CIA/SEE
PO 9	**Individual and team work:**Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

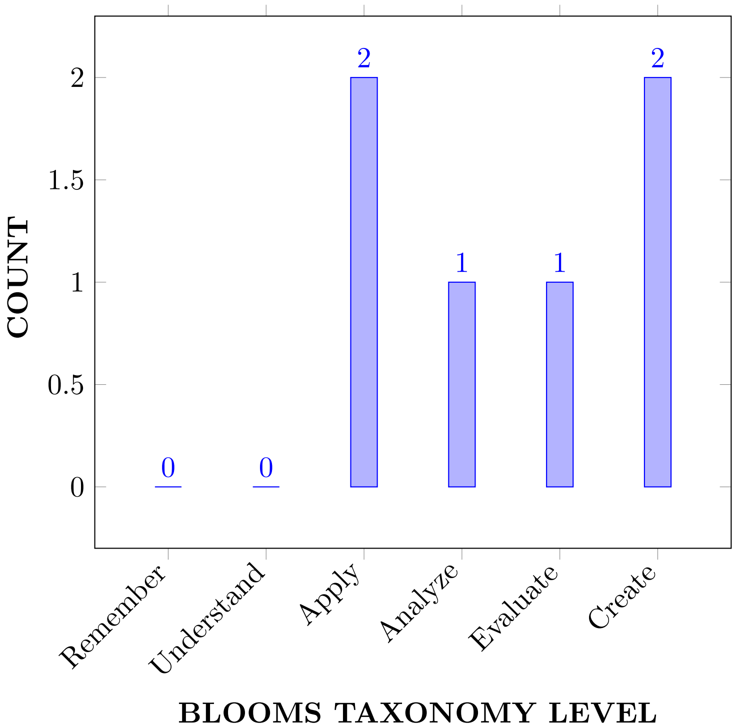
I	Configure and calibrate for physical quantities like pressure, temperature, speed, displacement
II	Experiment for condition monitoring of machine tools and IC engines by using seismic pickup (vibrometer).
III	Study the deflection by using strain gauge on cantilever beam.

IX COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO1	**Identify** various elements and their purpose in typical instruments, to identify various errors that would occur in instruments.	Apply
CO2	**Analysis** of errors so as to determine correction factors for each instrument.	Analyze
CO3	**Design** an instrument taking into account static and dynamic characteristics of instrument and should be able to determine loading response time.	Apply
CO4	**Choose** Transducer for given range of displacement should be able to specify it accurate and loading time of that transducer.	Evaluate
CO5	**Design** the thermocouple, Thermister and resistance temperature detector (RTD) for temperature measurement and control of furnace temperature	Create
CO6	**Choose** Optical, Proximity, Tacho Pickups used for the measurement and control of shaft speed.	Create

COURSE COURSE KNOWLEDGE COMPETENCY LEVEL:



X JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and engineering fundamentals.	2
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to making of sensors	3
CO 2	PO 1	Identify (knowledge) in suitable methods involved during welding for error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals**	2
	PO 2	Understand the given **problem statement and apply data validation techniques to solve** (complex) specific engineering problems related to temperature measurement with different sesnors.	3
CO 3	PO 1	Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2

	PO 5	Create, select, and apply metal forming techniques, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	2
CO 4	PO 1	Recall (knowledge) the basic molding processes uses plastics and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.**	2
	PSO 2	Make use of **concepts of Thermo-Fluid Systems** o provide solutions for Inter Disciplinary Engineering Applications.	2
CO 5	PO 1	Identify (knowledge) in suitable methods involved in design, casting to achieve error free components using in solving (complex) engineering problems by applying the principles of **mathematics and engineering fundamentals**	2
	PO 5	Design the ball bearing and estimation of life, and **modern engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	2
	PO 9	Design and develop the journal bearing effectively as an individual, and as a member in **diverse teams, and in multidisciplinary** settings for different sensors for various applications.	2
CO 6	PO 1	Recall (knowledge) the basic concepts of manufacturing processes and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals** for better solution.	2
	PO 5	Create, select, and apply appropriate mechanisms parameters, resources, and modern **engineering tools** including prediction and modeling to **complex engineering activities** with an understanding of the limitations for effective optimization of prototype / products.	2
	PSO 2	Make use of **concepts of Thermo-Fluid Systems** o provide solutions for Inter Disciplinary Engineering Applications.	2

3 = High; 2 = Medium; 1 = Low

XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

COURSE OUTCOMES	PROGRAM OUTCOMES				Program Specific Outcomes
	PO 1	PO 2	PO 5	PO 9	PSO 2
CO 1	2	3			

CO 2	2	3			
CO 3	2		2		
CO 4	2				2
CO 5	2		2	2	
CO 6	2		2		2

3 = High; 2 = Medium; 1 = Low

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-	Mini projects	-		

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIV SYLLABUS:

WEEK-1	**CAPACTIVE TRANSDUCER**
	Calibration of capacitive transducer for angular measurement.
WEEK-2	**CALIBRATION OF LVDT**
	Study and calibration of LVDT transducer for displacement measurement.
WEEK-3	**STUDY OF RESISTANCE TEMPERATURE DETECTOR**
	Study of resistance temperature detector for temperature measurement.
WEEK-4	**CALIBRATION OF THERMISTOR**
	Calibration of thermistor for temperature measurement.
WEEK-5	**CALIBRATION OF THERMOCOUPLE**
	Calibration of thermocouple for temperature measurement.
WEEK-6	**CALIBRATION OF PRESSURE GUAGE**
	Calibration of Pressure gauges.
WEEK-7	**CALIBRATION OF STRAIN GUAGE**
	Calibration of strain gauge for temperature measurement.
WEEK-8	**CALIBRATION OF PHOTO AND MAGNETIC SPEED PICKUP**
	Study and calibration of photo and magnetic speed pickups for the measurement of speed.
WEEK-9	**CALIBRATION OF ROTAMETER**
	Study and calibration of rotameter for flow measurement.

WEEK-10	**CALIBRATION OF VIBROMETER**
	Study and use of a Seismic pickup for the measurement of vibration amplitude of an engine bed at various loads.

TEXTBOOKS

1. D. S. Kumar, “Measurement Systems: Applications and Design”, Anuradha Agencies, 1st Edition, 2013.
2. C. Nakra, K. K. Choudhary, “Instrumentation, Measurement and Analysis”, Tata McGraw-Hill, 1st Edition, 2013.

REFERENCE BOOKS:

1. Chennakesava R Alavala, ”Principles of Industrial Instrumentation and Control Systems”, Cengage Learning, 1st Edition, 2013.
2. S. Bhaskar, ”Instrumentation and Control systems”, Anuradha Agencies, 1st Edition, 2013.
3. Holman, ”Experimental Methods for Engineers”, McGraw-Hill, 8th Edition, 2013
4. R. K. Jain, ”Mechanical and Industrial Measurements”, Khanna Publishers, 1st Edition, 2013.
5. Sirohi, Radhakrishna, ”Mechanical Measurements”, New Age, 3rd Edition, 2015.
6. A. K. Tayal, ”Instrumentation and Mechanical. Measurements”, Galgotia Publications, 1st Edition, 2013.

XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO’s	Reference
1	Calibration of capacitive transducer for angular measurement.	CO1, CO 5	T1:2.1.5 T2:2.3
2	Study and calibration of LVDT transducer for displacement measurement.	CO1, CO 5	T2:2.1.5 R1:2.6
3	Study of resistance temperature detector for temperature measurement.	CO 1, CO 4, CO 5, CO 6	T1:2.6 R3:3.6.5
4	Calibration of thermistor for temperature measurement.	CO 2, CO 6	T2:2.7 R2:2.18
5	Calibration of thermocouple for temperature measurement.	CO 2, CO 6	T2:2.22 R3:3.1.1
6	Calibration of Pressure gauges.	CO 2, CO 6	T1:2.5.1 T2:2.25
7	Calibration of strain gauge for temperature measurement.‘	CO 3, CO 6	T2:2.26 R3:2.55
8	Study and calibration of photo and magnetic speed pickups for the measurement of speed.	CO 3, CO 6	T2:2.3 R3:2.6
9	Study and calibration of rotameter for flow measurement.	CO 3, CO 6	T2:2.3 R1:2.6

10	Study and use of a Seismic pickup for the measurement of vibration amplitude of an engine bed at various loads.	CO 4, CO 6	T1:2.6
11	Study and calibration of Mcleod gauge for low pressure.	CO 4, CO 6	T2:2.8 R1:2.18

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design of Resistance Temperature Dector for temperature measurement.
2	Design of Rotameter for flow measurement.
3	Design of LVDT transducer for displacements measurements
4	Design of strain guage for measurement of temperature measurement
5	Design of thermocouple for temperature measurement.

Prepared by: **HOD, ME**
Mr M.Sunil Kumar, Assistant professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**AUTOMOBILE ENGINEERING**				
Course Code	AME020				
Program	B.Tech				
Semester	VIII	ME			
Course Type	Core				
Regulation	IARE-R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr G Sarat Raju, Assistant Professor				

I COURSE OVERVIEW:

This course introduces structural and operational details of automobile and its systems. Major systems that contribute in the functioning of automobile which include fuel supply, cooling, ignition, electrical, transmission, suspension, braking and steering. Introduction of S.I and C.I engines which will work on Otto and Diesel cycles. The advanced ignition, braking and transmission systems are discussed. Also Focuses the alternative fuels for sustainable environment and low emission of the HC's and NOx to protect the global environment and reduces the possibility of minimizing the ozone layer depletion.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME007	IV	Applied Thermodynamics
B.Tech	AME009	IV	Kinematics of machines

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Automobile engineering	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
20 %	Understand
70 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

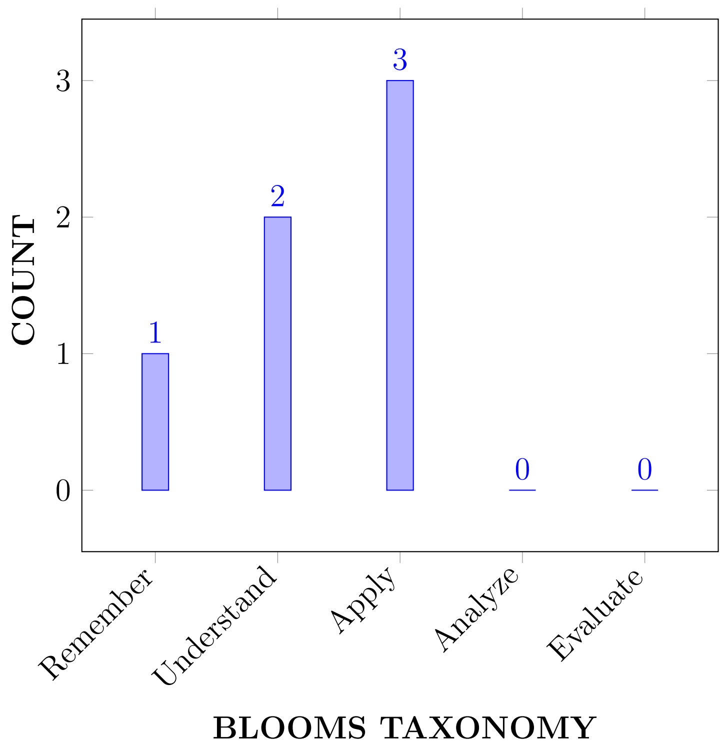
I	The need and scope of automobile engineering in the field of automotive industry.
II	The basic concepts and working principles of various automobile systems.
III	The mechanisms associated with the power transmission from engine to rear axles by using the concepts of kinematics of machines.
IV	The automobile emissions and preventive measures according to the national and international standards.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Identify** the basic components of automobile and working principles Of fuel injection systems to meet the load demands.	Apply
CO 2	**Explain** the working and operation process of various types of cooling systems used in automobile.	Understand
CO 3	**Identify** the power transmission through clutches, gears, propeller shafts, universal joints and differential gear boxes to achieve differential outputs.	Apply
CO 4	**Demonstrate** different suspension systems used in motor bikes, cars, trucks for effective travel under several load conditions.	Understand
CO 5	**Select** the correct steering mechanism by comparing various steering mechanisms.	Remember
CO 6	**Explain** the alternative energy sources, alternative fuels in order to reduce the emissions coming from automobiles.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 7	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	3	CIE/Quiz/AAT
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing.	2	AAT

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	✓	✓	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	✓	-	-	-	-	-	✓	-	-	-	-		-	-	-
CO 5	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-
CO 6	✓	-	-	-	-	-	-	-	-	-	-		✓	-	-

XI JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Apply knowledge of **science, engineering** fundamentals to understand the concept of fuel injection system and the working of principal of different fuel injection systems, in order to **mathematically** relate the performance of various injection systems.	3
	PO 2	**Recognize** the basic components of automobile and **Understand** the function of each component and **interpret** which **design** is appropriate.	4
CO 2	PO 1	**Identify and compare** the processes of supplying fuel supply to different types of engines and **analyse** the various components in fuel supply system.	3
CO 3	PO 1	**Apply** the knowledge of science, engineering fundamentals to **demonstrat**e the working and operation process of various types of cooling systems utilized in automobile.	3

	PO2	**Compare** the different ignition systems and **interpret** the performance of characteristics of SI and CI engines by **stating the limitations.**	4
CO 4	PO 1	**Apply** the knowledge of engineering fundamentals and science to **illustrate** starting motor, Horn and Wiper and electric circuits.	2
	PO 7	**Apply** the fundamentals of electrical and electronics to **Demonstrate** the different circuits used in Bendix drive solenoid head lamps.	2
CO 5	PO 2	**Identify, formulate and analyse** how power is transmitted from engine to wheels by using engineering fundamentals.	3
	PSO 1	**Analyse and compare** different power transmitting systems in automobile engineering.	2
CO 6	PO 1	**Apply** the knowledge of science and engineering fundamentals to **Illustrate** the importance of suspension system.	2
	PSO 1	**Interpret** the failure of suspension system by **applying** the basic concepts of spring mass systems.	2

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE	Program Outcomes/ No. of Key Competencies Matched												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	4	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	-	-	-	2	-	-	-	-		1	-	-
CO 5	-	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 6	2	-	-	-	-	-	-	-	-	-	-		2	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	40	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	-	-	-	-	-	66.6	-	-	-	-		-	-	-
CO 5	-	30	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 6	66.6	-	-	-	-	-	66.6	-	-	-	-		100	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - 0≤ C≤ 5% – No correlation
2 - 40 % <C < 60% –Moderate
1-5 <C≤ 40% – Low/ Slight
3 - 60% ≤ C < 100% – Substantial /High

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	3	-	-	-	-	-	-		-	-	-
CO 5	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 6	3	-	-	-	-	-	3	-	-	-	-		2	-	-
TOTAL	12	3	-	-	3	-	3	-	-	-	-	-	4	-	-
AVERAGE	3.0	2.0	-	-	1.0	-	1.0	-	-	-	-	-	2.0 -	-	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	-				

XVI ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XVII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to automobile engineering,chassis and body components,types of automobile engines,engine lubrication, engine servicing; Fuel system; spark ignition engine fuel supply systems,mechanical and electrical fuel pump, filters, carburetor types, air filters, petrol injection, multipoint fuel injection(MPFI)and gasoline direct injection systems; Compression ignition engines fuel supply systems, requirement of diesel injection systems,types of injection systems,direct injection systems,indirect injection(IDI)systems ,fuel pump nozzle, spray formation, injection timing, testing of fuel pumps, CRDI and turbocharged direct injection (TDI) systems.
MODULE II	**COOLING SYSTEM**
	cooling requirements, air cooling, water cooling, thermo, water and forced circulation system, radiators types cooling fan,water pump,thermostat,pressure sealed cooling,anti freeze solutions, intelligen tcooling; Ignition system: Function of an ignition system,battery ignition system constructional features of storage, battery, contactbreakerpoints, condenser and sparkplug, magnetocoilignition system, electronic ignition system using contact breaker, electronic ignition using contact triggers, spark advance and retard mechanism; Electrical system: Charging circuit, generator, current-voltage regulator, starting system, bendix drive mechanism solenoid switch, lighting systems, automatic high beam control, horn, wiper, fuel gauge, oil pressure gauge, engine temperature indicator
MODULE III	**TRANSMISSION AND SUSPENSIONS SYSTEMS**
	Transmission system: Clutches, principle, types, cone clutch, single plate clutch, multi plate clutch, magnetic and centrifugal clutches, fluid flywheel, gear box, types, sliding mesh, constant mesh, synchro mesh gear boxes, epicyclic gear box, auto transmission,continuous variable transmission over drive, torque converter, propeller shaft, Hotch-Kiss drive, torque tube drive, universal joint, differential, rear axles, types, wheels and tires.Suspension system: Objects of suspension systems, rigid axle suspension system, torsion bar, shock absorber, independent suspension system, air suspension system, Daimler-benz vehicle suspension.
MODULE IV	**BRAKING AND STEERING SYSTEMS**
	Braking system: Mechanical brake system, Hydraulic brakes system, Master cylinder, wheel cylinder tandem master cylinder; Requirement of brake fluid, Pneumatic and vacuum brake, anti-skid braking (ABS), regenerative braking; Steering system: Steering geometry, camber, castor, king pin, rake, combined angle, toe-in, toe-out, center point steering, types of steering mechanism, power steering, Hydraulic, electronics,Ackerman steering mechanism, Davis steering mechanism, steering gears types, steering linkages, special steering columns.

MODULE V	**EMISSIO NS FROM AUTOMOBILES**
	Emissions from Automobiles, Pollution standards national and international, various pollution control techniques: Multipoint fuel injection for spark ignition engines, common rail diesel injection, variable valve timing, closed crank cake ventilation, pc valves, EGR value, catalytic converters, catalyst window, lambda probe, energy alternatives, solar, photo-voltaic, hydrogen, biomass, alcohols, LPG, CNG, liquid Fuels and gaseous fuels, hydrogen as a fuel for internal combustion engines, their merits and demerits, standard vehicle maintenance practice.

TEXTBOOKS

1. Willam H Crouse, DonaldL. Angling, —Automobile Engineering, McGraw-Hill,10th Edition,2006.
2. Manzoor, NawazishMehdi, YosufAli, —A Text Book Automobile Engineering, Frontline Publications, 1st Edition, 2008.
3. Dr. Kirpal Singh,—Automobile Engineering,Standard Publishers,2nd Edition,2013.

REFERENCE BOOKS:

1. R.K. Rajput,—A Text Book of Automobile Engineering, Laxm iPublications,1st Edition, 2010.
2. S. Srinivasan,—Automotive Engines, McGraw-Hill, 2nd Edition, 2003.
3. Khalil U Siddiqui, —A Text Book of Automobile Engineering, New Age International, 1st Edition, 2009.

WEB REFERENCES:

1. https://nptel.ac.in/courses/107106088

COURSE WEB PAGE:

https://www.iare.ac.in/?q=courseslist/72

XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	References
	OBE DISCUSSION		
1	Course Description on Outcome Based Education(OBE): Course Objectives ,Course Outcomes(CO),Program Outcomes(PO) and CO-PO Mapping	-	lms/ iare.ac.in
	CONTENT DELIVERY (THEORY)		
2	Define Heat engine and working of SI and CI engines	CO 1	T2:2.3
3	Illustrate crank angle valve and port diagrams	CO 1	T1:2.6
4	Explain different Fuel injection and ignition systems for CI engines	CO 1	T2:2.22

5	Explain Cooling and Lubrication system	CO 1	T2:2.26 R1:2.55
6	Illustrate different fuels and its properties with their stoichiometry.	CO 1	T2:2.16 R1:2.61
7	Discuss phenomena of combustion process	CO 2	T2:2.30 R1:2.58
8-9	Emphasize Normal and abnormal combustion phenomena.	CO 2	T2:3.6 R1:4.29
10-11	Discuss Importance of flame speed and its effect on engine variables	CO 2	T2:3.14 R1:4.31
12	Demonstrate Knocking and its additives	CO 2	T2:3.14 R1:4.33
13-14	Illustrate different types of combustion chambers	CO 2	R1:4.36
15	Explain Four stages of combustion in C.I. Engines. Discuss delay period	CO 2	T2:3.18 R1:4.64
16-18	Discuss knocking and its effect on engine variables.	CO 2	T2:3.22
19	What is the need for air movement and discuss different combustion chambers.	CO 2	T2:3.28 R1:4.67
20-21	What are the fuel requirements, performance characteristics	CO 3	T2:4.2
22	Determination of frictional power, efficiency, brakes power.	CO 3	T1:4.8 R2:4.68
23	Discuss sankey diagram for heat balance sheet by means of losses.	CO 3	T2:4.15 R1:5.74
24	Performance analysis of IC engines and Classify compressors and types	CO 4	T1:4.12 R2:5.75
25	Explain the working of roots blower vane sealed compressor and its mechanisms and Mechanism details of centrifugal compressors	CO 4	T1:5.14 R1:6.78
26-28	Define power input factor, pressure coefficient and adiabatic coefficient	CO 4	T1:6.4 R2:6.8
29	Draw velocity diagrams and find power	CO 4	T2:7.7 R1:7.74
30-31	Discuss working principle of Axial flow compressor and find the efficiency and work done factor, isentropic, polytropic efficiency.	CO 5	T1:7.12 R2:8.75
32	Define refrigerating effect and its principle of operation and Air refrigeration system	CO 6	T1:9.14 R1:10.78
33	Discuss vapour compression system components and calculate cop.	CO 6	T1:10.4 R2:11.68
34	Explain vapour absorption system-mechanical details-working principle and Problems on p-h chart.	CO 6	T2:10.7 R1:12.74

35	Numerical problems: Testing and performance of engine parameters,Calculation of efficiencies of IC engine,heat balance sheet	CO 6	T1:1.5 R1:2.4
36	Single stage,multi and air compressor	CO 5	T1:2.5 R1:2.6
37	Velocity diagram for compressor	CO 5	T1:18.10 R1:17.7
38	Air refrigeration system	CO 6	T1:18.10 R1:17.7
39	Vapour compression refrigeration system	CO 5	T1:19.3 R1:18.2
40	Vapour absorption refrigeration system	CO 6	T1:19.5 R1:18.4
PROBLEM SOLVING/ CASE STUDIES			
41	Parameters of performance, measurement of cylinder pressure,	CO 3	T2:2.3
42	Parameters of performance, measurement offuel consumption	CO 3	T1:4.8 R2:4.68
43	Parameters of performance, measurement of air intake	CO 3	T1:4.12 R2:5.75
44	exhaust gas composition	CO 3	T1:4.8 R2:4.68
45	brake power	CO 3	T1:4.8 R1:5.72
46	determination of frictional losses and indicated power	CO 3	T1:5.14 R1:6.78
47	performance test	CO 3	T2:7.7 R1:7.74
48	heat balance sheet and chart	CO 3	T1:8.8 R1:8.73
49	mechanical details and principle of operation, velocity and Pressure variation,	CO 4	T1:12.4 R2:13.68
50	Energy transfer, impeller blade shape-losses, slip factor, and power input factor.	CO 5	T2:13.7 R1:14.74
51	pressure coefficient and adiabatic coefficient	CO 5	T2:9.19 R1:10.814
52	velocity diagrams, power; Axial flow compressors,Mechanical details and principle of operation	CO 5	T2:9.19 R1:10.814
53	velocity triangles and energy transfer per stage degree of reaction	CO 5	T1:10.4 R2:11.68
54	work done factor, isentropic efficiency	CO 5	T1:10.4 R2:11.68
55	work done factor, isentropic efficiency	CO 5	T2:10.7 R1:12.74

DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Module I: Introdcution	CO 1	T2:2.3
57	Module II: Cooling systems	CO 2	T2:3.14 R1:4.33
58	Module III:Transmission and suspension	CO 3, CO 4	T2:4.2 R1:5.72
59	Module IV:Braking and steering systems	CO 5	T2:7.7 R1:7.74
60	Module V:Emissions and automobiles	CO 6	T2:9.19 R1:10.814
DISCUSSION OF QUESTION BANK			
61	Module I: Introduction	CO 1	T2:2.3
62	Module II: Cooling system	CO 2	T2:3.14 R1:4.33
63	Module III:Transmission and suspension	CO 3, CO 4	T2:4.2 R1:5.72
64	Module IV:Braking and steering systems	CO 5	T2:7.7 R1:7.74
65	Module V:Emissions and automobiles	CO 6	T2:9.19 R1:10.814

Signature of Course Coordinator **HOD, ME**
Mr G Sarat Raju Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	Mechanical Engineering				
Course Title	Operations Research				
Course Code	AME021				
Program	B. Tech				
Semester	VIII SEM				
Course Type	Core				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr C Labesk Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB02	I	Linear Algebra and Calculus
B.Tech	AHSB11	II	Mathematical Transformation Techniques

II COURSE OVERVIEW:

The operations research is also called Operations research for short and it is a scientific approach to decision making which seeks to determine how best to design and operate a system under conditions requiring allocation of scarce resources. Optimization Technique as a research tool, primarily has a set or collection of algorithms which act as tools for problems solving in chosen application areas. This course has extensive applications in engineering, business and public systems and is also used by manufacturing and service industries to solve their day to day problems. This course facilitates to learn various models to optimize the solution of a problem.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Operations research	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	x	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Videos

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50 %	Understand
25%	Apply
15%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

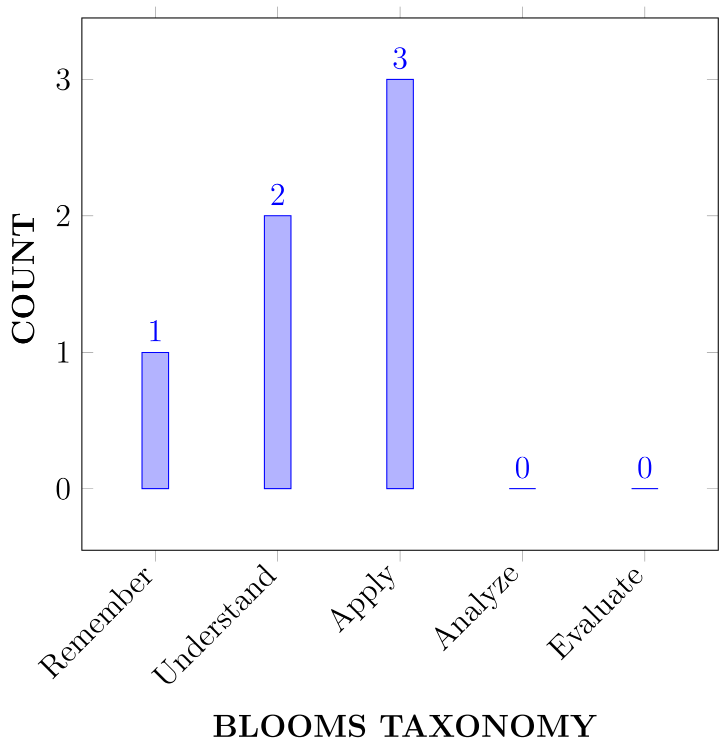
I	Operation research models using optimization techniques based upon the fundamentals of engineering mathematics (minimization and Maximization of objective function).
II	The problem formulation by using linear, dynamic programming, game theory and queuing models.
III	The stochastic models for discrete and continuous variables to control inventory and simulation of manufacturing models for the production decision making.
IV	Formulation of mathematical models for quantitative analysis of managerial problems in industry.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Understand** the concepts operations research modeling techniques to solve complex problems involved in various industries.	Understand
CO 2	**Find** the appropriate algorithm for transportation and assignment of resources to optimize the process of assignment.	Remember
CO 3	**Understand** the Concepts of sequencing to solve complex problems for effective scheduling of jobs on machines.	Understand
CO 4	**Identify** appropriate equipment replacement technique to be adopted to minimize maintenance cost by eliminating equipment break-down.	Apply
CO 5	**Apply** the knowledge of game theory concepts to articulate real-world competitive situations to identify strategic decisions to counter the consequences.	Apply
CO 6	**Identify** appropriate method for application of simulation to solve inventory and queuing problems for real world applications.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Capability to apply the knowledge of mathematics, science and engineering in the field of mechanical engineering.	3	CIA/SEE
PO 2	**Problem analysis:** An ability to analyze complex engineering problems to arrive at a relevant conclusion using knowledge of mathematics, science and engineering.	2	CIA/SEE
PO 3	**Design/Development of Solutions:** Competence to design a system, component or process to meet societal needs within realistic constraints.	1	CIA/SEE
PO 4	**Conduct Investigations of Complex Problems:** Competence to develop mathematical models to solve complex engineering problems with constraints.	2	CIA/SEE
PO 5	**Modern Tool Usage:** Knowledge on simulation software packages like GAMS and LINDO	3	CIA/SEE
PO 11	**Project Management and finance:** Knowledge of operations research models and techniques to optimize complex engineering problems	2	CIA/SEE
PO 12	**Life-Long Learning:** The subject knowledge of operational research is useful for career advancement	1	CIA/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	Make use of computational and experimental tools for building career paths towards innovative startups, employability and higher studies.	2	CIA/SEE

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	✓	✓	-	-	-	-	-	✓	✓	-	-	-
CO 2	✓	✓	✓	✓	-	-	-	-	-	-	✓	✓	-	-	-
CO 3	✓	✓	-	-	-	-	-	-	-	-	✓	✓	-	-	-
CO 4	✓	✓	-	-	-	-	-	-	-	-	✓	✓	-	-	✓
CO 5	✓	✓	-	-	-	-	-	-	-	-	✓	✓	-	-	✓
CO 6	✓	✓	✓	-	-	-	-	-	-	-	✓	✓	-	-	✓

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recognize (knowledge) the importance of optimization techniques and different operation research models to formulate and solve various types of Linear Programming Problems by applying the principles of **mathematics, science and Engineering fundamentals.**	3
	PO 2	A good **knowledge** in various methods of optimization to **design solutions to complex engineering Problems** by using appropriate technique for a specific real world problem which are affecting them.	7
	PO 3	Application of various linear programming models to **development solutions** for real life problems.	5
	PO 4	A good **knowledge** in various linear programming models to **design solutions to complex engineering Problems** by using appropriate techniques.	5
	PO 5	Application of **Simulation software packages like GAMS and LINDO** for a specific real world problems.	1
	PO 11	A good **knowledge of operations research** models and techniques to optimize complex engineering problems.	5
	PO 12	Advanced **knowledge of** linear programming models is useful for career advancement.	4

CO 2	PO 1	Understand various methods of optimization to suggest a appropriate technique for a specific real world problem by applying the principles of **manufacturing engineering fundamentals, mathematics and scientific methodologies.**	3
	PO 2	A good **knowledge** in various methods of Transportation to **design solutions to complex engineering Problems** by using appropriate technique for a specific real world problem which are affecting them.	6
	PO 3	Application of various transportation models to **development solutions** for real life problems.	5
	PO 4	A good **knowledge** in various linear programming models to **design solutions to complex engineering Problems** by using appropriate techniques.	5
	PO 11	A good **knowledge of operations research** models and techniques to optimize complex engineering problems	5
	PO 12	Advanced **knowledge of** transportation models models are useful for solving industrial related problems.	4
CO 3	PO 1	Apply knowledge to resolve decision for effective scheduling of Jobs for optimal values by applying the **knowledge of mathematics, science and production engineering fundamentals.**	3
	PO 2	Problem analysis based on **principles of mathematics, Manufacturing engineering fundamentals** and **sciences** is essential to resolve decision for effective scheduling of Jobs for optimal service.	5
	PO 11	**Problem analysis** based on **principles of mathematics and engineering fundamentals** is essential to identify and analyze the material distribution schedule to minimize total distribution cost.	5
	PO 12	**Problem analysis** based on **principles of mathematics and engineering fundamentals** is essential to identify and analyze the material distribution schedule to minimize total distribution cost.	2
CO 4	PO 1	**Apply** the material distribution schedule to minimize total distribution cost by applying the **knowledge of mathematics, science and engineering fundamentals.**	2
	PO 2	**Problem analysis** based on **principles of mathematics and engineering fundamentals** is essential to identify and analyze the material distribution schedule to minimize total distribution cost.	5
	PO 11	**Problem analysis** based on **principles of mathematics and engineering fundamentals** is essential to identify and analyze the material distribution schedule to minimize total distribution cost.	5

CO 4	PO 12	Advanced **knowledge of** Job scheduling models are useful for solving real life complex problems.	2
	PSO 3	Develop practical experience for solving the real time problem using **computational and experimental tools** the field of Manufacturing process.	1
CO 5	PO 1	Selection of algorithm for assigning a suitable person to existing vacancy of jobs positions, need the knowledge of **science** and **engineering fundamentals**	3
	PO 2	**Problem analysis** based on **principles of mathematics and engineering fundamentals** is essential to identify and analyze the material distribution schedule to minimize total distribution cost.	5
	PO 11	**Problem analysis** based on **principles of mathematics and engineering fundamentals** is essential to identify and analyze the inventory schedule to minimize the total inventory cost.	5
	PO 12	Advanced **knowledge of** theory of games are useful for many industrial problems.	2
	PSO 3	Develop practical experience for solving the real time problem using **computational** and **experimental tools** in the field of Manufacturing process.	1
CO 6	PO 1	Apply knowledge for waiting line problems for optimal values by applying the **knowledge of mathematics, science and production engineering fundamentals.**	3
	PO 2	Problem analysis based on **principles of mathematics, Manufacturing engineering fundamentals** and **sciences** is essential to resolve dynamic problems	6
	PO 3	**Development solutions** based on **principles of mathematics and engineering fundamentals** is essential for solving complex engineering problems with model constraints	5
	PO 11	**Problem analysis** based on **principles of mathematics and engineering fundamentals** is essential for solving complex dynamic problems.	5
	PO 12	Advanced **knowledge of** dynamic problems is essential problems for solving the research based problems	4
	PSO 3	Develop practical experience for solving the real time problem using **computational and experimental tools** the field of Manufacturing process.	1

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	7	5	5	1	-	-	-	-	-	5	4	-	-	-
CO 2	3	6	5	5	-	-	-	-	-	-	5	4	-	-	-
CO 3	3	5	-	-	-	-	-	-	-	-	5	2	-	-	-
CO 4	2	5	-	-	-	-	-	-	-	-	5	2	-	-	1
CO 5	3	5	-	-	-	-	-	-	-	-	5	2	-	-	1
CO 6	3	6	5	-	-	-	-	-	-	-	5	4	-	-	1

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	70	50	45.4	100	-	-	-	-	-	50	50	-	-	-
CO 2	100	60	50	45.4	-	-	-	-	-	-	50	50	-	-	-
CO 3	100	50	-	-	-	-	-	-	-	-	50	25	-	-	-
CO 4	66.7	50	-	-	-	-	-	-	-	-	50	25	-	-	50
CO 5	100	50	-	-	-	-	-	-	-	-	50	25	-	-	50
CO 6	100	60	50	-	-	-	-	-	-	-	50	50	-	-	50

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
0 - $0 \leq C \leq 5\%$ – No correlation
1 -5 $< C \leq 40\%$ – Low/ Slight
2 - 40 % $< C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	2	2	3	-	-	-	-	-	2	2	-	-	-
CO 2	3	3	2	2	-	-	-	-	-	-	2	2	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	2	1	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	2	1	-	-	2
CO 5	3	2	-	-	-	-	-	-	-	-	2	1	-	-	2
CO 6	3	3	2	-	-	-	-	-	-	-	2	2	-	-	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓	Seminar	-
Laboratory Practices	-	Student Viva	-	Mini Projects	-	Certi fication	-
Term Paper	-	Concept Video	✓	Tech Talk	✓	Open Ended Experi-ments	✓

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	End Semester OBE Feedback	X	Assessment of Mini Project By Experts

XVIII SYLLABUS:

MODULE I	**DEVELOPMENT OF O.R AND ALLOCATION**
	Development, definition, characteristics and phases, types of operation research models, applications; Allocation: linear programming, problem formulation, graphical solution, simplex method, artificial variables techniques, two–phase method, big-M method.
MODULE II	**TRANSPORTATION AND ASSIGNMENT PROBLEM**
	Transportation problem: Formulation, optimal solution, unbalanced transportation problem, Degeneracy; Assignment problem, formulation, optimal solution, variants of assignment problem, traveling salesman problem.
MODULE III	**SEQUENCING AND REPLACEMENT**
	Sequencing: Introduction, flow, shop sequencing, n jobs through two machines, n jobs through three machines, job shop sequencing, two jobs through m machines. Replacement: Introduction: Replacement of items that deteriorate with time, when money value is not counted and counted, replacement of items that fail completely, group replacement.
MODULE IV	**THEORY OF GAMES AND INVENTORY**
	Theory Of Games: Introduction – Terminology, Solution of games with saddle points and without saddle points, 2×2 games, dominance principle, m X 2, 2 X n games, Graphical method. Inventory: Introduction, Single item, Deterministic models, Purchase inventory models with one price break and multiple price breaks, Stochastic models, demand may be discrete variable or continuous variable, Single period model and no setup cost.

MODULE V	**WAITING LINES, DYNAMIC PROGRAMMING AND SIMULATION**
	Waiting Lines: Introduction, Terminology, Single Channel, Poisson arrivals and exponential service times with infinite population and finite population models, Multichannel, Poisson arrivals and exponential service times with infinite population. Dynamic Programming: Introduction, Terminology, Bellmans Principle of optimality, Applications of dynamic programming, shortest path problem, linear programming problem. Simulation: Introduction, Definition, types of simulation models, steps involved in the simulation process - Advantages and Disadvantages, Application of Simulation to queuing and inventory.

TEXTBOOKS

1. J. K. Sharma, "Operations Research", Macmillan, 5th Edition, 2012.
2. R. Pannerselvan, "Operations Research", 2nd Edition, PHI Publications, 2006.

WEB REFERENCES:

1. https://www.aicte-india.org/flipbook/pap/Vol.
2. https://www.britannica.com/topic/operations-research

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=pages/btech-lecture-notes-iare-r18-7

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
1	Introduction to Outcome Based Education	-	-
	CONTENT DELIVERY (THEORY)		
2	Introduction – Definition– Characteristics and Phases – Types of operation Research models	CO 1	T1:1.1, R1:1.2
3	Modeling in operations research , principles and application	CO 1	T1:1.6
4-5	Allocation - Linear Programming Problem formulation	CO 1	T1:2.7
6	Concepts of Graphical solution	CO 1	T2:3.1
7	Concepts of Simplex method	CO 1	T1:4.1, R1:6.3
8	Artificial variables techniques	CO 1	T2:2.26 R1:2.55
9-10	Concepts of Two–phase method	CO 1	T2:2.16 R1:2.61
11-12	Concepts of Big-M method	CO 1	T2:14.1 R1:2.58
13-14	Transportation model Formulation-Optimal solution balanced model.	CO 2	T2:9.1
15-16	Formulation of optimal solution balanced and unbalanced and transportation models	CO 2	T2:9.5

17-18	Degeneracy type transportation model	CO 2	R2:6.3
19-20	Assignment problem- Formulation – Optimal solution	CO 2	T1:10 R2:13.1
21-22	Concepts of variants of Assignment Problem, travelling salesman problem	CO 2	T1:10.4
23-24	Introduction-Flow-Shop sequencing-n jobs through two machines-n jobs through three machines	CO 3	T2:11.1 R2:2.6
25-26	Job shop sequencing – two jobs through “m: machines	CO 3	T2:11.5
27-28	Replacement of items that deteriorate with time-when money value is not counted	CO 4	T1:17.1, R1:4.71
29-30	Concept of replacement of items that deteriorate with time-when money value is counted	CO 4	T1:17.3 R2:4.68
31-32	Concept of replacement of items that fail completely, group replacement. Group replacement	CO 4	T1:17.4 R1:5.74
33-34	Game theory terminology, Solution of games with saddle points	CO 5	T1:12.1 R2:5.75
35	Rectangular games without saddle points-2 x 2 games conductivity gauges	CO 5	T1:4.8 R2:5.72
36-37	Dominance principle for solving Transportation problem, Concept of *2, 2 * n games -graphical method	CO 5	T1:12.4 R1:5.73
38	Inventory: Introduction-Single item, Derive the formula for Inventory models	CO 5	T1:14.1 R1:6.78
39	Purchase inventory models with one price break and multiple price breaks	CO 5	T1:14.1
40	Concepts of Stochastic Models	CO 5	T1: 14.11
41	Concepts of demand may be discrete variable or continuous variable – Single period model and no setup cost	CO 5	T1:7.8 R1:8.72
40	Remember the concepts of Waiting Lines, Introduction-Single Channel- Poisson arrivals	CO 6	T1:16.1, R1:10.814
41-42	Multi channel-Poisson arrivals, Dynamic programming concepts and models	CO 6	T2:16.7, R1:10.814
43	Types of Simulation, models-phases of simulation-applications of simulation	CO 6	T1:19.1 R1:10.814
44	Advantages and disadvantages and application of simulation to queuing and inventory.	CO 6	T1:19.5, R1:10.814
PROBLEM SOLVING/ CASE STUDIES			
45	Linear Programming Problem formulation	CO 1	T2:2.3, R1:2.6
46	Graphical Method	CO 1	T2:2.7, R1:2.18
47	Simplex method	CO 1	T2:2.16 R1:2.61
48	Big M Method	CO 1	T2:2.16 R1:2.61
49	Transportation Problems	CO 2	R1:2.61
50	Assignment Problems	CO 2	T2:2.30 R1:2.58

51	Replacement Models	CO 4	T2:3.22 R1:4.67
52	Game Theory	CO 5	T1:2.6
53	Inventory Models	CO 5	T1:4.8 R2:4.68
54	Dynamic programming concepts and models	CO 6	T1:4.8 R2:4.7
	DISCUSSION OF DEFINITION AND TERMINOLOGY		
55	Module: I-Operations Research, duality, Optimization	CO 1	T1,T2, R1, R2
56	Module: II- Transportation, degeneracy, balanced	CO 2	T1,T2, R1, R2
57	Module: III-Definition of assignment, Optimal Solution, Balanced Problem	CO 3	T1,T2, R1, R2
58	Module: IV- Concept of Scheduling, Job shop, flow shop	CO 4	T1,T2, R1, R2
59	Module: V- Game Theory, saddle Point	CO 5	T1,T2, R1, R2
	Tutorial QUESTION BANK		
60	A company manufactures two products (A and B) and the profit per unit sold is £3 and £5 respectively. Each product has to be assembled on a particular machine, each unit of product A taking 12 minutes of assembly time and each unit of product B 25 minutes of assembly time. The company estimates that the machine used for assembly has an effective working week of only 30 hours (due to maintenance/breakdown).	CO 1	T1,T2, R1, R2
61	what is feasible solution and non degenerate solution in transportation problem?	CO 2	T1,T2, R1, R2
62	Discuss the situations involving complex sequential problems.	CO 3	T1,T2, R1, R2
63	What is Economic Order Quantity? Discuss step by step the development of Economic Order Quantity equation.	CO 4	T1,T2, R1, R2
64	What is Dynamic programming and explain the steps involved in the calculus method of solution.	CO 5	T1,T2, R1, R2

Signature of Course Coordinator **HOD, ME**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**PRODUCTION PLANNING CONTROL**				
Course Code	AME518				
Program	B.Tech				
Semester	EIGHT				
Course Type	Elective				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. V . Mahidhar Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
ug	AME021	VI	Operation Research
UG	AME018	VII	CAD/CAM

II COURSE OVERVIEW:

Production planning and control refers two strategies that work cohesively throughout the manufacturing process. It involves what to produce, when to produce it, how much to produce, and more. Production system requires the optimal utilization of natural resources like men, money, machine, materials and time. A long-term view of production planning is necessary to fully optimize the production flow based the utilization of resource allocation of activities of employees, materials and production capacity. to develop, manage and control all aspects of an effective and efficient manufacturing planning and control system- a key to the success of any product manufacturing company

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Production Planning Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

x	Chalk & Talk	✓	Quiz	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	✓	Videos
✓	LCD / PPT						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
20%	Remember
30%	Understand
60%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 50 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

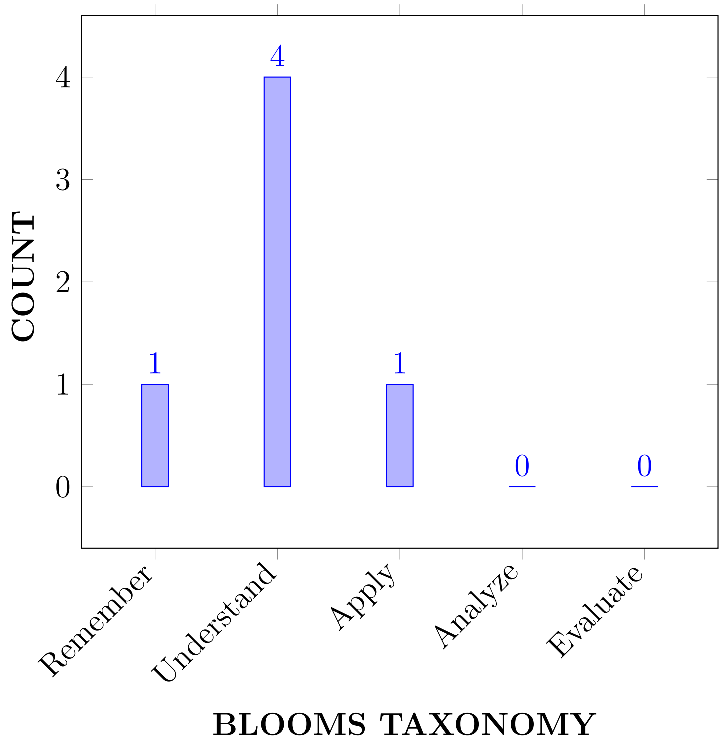
I	To develop, manage and control all aspects of an effective and efficient manufacturing planning and control system which is a key component to the success of any product manufacturing company.
II	The Methodology and models related to forecasting, business operations & productivity in supply chain management
III	The Strategies of capacity planning, materials requirements, inventory models,scheduling methods in various aspects of the manufacturing and service industry

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Recall** different inventory methods in Production Planning that empower manufacturers toenhance smarter and optimized production process. Select the necessity and importance of expediting based on functionality, cost and time in development of business activity.	Remember
CO 2	**Classify** various Forecasting techniques (Qualitative & Quantities) to provide valuable inputs for number of planning decisions and continuous improvement.	Understand
CO 3	**Explain** different types of inventories and select the ordering quantityfor minimizing the operation cost. Master Production Schedule and a resultant Materials Requirement Plan (MRP)for a complete production facility.	Understand
CO 4	**Identify** he forecasting models and errors associated with production to develop business enterprise for product demand, profits, sales, material requirements & the capacity planning process for business operations.	Apply
CO 5	**Make use of** the impact of production/inventory cost decisions and operations strategies on the break-even, return on investment and profit analysis of a business enterprisexxx Apply forward and backward scheduling policies to analyze different job shop schedules with reference to prioty rules.	Understand
CO 6	**Summarize** production and inventory planning/control systems and scheduling techniques by using engineering techniques for a complete production facility. Make use of centralized and decentralized dispatching techniques forproduct delivery as per customer needs.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (Conduct Investigations of Complex Problems).
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations (Modern Tool Usage).
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Program Outcomes	
PO 9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	SEE/CIA
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	SEE/CIA
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	SEE/CIA
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing	1	Discussion /AAT
PSO 3	Make use of computational and experimental tools for building career paths towards innovative startups, employability and higher studies.	3	SEE/CIA

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	✓	✓	-	-	-	-	-	-	-	✓	-	-	-	-
CO 2	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	✓	✓	-	-	-	-	-	-	-	-	✓	✓	-	✓
CO 5	-	✓	✓	-	-	-	-	-	-	-	✓	-	✓	-	-
CO 6	-	✓	-	-	-	✓	-	-	-	-	-	-	-	-	

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall (knowledge) different inventory methods in Production Planning that empower manufacturers to enhance smarter and optimized production process by applying the scientific principles of mathematics and science..	2
	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design	3
	PO 3	Forging techniques for the development of critical products for public health and safety, and the cultural, societal, and Environmental considerations.	3
	PO 11	Demonstrate knowledge and understanding of Engineering and management principles and Apply these to ones own work, as a member and leader in a team, to Relate projects and in multidisciplinary environments	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Recall (knowledge) different inventory methods in Production Planning that empower manufacturers to enhance smarter and optimized production process by applying the scientific principles of mathematics and science.	2
CO 3	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design	4
	PO 3	Forging techniques for the development of critical products for public health and safety, and the cultural, societal, and Environmental considerations.	2
CO 4	PO 2	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies in the field of production planning and control.	3
	PO 3	Forging techniques for the development of critical products for public health and safety, and the cultural, societal, and Environmental considerations	3
	PO 12	Identify the need for and have the preparation and ability To take part in independent and life- long learning in the broadest context of technological change	2
	PSO 1	To Construct engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	1
	PSO 3	Make use of computational and experimental tools forcreating innovative career paths, to be an entrepreneur and desire for higher studies in the field of production planning and control.	2
CO 5	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design	4
	PO 3	Forging techniques for the development of critical products for public health and safety, and the cultural, societal, and Environmental considerations.	2
	PO 11	Demonstrate knowledge and understanding of Engineering and management principles and Apply these to ones own work, as a member and leader in a team, to Relate projects and in multidisciplinary environments .	2
	PSO 1	To Construct engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams	1
CO 6	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design	2
	PO 6	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities Classify the professional engineering practice.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	4	-	-	-	-	-	-	-	2	-	-	-	-
CO 2	2	3	4	-	-	-	-	-	-	-	2 -	-	-	-	-
CO 3	-	4	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	3	5	-		-	-	-	-	-	-		2	-	2
CO 5	-	4	2	-	-	-	-	-	-	-	2	-	2	-	-
CO 6	-	4	-	-	-	2	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	20	40	-	-	-	-	-	-	-	-	16.6	-	-	-
CO 2	66.7	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	40	20	-		-	-	-	-	-	-		100	100	-
CO 4	-	30	50	-	-	-	-	-	-	-	-	-	33.3	-	100
CO 5	-	40	20	-		-	-	-	-	-	16.6	-	33.3	-	-
CO 6	-	40	-	-	-	20	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -5 $<C \leq 40\%$ – Low/ Slight
2 - 40 % $<C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	3	4	-	-	-	-	-	-	-	2	-	-	-	
CO 2	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	4	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	3	5	-	-	-	-	-	-	-	-	2	2	-	2
CO 5	-	4	2	-	-	-	-	-	-	-	2	-	1	-	-
CO 6	-	2	-	-	-	2	-	-	-	-	-	-	-	-	-
TOTAL	4	20	13	-	-	2	-	-	-	-	4	2	3	-	2
AVERAGE	2.0	3.3	3.2	-	-	1	-	-	-	-	2	1	1.5	-	1.0

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1, PO 2, PSO 3	SEE Exams	PO 1, PO 2, PO 4, PSO 3	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	PO 1, PO 3	5 Minutes Video	PO 4	Open Ended Experiments	-
Assignments	PO 1,PO 2, PO 3,PO 4				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**OVERVIEW OF PRODUCTION PLANNING CONTROL**
	Introduction: Definition, Objectives of production planning and control, functions of production planning and control, elements of production control, types of production, organization of production planning and control department, internal organization of department
MODULE II	**FORECASTING**
	Introduction to MRP and ERP, LOB (Line of Balance), JIT inventory, and Japanese concepts. Routing, definition, routing procedure Route sheets, bill of material, factors affecting routing procedure, Schedule, definition, difference with loading.
MODULE III	**INTRODUCTION TO MRP**
	Introduction to MRP and ERP, LOB (Line of Balance), JIT inventory, and Japanese concepts. Routing, definition, routing procedure Route sheets, bill of material, factors affecting routing procedure, Schedule, definition, difference with loading
MODULE IV	**SCHEDULING**
	Scheduling Policies, techniques, Standard scheduling methods; Line balancing, aggregate planning, chase planning, expediting, controlling aspects
MODULE V	**DESPATCHING**
	Dispatching: Activities of dispatcher, dispatching procedure, followup, definition, reason for existence of functions, types of followup, applications of computer in production planning and control.

TEXTBOOKS

1. Frank M. White, "PPC ", McGraw Hill Education Private Limited, 8th Edition, 2017 .

REFERENCE BOOKS:

1. Yuan S W, "Line production", Prentice-Hall, 2nd Edition, 1987.

WEB REFERENCES:

1. https://nptel.ac.in/courses/1526489/1

COURSE WEB PAGE:

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

OBE DISCUSSION			
S.No	Course Description on Outcome Based Education (OBE): Course Objectives, Course Ourcomes(CO), Program Outcomes(PO) and Co - PO Mapping	-	**lms.iare.ac.in**
CONTENT DELIVERY (THEORY)			
S.No	**Topics to be covered**	**CO's**	**Reference**
1	Introduction: Definition of production planning and control	CO 1	T2:2.3
2	Objectives of production planning and control	CO 1, CO 5	T1:2.6
3	Applications of computer in production planning and controll	CO 1, CO 5	T1:2.6
4	Functions of production planning and control	CO 3, CO 5	T2:2.7 R1:2.18
5	Functions of production planning and control	CO 5, CO 1, CO2	T2:2.22
6	Elements of production control	CO 2, CO4, CO 6	T2:2.25
7	Types of production	CO 6, CO 1, CO4	T2:2.26 R1:2.55
8	Organization of production planning and control department	CO 1, CO 5	T2:2.16 R1:2.61
9	Organization of production planning and control department	CO 5, CO 1, CO2	T2:2.30 R 1:2.58
10	Internal organization of department.	CO 6, CO 1, CO4	T2:3.6 R1:4.29
11	Forecasting: Importance of forecasting	CO 3, CO5, CO 6	T2:3.14 R1:4.31
12	Forecasting: Importance of forecasting	CO 1, CO 5	T2:3.14 R1:4.33
13	Types of forecasting, their uses	CO 2, CO4, CO 6	R1:4.36
14	General principles of forecasting	CO 3, CO5, CO 6	T2:3.18 R1:4.64
15	Forecasting techniques, qualitative methods and quantitive Methods	CO 1, CO 5	T2:3.22
16	Forecasting techniques, qualitative methods and quantitive methods	CO 3, CO5, CO 6	T2:3.28 R1:4.67
17	Inventory management, functions of inventories	CO 6, CO 1, CO4	T2:4.2
18	Inventory management, functions of inventories	CO 3, CO 2, CO6	T2:4.3 R1:4.71
19	Relevant inventory costs ABC analysis, VED analysis	CO 1, CO 5	T1:4.8 R2:4.68
20	Relevant inventory costs ABC analysis, VED analysis	CO 3, CO 2, CO6	T2:4.15 R1:5.74

21	EOQ model, inventory control systems	CO 3, CO 2, CO6	T1:4.12 R2:5.75
22	EOQ model, inventory control systems	CO 1, CO 5	T1:4.8 R1:5.72
23	P-Systems and Q-Systems	CO 3, CO5,Co 6	T1:5.8 R1:5.73
24	P-Systems and Q-Systems	CO 6	T1:5.14 R1:6.78
25	Introduction to Material Requirement Planning	CO 6, CO 1, CO4	T2:5.19 R1:6.81
26	ERP, LOB (Line of Balance)	CO 3, CO 2, CO6	T1:6.4 R2:6.8
27	ERP, LOB (Line of Balance)	CO 2, CO4, CO 6	T2:7.7 R1:7.74
28	JIT inventory, and Japanese concepts	CO 1, CO 5	T1:7.12 R2:8.75
29	JIT inventory, and Japanese concepts	CO 3, CO 2, CO6	T1:7.8 R1:8.72
30	Definition : Routing System	CO 3, CO 2,CO6	T1:8.8 R1:8.73
31	Routing procedure Route sheet	CO 6, CO 1, CO4	T1:9.14 R1:10.78
32	Bill of material, factors affecting routing procedure	CO 1, CO 5	T2:9.19 R1:10.814
33	Bill of material, factors affecting routing procedure	CO 3, CO5, CO 6	T1:10.4 R2:11.68
34	Schedule, definition, difference with loading	CO 1, CO 5	T2:10.7 R1:12.74
35	Schedule, definition, difference with loading	CO 1, CO 5	T1:11.12 R2:12.75
36	Scheduling Policies	CO 3, CO5, CO 6	T2:7.7 R1:7.74
37	Scheduling Policies	CO 1, CO 5	T1:7.12 R2:8.75
38	Scheduling techniques, Standard scheduling methods	CO 1, CO 5	T1:7.8 R1:8.72
39	Scheduling techniques, Standard scheduling methods	CO 2, CO4, CO 6	T1:8.8 R1:8.73
40	Line balancing, Aggregate planning	CO 3, CO5, CO 6	T1:9.14 R1:10.78
PROBLEM SOLVING/ CASE STUDIES			
1	Calculating EOQ using ABC Analysis	CO 1	R2:7.5
2	Calculate Demand as per the previous years sales	CO 2	R2:4.5
3	Calculating XYZ using ABC Analysis	CO 5	R2:2.5
4	Calculate out put of production using program evalaute review technique	CO 3	R2:5.5

5	supply chain management calculations based on the routes	CO 6	R2:6.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Production planning in Line Production and Batch Porduction	CO 3	R2:2.5
2	Exponential smoothing method of forecasting	CO 2	R2:6.5
3	Practical limitations of the EOQ formula	CO 5	R2:1.5
4	Detail on Job shop and Flow shop problems	CO 2	R2:4.5
5	Sequence of dispatching activities	CO 5	R2:6.5
DISCUSSION OF QUESTION BANK			
1	Discussed the type of production in mass production	CO 2, 5	R4:1.1
2	Qualitative and Quantitative methods are detailed	CO 4,6	T4:5.3
3	ABC Analysis and XYZ Analysis on EoQ	CO 1,3	R4:6.1
4	Routing method analysis and issues in PERT	CO 1,5	T1:3.5
5	Digital application in PPC	CO 5,6	T1: 2.1

Signature of Course Coordinator **HOD,ME**
Mr. V . Mahidhar Reddy, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**DESIGN FOR MANUFACTURING AND ASSEMBLY**				
Course Code	AME520				
Program	B.Tech				
Semester	VIII				
Course Type	Professional Elective				
Regulation	R-16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. A. Venu Prasad, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AME006	IV	PRODUCTION ENGINEERING

II COURSE OVERVIEW:

To provide an overview of Design for Manufacturingand Assembly (DFMA) techniques, which are used tominimize product cost through design and processimprovements. Design for Manufacturing (DFM) and Designfor Assembly (DFA) are now commonlyreferred to as a single methodology, Design-forManufacturing and Assembly (DFMA).Thiscoursebridgesgapbetweendesignandmanufacturing,it introducestheprinciplesof design for developing the product, which includes design considerations in casting, forging, metal forming and inwelding.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
DESIGN FOR MANUFACTURING AND ASSEMBLY	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
x	Others						

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIE examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage

in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
15%	Remember
50%	Understand
35%	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Quiz \Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz \AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Complex Problem Solving
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

I	Understand various general design rules for manufacture ability and criteria for material selection.
II	Apply various machining process and tolerance aspects in machining.
III	Analyze the design considerations for casting and welding process.

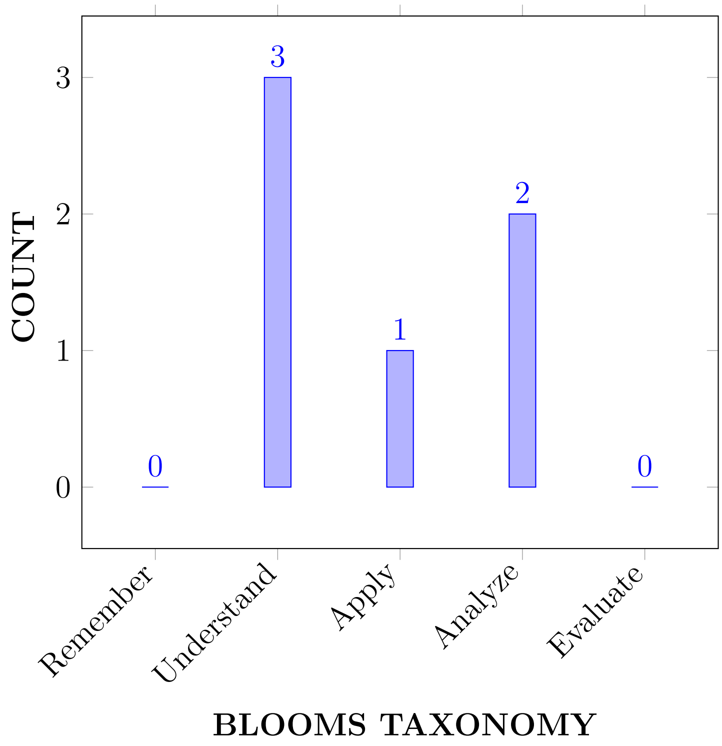
IV	Apply the conceptual design factors to be considered in forging, extrusion and sheet metal work,design guidelines for manual assembly and development of DFA methodology.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Outline** the primary and secondary components through functional analysis.	Understand
CO 2	**Make** use of the design efficiency for different machining processes.	Apply
CO 3	**Classify** various design recommendation of design process in metal casting.	Understand
CO 4	**Classify** various design recommendation of design process in metal joining.	Understand
CO 5	**Analyse** and derive the gripping, insertion and fixing values through fitting analysis of the product.	Analyse
CO 6	**Apply** the Design guidelines and assembly techniques to mechanical designs.	Analyse

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Program Outcomes	
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	1	Quiz

3 = High; 2 = Medium; 1 = Low

XI MAPPING OF EACH CO WITH PO(s),PSO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	✓	-	✓	✓	-	-	-	-	-	-	-	✓	✓	-	-
CO 2	✓	✓	✓	-	-	✓	-	-	-	-	-	✓	-	✓	-
CO 3	✓	✓	-	✓	✓	✓	-	-	-	-	-	-	-	-	-
CO 4	✓	-	✓	-	-	✓	-	-	-	-	-	✓	-	-	-
CO 5	✓	✓	✓	✓	✓	-	-	✓	-	-	✓	✓	-	-	✓
CO 6	✓	-	✓	-	✓	✓	✓	-	-	-	✓	✓	✓	-	✓

XII JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO3	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
	PO4	Recognize (knowledge) the charecteristics of various kinds of performances indicators and processes of design of machine parts, understand the corresponding context of the engineering knowledge related to the performance indicators and measures.	5
	PSO1	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	2
CO2	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
	PO3	Design the solution for problems of machining processes and casting.	3
	PO6	Knowledge and understanding of commmercial and economic context of engineering processes.	2
	PO12	Recognize the needs for ability to engage in independent and life long learning in the broadset of technological change	3
	PSO2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	2
CO3	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
	PO3	Design the solution for problems of machining processes and casting.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO4	Recognize (knowledge) the charecteristics of various kinds of performances indicators and processes of design of machine parts, understand the corresponding context of the engineering knowledge related to the performance indicators and measures.	5
	PO5	Apply reasoning informed by the contextual knowledge to assess societal helath and saftey(The Engineer and Society)	2
CO4	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO3	Design the solution for problems of voltage doublers and multiplier circuits.	2
	PO6	Knowledge and understanding of commmercial and economic context of engineering processes.	2
	PO12	Recognize the needs for ability to engage in independent and life long learning in the broadset of technological change	3
CO5	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
	PO3	Design the solution for problems of voltage doublers and multiplier circuits.	2
	PO5	Apply reasoning informed by the contextual knowledge to assess societal helath and saftey(The Engineer and Society)	2
	PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	1
	PO11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work(Project Management and Finance)	5
	PO12	Recognize the needs for ability to engage in independent and life long learning in the broadset of technological change	3
	PSO3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO6	PO 1	Recall (knowledge) the basic steps involved in robotics and identify the importance of system by (apply), implementing (complex) various techniques using Scientific Principles of Methodology using mathematics and physics and engineering fundamentals.	3
	PO3	Design the solution for problems of voltage doublers and multiplier circuits.	2
	PO5	Apply reasoning informed by the contextual knowledge to assess societal helath and saftey(The Engineer and Society)	2
	PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	1
	PO11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work(Project Management and Finance)	5
	PO12	Recognize the needs for ability to engage in independent and life long learning in the broadset of technological change	3
	PSO3	Gain the Hands-On Competency Skills in PLC Automation, Process Controllers, HMI and other Computing Tools necessary for entry level position to meet the Requirements of the Employer.	2

XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	5	5	-	-	-	-	-	-	-		2	-	-
CO 2	3	5	3	-	-	2	-	-	-	-	-	3	-	2	-
CO 3	3	5	3	5	1	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	2	-	-	2	-	-	-	-	-	3	-	-	-
CO 5	3	5	2	-	1	-	-	1	-	-	5	3	-	-	2
CO 6	3	-	2	-	1	-	-	1	-	-	5	3	-	-	2

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	50	45	-	-	-	-	-	-	-		100	-	-
CO 2	100	50	30	-	-	-	-	-	-	-	-	37.5	-	100	-
CO 3	100	50	30	45	45	100	-	-	-	-	-	-	-	-	-
CO 4	100	-	20	-	-	40	-	-	-	-	-	37.5	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	100	50	20	-	100	-	-	33.3	-	-	41.6	37.5	-	-	100
CO 6	100	-	20	-	100	-	-	33.3	-	-	41.6	37.5	-	-	100

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -5 $< C \leq 40\%$ – Low/ Slight
2 - 40 % $< C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	2	2	-	-	-	-	-	-	-	2	2	-	-
CO 2	3	2	2	-	-	2	-	-	-	-	-	2	-	2	-
CO 3	3	-	2	-	1	2	1	-	-	-	-	-	-	-	-
CO 4	3	-	2	-	-	2	-	-	-	-	-	2	-	-	-
CO 5	3	2	2	2	1	-	-	2	-	-	2	2	-	-	2
CO 6	3	-	2	-	2	2	2	-	-	-	2	2	1	-	2
TOTAL	18	4	12	4	4	8	3	2	-	-	4	10	3	2	4
AVERAGE	3	2	2	2	1.3	2	1.5	2	-	-	2	2	1.5	2	2

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1, PO 2, PO 3	SEE Exams	PO 1, PO 2, PO 3, PO 4	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 4	Open Ended Experiments	-
Assignments		Tech Talk	PO 1		

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	INTRODUCTION
	Introduction: Design philosophy steps in design process, general design rules for manufacturability, basic principles of design Ling for economical production, creativity in design; Materials selection of materials for design developments in material technology, criteria for material selection, material selection interrelationship with process selection process selection charts.

MODULE II	**MACHINING PROCESS, CASTING**
	Machining process: Overview of various machining processes, general design rules for machining, dimensional tolerance and surface roughness, design for machining, ease of redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.
MODULE III	**METAL JOINING, FORMING**
	Metal casting: Appraisal of various casting processes, selection of casting processes, general design considerations for casting, casting tolerances, use of solidification simulation in casting design, product design rules for sand casting Metal joining: Appraisal of various welding processes, factors in design of weldments, general design guidelines, pre and post treatment of welds, effects of thermal stresses in weld joints, design of brazed joints..
MODULE IV	**DESIGN FOR FORGING**
	Forging, design factors for forging, closed dies forging design, parting lines of die drop forging die design general design recommendations. extrusion and sheet metal work: Design guidelines for extruded sections, design principles for punching, blanking, bending, deep drawing, Keeler Goodman forming line diagram, component design for blanking.
MODULE V	**DESIGN FOR ASSEMBLY AND AUTOMATION**
	Design for assembly: General design guidelines for manual assembly, development of systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time.

TEXTBOOKS

1. Geoffrey Boothroyd, —Assembly Automation and Product Design‖, Marcel Dekker Inc., NY,1st Edition, 2013.
2. George E, Dieter, —Engineering Design - Material & Processing Approach‖, McGraw-Hill,2ndEdition, 2000.
3. Geoffrey Boothroyd, —Hand Book of Product Design‖, Marcel and Dekken,1 stEdition, 2013.
4. Geoffrey Boothroyd, Peter Dewhurst, Winston —Product Design for Manufacturing and Assembly‖, CRC Press, 1 st Edition, 2010.

REFERENCE BOOKS:

1. Geoffrey Boothroyd, —Hand Book of Product Design‖, Marcel and Dekken,1stEdition, 2013.
2. Geoffrey Boothroyd, Peter Dewhurst, Winston —Product Design for Manufacturing and Assembly,CRC Press, 1stEdition, 2010.

WEB REFERENCES:

1. https://onlinecourses.nptel.ac.in/noc22_me39/preview

XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Introduction to Outcome Based Education		
CONTENT DELIVERY (THEORY)			
1	Introduction: Design philosophy steps in design process, general design rules for manufacturability	CO 1	T1:1.7 R1:3.7
2	Basic principles of design Ling for economical production, creativity in design	CO 2	T1:1.8 R1:3.12
3	Materials selection of materials for design developments in material technology,	CO 3	T1:3.1 R1:3.13
4	Criteria for material selection, material selection interrelationship with process selection process selection charts.	CO 3	T1:2.1 R1:4.2
5	Machining process: Overview of various machining processes, general	CO 4	T1:3.3 R1:3.14
6	Design rules for machining, dimensional tolerance and surface roughness	CO 4	T1:4.1 R1:4.4
7	Metal casting: Appraisal of various casting processes, selection of casting process,	CO 5	T1:5.1 R1:5.2
8	General design considerations for casting, casting tolerances, use of solidification simulation in casting design, product design rules for sand casting.	CO 6	T1:6.1 R1:7.2
9	Metal joining: Appraisal of various welding processes, factors in design of weldments, general design guideline.	CO 7	T1:6.6 R:7.4
10	Pre and post treatment of welds, effects of thermal stresses in weld joints, design of brazed joints.	CO 7	T1:6.11 R1:8.5
11	Forging, design factors for forging, closed dies forging design,	CO 8	T1:7.1 R1:6.5
12	Parting lines of die drop forging die design general design recommendations	CO 8	T1:8.1 R3:3.2
13	Extrusion and sheet metal work: Design guidelines for extruded sections, ,	CO 9	T1:9.1 R3:3.4
14	Design principles for punching, blanking	CO 9	T1:9.5 R3:4.4
15	Bending, deep drawing, Keeler Goodman forming line diagram,	CO 10	T1:10.1 R3:5.3
16	Component design for blanking.	CO 10	T1:10.4 R3:7.2
17	Assembly advantages: Development of the assemble process	CO 11	T1:10.8 R3:7.6
18	Choice of assemble method assemble , advantages social effects of automation	CO 12	T1:10.9 R3:7.7
19	Indexing mechanisms, and operator, paced free, transfer machine.	CO 13	T1:10.10 R3:7.8
20	Design of manual assembly: Design for assembly fits in the design process	CO 13	T1:15.1 R3:7.9
21	General design guidelines for manual assembly, development of the systematic DFA methodology	CO 14	T1:13.5 R3:9.2

22	Assembly efficiency, classification system for manual handling,	CO 14	T1:13.7 R3:9.4
23	Classification system for manual insertion and fastening, effect of part symmetry on handling time,	CO 15	T1:13.8
24	Effect of part thickness and size on handling time, effect of weight on handling time	CO 14	T1:13.6 R3:10.3
25	Parts requiring two hands for manipulation, effects of combinations of factors,	CO 15	T1:13.9 R3:12.3
26	Effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time.	CO 16	T1:14.8 R3:12.6
PROBLEM SOLVING/ CASE STUDIES			
1	Numerical Examples Design of manufacturing	CO 1	R2:7.5
2	Numerical examples on economical production	CO 2	R2:7.5
3	Numerical examples on design developement in material technology	CO 2	R2:7.5
4	Numerical examples on interrelationship with process selection charts	CO 2	R2:7.5
5	Solving the dimensional tolerances	CO 2	R2:7.5
6	Solving the dimensional tolerances	CO 3	R2:7.5
7	Solving the dimensional tolerances	CO 3	R2:7.5
8	Solving the dimensional tolerances	CO 3	R2:7.5
9	Solving the design of various casting processes	CO 3	R2:7.5
10	Solving the apprisal of various welding processes	CO 4	R2:7.5
11	Solving the pre and post thermal stresses in weld	CO 4	R2:7.5
12	Problems on forging	CO 5	R2:7.5
13	Problems on assembly design	CO 5	R2:7.5
14	Problems on design for blaknking	CO 6	R2:7.5
15	Problems on indexing mechanism	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definitions and Terminology of design philosophy.	CO 1	R4:2.1
2	Definitions and Terminology of machining processes	CO 2	R4:2.1
3	Definitions and Terminology of metal joining techniques	CO 3,4	R4:2.1
4	Definitions on design for forging	CO 5	R4:2.1
5	Definitions and Terminology of design for assembly and automation	CO 6	R4:2.1
DISCUSSION OF QUESTION BANK			
1	Discussion on question bank of machining processes.	CO 1	R4:2.1
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4	Definitions and Terminology of design for forging	CO 5	T1:7.5
5	Discussion on question bank of design for assembly and automation	CO 6	T1: 4.1

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