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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**LINEAR ALGEBRA AND CALCULUS**				
Course Code	AHSB02				
Program	B.Tech				
Semester	I				
Course Type	Foundation				
Regulation	R - 18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. P Shantan Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

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

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 and its applications, maxima and minima of functions of several variables, solutions of higher order ordinary differential equations, multiple integrals and vector calculus. 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
Linear 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:

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.

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

10 %	Remember
30 %	Understand
60 %	Apply
0 %	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.

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:

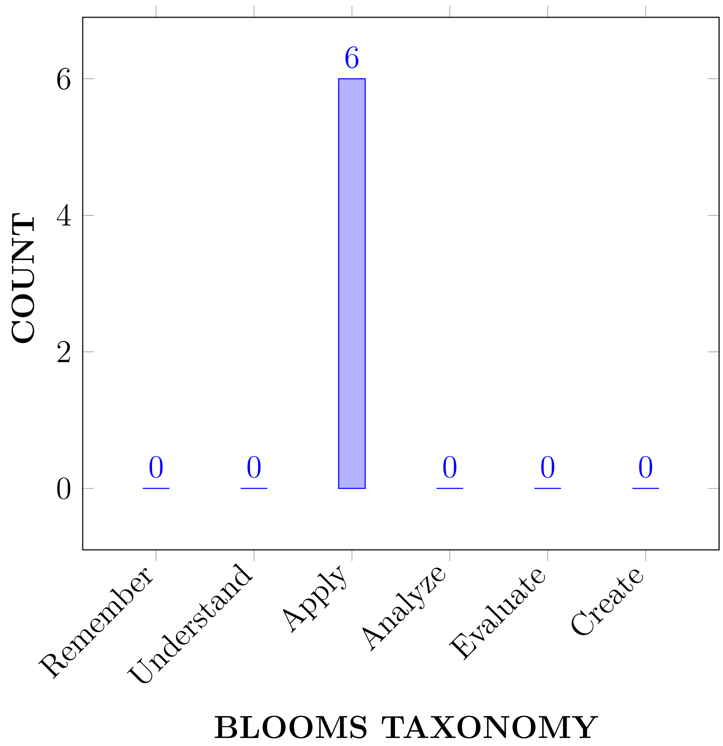
I	Apply and solve linear system of equations by using elementary transformations.
II	Determine the maxima and minima of functions of several variables by using partial differential coefficients.
III	Apply second and higher order linear differential equations to solve electrical circuits.
IV	Apply multiple integration to evaluate mass, area and volume of the plane.
V	Apply gradient, divergence and curl to evaluate the integration over a vector field.

VII COURSE OUTCOMES:

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

CO 1	**Compute** the rank and inverse of real and complex matrices with elementary transformation methods.	Apply
CO 2	**Make use of** Eigen values, Eigen vectors for developing modal, Spectral matrices and Cayley Hamilton for powers of the matrix.	Apply
CO 3	**Utilize** the mean–value theorems and partial derivatives in estimating the extreme values for functions of several variables.	Apply
CO 4	**Solve** the Second and higher order linear differential equations with constant coefficients by using substitution method and method of variation of parameters.	Apply
CO 5	**Apply** the definite integral calculus to a function of two or more variable in calculating the area of solid bounded regions.	Apply
CO 6	**Calculate** scalar and vector point function, line, surface, volume integral for bounded regions.	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

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		
	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	**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).**	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).**	2
	PO 2	**Model** the **problem into matrices** and apply the concepts of Eigen values and Eigen vectors along with **basic principles of mathematics** to **develop the solution.**	5
CO 3	PO 1	**Explain** the mean–value theorems for the single variable functions and extreme values apply them in the **complex engineering problems** modeled by functions of single variables **with their geometrical interpretation and partial derivatives (principles of mathematics).**	2
CO 4	PO 1	**Determine** the solution of **complex engineering problems** modeled by Second and higher order linear differential equations with constant coefficients by using substitution method and method of variation of parameters **(principles of mathematics)**.	2
	PO 2	**Model** the **problems** with the help of ordinary differential equations and analyze them using substitution method along with **basic principles of mathematics** to **develop the solution** with the help of method of variation of parameters **(principles of mathematics)**	5
CO 5	PO 1	**Apply** the definite integral calculus to a function of two or more variable in **for the complex engineering problems** modeled by given calculating the area of solid bounded regions. **(principles of mathematics).**	2
	PO 2	**Model** the **problem** in to definite integral expansion for the problem using **formulation** of two or more variable along with **basic principles of mathematics** to **develop the solution.**	5
CO 6	PO 1	**Calculate** the scalar and vector point function, line, surface, volume integral for **complex engineering problems** by using **(principles of mathematics).**	2
	PO 2	**Model** the **problem in to vector function** and **then build** the vector function for **develop the solution** and **solve** them in various situations with **basic principles of mathematics.**	5

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	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-

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	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	67	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	67	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	67	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	67	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		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	8	-	-	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**THEORY OF MATRICES AND LINEAR TRANSFORMATIONS**
	Real matrices: Symmetric, skew-symmetric and orthogonal matrices; Complex matrices: Hermitian, Skew-Hermitian and unitary matrices; Elementary row and column transformations; Rank of a matrix: Echelon form and normal form; Inverse by Gauss-Jordan method; Cayley-Hamilton theorem: Statement, verification, finding inverse and powers of a matrix; Linear dependence and independence of vectors; Eigen values and Eigen vectors of a matrix and Properties (without proof); Diagonalization of matrix by linear transformation.
MODULE II	**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.
MODULE III	**HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS AND THEIR APPLICATIONS**
	Linear differential equations of second and higher order with constant coefficients. Non-homogeneous term of the type f(x) $= e^{ax}$, sinax , cosax , x^n , e^{ax}v(x) and Method of variation of parameters,Applications to electrical circuits.
MODULE IV	**MULTIPLE INTEGRALS**
	Double and triple integrals; Change of order of integration. Transformation of coordinate system; Finding the area of a region using double integration and volume of a region using triple integration.
MODULE V	**VECTOR CALCULUS**
	Scalar and vector point functions; Definitions of Gradient, divergent and curl with examples; Solenoidal and irrotational vector point functions; Scalar potential function; 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.

TEXT BOOKS

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36^{th} Edition, 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, 9^{th} Edition, John Wiley & Sons, 2006.

2. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.

3. D. Poole, Linear Algebra: A Modern Introduction, 2^{nd} Edition, Brooks/Cole, 2005.

4. Dr. M Anita, Engineering Mathematics-I, Everest Publishing House, Pune, First Edition, 2016.

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	Outcome based education	-	-
CONTENT DELIVERY (THEORY			
2	Theory of Matrices: Types of Real Matrices	CO 1	T2:32.1 R1:4.1
3	Real Matrices: Symmetric, Skew-Symmetric Matrices	CO 1	T2:32.1 R1:4.2
4	Real Matrices: Orthogonal Matrices	CO 1	T2:32.1 R1:4.3
5	Complex Matrices: Hermitian, Skew- Hermitian	CO 1	T2:32.1 R1:4.3
6	Complex Matrices: Unitary Matrices	CO 1	T2:32.5 R1:4.6
7	Elementary Operations: Elementary Row and Column Transformations	CO 1	T2:32.5 R1:4.6
8	Rank of a Matrix by Echelon Form	CO 1	T2:32.4 R1:4.5
9	Rank of a Matrix by Normal Form	CO 1	T2:32.7 R1:4.8
10	Inverse of a Matrix by Gauss-Jordan Method	CO 1	T2-7.1 R1:7.4

11	Eigen Values of a Matrix	CO 2	T2-7.1 R1:7.4
12	Eigen Vectors of a Matrix	CO 2	T2-7.1 R1:7.4
13	Diagonalization of Matrix by Linear Transformation.	CO 2	T2:7.1 R1:7.4
14	Cayley-Hamilton Theorem- Statement, Verification	CO 2	T2:7.1 R1:7.4
15	Applications of Cayley – Hamilton: Finding Inverse and Powers of a Matrix	CO 2	T3-2.9 R1:2.1
16	Linear Dependence and Independence of Vectors	CO 2	T3-2.5 R1:2.8
17	Mean Value Theorems:1: Rolle's Theorem	CO 3	T3-2.5 R1:2.8
18	Mean Value Theorems:2: Lagrange's Theorem	CO 3	T3-2.5 R1:2.8
19	Mean Value Theorems:3: Cauchy's Theorem	CO 3	T3-2.5 R1:2.8
20	Functions of Several Variables: Partial Differentiation	CO 3	T3-2.5 R1:2.8
21	Jacobian Transformations	CO 3	T3-2.61 R1:2.10
22	Functional Dependence	CO 3	T1-7.1 R2:7.5
23	Maxima and Minima of Functions with Two Variables	CO 3	T3-2.61 R1:2.10
24	Maxima and Minima of Functions with Three Variables	CO 3	T1-7.1 R2:7.6
25	Application Method of Lagrange Multipliers	CO 3	T1-7.1 R2:7.7
26	Method of Lagrange Multipliers	CO 3	T3-2.5 R1:2.8
27	Linear Differential Equations of Second and Higher Order with Constant Coefficients	CO 4	T3-2.5 R1:2.8
28	Linear Differential Equations of Second and Higher Order with Constant Coefficients	CO 4	T3-2.5 R1:2.8
29	Non-Homogeneous term of the type F (X) = e^{ax}	CO 4	T3-2.5 R1:2.8
30	Non-Homogeneous term of the type F (X) = Sinax , Cosax	CO 4	T2-7.1 R1:7.4
31	Non-Homogeneous term of the type F (X) = X^n	CO 4	T2:7.1 R1:7.4
32	Non-Homogeneous term of the type F (X) = e^{ax}v(X)	CO 4	T2:7.1 R1:7.4
33	Method of Variation of Parameters	CO 4	T3-2.9 R1:2.1
34	Double Integrals	CO 5	T3-2.61 R1:2.10

35	Triple Integrals	CO 5	T1-7.1 R2:7.5
36	Change of order of integrations Cartesian and polar form	CO 5	T3-2.61 R1:2.10
37	Transformation of Coordinate System to Evaluate Double Integral	CO 5	T1-7.1 R2:7.6
38	Surface Area of field	CO 6	T3-2.61 R1:2.10
39	Volume of Field	CO 6	T1-7.1 R2:7.5
40	Green's Theorem	CO 6	T3-2.61 R1:2.10
41	Stokes' Theorem	CO 6	T1-7.1 R2:7.6
PROBLEM SOLVING/ CASE STUDIES			
42	Rank of the Matrix	CO 1	T2:32.1 R1:4.2
43	Eigen Values and Eigen Vectors	CO 2	T2:32.1 R1:4.3
44	Cayley Hamilton Theorem	CO 2	T2:32.1 R1:4.3
45	Spectral Matrix by Linear Transformation.	CO 2	T2-7.1 R1:7.4
46	Jacobian Transformation in Cartesian and Polar Forms	CO 3	T2-7.1 R1:7.4
47	Functional Relationship.	CO 3	T2:7.1 R1:7.4
48	Critical Points.	CO 3	T2:7.1 R1:7.4
49	Non-Homogeneous Differential Equations.	CO 4	T3-2.5 R1:2.8
50	Second Order Non-Homogeneous Differential Equations by Method of Variation of Parameters.	CO 4	T3-2.5 R1:2.8
51	Double Integrals	CO 5	T3-2.61 R1:2.10
52	Triple Integrals	CO 5	T1-7.1 R2:7.5
53	Change of order of integrations Cartesian and polar form	CO 5	T3-2.61 R1:2.10
54	Surface Area of field	CO 6	T3-2.61 R1:2.10
55	Green's Theorem	CO 6	T3-2.61 R1:2.10
56	Stokes' Theorem	CO 6	T1-7.1 R2:7.6
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Real, Complex Matrices and Rank of a Matrix	CO 1,2	T3-2.5 R1:2.8

58	Mean value theorems, Jacobian transformations, functionally dependent and independent	CO 3	T3-2.5 R1:2.8
59	Higher order differential equations	CO 4	T3-2.5 R1:2.8
60	Multiple Integrals	CO 5	T3-2.5 R1:2.8
61	Vector Calculus	CO 6	T3-2.5 R1:2.8
DISCUSSION OF QUESTION BANK			
62	Theory of matrices and linear transformations	CO 1,CO 2	T2:7.1 R1:7.4
63	Functions of Several Variables	CO 3	T3-2.5 R1:2.8
64	Higher order differential equations	CO 4	T2:32.1 R1:4.3
65	Multiple Integrals	CO 5	T3-2.5 R1:2.8
66	Vector Calculus	CO 6	T3-2.5 R1:2.8

Signature of Course Coordinator **HOD, ME**
Mr. P Shantan Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**WAVES AND OPTICS**				
Course Code	AHSB04				
Program	B.Tech				
Semester	I	AE/ECE/ME			
Course Type	Foundation				
Regulation	IARE - R 18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	4	3	1.5
Course Coordinator	Dr.Rizwana, Professor				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

This course is structured specifically to make the students understand some of the core topics in physics essential for further studies in engineering. It focuses on illustrating and developing an understanding of the interplay between problem solving and their practical applications which include experimental techniques and modern equipment. The topics include quantum mechanics, semiconductors, LASER and fiber optics,light and optics, harmonic oscillations and waves in one dimension. At the end, this course helps students to appreciate the diverse real-time applications in technological fields in respective branches.

III MARKS DISTRIBUTION:

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

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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0 %	Remember
60 %	Understand
40 %	Apply
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Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

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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 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 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.

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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 below.

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

VI COURSE OBJECTIVES:

The students will try to learn:

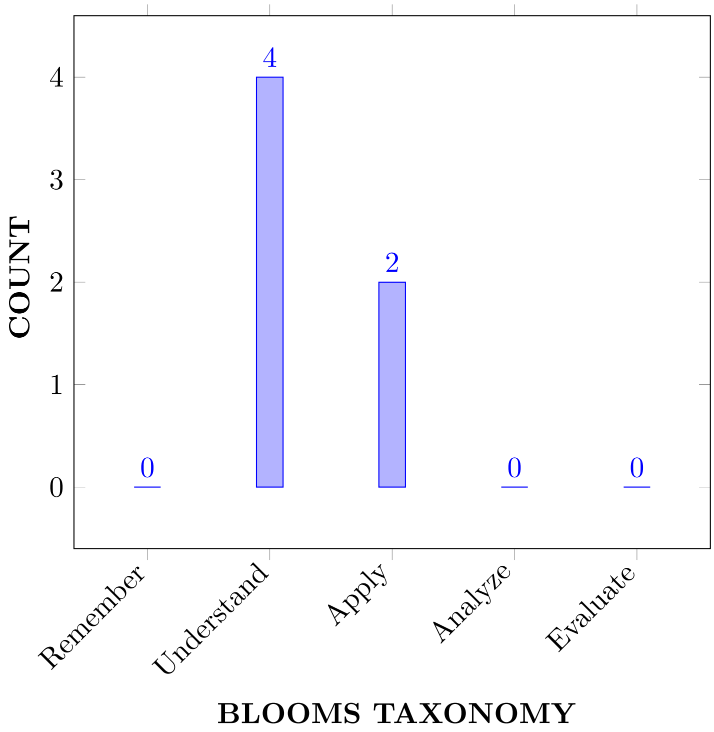
I	Basic formulations in wave mechanics for the evolution of energy levels and quantization of energies for a particle in a potential box with the help of mathematical description.
II	Fundamental properties of semiconductors including the band gap, charge carrier concentration, doping and charge carrier transport mechanisms.
III	Simple optical setups and experimental approaches of light and LASER using its interaction with matter.
IV	Basic comparative studies between different harmonic oscillators and different waves using such relationships on practical problems. .

VII COURSE OUTCOMES:

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

CO 1	**Apply** the concepts of dual nature of matter and Schrodinger wave equation to a particle enclosed in simple systems.	Understand
CO 2	**Demonstrate** the classification of solids and important aspects of semiconductors in terms of carrier concentration and Fermi level.	Apply
CO 3	**Compare** the concepts of LASER and normal light in terms of mechanism and working principles for applications in various fields and scientific practices.	Understand
CO 4	**Explain** functionality of components in optical fiber communication system by using the basics of signal propagation, attenuation and dispersion.	Understand
CO 5	**Interpret** the phenomenon of interference and diffraction by using the principles of wave motion and superposition.	Understand
CO 6	**Make use of** the concept of simple harmonic motion and arrive at expressions for damped, forced harmonic oscillators and wave equations by using necessary mathematical formulations.	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/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/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	AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Make use of the knowledge of quantum mechanics in experimental tools.	1	Laboratory experiments

3 = High; 2 = Medium; 1 = Low

XI 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	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-

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	**Outline** drawbacks of classical mechanics,basic principles of dual nature of matter wave,derive mathematical equation of matter waves and come to conclusion of quantization of energy used in quantum dots.	3
	PO 2	**Explain** the given **problem statement** and **formulate** quantum confinement problems related to particle enclosed in small dimension from the provided **information** and **data** in reaching substantial conclusions by the **interpretation of results**	4
	PSO 1	**Make use of** the knowledge of **quantum mechanics in experimental tools.**	4

CO 2	PO 1	**Illustrate** the charge transport mechanism in intrinsic and extrinsic semiconductors using energy level diagrams,calculate their charge carrier concentration and use those expressions to integrate with other engineering disciplines.	3
CO 2	PO 2	**Explain** the given problem statement and formulate mobility and conductivity aspects of a material from the provided information and data in reaching substantial conclusions **by the interpretation** of **Hall coefficient value.**	4
	PO 4	**Identify** the use of semiconductors under study and their conduction mechanism for the **research based knowledge** and **technological development.**	2
CO 3	PO 1	**Compare** the concepts of LASER and normal light in terms of mechanism and **working principles** for **applications** in different fields and **scientific practices.**	3
CO 4	PO 1	**Explain** functionality of components in optical fiber communication **system** by using the **basics** of signal propagation, attenuation and dispersion.	3
	PO 2	**Identify the given problem** and **formulate** expressions for acceptance angle and numerical aperture with the given **information and data** by applying principles of information propagation through optical wave guides.	4
CO 5	PO 1	**Outline** the **scientific principles** of light and its propagation evolution of different theories, and use the principles of wave motion and superposition using **mathematical principles** to understand the interference and diffraction phenomena in light	3
	PO 4	**Explain** from **technical literature the knowledge of the equipment** on which scientists performed experiments to understand the superposition of light and pattern formation by relating it to conditions for constructive and destructive interference.	2
	PSO 3	**Make use of**interference in computational fluid dynamics and flight simulation tools.	1
CO 6	PO 1	**Outline** the basic **scientific principles** of force and characteristics of a simple harmonic oscillator to understand the forces acting on given oscillator to arrive at equations of damped,forced oscillators and wave equations using basic **mathematical principles**	3

CO 6	PO 2	**Explain** how damping and forced oscillations happen in a system and **identify the problems** and advantages for different conditions of damping.	4

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

COURSE OUTCOMES	**Program Outcomes/ No. of Key Competencies Matched**												**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	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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**												**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	-	-	-	-	-	-	-	-	-	-	35	-	-
CO 2	100	40	-	18	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	-	-	18	-	-	-	-	-	-	-	-	-	-	-
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												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	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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	PO 1,PO 2, PO 4	SEE Exams	PO 1,PO 2, PO 4	Seminars	-
Term Paper	-	Concept Video	PO 1,PO 2, PO 4	Open Ended Experiments	-
Tech Talk	PO 1, PO 2, PO 4,	Assignments	-		

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**QUANTUM MECHANICS**
	Introduction to quantum physics, De-broglie's hypothesis, Wave-particle duality, Davisson and Germer experiment, Time-independent Schrodinger equation for wave function, Physical significance of the wave function, Schrodinger equation for one dimensional problems–particle in a box.
MODULE II	**INTRODUCTION TO SOLIDS AND SEMICONDUCTORS**
	Introduction to classical free electron theory and quantum theory, Bloch's theorem for particles in a periodic potential (Qualitative treatment), Kronig-Penney model (Qualitative treatment), classification: metals, semiconductors, and insulators. Intrinsic and extrinsic semiconductors, Carrier concentration, Dependence of Fermi level on carrier-concentration and temperature, Hall effect
MODULE III	**LASERS AND FIBER OPTICS**
	Characteristics of lasers, Spontaneous and stimulated emission of radiation, Metastable state, Population inversion, Lasing action, Ruby laser, He-Ne laser and applications of lasers. Principle and construction of an optical fiber, Acceptance angle, Numerical aperture, Types of optical fibers (Single mode, multimode, step index, graded index), Optical fiber communication system with block diagram and Applications of optical fibers .
MODULE IV	**LIGHT AND OPTICS**
	Principle of superposition of waves, Young's double slit experiment, Fringe width, Newton's rings. Fraunhofer diffraction from a single slit, double slit (extension to N slits) and diffraction grating experiment.
MODULE V	**HARMONIC OSCILLATIONS AND WAVES IN ONE DIMENSION**
	Simple harmonic oscillator, Damped harmonic oscillator, Forced harmonic oscillator. Transverse waves and Longitudinal wave equation, Reflection and transmission of waves at a boundary, Harmonic waves.

TEXTBOOKS

1. P.K.Palanisamy, "Engineering Physics", SCITECH publications, 2nd Edition,2010.
2. R. K. Gaur, S. L. Gupta, "Engineering Physics", Dhanpat Rai Publications, 8th Edition, 2001.
3. Dr. K. Vijaya Kumar, Dr. S. Chandralingam, "Modern Engineering Physics", Chand & Co. New Delhi, 1st Edition, 2010.
4. Manoj.K.Harbola, T.Vijaya Krishna, T. Madhu Mohan," Engineering Physics", Cengage Publications,1st Edition, 2010.

REFERENCE BOOKS:

1. H.J. Pain, "The Physics of Vibrations and Waves", Wiley, 2006.
2. Ghatak, "Optics", McGraw Hill Education, 2012.
3. O. Svelto, "Principles of Lasers", Springer Science & Business Media, 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
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	Introduction to quantum physics- Black body radiation, Planck's law, Photoelectric effect, Compton effect	CO 1	T1:6.1 R1:1.12.1,
3	De-Broglie's hypothesis,	CO 1	T1:6.3 R1:1.16
4	Wave-particle duality -Matter wave concept	CO 1	T1:6.2 R1:1.13.1
5	Davisson and Germer experiment	CO 1	T1:6.4.1 R1:1.13.2
6	Time-independent Schrodinger equation for wave function	CO 1	T1:6.6 R1:1.13.3
7	Born interpretation of the wave function	CO 1	T1:6.6.1 R1:1.17.1
8	Schrodinger equation for one -dimensional problems– particle in a box.	CO 1	T1:6.7 R1:1.17.3
9	Introduction to classical free electron theory & quantum theory.	CO 2	T1:7.2 R1:1.17.3
10	Bloch's theorem for particles in a periodic potential,	CO 2	T1:7.4 R1:2.3
11	Kronig-Penney model (Qualitative treatment)	CO 2	T1:7.5 R1:2.3
12	Types of electronic materials: metals, semiconductors, and insulators	CO 2	T1:7.6,7.7 R1:2.6.2
13	Intrinsic semiconductors - concentration of electrons in conduction band.	CO 2	T1:8.3.1 R1:2.8
14	Intrinsic semiconductors - concentration of holes in valence band	CO 2	T1:8.3.2 R1:2.9.2
15	Extrinsic semiconductors- Carrier concentration in N-Type	CO 2	T2:8.5 R1:2.10
16	Extrinsic semiconductors- Carrier concentration in P-Type	CO 2	T1:8.6 R1:2.10
17	Dependence of Fermi level on carrier-concentration and temperature	CO 2	T1:8.5,8.6 R1:2.10.2
18	Hall effect	CO2	T1:8.9 R1:2.32

19	Introduction and characteristics of LASER	CO 3	T1:12.1. R1:8.2
20	Spontaneous and stimulated emission of radiation,Meta stable state, Population inversion, Lasing action	CO 3	T1:12.2 R1:8.3.3
21	Ruby laser,He-Ne laser	CO 3	T1:12.3,12.8 R1:8.7.2
22	Applications of LASER	CO 3	T1:12.8.12.9 R1:8.7.2
23	Principle and construction of an optical fiber	CO 4	T1:13.2 R2:12.24
24	Acceptance angle, Numerical aperture	CO 4	T1:13.2 R3:12.25
25	Types of optical fibers (Single mode, multimode, step index, graded index)	CO 4	T1:13.3 R3:3.2
26	Optical fiber communication system with block diagram	CO 4	T1:13.7 R3:3.2
27	Applications of optical fibers .	CO 4	T1:13.12 R1:8.10
28	Principle of Superposition of waves	CO 5	T4:4.3 R1:8.11.1
29	Young's double slit experiment	CO 5	T4:4.7 R1:8.11.2
30	Newton's rings	CO 5	T4:4.14 R1:8.12.1
31	Fraunhofer diffraction from a single slit	CO 5	T4:4.19 R1:8.12.2
32	Fraunhofer diffraction from a Double slit	CO 5	T4:4.21 R1:8.20
33	Fraunhofer diffraction from diffraction grating	CO 5	T4:4.22 R1:8.19
34	Simple Harmonic Oscillators	CO 6	T4:2.3 R1:8.77
35	Damped harmonic oscillator	CO 6	T4:2.8,2.9 R1:7.2
36	Forced mechanical oscillators	CO 6	T4:2.14 R1:7.7
37	Impedance, Steady state motion of forced damped harmonic oscillator	CO 6	T4:2.17 R1:7.8
38	Transverse wave on a string, the wave equation on a string	CO 6	T4:3.3 R1:7.9.2
39	Longitudinal waves and the wave equation	CO 6	T4:3.7 R1:7.9.1
40	Reflection and transmission of waves at a boundary	CO 6	T4:3.4 R1:7.10

41	Harmonic waves	CO 6	T4:3.6 R1:7.11, 11.1
PROBLEM SOLVING/ CASE STUDIES			
1	De-Broglie hypothesis-wavelength expression	CO 1	T1:6.3 R1:1.161
2	Schrodinger equation for one dimensional problems–particle in a box.	CO 1	T1:6.6 R1:1.161
3	Physical significance of the wave function	CO 1	T1: 6.6.1 R1:1.161.
4	Carrier concentration	CO 2	T1:8.3-6, R1:2.8,2.10
5	Fermi level	CO 2	T1:8.5,8.6 R1: 2.10
6	Hall Effect	CO 2	T1:8.9, R1: 2.32
7	Lasers	CO 3	T1: 12.3 R3:12.26
8	Acceptance angle & Numerical aperture	CO 4	T1: 13.2 R3:12.26
9	Refractive indices of core and cladding, fractional refractive index change	CO 4	T1: 13.3 R3:12.26
10	Youngs double-slit	CO 5	T4: 4.7 R1:8.12.1
11	Fringe width	CO 5	T4: 4.7 R1:8.12.1
12	Newton rings	CO 5	T4: 4.14 R1:8.12.1
13	Diffraction grating	CO 5	T4: 4.22 R1:8.12.1
14	Simple Harmonic Oscillator	CO 6	T4:2.3 R1: 8.78
15	Harmonic waves	CO 6	T4:3.6 R1: 7.9.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Quantum mechanics	CO 1	T1:6.1-6.7 R1:1.161.
2	Introduction to Solids and Semiconductors	CO 2	T1:7.2-7, 8.3-9 , R1: 2.8, 2.10
3	Lasers and Fiber Optics	CO 3, CO 4	T1: 12.1-12.9,13.2-13.12 R3:12.26

4	Light and Optics.	CO 5	T4: 4.3-4.22 R1:8.12.1
5	Harmonic Oscillations and Waves in One Dimension	CO 6	T4:2.3-3.7 R1: 8.78, 7.9.3
DISCUSSION OF QUESTION BANK			
1	Module 1	CO 1	T1:6.1-6.7 R1:1.161.
2	Module 2	CO 2	T1:6.1-6.7 R1: 2.8, 2.10
3	Module 3	CO 3, CO 4	T1: 12.1-12.9,13.2-13.12 R3:12.26
4	Module 4	CO 5	T4: 4.3-4.22 R1:8.12.1
5	Module 5	CO 6	T4:2.3-3.7 R1: 8.78, 7.9.3

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	PROGRAMMING FOR PROBLEM SOLVING USING C					
Course Code	ACSB01					
Program	B.Tech					
Semester	I					
Course Type	FOUNDATION					
Regulation	R-18					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	-	3	-	-	
Course Coordinator	Mr. P Ravinder, Assistant Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	-	-	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 CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	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). 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
20%	Remember
30%	Understand
50%	Apply
0 %	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:

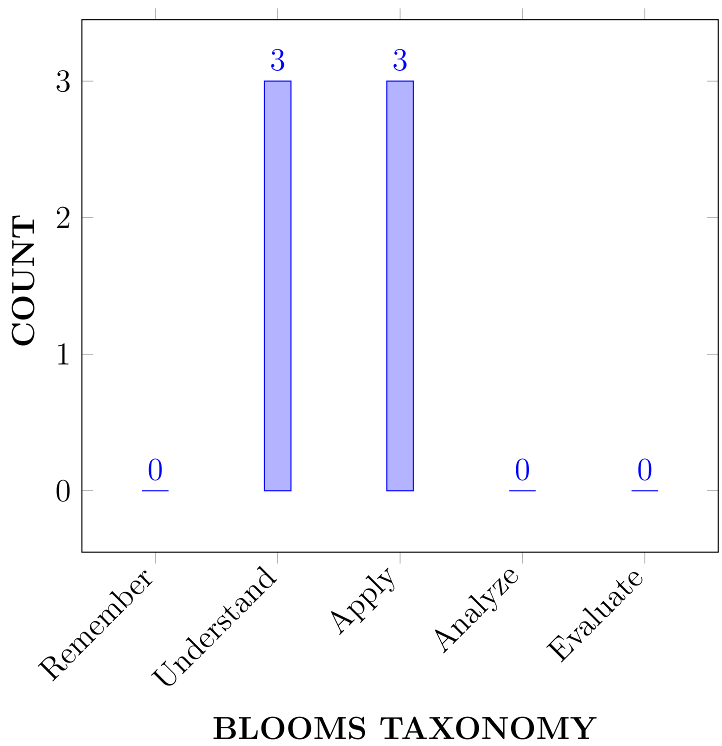
I	Learn adequate knowledge by problem solving techniques.
II	Understand programming skills using the fundamentals and basics of C Language.
III	Improve problem solving skills using arrays, strings, and functions.
IV	Understand the dynamics of memory by pointers.
V	Study files creation process with access 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.	Understanding
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** arious types of functions, parameters, and return values for complex problem solving.	Understand
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.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
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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.	3	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	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	2	Open Ended Experiments

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Understand, design and analyze computer programs in the areas related to problem solving through programming.	2	Tech talk/Open ended experiments
PSO 2	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	Tech talk/Open ended 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	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 **draw** a flowchart, **identify** the appropriate symbols to solve a problem, then **formulate** the solution, and **interpret** the result for the **improvement** of the **solution.**	6
	PSO 1	Understand the features of procedural programming for **designing** and **analyzing** computer programs for **problem-solving.**	3
CO 2	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 **analyze** the same to **validate** the results in a program to solve **complex** engineering problems.	6
	PO 3	**Recognize** an appropriate control structure to **design** and **develop** a solution for a **real-time** scenario, and **communicating** effectively with engineering community.	5
CO 3	PO 1	Recognize the importance of recursionfor developing programs in real-time scenarios using principles of **mathematics**, and **engineering fundamentals**.	3
	PO 2	Understand the various kinds of **functions**, **identify** the suitable type of function to **solve** a problem, **formulate** the solution, and **interpret** the result for the **improvement** of the solution.	6
	PO 5	Apply techniques of **structured decomposition** to dividea problem into smaller pieces with an understanding of its limitations.	1

CO 4	PO 1	Extend the focus on the usage of heterogeneous data types as a **basic building block** in problem solving using principles of **science**, and **engineering** fundamentals.	3
	PO 2	**Recognize** the representation of the structure, **assess** in solving a problem, **express the solution**, and **analyze** the result for **solution enhancement**.	5
	PO 5	Understand pointers conceptually and apply them in modeling a **complex engineering** activity.	1
CO 5	PO 1	Make a use of an appropriate type of file to store a large volume of **persistent data** and give solution to **engineering problems**.	2
	PO 5	To identify appropriate mode to access a file and run the same **program** multiple times.	1
CO 6	PO 12	**Realize** the need and the desire to **train** and **invest** in autonomous and **lifelong learning** in the widest sense of **technical transition** to achieve **employability expertise** and excel advanced **engineering concepts**.	7
	PSO 3	Attain the **knowledge** and **skills** for employability and to succeed in national and international level **competitive examinations**.	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	6	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 2	3	6	5	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	6	-	-	1	-	-	-	-	-	-	-	-		-
CO 4	3	5	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 5	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	-	-	7	-	-	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	60	-	-	-	-	-	-	-	-	-	-	50	-	-
CO 2	100	60	50	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	60	-	-	100	-	-	-	-	-	-	-	-	-	-
CO 4	100	50	-	-	100	-	-	-	-	-	-	-	-	-	-
CO 5	66	-	-	-	100	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	-	-	58	-	-	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	-	-
CO 2	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	3	-	-	3	-	-	-	-	-	-	-	-		-
CO 4	3	2	-	-	3	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	3	-	-	-	-	-	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2
TOTAL	15	11	2	-	9	-	-	-	-	-	-	2	2	-	2
AVERAGE	3	2.7	2.5	-	3	-	-	-	-	-	-	2	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:

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

XVIII SYLLABUS:

MODULE I	INTRODUCTION
	Introduction to components of a computers: Introduction to Programming: Computer system, components of a computer system, computing environments, computer languages, creating and running programs, algorithms, flowcharts;**Introduction to C Language:** Computer languages, 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.

MODULE II	**CONTROL STRUCTRES**
	Conditional Control structures: Decision statements; Simple if, if-else, else if ladder, Nested if and Case Statement-switch statement; **Loop control statements:** while, for and do while loops. jump statements, break, continue, goto statements;
MODULE III	**ARRAYS AND FUNCTIONS**
	Arrays: 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; **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 directive.
MODULE IV	**STRUCTURES, UNIONS AND POINTERS**
	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; **Pointers:**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:**Basic concepts, library functions.
MODULE V	**FILE HANDLING AND BASIC ALGORITHMS**
	Files: Streams, basic file operations, file types, file opening modes, input and output operations with files, special functions for working with files, file positioning functions, command line arguments. Searching, basic sorting algorithms (bubble, insertion, selection), algorithm complexity through example programs (no formal definitions required).

TEXTBOOKS

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, 2nd Edition, 1988.
2. Yashavant Kanetkar, “Exploring C”, BPB Publishers, 2nd Edition, 2003.
3. Schildt Herbert, “C: The Complete Reference”, Tata McGraw Hill Education, 4th Edition, 2014.
4. R. S. Bichkar, “Programming with C”, Universities Press, 2 nd Edition, 2012.
5. Dey Pradeep, Manas Ghosh, “Computer Fundamentals and Programming in C”, Oxford University Press, 2nd Edition, 2006.
6. Stephen G. Kochan, “Programming in C”, Addison-Wesley Professional, 4th Edition, 2014.

WEB REFERENCES:

1. https://www.nptel.ac.in/courses/108106073/
2. https://www.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	PSO'S Course Description on Outcome Based Education (OBE): Course Objectives,Course Outcomes (CO), ProgramOutcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Understand components of a computer	CO 1	T2: 1.1-1.2,R4: 1.1-1.3
3	Identify and apply algorithms and flowcharts for problem solving	CO 1	T2: 2.1-2.2,R4: 1.4
4	Understand pseudo code for a given problem	CO 1	T2: 2.1-2.2
5	Understand the basic structure, process of compiling and running a C program	CO 1	T2: 2.1-2.2,
6	Understand keywords, identifiers, constants, strings, special symbols, variables	CO 1	T2: 1.4 -1.5, R4: 2.1 - 2.4
7	Define the data types, and operators to write C Program	CO 1	T2: 2.1-2.2
8	Understand precedence of operators, expression evaluation	CO 1	T2: 2.3-2.6
9	Understand formatted input/output functions, Type Conversion and type casting in C Programming	CO 1	T2:2.3-2.7
10	Identify and apply decision making statements in C programming	CO 2	T2: 3.1-3.5
11	Identify and apply loop control structures in C programming	CO 2	T2: 5.2-5.3
12	Identify and apply unconditional control structures in C programming	CO 2	T2: 6.1-6.6
13	Understand single dimensional array and multi-deimensional array: declaration, initialization, accessing	CO 3	T2: 6.7
14	Operations on arrays: traversal, reverse, insertion	CO 3	T2: 8.1-8.2, R4: 15.1
15	Operations on arrays: deletion, merge, search	CO 3	T2: 8.3, R4: 15.1

16	Arrays of characters, Reading and writing strings, String handling functions	CO 3	T2: 11.1-11.5
17	Operations on strings: array of strings	CO 3	T2: 4.1-4.5
18	Concept of user defined functions, Function declaration	CO 3	T1: 7
19	return statement, Function prototype	CO 3	T2: 6.9
20	Types of functions, Inter function communication	CO 3	T1: 10, T2:10.1-10.2
21	Function calls, Parameter passing mechanisms, Recursion	CO 3	T2: 10.3-10.4, R4:8.3-8.4
22	Passing arrays to functions, passing strings to functions	CO 3	T2:10.5
23	Storage classes	CO 3	T1: 8.9, R4:8.6.3
24	Basics of pointers, Pointer arithmetic	CO 4	T2: 3.1, R4:11.1
25	Pointer to pointers	CO 4	T2: 3.2
26	Array of pointers	CO 4	T2: 3.2
27	Generic pointer, Null pointers	CO 4	T2: 3.3
28	Pointers as function arguments, Functions returning pointers	CO 4	T2: 3.4-3.5
29	Dynamic memory allocation	CO 4	T2: 6.1-6.6
30	Structure definition, initialization, structure members	CO 4	T2: 12.3-12.4, R4:13.4
31	Nested structures	CO 4	T2: 12.3-12.4, R4:13.4
32	Arrays of structures, structures and functions	CO 4	T2: 2.1-2.2, R4:13.2
33	Structures and pointers, self-referential structures	CO 4	T2: 2.1-2.2
34	Union, bit fields, typedef	CO 4	T2: 12.4
35	Enumerations, Preprocessor directives	CO 4	T1: 8.9, T2: 2.3-2.5
36	Concept of a file, text files and binary files, streams	CO 5	T2: 10.4, R4:14.1-14.4
37	Standard I/O, formatted I/O, file I/O operations	CO 5	T2: 10.4, R4:14.1-14.4
38	Error handling	CO 5	R3: 12.1 - 12.3

39	Line I/O, miscellaneous functions	CO 5	R3: 12.1 - 12.3
40	Applications of C	CO 6	R4: 17
PROBLEM SOLVING/ CASE STUDIES			
1	Write a program in C that takes minutes as input, and display the total number of hours and minutes.	CO 1	T2:2.3-2.6
2	Write a program in C that reads a forename, surname and year of birth and display the names and the year one after another sequentially.	CO 1	T2:2.3-2.7
3	Write a C program to find the third angle of a triangle if two angles are given.	CO 2	T2:3.1-3.5
4	Write a program in C to display the such a pattern for n number of rows using a number which will start with the number 1 and the first and a last number of each row will be 1.	CO 2	T2:5.2-5.3
5	Write a program in C to find the prime numbers within a range of numbers.	CO 2	T2:5.2-5.3
6	Write a program in C to display the n terms of harmonic series and their sum.	CO 2	T2:6.1-6.6
7	Write a program in C to display the pattern like right angle triangle using an asterisk.	CO 2	T2:5.2-5.3
8	Program to accept N integer number and store them in an array AR. The odd elements in the AR are copied into OAR and other elements are copied into EAR. Display the contents of OAR and EAR	CO 3	T2: 6.7
9	Write a C program to illustrate how user authentication is made before allowing the user to access the secured resources. It asks for the user name and then the password. The password that you enter will not be displayed, instead that character is replaced by '*'	CO 3	T2: 8.3, R4:15.1
10	Write a C program to accept a matric and determine whether it is a sparse matrix. A sparse martix is matrix which has more zero elements than nonzero elements	CO 3	T2: 8.1-8.2, R4: 15.1
11	Write a C program to accept a amtric of order MxN and sort all rows of the matrix in ascending order and all columns in descendng order	CO 3	T2: 6.7
12	Write a C program to accept a set of names and sort them in an alphabetical order, Use structures to store the names	CO 4	T2:12.3-12.4, R4:13.4
13	Write a C program to find the sum of two one-dimensional arrays using Dynamic Memory Allocation	CO 4	T2:6.1-6.6
14	Write a program in C to find the content of the file and number of lines in a Text File.	CO 5	T2:10.4, R4:14.1-14.4
15	Write a program in C to replace a specific line with another text in a file.	CO 5	T2:10.4, R4:14.1-14.4
DISCUSSION OF DEFINITION AND TERMINOLOGY			

1	Module I- Components of computers, C programming language	CO 1	T2:1.1-2.6, R4:1.1-2.4
2	Module II- Control structures	CO 2	T2:3.1-6.6
3	Module III- Arrays, Strings and Functions	CO 3	T1:7, T2:6.7-11.5
4	Module IV- Pointers and Structures	CO 4	T2:3.1-6.6, R4:11.1-13.4
5	Module V- File handling functions	CO 5	T2:10.4, R4:14.1-14.4, R3:12.1-12.3
DISCUSSION OF QUESTION BANK			
1	Module I- Components of computers, C programming language	CO 1	T2:1.1-2.6, R4:1.1-2.4
2	Module II- Control structures	CO 2	T2:3.1-6.6
3	Module III- Arrays, Strings and Functions	CO 3	T1:7, T2:6.7-11.5
4	Module IV- Pointers and Structures	CO 4	T2:3.1-6.6, R4:11.1-13.4
5	Module V- File handling functions	CO 5	T2:10.4, R4:14.1-14.4, R3:12.1-12.3

Signature of Course Coordinator **HOD,ME**

Mr. P Ravinder, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**ENGINEERING PHYSICS LABORATORY**				
Course Code	AHSB10				
Program	B.Tech				
Semester	I	ME			
Course Type	FOUNDATION				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
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	1.5

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
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:

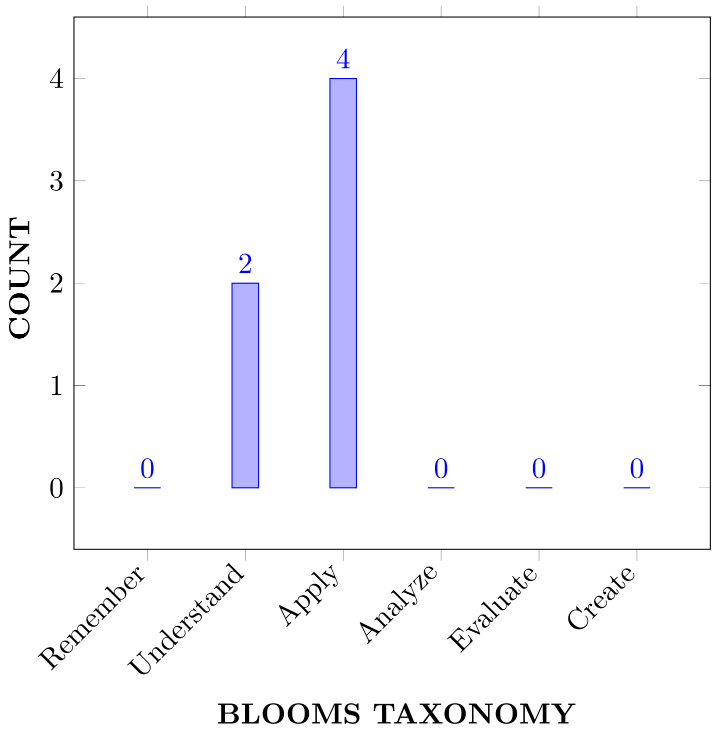
I	To familiarize with the lab facilities, equipment, standard operating procedures.
II	About the different kinds of functional electric and magnetic materials which paves a way for them to use in various technical and engineering applications.
III	The analytical techniques and graphical analysis to study 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	**Identify** the type of semiconductor using the principle of Hall Effect and also determine the energy gap of a semiconductor diode.	Apply
CO 2	**Illustrate** principle, working and application of wave propagation and compare results with theoretical harmonics and overtones.	Understand
CO 3	**Investigate** the energy losses associated with a given Ferro magnetic material and also magnetic field induction produced at various points along the axis of current carrying coil.	Apply
CO 4	**Examine** launching of light through optical fiber from the concept of light gathering capacity of numerical aperture.	Understand
CO 5	**Utilize** ththe phenomena of interference and diffraction for the determination of various parameters like radius of curvature of convex lens, wavelength of laser light and width of single slit.	Apply
CO 6	**Investigate** V-I/L-I characteristics of various optoelectronic devices like Light Emitting Diode, Photodiode to understand their basic principle of functioning as well as to infer the value of Planck's constant.	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 modern computer tools for creating innovative career paths, to be an entrepreneur and desire for 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 Hall effect and make use of mathematical expression for Hall coefficient to deduce the type of semiconductor.	2
	PO 2	Understand the given problem statement of identification of type of semiconductor and formulate Hall coefficient from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	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 energy losses associated with a given ferromagnetic material and make use of graphical representation of hysteresis loop exhibited by magnetic material.	2
	PO 2	Understand the given problem statement of energy losses associated with a given ferromagnetic material and formulate hysteresis loop from experimental collection of information and data in reaching substantial conclusions by the interpretation of results.	4
	PO 4	Apply simulation tool to get hysteresis curve of a ferromagnetic material and understand energy losses associated with material.	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	Understand the phenomenon of single slit diffraction and make use of it to determine the slit width by using laser light as monochromatic source.	1
CO 6	PO 1	Explain the V-I characteristics of light emitting diode and infer the value of planck's constant by plotting temperature versus current curve.	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 photo 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	**HAL LEFFECT (LORENTZFORCE)**
	Determination of charge carrier density.
WEEK 2	**MELDE'S EXPERIMENT**
	Determination of frequency of a given tuning fork
WEEK 3	**STEWART GEE'S APPARATUS**
	Magnetic field along the axis of current carrying coil – Stewart and Gee's method.
WEEK 4	**B-H CURVE WITH CRO**
	To determine the value of retentivity and coercivity of a given magnetic material.
WEEK 5	**ENERGY GAP OF A SEMICONDUCTOR DIODE**
	Determination of energy gap of a semiconductor diode.
WEEK 6	**PHOTO DIODE**
	Studying V-I characteristics of Photo Diode.
WEEK 7	**OPTICAL FIBER**
	Evaluation of numerical aperture of a given optical fiber.
WEEK 8	**WAVELENGTH OF LASER LIGHT**
	Determination of wavelength of a given laser light using diffraction grating.
WEEK 9	**PLANK'S CONSTANT**
	Determination of Plank's constant using LED.
WEEK 10	**LIGHT EMITTING DIODE**
	Studying V-I Characteristics of LED.
WEEK 11	**NEWTONS RINGS**
	Determination of radius of curvature of a given plano - convex lens.
WEEK 12	**SINGLE SLIT DIFFRACTION**
	Determination of width of a given single slit.

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	Determination of charge carrier density.	CO 1	T1:13.5
2	Determination of frequency of a given tuning fork.	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 the energy loss per unit volume of a given magnetic material per cycle by tracing the Hysteresis loop.	CO 3	T1:15.7
5	Determination of energy gap of a semiconductor diode.	CO 1	T1:16.8
6	Studying V-I Characteristics of Photo Diode.	CO 6	T1:16.9
7	Evaluation of numerical aperture of a given optical fiber.	CO 4	T1:17.9
8	Determination of wavelength of a given laser light using diffraction grating.	CO 5	T1:18.10
9	Determination of Plank's constant using LED.	CO 6	T1:19.10
10	Studying V-I characteristics of LED	CO 6	T1:19.9
11	Determination of radius of curvature of a given Plano-convex lens.	CO 5	T1:23.10
12	Determination of width of a given single slit.	CO 5	T1:23.10

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	To determine the wavelength of different colored light using white light source by Newton's ring method
2	To study the bending losses and transmission losses of an optical Fiber
3	To observe the dispersion of prism by using spectrometer.
4	Study the characteristics of Laser diode.
5	To illustrate the interference pattern produced from the air wedge.
6	To determine the voltage current characteristics of solar cell

Signature of Course Coordinator
Mr.K Saibaba, Assistant Professor

HOD,CSE

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

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**PROGRAMMING FOR PROBLEM SOLVING LABORATORY**				
Course Code	ACSB02				
Program	B.Tech				
Semester	I	ME			
Course Type	Foundation				
Regulation	IARE - R18				
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.

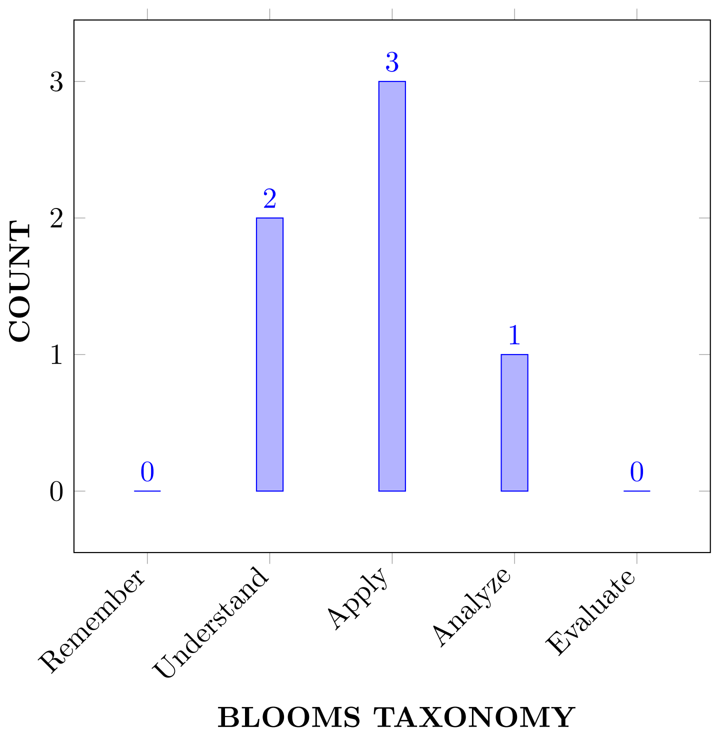
III	The practical implementation and usage of non linear data structures for solving problems of different domain.
IV	The knowledge of more sophisticated data structures to solve problems involving balanced binary search trees, AVL Trees, B-trees and B+ trees, hashing.
V	The graph traversals algorithms 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				
CO	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	WORKSHOP / MANUFACTURING PRACTICES LABORATORY				
Course Code	AMEB01				
Program	B. Tech				
Semester	I				
Course Type	FOUNDATION				
Regulation	IARE-R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. B. Vijaya Krishna, Assistant Professor				

I COURSE OVERVIEW:

Workshop or Manufacturing 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
Manufacturig 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	The application of jigs and fixtures, measuring, marking and cutting tools in various types of manufacturing processes.
II	The preparation of different joints in carpentry and fitting and also familiarizes wood working machinery.
III	The concepts of forming processes by forging, black-smithy and tin-smithy with an application extracts of Engineering Drawing.
IV	The standard electrical wiring practices for domestic and industrial appliances. of Engineering Drawing.
V	The current advancements in developing the prototype models through digital manufacturing facilities.

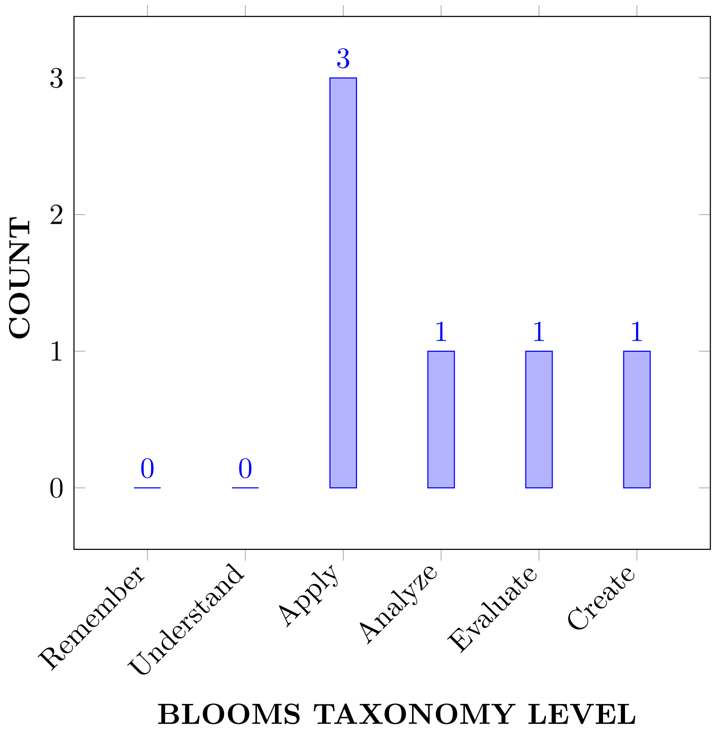
IX COURSE OUTCOMES:

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 such as moulding and machine shop.	Apply
CO 2	**Determine** the ability to Produce Fitting and welding 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	**MACHINE SHOP-Turning and other Machines.**
	Batch I: Working on central lathe and shaping machine. Batch II: Working on drilling, grinding machines.
WEEK 2	**MACHINE SHOP-Milling and other Machines**
	Batch I: Working on drilling, grinding machines. Batch II: Working on milling and shaping machine.
WEEK 3	**ADVANCED MACHINE SHOP**

	Batch I: Working on CNC Turning machines. Batch II: Working on CNC Vertical Drill Tap Center.
WEEK 4	**FITTING**
	Batch I: Make an electrical connection to demonstrate domestic voltage and current sharing. Batch II: Make an electrical connection to control one bulb with two switches-stair case connection.
WEEK 5	**CARPENTRY-I**
	Batch I: Preparation of lap joint as per given dimensions. Batch II: Preparation of dove tail joint as per given taper angle.
WEEK 6	**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 7	**ELECTRICAL AND ELECTRONICS**
	Batch I: Make an electrical connection to demonstrate domestic voltage and current sharing. Batch II: Make an electrical connection to control one bulb with two switches-stair case connection.
WEEK 8	**WELDING**
	Batch I: Arc welding and Gas Welding. Batch II: Gas welding and Arc Welding.
WEEK 9	**MOULD PREPARATION**
	Batch I: : Prepare a wheel flange mould using a given wooden pattern. Batch II: Prepare a bearing housing using an aluminum pattern.
WEEK 10	**MOULD PREPARATION**
	Batch I: Prepare a bearing housing using an aluminum pattern Batch II: Prepare a wheel flange mould using a given wooden pattern.
WEEK 11	**BLACKSMITHY- I, TINSMITHY- I**
	Batch I: Prepare S-bend and J-bend for given MS rod using open hearth furnace. Batch II: Prepare the development of a surface and make a rectangular tray and a round tin. .
WEEK 12	**TINSMITHY- I, BLACKSMITHY- I**
	Batch I: Prepare the development of a surface and make a rectangular tray and a round tin. Working on milling machine. Batch II: Prepare S-bend and J-bend of given MS rod using open hearth furnace.
WEEK 13	**PLASTIC MOULDING, INJECTION MOULDING, GLASS CUTTING**
	Batch I: : Plastic Moulding and Glass cutting. Batch II: : Plastic Moulding and Glass cutting.

WEEK 14	**BLOW MOULDING**
	Batch I: Blow Moulding.
	Batch II: : Batch II: Blow Moulding.

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
COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ENGLISH**				
Course Code	AHSB01				
Program	B. Tech				
Semester	II				
Course Type	Foundation				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	2	-	-
Course Coordinator	Dr. M.Sailaja, Associate 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). 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:

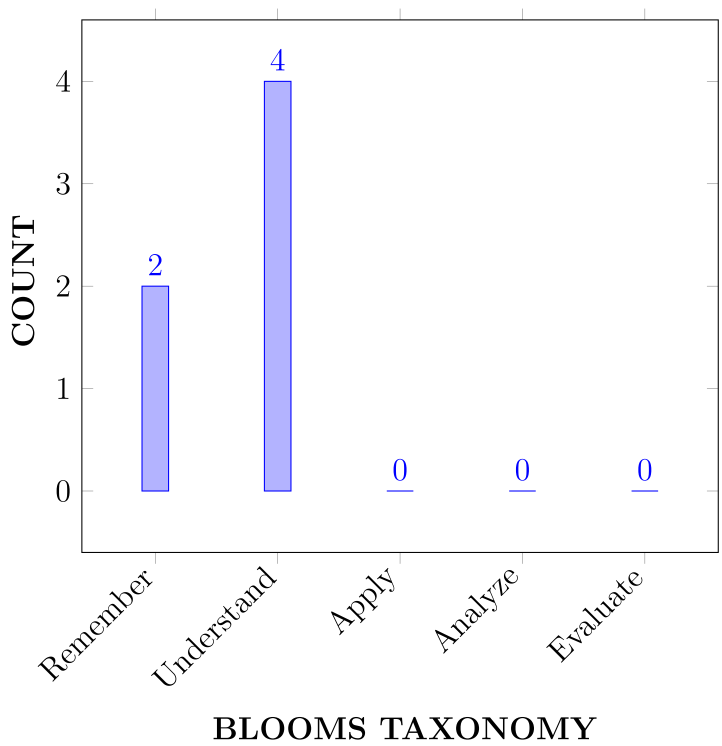
I	Communicate in an intelligible English pronunciation to meet the global standards.
II	Effectively use of four language skills (listening skill, speaking skill, reading skill and writing skill) in day-to-day affairs.
III	A critical aspect of speaking and reading for interpreting in-depth meaning between 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	Understand, analyze, design and supervise sub-structures and superstructures for residential and public buildings, industrial structures, irrigation structures, powerhouses, highways, railways, airways, docks and harbors.	-	-
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	-	-
PSO 3	Make use of advanced software for creating modern avenues to succeed as an entrepreneur or to pursue 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	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-

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 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, ME**

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**MATHEMATICAL TRANSFORM TECHNIQUES**				
Course Code	AHSB11				
Program	B.Tech				
Semester	II				
Course Type	Foundation				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr. S Jagadha, Associate Professor				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

This course focuses on transformations from theoretical based mathematical laws to its practical applications in the domain of various branches of engineering field. The course includes the transformations such as Laplace, Fourier, applications of scalar and vector field over surface, volume and multiple integrals. The course is designed to extract the mathematical developments, skills, from basic concepts to advance level of engineering problems to meet the technological challenges.

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	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
10%	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	Enrich the knowledge of solving algebraic, transcendental and differential equation by numericalmethods
II	The operation of non-periodic functions by Fourier transforms.

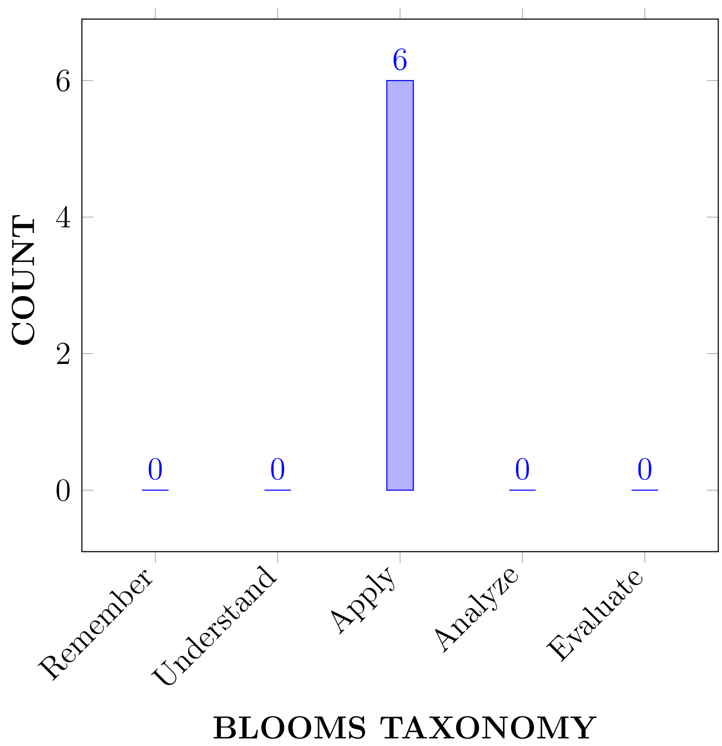
III	The transformation of ordinary differential equations in Laplace field and its applications
IV	The partial differential equation for solving non-linear equations

VII COURSE OUTCOMES:

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

CO 1	**Solve** algebraic and transcendental equations using Bisection method, Regula-falsi method and Newton-Raphson method	Apply
CO 2	**Apply** numerical methods in interpolating the equal and unequal space data	Apply
CO 3	**Make use of** method of least squares to fit poliynomial curves and differential equation by numerical methods	Apply
CO 4	**Apply** the Fourier transform as a mathematical function that transforms a signal from the time domain to the frequency domain, non-periodic function up to infinity	Apply
CO 5	**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 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.

Program Outcomes	
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
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	**Solve complex engineering problems** involving algebraic and transcendental equations using Bisection method, Regula-falsi method and Newton-Raphson method along with **principles of mathematics**.	2
CO 2	PO 1	Apply numerical methods in interpolating the data and fitting the suitable curve in solving complex engineering problems with the help of basic Principle of mathematics to reach valid conclusions.	2
CO3	PO 1	Use numerical methods Taylor's series, Euler's, Picard's and Runge-Kutta methods in solving differential equations encountered in complex engineering problems with the help of basic Principle of mathematics	2
	PO 2	Make use of method of least squares and numerical methods to Identify the statement of the complex engineering problems involving the role of fitting the straight lines, second degree, exponential, power curves,differential equations along with principle of mathematics and interpret the results..	4
	PO4	Make use of the method of least squares in fitting the straight lines ,second degree, exponential, power curves in which coefficients are quantitatively measured by using MATLAB computer software.	1
	PSO1	Make use of the method of least squares in fitting the straight lines ,second degree, exponential, power curves in the design and implementation of complex systems triggered in Aeronautical Engineering	1
CO4	PO 2	Identify the range of non-periodic functions up to infinity and properties of complex Fourier transform in the statement of complex engineering problems which intensifies (apply) the boundary value problems using principle of mathematics related to engineering by the interpretation of results by Fourier integral and Fourier transform	2
	PSO1	Identify the properties of complex Fourier transform concern Aeronautical Engineering which intensifies (apply) the boundary value problems in the design and implementation of complex systems	1
CO5	PO1	Interpret the properties of Laplace and inverse Laplace transform (apply)in solving complex engineering problems for a function of a real variable 't' (time) (apply) to a function of a complex variable 's' (complex frequency) of various functions such as continuous, piecewise continuous, step and impulsive functions with basic Principle of mathematics to reach valid conclusions of engineering problems	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO2	Describe the formulation of integral transforms (knowledge) which converts complex engineering problems using (apply) operations of calculus to algebra along with basic principles of mathematics reaching substantiated conclusions by the interpretation of results in solving linear differential equations	4
CO6	PO1	Apply the method of Lagrange's linear equation Variable separaible to complex engineering problems such as Heat and Wave equations in the domain of engineering (Principle of mathematics and engineering)	2
	PO2	Identify the statement ofproperties of complex Fourier transform (understand)incomplex engineering problemswhich intensifies (apply) the boundary value problems using principle of mathematics related to 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	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	4	-	1	-	-	-	-	-	-	-	-	1	-	-
CO 4	-	4	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 5	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	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	66.7	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40	-	9	-	-	-	-	-	-	-	-	50	-	-
CO 4	-	40	-	-		-	-	-	-	-	-		50	-	-
CO 5	66.7	40	-	-	-	-	-	-	-	-	-	-	-	-	-
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	-	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
TOTAL	15	8	-	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 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	**FOURIER TRANSFORMS**
	Fourier integral theorem, Fourier sine and cosine integrals; Fourier transforms; Fourier sine and cosine transform, properties, inverse transforms, finite Fourier transforms Triple Integrals: Evaluation of triple integrals in Cartesian coordinates; volume of a region using triple integration.
MODULE IV	**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 to ordinary differential equations.
MODULE V	**PARTIAL DIFFERENTIAL EQUATIONS**
	Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions, solutions of first order linear equations; Charpit's method; Applications of partial differential equations of wave and heat equations

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 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	CO2	T1:12.4, R1:4.13
7	Explain the relation between symbols	CO2	T1:12.4, R1:4.15
8	Solve the problems by Newton's forward method	CO2	T1:12.4, R1:4.20
9	Solve the problems by Newton's backward method	CO 2	T1:12.5, R1:8.8
10	Solve the problems by Gauss forward method	CO 2	T1:13.1, R1:5.3
11	Solve the problems by Gauss backward method	CO 2	T1:13.2, R1:5.5
12	Solve the problems by lagrange's and Newtons dividend difference	CO 2	T1:13.3, R1:5.9
13	Solve a straight line	CO 3	T1:14.4, R1:6.2
14	Solve a second degree parabola	CO 3	T1:15.2 , R1:6.6
15	Solve an exponential curve	CO 3	T1:15.1, R1:7.4,
16	Solve the ODE by Taylor's series method	CO 3	T1:15.1, R1:6.5
17	Solve the ODE by Euler's Method- Euler's modified method	CO 3	T1:15.3, R1:7.9
18	Solve the ODE by Runge-Kutta Methods	CO 3	T2: 7.15, R1:1.65
19	Fourier transform	CO4	T1:22.3 R1:10.8
20	Fourier sine transform	CO4	T1:22.4 R1:10.9
21	Fourier Cosine Transforms	CO4	T1:22.5 R1:10.9

22	Properties of Fourier Transforms	CO4	T1:22.4 R1:10.9
23	Inverse Fourier Transform	CO4	T2:15.5 R1:7.5
24	Finite Fourier Transform	CO4	T2:16.5 R1:7.6
25	Infinite Fourier Transform	CO4	T2:16.5 R1:7.6
26	Aplications of Fourier Transform	CO4	T2:16.5 R1:7.6
27	First, second shifting theorems and change of scale property of Laplace transforms	CO5	T1:21.2 R1:5.1
28	Laplace transforms of Derivatives, Integrals, multiplication and Division by t to a function	CO5	T1:21.4 R1:5.1
29	Laplace transform of periodic functions	CO5	T1:21.7-21.10 R1:5.2-5.4
30	First, second shifting theorems and change of scale property of Inverse Laplace Transforms	CO5	T1:21.12 R1:5.1,5.6
31	Inverse Laplace transforms of Derivatives, Integrals, multiplication and Division by s to a function	CO5	T1:21.13 R1:5.1,5.3
32	Convolution theorem	CO5	T1:21.13 R1:5.4
33	Application of Laplace Transforms	CO5	T1:21.14 R1:5.5
34	Elimination of arbitrary constants(Formation of PDE)	CO6	T1:17.1-17.2 R1:16.1-16.2
35	Elimination of arbitrary functions(Formation of PDE)	CO6	T1:17.5-17.6 R1:16.3.1
36	Non-Linear Partial differential equation of first order	CO6	T1:17.1-17.2 R1:16.1-16.2
37	Standard forms I, II ,III and IV	CO6	T1:17.1-17.2 R1:16.1-16.2
38	Non-Linear Partial differential equation of first order Standard forms V	CO6	T1:17.5-17.6 R1:16.3.1
39	Non-Linear Partial differential equation of first order Standard forms VI	CO6	T1:17.1-17.2 R1:16.1-16.2

40	Lagrange's Linear equation- Method of grouping	CO11	T1:17.5-17.6 R1:16.3.1
41	Lagrange's Linear Equation -Method of Multipliers	CO12	T1:17.1-17.2 R1:16.1-16.2
PROBLEM SOLVING/ CASE STUDIES			
42	Solving problems by Bisection method to find the root	CO 1	T1:12.3, R1:4.4
43	Solving problems on False Position method to find the root	CO 1	T1:12.3, R1:4.6
44	Solving problems on Newton-Raphson method to find roots	CO 1	T1:12.3, R1:4.7
45	Solve the problems by Newton's forward method	CO2	T1:12.4, R1:4.20
46	Solve the problems by Newton's backward method	CO 2	T1:12.5, R1:8.8
47	Solve the problems by Gauss forward method	CO 2	T1:13.1, R1:5.3
48	Solve the problems by Gauss backward method	CO 2	T1:13.2, R1:5.5
49	Solve the problems by lagrange's and Newtons dividend difference	CO 2	T1:13.3, R1:5.9
50	Solve the ODE by Euler's Method- Euler's modified method	CO 3	T1:15.3, R1:7.9
51	Solve the ODE by Runge-Kutta Methods	CO 3	T2: 7.15, R1:1.65
52	Solving problems on Laplace Transform of First, second shifting theorems and change of scale property	CO 4	T1:21.1,21.4 R1:5.1
53	Solving problems on Inverse Laplace transforms of derivatives, integrals, multiplied by s, divided by s	CO 4	T1:21.13 R1:5.1,5.3
54	Solving problems on Convolution theorem	CO 4	T1:21.14 R1:5.5
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 Roots finding techniques and interpolation	CO 1,2	T1:21.1,21.4 R1:5.1
58	Definitions and terminology on Curve fitting and Numerical solution of ordinary differential equations	CO 3	T1:22.1-22.2R1:10.8

59	Definitions and terminology on Fourier transforms	CO 4	T1:22.1-22.2R1:10.8
60	Definitions and terminology on Laplace transforms	CO 5	T1:21.1,21.4 R1:5.1
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	Discussion of Roots finding techniques and interpolation	CO 1,2	T1:21.1,21.4 R1:5.1
63	Discussion ofCurve fitting and Numerical solution of ordinary differential equations	CO 3	T1:22.1-22.2 R1:10.8
64	Discussion of Fourier transforms	CO 4	T2:15.5 R1:7.5
65	Discussion of Laplace transforms	CO 5	T2:10.3 R1:16.4
66	Discussion of partial differential equations	CO 6	T1:17.1-17.2 R1:16.1-16.2

Signature of Course Coordinator **HOD,AE**

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ENGINEERING CHEMISTRY**				
Course Code	**AHSB03**				
Program	**B.Tech**				
Semester	**II**				
Course Type	**FOUNDATION**				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	1.5
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 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.

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
50%	Understand
50%	Apply
0 %	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.

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:

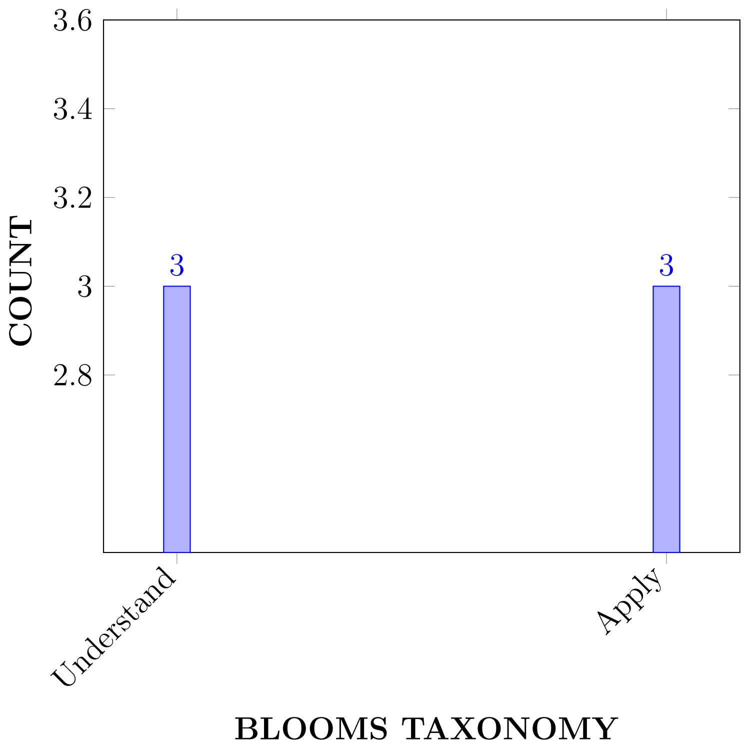
I	The concepts of electrochemical principles and causes of corrosion in the new development and breakthroughs efficiently in engineering and technology.
II	The different parameters to remove causes of hardness of water and their reactions towards the complexometric method.
III	The microscopic chemistry 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 electrochemical principles, corrosion process in metals for protection of different metals from corrosion.	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	**Identify** the hardness of water by different treatment methods for finding the hardness causing salts in water.	Apply
CO 4	**Illustrate** the molecular orbital energy level diagrams of different molecules and theories of bonding for understanding the magnetic properties of coordination compounds.	Understand
CO 5	**Explain** the mechanism of different chemical reactions, stereo isomers for finding the optically active compounds and synthesizing the drug molecules.	Understand
CO 6	**Make use of** green synthesis methods, 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	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	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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
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	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-	-	3	-	-	-	-	-	-	-	-
TOTAL	18	3	-	-	-	-	3	-	-	-	-	-	-	-	-
AVERAGE	3	1	-	-	-	-	3	-	-	-	-	-	-	-	-

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:

MODULE 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.
MODULE II	**WATER AND ITS TREATMENT**
	Introduction: Hardness of water, Causes of hardness; Types of hardness: temporary and permanent, expression and units of hardness; Estimation of hardness of water by complexometric method; Potable water and its specifications, Steps involved in treatment of water, Disinfection of water by chlorination and ozonization; Boiler feed water and its treatment, Calgon conditioning, Phosphate conditioning and Colloidal conditioning; External treatment of water; Ion-exchange process; Desalination of water: Reverse osmosis, numerical problems.
MODULE III	**MOLECULAR STRUCTURE AND THEORIES OF BONDING**
	Atomic and Molecular orbitals: Linear Combination of Atomic Orbitals LCAO), molecular orbitals of diatomic molecules; Molecular orbital energy level diagrams of N2, O2F2, CO and NO molecules. Crystal Field Theory (CFT): Salient Features of CFT-Crystal Field; Splitting of transition metal ion d- orbitals in Tetrahedral, Octahedral and square planar geometries; Band structure of solids and effect of doping on conductance.
MODULE IV	**STEREOCHEMISTRY, REACTION MECHANISM AND SYNTHESIS OF DRUG MOLECULES**
	Introduction to representation of 3-dimensional structures: Structural and stereoisomers, configurations, symmetry and chirality; Enantiomers, diastereomers, optical activity and Absolute configuration; Conformation analysis of n- butane. Substitution reactions: Nucleophilic substitution reactions, Mechanism of SN1, SN2 reactions; Electrophilic and nucleophilic addition reactions; Addition of HBr to propene; Markownikoff and anti Markownikoff's additions; Grignard additions on carbonyl compounds; Elimination reactions: Dehydro halogenation of alkylhalides; Saytzeff rule; Oxidation reactions: Oxidation of alcohols using KMnO4 and chromic acid; Reduction reactions: Reduction of carbonyl compounds using LiAlH4 & NaBH4; Hydroboration of olefins; Structure, synthesis and pharmaceutical applications of Paracetamol and Aspirin.
MODULE V	**FUELS AND COMBUSTION**

	Fuels: 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

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	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	Stereo 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	Stereo 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**

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**BASIC ELECTRICAL AND ELECTRONCIS ENGINEERING**				
Course Code	AEEB04				
Program	B.Tech				
Semester	II	ME			
Course Type	Foundation				
Regulation	IARE - R18				
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	AHSB02	I	Linear Algebra and 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
Basic 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 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
0%	Remember
67%	Understand
33%	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:

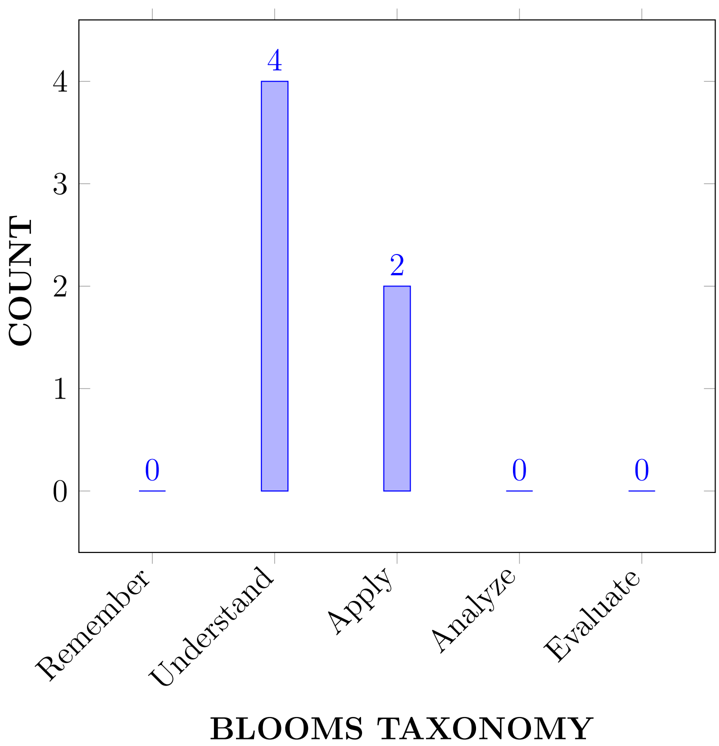
I	Understanding of the basic elements encountered in electric networks, and operation of measuring instruments.
II	The construction and working principle of DC generator, DC motor, andtypes of DC machines based on field excitation method.
III	Analyze the characteristics of alternating quantities and 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	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	Build the prototype of UAVs and aero-foil models for testing by using low speed wind tunnel towards research in the area of experimental aerodynamics.	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**	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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. M
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/aeronautical-engineering-autonomous/basic-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
COURSE DESCRIPTION

Branch	**MECHANICAL ENGINEERING**				
Course Title	**ENGLISH LANGUAGE AND COMMUNICATION SKILLS LABORATORY**				
Course Code	AHSB08				
Program	B.Tech				
Semester	II	ME			
Course Type	Foundation				
Regulation	R18				
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:

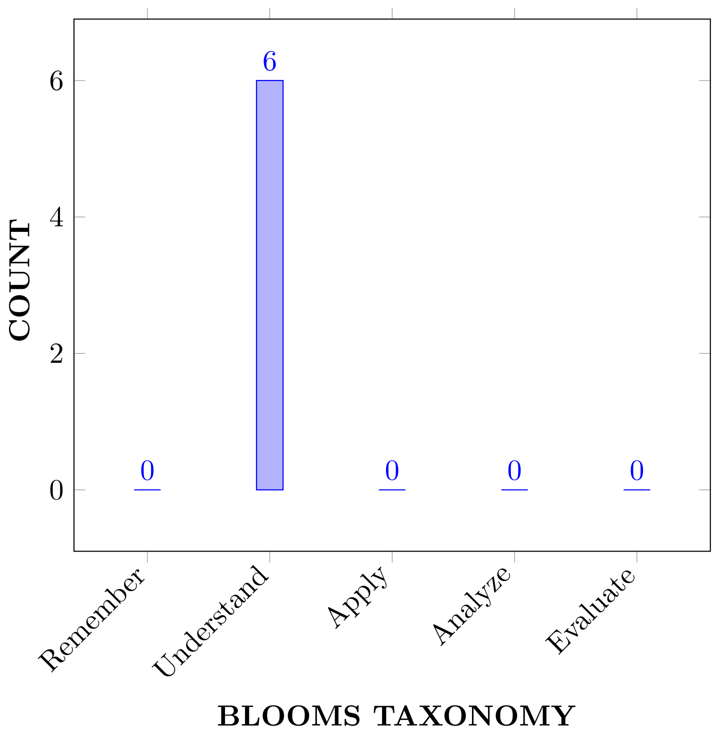
I	Facilitate computer-assisted multi-media instructions to make possible individualized and independent language learning.
II	The critical aspect of speaking and reading for interpreting in-depth meaning of the sentences.
III	Use language appropriately for social interactions such as public speaking, 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, ME**
Dr.Jetty Wilson, Professor

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

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**ENGINEERING CHEMISTRY LABORATORY**				
Course Code	AHSB09				
Program	B.Tech				
Semester	II	ME			
Course Type	FOUNDATION				
Regulation	IARE – R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
				3	1.5
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:

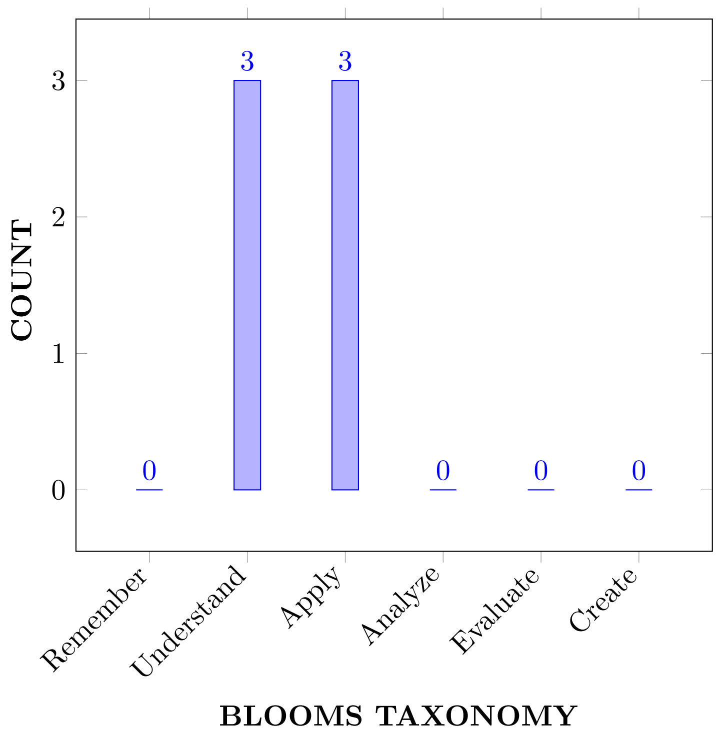
I	The basic principles involved in chemical analysis and mechanism of synthetic organic reactions.
II	The need and importance of quality of water for industrial and domestic use.
III	The measurement of physical properties like surface tension and viscosity.
IV	The knowledge on existing future upcoming 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	**ENGINEERING GRAPHICS AND DESIGN LABORATORY**				
Course Code	AMEB02				
Program	B.Tech				
Semester	II				
Course Type	Foundation				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	1	-	-	4	3
Course Coordinator	Mr. R.Srinivas, Assistant 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
Engineering Graphics and Design laboratory	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 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:

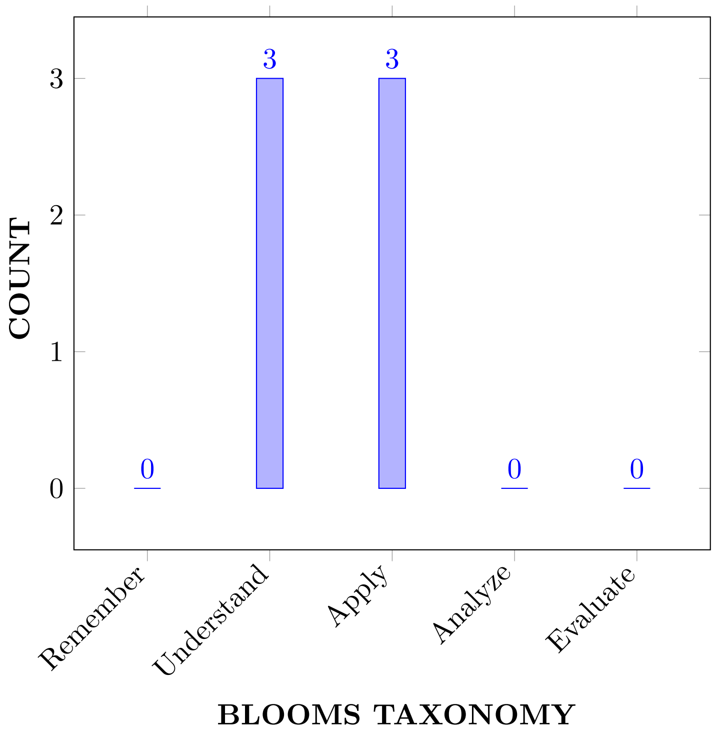
I	The basic knowledge about engineering drawing as a communicative language of engineers in ideation.
II	The ability to visualize, create and edit any object with all the physical and dimensional configurations using computer aided drawing tools.
III	The code of engineering drawing practice as per the Bureau of Indian Standards and International practices.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** bureau of Indian standards conventions of engineering drawing with basic concepts, ideas and methodology for different geometries and their execution. .	Understand
CO 2	**Apply** the commands used in AutoCAD for development of multi-aspect sketches, additional and sectional view.	Apply
CO 3	**Construct** parabolic, Hyperbolic and elliptical curves for profiles likes buildings and bridges. **Build** Cycloidal and involutes profiles for developing new products like gears and other engineering applications.	Apply
CO 4	**Explain** various types of scales for engineering applications like maps, buildings, bridges.	Understand
CO 5	**Explain** the concept of projection of solids inclined to both the planes for interpretation of different views and orthographic projection concepts in solid modeling.	Understand
CO 6	**Recall** the orthographic projection concepts in solid modeling for use in conversation to isometric and Vice-versa	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 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	Videos

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	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 drawings and draw 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
CO 3	PO 1	Develop expression for eccentricity and Identify the appropriate type of curve for **problem solving** using **engineering sciences**.	2
	PO 3	Use research based knowledge for different methods of drawing engineering curves and draw with **modern tools** .	3
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
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
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

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		1	2
CO 2	2	1		
CO 3	2	1		
CO 4	1	2		
CO 5			2	
CO 6	2		2	

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	-
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	**OVERVIEW OF COMPUTER GRAPHICS**
	Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software
WEEK III	**OVER VIEW OF COMPUTER AIDED DRAFTING**
	Practial session of ACAD editing and Modify Commands and practice.
WEEK IV	**CONIC SECTIONS**
	Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute
WEEK V	**DRAWING PAPER SIZES AND SCALES**
	Drawing paper standards and Scales-Plain, Diagonal and Vernier Scales
WEEK VI	**PROJECTION OF POINTS**
	Principles of Orthographic Projections-Conventions-Projections of Points and lines inclined to both planes..
WEEK VII	**PROJECTION OF LINES**
	Projections of planes, Planes inclined to both the planes.
WEEK VIII	**PROJECTION OF REGULAR SOLIDS**
	Draw the orthographic views of geometrical solids of Prism, Pyramid, Cylinder and Cone.
WEEK IX	**ISOMETRIC PROJECTIONS**
	Principles of Isometric projection–Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids;.
WEEK X	**ORTHOGRAPHIC PROJECTIONS**
	Conversion of Isometric Views to Orthographic Views and Vice-versa
WEEK XI	**INTRODUCTION TO 3D**
	Setting environment for 3D drawings and UCS
WEEK XII	**PLOTTING AND TYPES OF EXPORTING DRAWING**
	Understanding how to export the drawing in other usable formats

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 drawing – Geometrical construction.	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	Familiarization of auto-cad commands. Draw and modify commands, dimensions, line properties, status bar, etc..,	CO 2	T1:2.5 R1:2.5
4	Construction of Ellipse – General method	CO 3	T2:2.5 R1:2.6
5	Construction of parabola curves. – General method	CO 3	T1:22.7
6	Construction of hyperbola curves- General method	CO 3	T1:6.3 R2:5.3
7	Construction of various curves cycloid, epicycloids, hypocycloid and involutes	CO 4	T1:7.5 R1:6.3
8	Construction of various scales for engineering use- plain, diagonal, and vernier.	CO 5	T1:8.5 R1:6.8
9	Projection of points and lines inclined to single plane and both the planes.	CO 6	T1:12.2 R3:13.1
10	Projection of planes- inclined to single plane and both the planes.	CO 5	T1:12.3 R1:13.2
11	Projection of solids inclined tosingle plane and both the planes.	CO 4	T1:1.4 R1:1.2
12	Draw the basic isometric views. Convert the pictorial views to orthographic views and vice versa.	CO 5	T1:1.5 R1:2.4

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Demonstration of twin vortex :** formation and calculation of vortex size for different geometries.
2	**Construction of hyperbolic curves:** –rectangle method, and parallelogram methods..
3	**Draw the development** of lateral surfaces of cube
4	**Draw the development** of lateral surfaces of prism
5	**Draw the development** of lateral surfaces of pyramid
6	**Draw the development** of lateral surfaces of cylinder
7	**Draw the development** of lateral surfaces of cone

Signature of Course Coordinator **HOD, ME**
R.Srinivas, Assistant Professor

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

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	BASIC ELECTRICAL AND ELECTRONICS ENGG LAB				
Course Code	AEEB08				
Program	B.Tech				
Semester	II	ME			
Course Type	Foundation				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
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. The purpose of lab experiment is to continue to build circuit construction skills using different circuit element. 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.	AHSB02	I	Linear ALgebra and Calculus

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Basic Electrical 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:

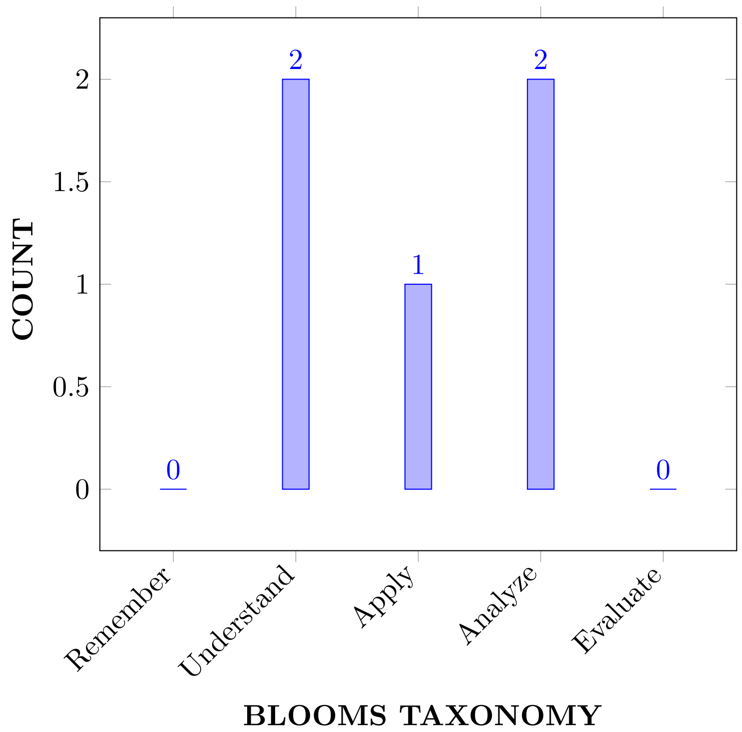
I	The basic laws for different circuits.
II	The elementary experimental and modelling skills for handling problems with electrical machines in the industries and domestic applications to excel in professional career.
III	The intuitive knowledge needed to test and analyse the performance leading to design of electric machines by conducting various tests and calculate the performance parameters.
IV	Gain knowledge on semiconductor devices like diode and transistor.
V	Interpret different transistor configurations.

VII COURSE OUTCOMES:

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

CO 1	**Analyze** an electric circuit using Ohm's and Kirchhoff's laws.	Analyze
CO 2	**Analyze** the performance characteristics of DC shunt machine at various loading conditions.	Analyze
CO 3	**Examine** the performance of single-phase transformers, induction motors and alternator by conducting a suitable test.	Understand
CO 4	**Acquire** basic knowledge on the working of PN-junction diode, Zener diode to plot their V-I characteristics.	Understand
CO 5	**Identify** transostor configuration and their working to deduce its working as switch and amplifier.	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 professikonal ethics and responsibilties and norms of the engineering practice.	3	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.	2	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.	2	Laboratory experi-ments,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.	2	Laboratory experiments, internal and external lab exam

3 = High; 2 = Medium; 1 = Low

IX 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 5	Create,select and apply appropriate techniques,resources and modern engineering and IT tools **in solving the circuits**	1
	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**.	5

	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
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**	5
CO 3	PO 1	Understand the performance characteristics of transformer, Imduction motors and alternator by using principles of **mathematics and engineering science**	3
	PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice **by understanding the performance characteristics of transformer, Imduction motors and alternator**	1
	PO 9	Work effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **by understanding the performance characteristics of transformer, Imduction motors and alternator**	3
	PO 10	Communicate effectively on complex engineering activities with the engineering community and with society **by understanding the performance characteristics of transformer, Imduction motors and alternator**	5
CO 4	PO 1	Understand the working of PN-junction diode,Zener diode by using principles of **mathematics and engineering science**	3
	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**	5
	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 5	PO 1	Identify transistor configuration by using principles of **mathematics and engineering science**	3
	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**	5
	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

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

COURSE OUTCOMES	PROGRAM OUTCOMES				
	PO 1	PO 8	PO 9	PO10	PO12
CO 1	3	1	3	3	3
CO 2	3	1	3	3	
CO 3	3	1	3	3	
CO 4	3	1	3	3	3
CO 5	3	1	3	3	3

XI ASSESSMENT METHODOLOGY DIRECT:

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

XII ASSESSMENT METHODOLOGY INDIRECT:

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

XIII SYLLABUS:

WEEK I	**KVL AND KCL**
	Verification of Kirchhoff's current law and Voltage law .
WEEK II	**OHM'S LAW**
	Verification of Ohm's.
WEEK III	**SWINBURNE'S TEST**
	Predetermination of efficiency of DC shunt machine.
WEEK IV	**MAGNITETIZATION CHARACTERISTICS**
	Determine the critical field resistance from magnetization characteristics of DC shunt generator.
WEEK V	**BRAKE TEST ON DC SHUNT MOTOR**
	Study the performance characteristics of DC shunt motor by brake test
WEEK VI	**OPEN CIRCUIT AND SHORT CIRCUIT TEST ON SINGLE PHASE TRANSFORMER**
	Determination of losses and efficiency of single-phase transformer.
WEEK VII	**SYNCHRONOUS IMPEDENCE METHOD**
	Determine the regulation of alternator using synchronous impedance method.
WEEK VIII	**PN JUNCTION DIODE**
	PN junction diode characteristics.
WEEK IX	**ZENER DIODE**
	Zener diode characteristics.
WEEK X	**HALF WAVE RECTIFIER**
	Half wave rectifier circuit.
WEEK XI	**FULL WAVE RECTIFIER**
	Full wave rectifier circuit.
WEEK XII	**COMMON EMMITTER**
	Transistor common emitter characteristics.
WEEK XIII	**COMMON BASE**
	Transistor common base 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.

XIV 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 Kirchhoff's current law and voltage law using hardware.	CO 1	T1:1.1
2	Verification of Ohm's.	CO 1	T1:2.1
3	Predetermination of efficiency of DC shunt machine.	CO 2	T2:4.11
4	Determine the critical field resistance from magnetization characteristics of DC shunt generator.	CO 2	T2:4.11
5	Study the performance characteristics of DC shunt motor by brake test.	CO 2	T2:4.12
6	Determination of losses and efficiency of single-phase transformer.	CO 3	T2:1.1
7	Determine the regulation of alternator using synchronous impedance method.	CO 3	T2:5.4
8	PN junction diode characteristics.	CO 4	T1:2.1
9	Zener diode characteristics.	CO 4	T1:2.1
10	Half wave rectifier circuit.	CO 4	T1:2.1
11	Full wave rectifier circuit.	CO 4	T1:2.1
12	Transistor common emitter characteristics.	CO 5	T1:2.1
13	Transistor common base characteristics.	CO 5	T1:2.1
14	Study of CRO.	CO 4	T1:2.1

XV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Mesh and Nodal analysis.
2	Verification of Thevenin's and Norton's 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	**ENGINEERING MECHANICS**				
Course Code	AMEB03				
Program	B. Tech				
Semester	THREE				
Course Type	Foundation				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. B D Y Sunil, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB02	1	Linear Algebra and Calculus

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 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
%	Remember
%	Understand
%	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:

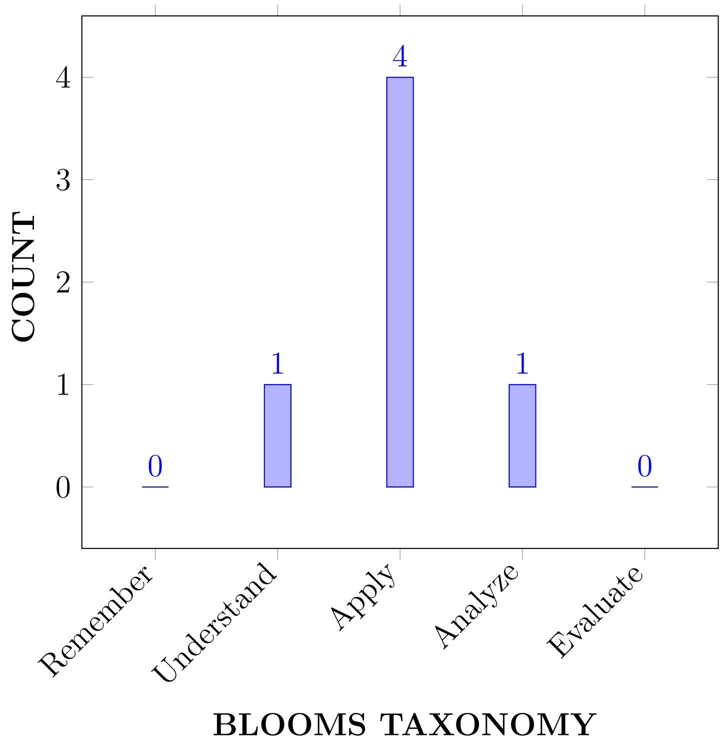
I	Students should develop the ability to work comfortably with basic engineering mechanics concepts required for analyzing static structures.
II	Identify an appropriate structural system to studying a given problem and isolate it from its environment, model the problem using good free-body diagrams and accurate equilibrium equations.
III	Understand the meaning of centre of gravity (mass)/centroid and moment of Inertia using integration methods and method of moments .
IV	To solve the problem of equilibrium by using the principle of work and energy, impulse momentum and vibrations for preparing the students for higher level courses such as Mechanics of Solids, Mechanics of Fluids, Mechanical Design and Structural Analysis etc .

VII COURSE OUTCOMES:

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

CO 1	**Deduce** the unknown forces by free body diagrams to a given equilibrium force system through mechanics laws and derived laws.	Analyze
CO 2	**Interpret** the static and dynamic friction laws for the equilibrium state of a wedge, ladder and screw jack.	Understand
CO 3	**Identify** the centroid and centre of gravity for the simple and composite plane sections from the first principles.	Apply
CO 4	**Calculate** moment of inertia and mass moment of inertia of a circular plate, cylinder, cone and sphere from the first principles.	Apply
CO 5	**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 6	**Determine** the governing equation for momentum and vibrational phenomenon of mechanical system by using energy principles for obtaining co efficient and circular frequency.	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	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	INTRODUCTION TO ENGINEERING MECHANICS
	Force Systems Basic concepts, Particle equilibrium in 2-D and 3-D; Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Components in Space – Resultant- Moment of Forces and its Application; Couples and Resultant of Force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium of Coplanar Systems and Spatial Systems; Static Indeterminacy.
MODULE II	FRICTION AND BASICS STRUCTURAL ANALYSIS
	Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, screw jack and differential screw jack; Equilibrium in three dimensions; Method of Sections; Method of Joints; How to determine if a member is in tension or compression; Simple Trusses; Zero force members; Beams and types of beams; Frames and Machines.

MODULE III	**CENTROID AND CENTRE OF GRAVITY AND VIRTUAL WORK AND ENERGY METHOD**
	Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia of circular plate, Cylinder, Cone, Sphere, Hook. Virtual displacements, principle of virtual work for particle and ideal system of rigid bodies, degrees of freedom. Active force diagram, systems with friction, mechanical efficiency. Conservative forces and potential energy (elastic and gravitational), energy equation for equilibrium. Applications of energy method for equilibrium. Stability of equilibrium.
MODULE IV	**PARTICLE DYNAMICS AND INTRODUCTION TO KINETICS**
	Particle dynamics- Rectilinear motion; Plane curvilinear motion (rectangular, path, and polar coordinates). 3-D curvilinear motion; Relative and constrained motion; Newton's 2nd law (rectangular, path, and polar coordinates). Work-kinetic energy, power, potential energy. Impulse-momentum (linear, angular); Impact (Direct and oblique). Introduction to Kinetics of Rigid Bodies covering, Basic terms, general principles in dynamics; Types of motion, Instantaneous centre of rotation in plane motion and simple problems.
MODULE V	**MECHANICAL VIBRATIONS**
	Basic terminology, free and forced vibrations, resonance and its effects; Degree of freedom; Derivation for frequency and amplitude of free vibrations without damping and single degree of freedom system, simple problems, types of pendulum, use of simple, compound and torsion pendulums.

TEXTBOOKS

1. Irving H. Shames (2006), "Engineering Mechanics", Prentice Hall, 4th Edition,2013

2. F. P. Beer and E. R. Johnston (2011), "Vector Mechanics for Engineers", Vol I - Statics, Vol II, – Dynamics, Tata McGraw Hill , 9th Edition,2013

3. R. C. Hibbler (2006), "Engineering Mechanics: Principles of Statics and Dynamics", Pearson Press.

REFERENCE BOOKS:

1. S.Bhavikatti,"ATextBookofEngineeringMechanics",NewAgeInternational,1st Edition,2012.

2. A.K.Tayal, "Engineering Mechanics", Uma Publications, 14th Edition, 2013.

3. R. K. Bansal "Engineering Mechanics", Laxmi Publication, 8thEdition, 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 Engineering Mechanics, Classification and Laws of mechanics	CO 1	T2:5.5 R1:1.12.1
2	Force and force characteristics, System of forces	CO 1	T2:5.6 R1:1.12.3
3	Resultant, Resultant of coplanar concurrent force system	CO 1	T2:5.10 R1:1.15
4	Composition and resolution of forces, Composition of concurrent forces by method of resolution	CO 1	T2:5.15 R1:1.16
5	Free body diagram, Supports and reactions	CO 1	T2:5.17 R1:1.13.1
6	Equilibrium of bodies, Equilibrant	CO 1	T2:5.18 R1:1.13.2
7	Conditions of equilibrium	CO 1	T2:5.19 R1:1.13.3
8	Moment, Varignon's theorem, Couple	CO 1	T2:5.20 R1:1.7.1
9	Resolution of force into force and a couple	CO 1	T2:5.24 R1:1.17.3
10	Introduction to friction, Laws of friction, Important terms in friction, Types of friction	CO 2	T2:6.3 R1:2.6.1
11	Equilibrium of body on horizontal plane and rough inclined plane	CO 2	T2:6.5 R1:2.6.2
12	Effect of friction in connected bodies	CO 2	T2:5.5 R1:1.12.1
13	Friction in ladder applications	CO 2	T2:5.6 R1:1.12.3
14	Friction in wedge applications	CO 2	T2:5.10 R1:1.15
15	Screw jack, Efficiency of a screw jack and condition for maximum efficiency	CO 2	T2:5.15 R1:1.16
16	Over hauling and self-locking screws, differential screw jack	CO 2	T2:5.17 R1:1.13.1
17	Centre of gravity, Centroid, difference between centre of gravity and centroid	CO 3	T2:5.18 R1:1.13.2
18	Determination of centroid for simple sections	CO 3	T2:5.19 R1:1.13.3
19	Determination of centroid for composite sections	CO 3	T2:5.20 R1:1.7.1
20	Determination of centre of gravity of bodies, lines and arcs	CO 3	T2:5.24 R1:1.17.3
21	Moment of inertia, Radius of gyration, Polar moment of inertia, Theorems of moment of inertia	CO 4	T2:5.5 R1:1.12.1

22	Moment of inertia from first principles	CO 4	T2:5.6 R1:1.12.3
23	Moment of inertia of standard sections and composite sections	CO 4	T2:5.10 R1:1.15
24	Mass moment of inertia, Parallel axis theorem/transfer formula, Mass Moment of inertia of Composite Bodies	CO 4	T2:5.15 R1:1.16
25	Kinetics – introduction, Important terms, Newtons laws of motion, Relation between force and mass	CO 5	T2:5.17 R1:1.13.1
26	D'Alembert's principle and its application in plane motion	CO 5	T2:5.18 R1:1.13.2
27	Motion of lift, Motion of body on inclined plane, Problems	CO 5	T2:5.19 R1:1.13.3
28	D'Alembert's principle and its application for connected bodies	CO 5	T2:5.20 R1:1.7.1
29	Work, Energy and Power, Principles for problem solving using work energy method	CO 5	T2:5.24 R1:1.17.3
30	Work energy equation for translation	CO 5	T2:6.3 R1:2.6.1
31	Work done by spring	CO 5	T2:6.5 R1:2.6.2
32	Linear impulse and momentum, Conservation of momentum	CO 6	T2:5.5 R1:1.12.1
33	Impact of elastic bodies, Impact and types of impact	CO 6	T2:5.6 R1:1.12.3
34	Coefficient of restitution, Recoil of gun	CO 6	T2:5.10 R1:1.15
35	Introduction to vibrations, Free and forced vibrations, Simple harmonic motion and important terms	CO 6	T2:5.15 R1:1.16
36	Derivation for frequency and time period of simple pendulum	CO 6	T2:5.17 R1:1.13.1
37	Time period of simple pendulum when hanging from the ceiling of a lift, Gain or loss of oscillations due to change in 'g' and 'l' of simple pendulum	CO 6	T2:5.18 R1:1.13.2
38	Derivation for frequency and time period of compound pendulum	CO 6	T2:5.19 R1:1.13.3
39	Derivation for frequency and time period of torsional pendulum	CO 6	T2:5.20 R1:1.7.1
40	Oscillation of spring and arrangement of springs	CO 6	T2:5.24 R1:1.17.3
PROBLEM SOLVING/ CASE STUDIES			
1	Resultant of a force system	CO 1	T2:5.5 R1:1.12.1
2	Equilibrium of bodies	CO 1	T2:5.6 R1:1.12.3
3	Resultant by using Varignon's theorem	CO 1	T2:5.10 R1:1.15
4	Frictional force implementation	CO 2	T2:5.15 R1:1.16

5	Ladder friction	CO 2	T2:5.17 R1:1.13.1
6	Wedge friction	CO 2	T2:5.18 R1:1.13.2
7	Screw jack	CO 2	T2:5.19 R1:1.13.3
8	Centroid of simple and composite sections	CO 3	T2:5.20 R1:1.7.1
9	Centre of gravity of simple and composite bodies	CO 3	T2:5.24 R1:1.17.3
10	Moment of inertia and mass moment of inertia	CO 4	T2:6.3 R1:2.6.1
11	D'Alembert's principle for kinetic problems	CO 5	T2:6.5 R1:2.6.2
12	Work energy equation for translation in plane motion and connected bodies	CO 5	T2:5.5 R1:1.12.1
13	Impulse momentum for connected bodies	CO 6	T2:5.6 R1:1.12.3
14	Impact of elastic bodies	CO 6	T2:5.10 R1:1.15
15	Time period and frequency for various pendulums	CO 6	T2:5.15 R1:1.16
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module – 1 – Introduction to Engineering Mechanics	CO 1	T2:5.5 R1:1.12.1
2	Module – 2– Friction and Basic Structural Analysis	CO 2	T2:5.6 R1:1.12.3
3	Module – 3 – Centroid, Centre of Gravity and Virtual Work and Energy Method	CO 3, CO4	T2:5.10 R1:1.15
4	Module – 4 – Particle Dynamics and Introduction to Kinetics	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 – Introduction to Engineering Mechanics	CO 1	T2:5.5 R1:1.12.1
2	Module – 2 – Friction and Basic Structural Analysis	CO 2	T2:5.6 R1:1.12.3
3	Module – 3 – Centroid, Centre of Gravity and Virtual Work and Energy Method	CO 3, CO4	T2:5.10 R1:1.15
4	Module – 4 – Particle Dynamics and Introduction to Kinetics	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

MECHANICALL ENGINEERING

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**THERMODYNAMICS**				
Course Code	AMEB04				
Program	B.Tech				
Semester	III				
Course Type	CORE				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	0	0
Course Coordinator	Mr. A Venuprasad, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB02	I	Linear Algebra and Calculus
B.Tech	AHSB04	I	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 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:

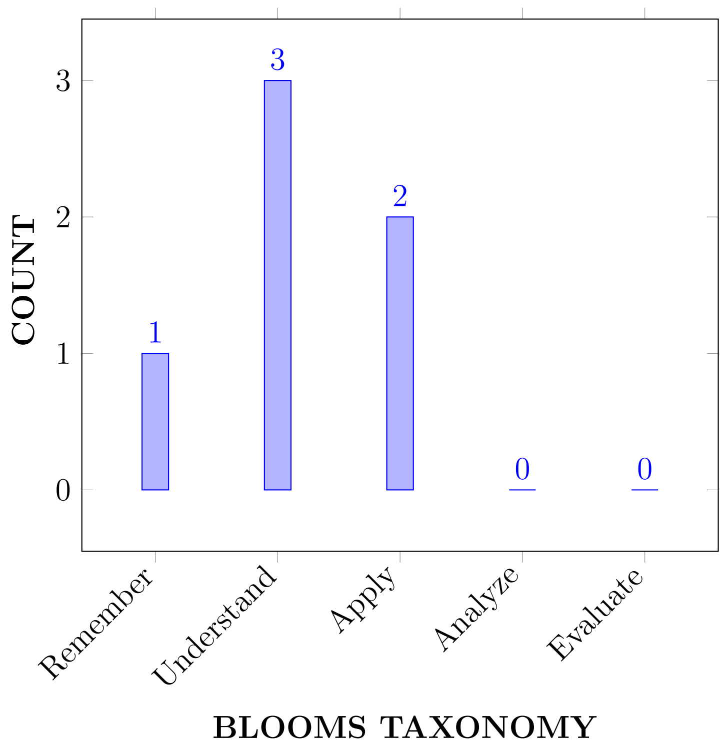
The students will try to learn:

I	The fundamental 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	Explain the thermodynamic properties and working principles of **energy** conversions in physical systems 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**.	7
	PO 6	Apply the working principles of energy conversions in physical systems to assess societal, health, safety, legal and cultural issues and the **consequent responsibilities** relevant to the professional **engineering practice**.	2
	PSO 2	Formulate and Evaluate the thermodynamic properties using the concepts of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary Engineering Applications**.	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 and **formulate** the statements of second law of **thermodynamics** using **first principles** of **mathematics**, **natural sciences**, and **engineering sciences**.	6
	PSO 2	Formulate and Evaluate the equivalence of two statements of second law of thermodynamics and the entropy principle using the concepts of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary Engineering Applications**.	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 solutions for complex Engineering problems and identify the properties of pure substances and steam to emit relevant inlet and exit conditions of thermodynamic **systems** used for the **public health**, **society**, and **environment**.	4
	PSO 2	Formulate and Evaluate the properties of pure substances and steam using the concepts of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary Engineering Applications**.	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 and **formulate** the significance of partial pressure and temperature of ideal gas mixtures using first principles of **mathematics**, **natural sciences**, and **engineering sciences**.	4
	PO 3	Explain the solutions for **complex problems** and identify the significance of partial pressure and temperature of ideal gas mixtures used for the **public health**, **society**, and **environment**.	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	Explain the solutions for **complex problems** and identify the the properties of air conditioning systems used for the **public health**, **society**, and **environment**.	4
	PSO 2	Evaluate the properties of air conditioning systems using the concepts of **Thermo-Fluid Systems** to provide solutions for Inter Disciplinary Engineering Applications.	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	Identify and **formulate** the performance characteristics of various **air standard cycles** using **first principles** of **mathematics**, **natural sciences**, and **engineering sciences**.	6
	PO 4	Explain the the performance characteristics of various **air standard cycles** 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**.	7
	PSO 2	Evaluate the properties of various air standard cycles using the 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/ 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 5	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**
Mr. A Venuprasad, Assistant Professor

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

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Manufacturing Processes**				
Course Code	AMEB05				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3		
Course Coordinator	Mr. G. Praveen Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech.	AMEB01	I	Workshop/Manufacturing Practices Laboratory

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
Manufacturing 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 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
40 %	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:

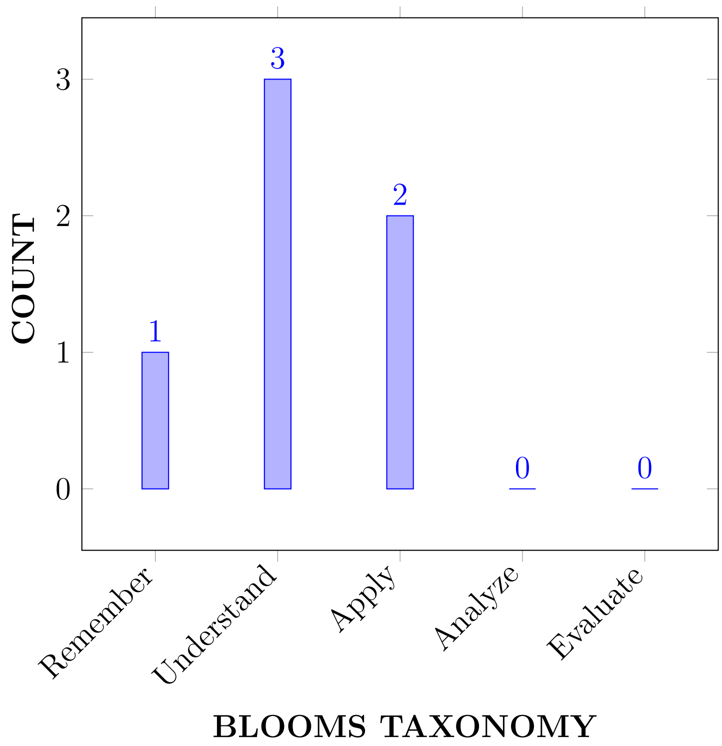
I	The Importance of manufacturing sciences in the day-to-day life, and study the basic manufacturing processes and tools used.
II	The knowledge in thermal, metallurgical aspects during casting and welding for defect free manufacturing components.
III	Design features that make each of these manufacturing 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 casting the desired pattern for automotive industry components cylinder heads, engine blocks etc.	Remember
CO 2	**Categorize** various defects and shortcomings during gas welding operation such as TIG, MIG and Spot welding etc. for real time applications.	Understand
CO 3	**Illustrate** the properties and bonding techniques of plastics for various plastic molding techniques.	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
CO 6	**Classify** the various forging techniques based on functionality, cost and time in development of critical products.	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

Program Outcomes	
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

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.	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.	2	Research papers/ Industry exposure
PSO 2	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining.	2	Quiz
PSO 3	Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies..	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	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 4	Investigate prototype models based on constraint including **Environmental sustainability, Health and safety risks assessment issues** and define specific problem.	2
CO 3	PO 3	**Identify** the various properties of Bonding 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
	PO 3	Understand the given **problem statement** related to their working principle and based upon type of **manufacturing process.**	4
	PSO 3	Build practical experience in building the real time products, using **industry standard tools and collaboration technique** in the field of Manufacturing System.	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 Hot and Cold Working Process by **Natural Science and Engineering Sciences.**	2
	PSO 3	Identify the principle involved in Hot and Cold Extrusion process by **Qualitative and Quantitative methods** to their engineering problems.	2
CO 6	PO 1	Explain (understand) the process parameter using (complex) the functions of engineering problems by applying the principles of **mathematics and engineering fundamentals.**	
	PO 2	**Categorise the concept of Forging Techniques based upon the information and data collection in engineering problems.**	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	-	-	3	-	-	-	-	-	-	-	-		-	-	-
CO 4	-	4	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 5	2	2	-	-	-	-	-	-	-	-	-		-	-	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	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	-	-	-	18.1	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	30.	-	-	-	-	-	-	-	-		-	-	-
CO 4	-	40	20	-	-	-	-	-	-	-	-	-	-	-	100
CO 5	66.7	20	-	-	-	-	-	-	-	-	-		-	-	100
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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	1	-	-	-	-	-	-	-	-		-	-	-
CO 5	-	1	-	-	-	-	-	-	-	-	-	-		-	3
CO 6	3	1	-	-	-	-	-	-	-	-	-		-	-	3
TOTAL	9	3	-	1	-	-	-	-	-	-	-	-	-	-	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:

x	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
	Welding: Welding types, Oxy-fuel gas welding, cutting, standard time and cost calculations, arc welding Process, forge welding, resistance welding, thermit 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 III	METAL 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.
MODULE IV	EXTRUSION AND RAPID PROTOTYPING
	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; Additive manufacturing: Rapid prototyping and rapid tooling
MODULE V	FORGING
	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. Kalpakjian and Schmid, Manufacturing processes for engineering materials -Pearson India, 5th Edition 2014.

REFERENCE BOOKS:

1. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems John Wiley and Sons Inc., 4th Edition, 2008.
2. Degarmo, Black and Kohser, Materials and Processes in Manufacturing (9th Edition) John Wiley and Sons Inc., 7th Edition, 2012.

WEB REFERENCES:

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

COURSE WEB PAGE:

https://www.iare.ac.in/sites/default/files/Courses-description/MECH-ManufacturingProcess-Syllabus.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 OBE discussion		
	CONTENT DELIVERY (THEORY)		
1	Introduction to manufacturing processes.	CO 1	T1:1.7 R1:3.7
2	Review on casting and pattern	CO 1	T1:1.8 R1:3.12
3	Discuss the casting processes and their types.	CO 2	T1:3.1 R1:3.13
4	Describe the solidification of casting	CO 2	T1:3.3 R1:3.14
5	Describe the welding techniques	CO 3	T1:2.22
6	Discuss the effect of TIG and MIG welding	CO 3	T1:2.25
7	Discuss the effect of Heat affected zone in welding	CO 3	T1: 3.3
8	Discuss the welding defects	CO 3	T1: 4.2
9	Discuss the causes and remedies	CO 4	T1: 5.1
10	Introduction to destructive and non-destructive testing of welds.	CO 4	T1: 5.2
11	Classifying and Demonstration of metal forming	CO 5	T1: 4.5
12	Discuss the hot and cold working.	CO 5	T1: 4.1
13	Discuss the strain hardening recovery and recrystallizationUnilateral and bilateral tolerance system, hole and shaft basis systems, Interchangeability and selective assembly	CO 5	T1: 4.2
14	Comparison of properties of cold and hot worked parts	CO 5	T1: 4.3
15	Introduction to rolling	CO 6	T1: 5.2
16	Demonstration of working of rolling operations	CO 6	T1: 5.2
17	Classifying rolling types.	CO 6	T1: 5.2
18	Demonstration of rolling theory.	CO 6	T1: 7.2
19	Introduction to mills and products and stamping	CO 6	T1: 7.5
20-21	Demonstration of forces in rolling and their calculations	CO 6	T1: 7.5
22	Discuss stamping forming and other cold operations.	CO 6	T1:13.5 R3:9.2
23-24	Explanation of blanking and piercing operations	CO 5	T1:13.7
25	Introduction to drawing and its types.	CO 5	T1:13.8
26-27	Discuss the wire and tube drawing techniques	CO 5	T1:13.6
28	Explain extrusion of metals	CO 5	T1:13.9
29-30	Discuss the characteristics of extrusion types	CO 6	T1:13.9
31	Describe the importance of impact and extruding equipment.	CO 6	T1:13.9

32-33	Describe hydrostatic extrusion, forces in extrusion	CO 6	T1:13.9
34	Introduction to Additive manufacturing	CO 6	T1:13.9
35	Draw and Describe Forging operations and principles	CO 6	T1:13.9
36	Introduction to Additive manufacturing	CO 6	T1:13.9
37-38	Describe the Smith forging, drop forging	CO 6	T1:13.9
39-40	Describe the importance of roll forging, forging hammers	CO 6	T1:13.9
41-43	Discuss the rotary forging, forging defects	CO 6	T1:13.9
44-45	Describe the cold forging, swaging, forces in forging operations.	CO 6	T1:13.9
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	T2:2.3
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	T6:2.3
4	Explain different types of flames with neat sketches in gas welding process. Give applications for each type.	CO 2	T7:2.3
5	Discuss parameters used in resistance spot welding process. Give the industrial applications of spot welding process.	CO 2	T9:2.3
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 4	T2:2.3
10	How do you find the forces in extrusion operation?	CO 5	T2:2.3
11	Summarize the key aspect of rapid prototyping. Explain With an example the historical development of rapid prototype technologies?	CO 5	T2:2.3
12	Explain, with suitable example, how rapid prototyping and tooling are the good examples as part of computer integrated Manufacturing.	CO 5	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 6	T2:2.3

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	CASTING	CO 1	R4:2.1
2	WELDING	CO 2	T4:7.3
3	METAL FORMING	CO 3,CO 4	R4:5.1
4	EXTRUSION AND RAPID PROTOTYPING	CO 4	T1:7.5
5	FORGING	CO 5	T1: 4.1
DISCUSSION OF QUESTION BANK			
1	CASTING	CO 1	R4:2.1
2	WELDING	CO 2	T4:7.3
3	METAL FORMING	CO 3,CO 4	R4:5.1
4	EXTRUSION AND RAPID PROTOTYPING	CO 4	T1:7.5
5	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	**PROBABILITY AND STATISTICS**				
Course Code	AHSB12				
Program	B.Tech				
Semester	III	ME			
Course Type	Foundation				
Regulation	R-18				
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:

Probability theory is the branch of mathematics that deals with modelling uncertainty. Inferential Statistics and regression analysis together with random variate distributions are playing an exceptional role in designing data driven technology which is familiarly known as data centric engineering. They also have wide variety applications in telecommunications and other engineering disciplines. The course covers advanced topics of probability and statistics with applications over real-world engineering problems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Probability and Statistics	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
10%	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:

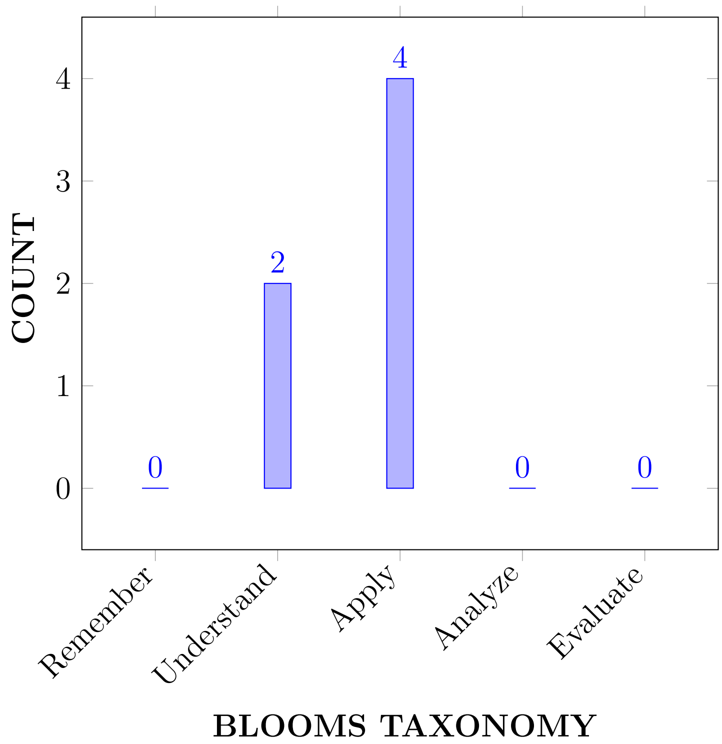
I	The Principles of probability, the theory of random variables, basic random variate distributions and their applications.
II	The Methods and techniques for quantifying the degree of closeness among two or more variables and linear regression analysis.
III	The Estimation statistics and Hypothesis testing which play a vital role in the assessment of the quality of the materials, products and ensuring the standards of the engineering process.
IV	The statistical tools which are essential for translating an engineering problem into probability model.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the concepts of Baye's theorem, discrete and continuous random variables under randomized probabilistic conditions.	Understand
CO 2	**Interpret** the parameters of random variate Probability distributions such as Binomial, Poisson and Normal distribution by using their probability functions, expectation and variance.	Understand
CO 3	**Apply** Bivariate Regression as well as Correlation Analysis for statistical forecasting.	Apply
CO 4	**Make Use of** estimation statistics in computing confidence intervals, Regression analysis and hypothesis testing.	Apply
CO 5	**Identify** the role of statistical hypotheses, types of errors, confidence intervals, the tests of hypotheses for large sample in making decisions over statistical claims in hypothesis testing	Apply
CO 6	**Identify** the tests of hypothesis for small sample 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.

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 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	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	-	-
PSO 2	Focus on improving software reliability, network security or information retrieval systems.	-	-
PSO 3	Make use of modern computer 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 (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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
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
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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
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	**PROBABILITY AND RANDOM VARIABLES**
	Probability, Conditional Probability, Baye's Theorem; Random variables: Basic definitions, discrete and continuous random variables; Probability distribution: Probability mass function and probability density functions; Mathematical expectation.
MODULE II	**PROBABILITY DISTRIBUTION**
	Binomial distribution; Mean and variances of Binomial distribution, Recurrence formula for the Binomial distribution; Poisson distribution: Poisson distribution as a limiting case of Binomial distribution, mean and variance of Poisson distribution, Recurrence formula for the Poisson distribution; Normal distribution; Mean, Variance, Mode, Median, Characteristics of normal distribution.
MODULE III	**CORRELATION AND REGRESSION**
	Correlation: Karl Pearson's Coefficient of correlation, Computation of correlation coefficient, Rank correlation, Repeated Ranks; Properties of correlation. Regression: Lines of regression, Regression coefficient, Properties of Regression coefficient, Angle between two lines of regression; Multiple correlation and Regression.

MODULE IV	**TEST OF HYPOTHESIS - I**
	Sampling: Definitions of population, Sampling, Parameter of statistics, standard error; Test of significance: Null hypothesis, alternate hypothesis, type I and type II errors, critical region, confidence interval, level of significance. One sided test, two-sided test. Large sample test: Test of significance for single mean, Test of significance for difference between two sample means, Tests of significance single proportion and Test of difference between proportions.
MODULE V	**TEST OF HYPOTHESIS - II**
	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; Chi-square test of goodness of fit.

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. N. P. Bali, "Engineering Mathematics", Laxmi Publications, 9th Edition, 2016.& Co., 6th Edition, 2014.
2. S. C. Gupta, V. K. Kapoor, "Fundamentals of Mathematical Statistics", S. Chand & Co., 10th Edition, 2000.
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	CO 1	T2:26.3
3	conditional probability	CO 1	R2:21.48
4	Baye's law	CO 1	T2:26.6 R2:21.50
5	Discrete Random variables	CO 1	T2:26.7 R2:21.51
6	Mean and variance, probability distribution of discrete Random variables.	CO 1	T2:26.8
7	Continuous Random variables	CO 1	T2:26.10
8	Mean and variance, probability distribution of continuous Random variables.	CO 1	T2:26.14 R2:21.55
9	Properties of random variables	CO 1	T2:26.15 R2:21.58
10	Binomial distribution	CO 2	T2:26.16 R2:21.61
11	Mean and variances of Binomial distribution	CO 2	T2:25.12 R2:21.24
12	Recurrence formula for the Binomial distribution	CO 2	T2:25.16 R2:21.29
13	Poisson distribution	CO 2	T2:25.14 R2:21.31
14	Mean and variance of Poisson distribution	CO 2	T2:25.14 R2:21.33
15	Recurrence formula for the Poisson	CO 2	R2:21.33
16	Normal distribution.	CO 2	T2:27.2 R2:21.64
17	Mean, Variance, Mode, Median, Characteristics of normal distribution	CO 2	T2:27.2

18	Correlation	CO 3	T2:27.2 R2:21.67
19	Karl Pearson's Coefficient of correlation	CO 3	T2:27.2
20	Rank correlation	CO 3	T2:27.3 R2:21.71
21	Properties of correlation	CO 3	T2:27.4 R2:21.68
22	Regression coefficients	CO 4	T2:27.7 R2:21.74
23	Properties of Regression coefficients	CO 4	T2:27.12 R2:21.75
24	Angle between two lines of regression	CO 4	T2:27.8 R2:21.72
25	Lines of regression,	CO 4	T2:27.8 R2:21.73
26	Sampling: Definitions	CO 5	T2:27.14 R2:21.78
27	Types of sampling	CO 5	T2:27.19 R2:21.814
28	Parameter vs. statistics, standard error.	CO 5	T2:27.12 R2:21.82
29	Type I and type II errors, 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	CO 6	T2:27.2
36	Test of significance difference between sample mean and population mean.	CO 6	T2:26.16 R2:21.61
37	difference between means of two small samples	CO 6	T2:25.12 R2:21.24
38	Snedecor's F-distribution properties.	CO 6	T2:25.16 R2:21.29
39	F-distribution properties	CO 6	T2:27.14 R2:21.78
40	Chi-square distribution and it's properties	CO 6	T2:27.19 R2:21.814
41	Applications of Chi-square –Distribution	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 mathematical expectation	CO 1	T2:26.6 R2:21.50
45	Problem solving session on Binomial distribution	CO 1	T2:26.7 R2:21.51
46	Problem solving session on Poisson distribution	CO 2	T2:26.8
47	Problem solving session on Normal distribution	CO 2	T2:26.10
48	Problem solving session on Karl Pearson's correlation	CO 3	T2:26.14 R2:21.55
49	Problem solving session on Spearman's rank correlation	CO 3	T2:26.15 R2:21.58
50	Problem solving session on linear regression	CO 4	T2:26.16 R2:21.61
51	Problem solving session on sampling distribution of means	CO 5	T2:25.12 R2:21.24
52	Problem solving session on central limit theorem	CO 5	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	CO 6	R2:21.33
56	Problem solving session on Chi-square - test	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 probability distributions.	CO 2	T2:26.7 R2:21.51
59	Definitions & terminology discussion on correlation and regression.	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.	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 probability distributions.	CO 2	T2:26.7 R2:21.51
64	Question bank discussion on correlation and regression.	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..	CO 6	R2:21.33

Signature of Course Coordinator **HOD, ME**
Mr. J Suresh Goud, Assistant Professor

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**DATA STRUCTURES**				
Course Code	ACSB03				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	3	1.5
Course Coordinator	Dr V Sitharamulu, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSB01	II	Programming for Problem Solving

II COURSE OVERVIEW:

The course covers some of the general-purpose data structures and algorithms, and software development. Topics covered include managing complexity, analysis, static data structures, dynamic data structures and hashing mechanisms. The main objective of the course is to teach the students how to select and design data structures and algorithms that are appropriate for problems that they might encounter in real life. This course reaches to student by power point presentations, lecture notes, and lab which involve the problem solving in mathematical and engineering areas.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Data Structures	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	whiteboard		Assignments	x	MOOC
✓	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
60%	Understand
20%	Apply
10%	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:

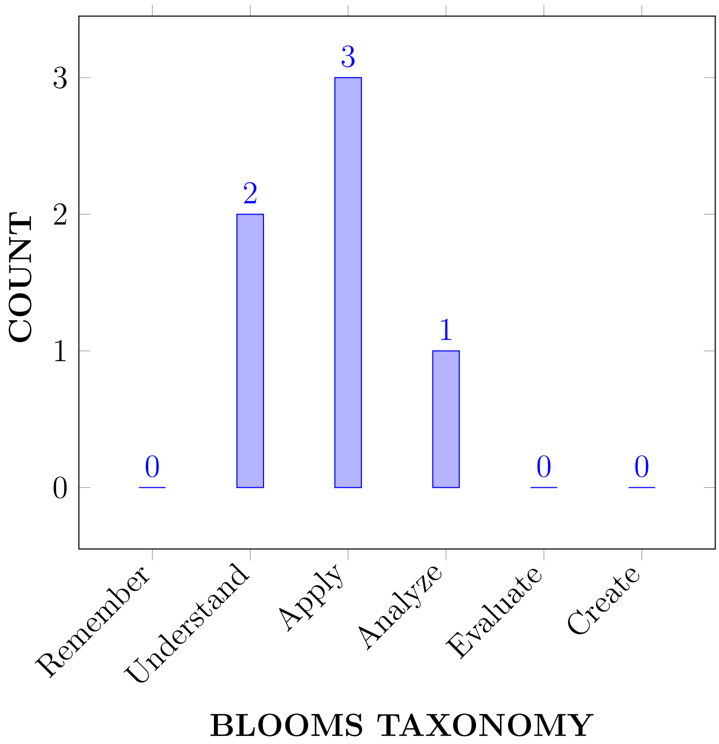
I	The skills needed to understand and analyze performance trade-offs of different algorithms implementations and asymptotic analysis of their running time and memory usage.
II	The knowledge of basic abstract data types (ADT) and associated algorithms: stacks, queues, lists, tree, graphs, hashing and sorting, selection and searching.
III	The fundamentals of Non-linear Data structure to store, retrieve, and process data efficiently.
IV	The implementing these data structures and algorithms and Understand essential for future programming and software engineering courses.
V	Analyze and choose appropriate data structure to solve problems in real world.

VII COURSE OUTCOMES:

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

CO 1	**Interpret** the complexity of algorithm using the asymptotic notations.	Understand
CO 2	**Select** appropriate searching and sorting technique for a given problem.	Apply
CO 3	**Construct** programs on performing operations on linear and nonlinear data structures for organization of a data	Apply
CO 4	**Make use of** linear data structures and nonlinear data structures solving real time applications.	Apply
CO 5	**Describe** hashing techniques and collision resolution methods for efficiently accessing data with respect to performance.	Understand
CO 6	**Compare** various types of data structures ; in terms of implementation, operations and performance.	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.
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 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	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

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	3	CIA/SEE/Open ended Experiments
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	Tech Talk/Concept Videos/Open ended Experiments
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	Tech Talk/Concept Videos/Open ended Experiments

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** 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.
CO1	PO 1	**Understand** (knowledge) the concept of conventional digital communication system and (understand) various types of pulse analog modulation techniques for signals analysis by applying the principles of **mathematics, science,** and **engineering fundamentals**.	3
	PO 2	**Problem Analysis** on different types of algorithms to analyze space and time complexities.	4
	PO 3	**Design the Solutions** for finding space and time complexities of a complex algorithm and representing it by asymptotic notations	2
	PO 10	**Subject matter and speaking style** assessed in explanation of various algorithms, algorithm complexity.	2
CO 2	PO 1	**Make use** of broad knowledge of searching and sorting techniques for an efficient search from a data structure and optimize the efficiency of other algorithms by applying the knowledge of mathematics, science, Engineering fundamentals.	1
	PO 2	**Problem Analysis** on different types of search sort algorithms to analyze space and time complexities.	5
	PO 3	**Design/Development of Solutions** using appropriate searching and sorting techniques for designing a solution for complex Engineering problems.	2
	PO 5	**Implementation of**different sorting and searching techniques for given problem with the help of computer software	1

	PO 10	**Subject matter and speaking style** assessed in explanation of searching and sorting along with efficiency of searching and sorting techniques in terms of space and time complexity	2
	PO 12	**Keeping current in CSE and advanced engineering concepts** of various searching , sorting and respective time and space complexity by tech talk, concept videos and open ended experiments.	3
CO 3	PO 1	**Make use of** linear and nonlinear 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	**Problem analysis:** Organizing the given data in particular way by performing the operations on linear and nonlinear data structures to use the data in the most effective way.	7
	PO 3	**Recognize the** need of linear and nonlinear data structures such as linked list, array, stack and queue by Designing solutions for complex Engineering.	5
	PO 4	**Conduct Investigations** Conduct Investigations of Complex Problems: Ability to apply operations on linear and nonlinear data structures in order to organize the given data in a particular way	4
	PO 5	**Implementation of** Implementation of different operations on linear and nonlinear data structures for given problem with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of linear and nonlinear data structures like linked lists, stacks and queues	2
	PO 12	**Keeping current in** CSE and advanced engineering concepts of linear and nonlinear data structures like linked lists, stacks and queues by tech talk, concept videos and open-ended experiments	3
CO 4	PO 1	**Make use of** linear and nonlinear data structures for solving real time applications by applying the basic knowledge of mathematics, science, engineering fundamentals	3
	PO 2	**Problem analysis:**Solving real time applications by performing the operations on linear or nonlinear data structures.	7
	PO 3	**Recognize the** need of linear and nonlinear data structures such as linked list, array, stack and queue for Designing real time applications.	2
	PO 4	**Conduct Investigations of Complex Problems:** Ability to apply operations on linear or nonlinear data structures in order to solve real time applications.	4

	PO 5	**Implementation of** different operations on linear and nonlinear data structures for solving real time applications with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of linear and nonlinear data structures like linked lists, stacks, queues, trees and graphs	2
	PO 12	**Keeping current** in CSE and advanced engineering concepts of linear and nonlinear data structures like linked lists, stacks, queues, trees and graphs by tech talk, concept videos and open-ended experiments for solving real time applications.	3
CO 5	PO 1	**Understand** the knowledge of hashing techniques and collision resolution methods and implementing for specified problem domain using knowledge of mathematics, science and engineering fundamentals	1
	PO 3	**Design the Solution** for efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	2
	PO 5	**Implementation of** hashing techniques and collision resolution methods for efficiently accessing data with respect to performance with the help of computer software	1
	PO 10	**Subject matter and speaking style** assessed in explanation of Hashing, Collision techniques	2
CO 6	PO 1	**Understand** various types of data structures in terms of implementations and choose appropriate data structure for specified problem domain using knowledge of mathematics, science and engineering fundamentals	3
	PO 2	**Problem Analysis:** Recognize the importance of suitable data structures in checking the efficiency of algorithms used for complex engineering problems.	7
	PO 3	**Design the Solution** complex problems or efficiently accessing data with respect to performance by using hashing techniques and collision resolution methods	5
	PO 4	**Conduct Investigations of Complex Problems:** Ability to apply operations on linear or nonlinear data structures in order to solve real time applications.	4
	PO 5	**Understand** the Implementation of various types of data structures with the help of computer software	1
	PO 10	**Subject matter and speaking** style assessed in explanation of Implementation of various types of data structures.	2
	PO 12	**Keeping current in CSE** and advanced engineering concepts of Implementation of various types of data structures by tech talk, concept videos and open ended experiments	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
	3	10	10	11	1	5	3	3	12	5	12	12	6	2	2
CO 1	1	4	2	-	-	-	-	-	-	2	-	-	-	-	-
CO 2	1	5	2	-	1	-	-	-	-	2	-	3	-	-	-
CO 3	2	7	5	4	1	-	-	-	-	2	-	3	-	-	-
CO 4	3	7	2	4	1	-	-	-	-	2	-	3	-	-	-
CO 5	1	-	2	-	1	-	-	-	-	2	-	-	-	-	-
CO 6	3	7	5	4	1	-	-	-	-	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
	3	10	10	11	1	5	3	3	12	5	12	12	2	2	2
CO 1	33.3	40	20	-	-	-	-	-	-	40	-	-	-	-	-
CO 2	33.3	50	20	-	100	-	-	-	-	40	-	25	-	-	-
CO 3	66.6	70	50	36.3	100	-	-	-	-	40	-	25	-	-	-
CO 4	100	70	20	36.3	100	-	-	-	-	40	-	-	-	-	-
CO 5	33.3	-	20	-	100	-	-	-	-	40	-	-	-	-	-
CO 6	100	70	50	36.3	100	-	-	-	-	40	-	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	1	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	1	2	1	-	3	-	-	-	-	1	-	1	-	-	-
CO 3	3	3	2	1	3	-	-	-	-	1	-	1	-	-	-
CO 4	3	3	1	1	3	-	-	-	-	1	-	1	-	-	-
CO 5	1	-	1	-	3	-	-	-	-	1	-	-	-	-	-
CO 6	3	3	2	1	3	-	-	-	-	1	-	1	-	-	-
TOTAL	**12**	**12**	**8**	**3**	**15**	**-**	**-**	**-**	**-**	**6**	**-**	**4**	**-**	**-**	**-**
AVERAGE	**2.0**	**2.4**	**1.3**	**1.0**	**3.0**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**-**	**-**

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO DATA STRUCTURES, SEARCHING AND SORTING**
	Basic concepts: Introduction to data structures, classification of data structures, operations on data structures; Algorithms Specification ,Recursive algorithms ,Data Abstraction, Performance analysis-time complexity and space complexity, Asymptotic Notation-Big O ,Omega and Theta notations. Introduction to Linear and Non Linear data structures, Searching techniques: Linear search, Binary search; Sorting techniques: Bubble, Selection, Insertion, Quick and Merge Sort and comparison of sorting algorithms
MODULE II	**LINEAR DATA STRUCTURES**
	Stacks: Stack ADT, definition and operations, Implementations of stacks using array, applications of stacks, Arithmetic expression conversion and evaluation; Queues: Primitive operations; Implementation of queues using Arrays, applications of linear queue, circular queue and double ended queue (deque).
MODULE III	**LINKED LISTS**
	Linked lists: Introduction, singly linked list, representation of a linked list in memory, operations on a single linked list; Applications of linked lists: Polynomial representation and sparse matrix manipulation. Types of linked lists: Circular linked lists, doubly linked lists; Linked list representation and operations of Stack, linked list representation and operations of queue
MODULE IV	**NON LINEAR DATA STRUCTURES**
	Trees: Basic concept, binary tree, binary tree representation, array and linked representations, binary tree traversal, binary tree variants, application of trees; Graphs: Basic concept, graph terminology, Graph representations-Adjacency matrix, Adjacency lists, graph implementation, Graph traversals-BFS,DFS, Application of graphs, Minimum spanning trees-Prims and Kruskal algorithms
MODULE V	**BINARY TREES AND HASHING**
	Binary search trees: Binary search trees, properties and operations; Balanced search trees: AVL trees; Introduction to M-Way search trees, B trees; Hashing and collision: Introduction, hash tables, hash functions, collisions, applications of hashing.

TEXTBOOKS

1. Rance D. Necaise, —Data Structures and Algorithms using Python, Wiley Student Edition.
2. Benjamin Baka, David Julian, —Python Data Structures and Algorithms, Packt Publishers, 2017.

REFERENCE BOOKS:

1. S. Lipschutz, —Data Structures , Tata McGraw Hill Education, 1st Edition, 2008.
2. D. Samanta, —Classic Data Structures, PHI Learning, 2nd Edition, 2004.

WEB REFERENCES:

1. http://www.tutorialspoint.com/data-structures-algorithms
2. https://www.geeksforgeeks.org/data-structures/
3. https://www.studytonight.com/data-structures/
4. https://www.coursera.org/specializations/data-structures-algorithms

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courses/computer-science-and-engineering-autonomous/datastructures

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	-	https://www.iare.ac.in/?q=courses/computer-science-and-engineering-autonomous/datastructures
CONTENT DELIVERY (THEORY)			
1	Basic concepts: Introduction to Data Structures	CO 3	T1:1.1.3 R2 : 1.2
2	Classification of data structures	CO 3	T1:1.1.3 R2 : 1.4
3	Operations on data Structures	CO 3	T1:1.2
4	Recursive algorithm, Performance Analysis	CO 1	T1:1.2 T1:5.1
5	Searching techniques: Linear search and binary search	CO 2, CO 6	T1:5.1
6	Searching techniques: Fibonacci search and comparison	CO 2, CO 6	T1:5.1
8	Sorting techniques: Bubble sort, selection sort and companding	CO 2 CO 6	R1:14.5

9	Sorting techniques: Insertion sort, Quick sort	CO 2, CO 6,	T1:5.2 R2 : 10.2
10	Merge sort ,comparison of sorting algorithms	CO 4, CO 6	T1:5.2 R2 : 10.2
13	Stacks: Primitive operations, implementation of stacks using Arrays	CO 3, CO 4	T1:7.1
14	Applications of stacks arithmetic expression conversion and evaluation	CO 4, CO 6	T1:7.2
16	Queues: Primitive operations; Implementation of queues using Array	CO 3, CO 4	T1:8.1
17	Applications of linear queue, circular queue	CO 3, CO 4	T1:8.4
18	Double ended queue (deque)l	CO 3, CO 4	R2 : 5.4
19	Linked lists: Introduction, singly linked list, representation of a linked list in memory	CO 3, CO 4	T1:9.1
20	Operations on a single linked list :creation, insertion and deletion	CO 3, CO 4	T1:9.2
21	Applications of linked lists	CO 4,	T1:9.3
22	Operations on a double linked lists :creation, insertion and deletion	CO 3, CO 4	T1:9.4
23	Operations on a double linked lists : deletion ,traversal.	CO 3, CO 4	T1:9.4
24	single linked list :polynomial expression	CO 3, CO 4	T1:9.3
25	single linked list :Sparse matrix manipulation.	CO 3, CO 4	T1:9.3
26	Operations on a Circular linked lists: creation, insertion and deletion	CO 3, CO 4	T1:9
30	Operations on a Circular linked lists: deletion, traversal	CO 3, CO 4	T1:9
31	Linked list representation and operations of Stack	CO 3, CO 4	T1:9.7
32	Linked list representation and operations of queue	CO 3, CO 4	T1:9.8
37	Trees: Basic concept, Tree terminology	CO 3	T1:13.1

CONTENT DELIVERY (THEORY)			
38	Binary tree :Binary Tree properties	CO 3, CO 4	T1:13.1
39	Binary tree representation using array	CO 3, CO 4	T1:13.2
40	Binary tree representation using linked list	CO 3, CO 4	T1:13.2
41	Binary tree traversal, binary tree variants	CO 3, CO 4	T1:13.2
42	Application of trees	CO 4	T1:13.2.3
44	Graphs: Basic concept, graph terminology	CO 3	R2 : 8.2
45	Types of graphs, Representation of graph	CO 3	R2 : 8.2
46	Graph traversals :DFS and BFS, Application of graphs	CO 3	T2:6.2
48	Minimum Spanning Trees-Prims and Kruskal algorithms	CO 4	T1:6.1 T2:5.6
50	Binary search trees, properties	CO 3	T1:13.2.3
51	Binary search trees operations	CO 3	T1:13.2.3
52	AVL trees	CO 3	T1:14.3
53	M- Way search trees, B trees	CO 3	T1:14.3
54	Hashing, Collision	CO 5	R2 : 6.4
7	Problems on linear search, binary search and Fibonacci search.	CO 2	T1:5.1
11	Problems on bubble sort, selection and insertion sort	CO 3, CO 4	T1:5.2 R2 : 10.2
12	Problems on quick and merge sort	CO 3, CO 4	T1:5.2 R2 : 10.2
15	Problems on Arithmetic expression conversion and evaluation	CO 3, CO 4	T1:7.2
27	Problems on single linked list to add, delete element	CO 3, CO 4	T1:9.8
28	Problems on double linked list to add, delete element	CO 3, CO 4	T1:9.8
33	Problems on circular linked list to add, delete element	CO 3, CO 4	T1:9.4
34	Problems on double linked list to add, delete element	CO 3, CO 4	T1:9.3
35	Problems on stack using linked list	CO 3, CO 4	T1:9.7
36	Problems on queue using linked list	CO 3, CO 4	T1:9.8
43	Problems on Binary tree :creation ,insertion and deletion of a node	CO 3, CO 4	T1:13.2
47	Problems on Graph Traversal: DFS and BFS	CO 3, CO 4	T2:6.2

49	Problems on MST: Prim's and Kruskal's	CO 3, CO 4	T1:6.1 T2:5.6
55	Problems on Binary search tree	CO 4	T1:14.3
56	Problems oh hashing	CO 5	R2 : 6.4
DISCUSSION ON DEFINITION AND TERMINOLOGY			
57	Definitions on Data Structures, searching and sorting	CO 1,CO2,CO 3	T1:1 R1:14
58	Definitions on Linear Data Structures	CO 3	T1:7,.T1:8
59	Definitions on Linked Lists	CO 3	T1:9
60	Definitions on Non Linear data Structures	CO 3	T1:7.5
61	Definitions on Binary Trees and Hashing	CO 3 CO 5	T1:14
DISCUSSION ON QUESTION BANK			
62	Module I	CO 1, CO2,CO6	T1:1 R1:14
63	Module II	CO 3,CO 4,CO 6	T1:9
64	Module III	CO 3,CO 4,CO 6	T1:2.5
65	Module IV	CO 3,CO 4,CO 6	T1: 4.1
66	Module V	CO 3,CO 5,CO 6	T1: 5.1

Course Coordinator **HOD**
Dr V Sitharamulu, Associate Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">MANUFACTURING PROCESSES LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">AMEB06</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>III</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 - R18</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>2</td><td>1</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr. G. Praveen Kumar, Assistant Professor</td></tr>
</table>

I COURSE OVERVIEW:

This course is to introduce the concept of manufacturing process with the help of various processes widely employed in the industries. This course consists of casting, welding, sheet metal forming, extrusion and forging processes with the related details of equipment and applications. It 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.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEC02	II	Manufacturing Practice

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Manufacturing Processes 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	The Importance manufacturing sciences in the day-to-day life, and study the basic manufacturing processes and tools used.
II	The knowledge in thermal, metallurgical aspects during casting and welding for defect free manufacturing components..
III	The design features that make each of this 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	**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	**Analyze** various defects during gas welding,arc welding process and their causes and remedies.	Analyze
CO 5	**Demonstrate** working principle of various sheet metal forming process such as Hydraulic press, deep drawing and bending operation. .	Understand
CO 6	**Demonstrate** the various process in making of plastic components for engineering / domestic applications.	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/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 sciencesy, and the cultural, societal, and Environmental considerations	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

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	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	Selection of operations which have to be carried out casting process for a specific application, need the **knowledge of science and engineering fundamentals**	3
	PSO 3	Make use of **computational and experimental tools** to real time practical problems in manufacturing process	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, Science and Engineering fundamentals**	3

	PO 2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to manufacturing process.	2
CO 3	PO 1	Apply the operational principles of different welding equipments for quality welding by 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	PO 1	Identify the causes and remedies of welding defects using **Scientific Principles of Methodology and engineering fundamentals**	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.	2
	PO 3	Understand the given problem statement related to their working principle and based upon type of manufacturing process.	2
	PSO 3	Identify the **scientific principle** involved in rolling processby **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

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	3			2
CO 2	3	2		
CO 3	3	2		
CO 4	3		2	
CO 5		2		2
CO 6				2

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	**PATTERN MAKING**
	Pattern design and making.
WEEK II	**SAND CASTING**
	Moulding, melting and casting
WEEK III	**METAL CASTING**
	Moulding, melting and casting .
WEEK IV	**ARC WELDING**
	ARC welding lap and butt joint
WEEK V	**SPOT WELDING**
	Spot welding lap and butt joint.
WEEK VI	**GAS WELDING**
	Gas Welding lap and butt joint.
WEEK VII	**BRAZING**
	Brazing lap and butt joint.
WEEK VIII	**APPLICATION OF SIMPLE DIE**
	Blanking and piercing.
WEEK IX	**APPLICATION OF COMPOUND DIE**
	Blanking and piercing
WEEK X	**PROCESSING OF PLASTICS**
	Injection moulding
WEEK XI	**PROCESSING OF PLASTICS**
	Blow moulding
WEEK XII	**RIVETING**
	Riveting of a plates
WEEK XIII	**SAND PROPERTIES TESTING**
	Sand properties testing for strengths and permeability

REFERENCE BOOKS:

1. R. K. Jain, "Production Technology", Khanna Publishers, 18th Edition,2013.
2. T. V. Ramana Rao, "Metal Casting", New Age, 1st Edition, 2010.
3. Philips Rosenthal, "Principles of Metal Castings", TMH, 2nd Edition, 2001
4. B. S.Raghuwamshi, "A Course in Workshop Technology", Dhanpat Rai and Sons, 2014.
5. Kalpakjin S, "Manufacturing Engineering and Technology", Pearson Education, 7th Edition,2014
6. 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.	CO 1	R1: 1.2
2	Sand properties testing for strengths and permeability.	CO 2	R2: 3.5
3	Moulding, melting and casting	CO 3	R1: 3.4
4	Arc welding lap and butt joint	CO 3	R1: 2.2
5	Spot welding, TIG welding.	CO 4	R1: 2.4
6	brazing	CO 4	R3: 4.5
7	Blanking and piercing operations	CO 5	R3: 4.6
8	study of simple, compound and progressive press tool.	CO 5	R3: 4.6
9	Hydraulic press: deep drawing and extrusion operation.	CO 5	R2: 5.1
10	Bending and other operation	CO 6	R2: 5.2
11	Injection moulding.	CO 6	R1: 7.1
12	Blow moulding.	CO 6	R1:7.2
13	Riveting of a plates	CO 6	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Design and develop:** Design and develop Gating system for cating process.
2	**Optimization:** welding Process parameters for optimal weld strength using a Design of Experiments approach.
3	**Design and develop:** Design and Development of Welded joints
4	**Design and develop:** Design and develop of Hydraulic press, deep drawing and bending dies
5	**Design and develop :** Design and develop Injection and blow moulding dies

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

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

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**MACHINE DRAWING THROUGH CAD LABORATORY**				
Course Code	AMEB07				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Dr.G.V.R. Seshagiri Rao, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
Foundation	AMEC03	II	Computer Aided Engineering Drawing

II 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.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Machine Drawing Through CAD 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
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

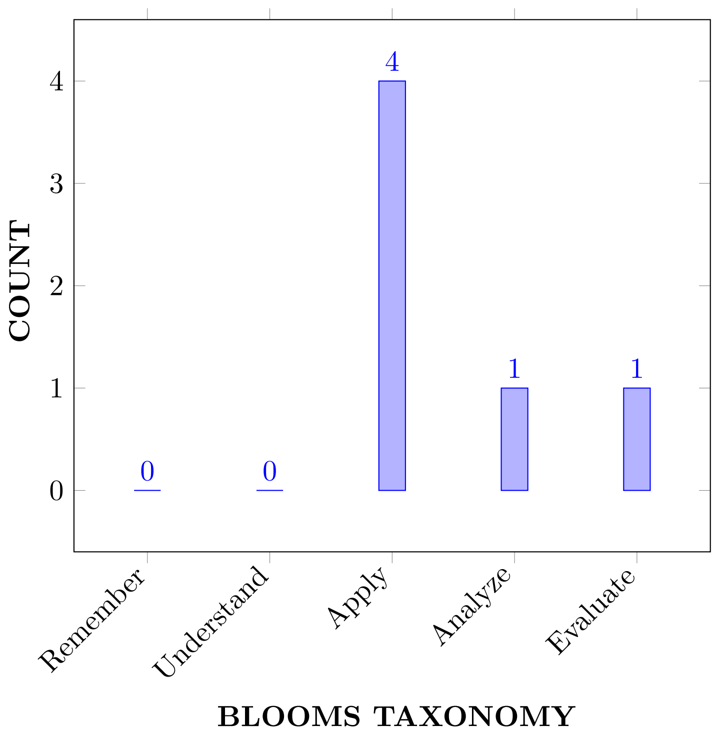
I	The Code of drawing practice as per BIS conventions for mechanical elements using AutoCAD.
II	The 2D drawing of joints, couplings, bearings and keys and their sectional views.
III	The preparation of component drawings, assembly drawings and bill of materials for selected assemblies.
IV	The part drawings of the assembly of various machines and engine components.

VII 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** the 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	**Illustrate** various machine components through drawings for Assembly	Apply
CO 5	**Identify** the different types of couplings are used for fastening components that require frequent assembly and disassembly.	Apply
CO 6	**Develop** detailed assembly drawings of Engine parts, Tailstock, Machine vice and safety valves to facilitate its manufacture.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		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.	3	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.	3	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.	3	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 modeling 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 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/CIA/SEE

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.	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 2	**Identify** the various mechanical machine elements to **illustration** of their materials and shape in an assembly drawings .	2
	PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product **development**using CAD/CAM softwares.	1
CO 2	PO 2	**Identify** the various mechanical machine elements to **illustration** of their materials and shape in an assembly drawings .	2
	PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product **development**using CAD/CAM softwares.	1
CO 3	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
	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
CO 4	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
	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
CO 5	PO 9	Function **effectively**as an individual, and as a member or leader in diverse teams, and in **multidisciplinary** to settings.	2
	PO 10	**Write**effective reports and **design** documentation, make effective presentations, and give and receive clear instructions on **complex engineering** activities.	3
	PSO 1	Focus on Ideation and Research towards Digital manufacturing in Product **development**using CAD/CAM softwares.	1
CO 6	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** to settings.	2

	PO 10	**Write**effective reports and **design** documentation, make effective presentations, and give and receive clear instructions on **complex engineering** activities.	3

XI COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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	**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 II	**SECTIONAL VIEWS**
	Types of sections, selection of section planes and drawing of sections and auxiliary sectional views, parts not usually sectioned.

WEEK III	**DIMENSIONING**
	Methods of dimensioning, general rules for sizes, and placement of dimensions for holes, centers, and curved and tapered features.
WEEK IV	**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 V	**KEYS AND COTTER JOINTS**
	Keys, cotter joints, and knuckle joint.
WEEK VI	**RIVETED JOINTS**
	Riveted joints for plates.
WEEK VII	**COUPLINGS**
	Shaft couplings and spigot joint.
WEEK VIII	**BEARINGS**
	Journal, pivot, and collar bearing.
WEEK IX	**ASSEMBLY DRAWINGS-I**
	Assembly drawings for the Engine parts–stuffing box, Eccentrics, I.C. engine connecting rod.
WEEK X	**ASSEMBLY DRAWINGS-II**
	Assembly drawings for the Screw jack.
WEEK XI	**ASSEMBLY DRAWINGS-III**
	Assembly drawings for the Machine vice and tailstock.
WEEK XII	**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 and 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 and 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 6	T1:15.5
11	Assembly drawings for the Machine vice and tailstock	CO 6	T1:15.6-15.8
12	Assembly drawings for the Rams-bottom Safety Valve	CO 6	T1:15.9

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1. 1	Explore the application of AutoCAD software and Design of various machine elements as Per BIS.
2. 2	Instead of 2D drawings develop the components or assembly of components in 3D using AutoCAD software.
3. 3	Prepare the real time machine components in reverse engineering.
4. 4	To illustrate new designs by using pictorial drawings for understanding exploded assemblies.

Signature of Course Coordinator **HOD, ME**
Dr.Gvr Seshagiri Rao, Associate Professor

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

MECHANICAL TECHNOLOGY
COURSE DESCRIPTION

Course Title	**DATA STRUCTURES LABORATORY**				
Course Code	ACSB05				
Program	B.Tech				
Semester	III	ME			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr.Ch. Suresh Kumar Raju,Assistant Professor,IT				

I COURSE OVERVIEW:

A data structure is a particular way of organizing data in a computer so that it can be used effectively. It covers the design and analysis of fundamental data structures and engages learners to use data structures as tools to algorithmically design efficient computer programs that will cope with the complexity of actual applications. A Data Structure is a particular way of storing and organizing data in a computer so that it can be stored, retrieved, or updated efficiently. Data structures are generally based on the ability of a computer to fetch and store data at any place in its memory, specified by an address. This course is essential for image viewer software, in this images are linked with each other so, images uses a linked list to view the previous and the next images using the previous and next buttons. Web pages can be accessed using the previous and the next URL links which are linked using linked list. The music players also use the same technique to switch between music. To keep the track of turns in a multi player game, a circular linked list is used.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	ACSB01	II	Programming for Problem Solving
B.Tech	ACSB02	II	Programming for Problem Solving Laboratory
B.Tech	ACSB03	III	Data Structures

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Data Structures 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 various data representation techniques in the real world.
II	Implement linear and non-linear data structures. .
III	Analyze various algorithms based on their time and space complexity

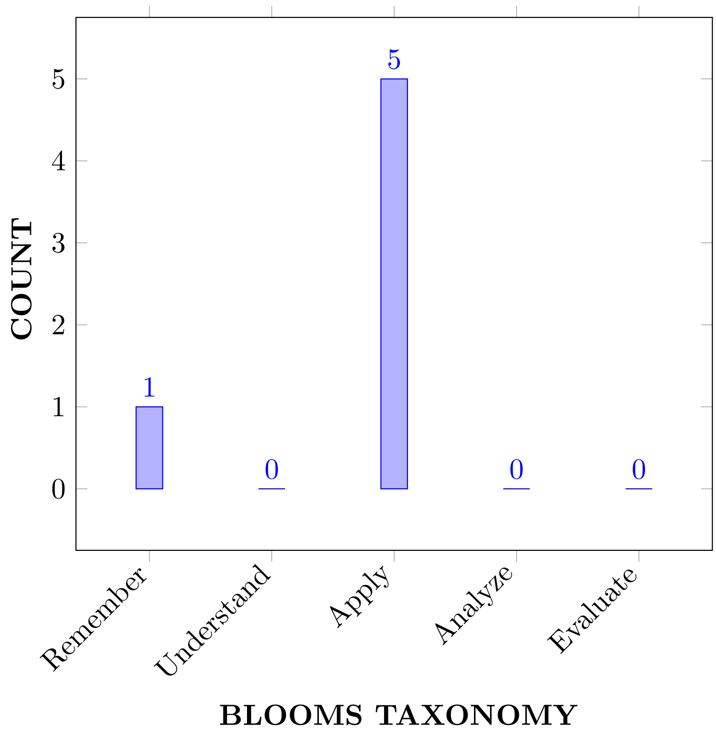
IV	Develop real-time applications using suitable data structure.
V	Identify suitable data structure to solve various computing problems

VII COURSE OUTCOMES:

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

CO 1	**Identify** appropriate searching technique for efficient retrieval of data stored location. .	Apply
CO 2	**choose** sorting technique to represent data in specified format to to optimize data searching.	Apply
CO 3	**Make use of** stacks and queues representation, operations and their applications to organize specified data	Understand
CO 4	**utilize** linked lists to implement and perform operations for for organizing specified data	Apply
CO 5	**Construct** tree to perform different traversal techniques	Apply
CO 6	**Select** Appropriate graph traversal techniques to visit the vertices of a graph	Remember

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:** Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences	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	2	Lab Exercises
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
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	Lab Exercises
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
PO 8	**Ethics** Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice	3	Lab Exercises
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 Exercises
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	4	Lab Exercises

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	3	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.	2	Lab Exercises
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications	2	Lab Exercises
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

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 appropriate searching technique for efficient retrieval of data stored location by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	Identify appropriate searching technique for efficient retrieval of data stored location by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	**Identify** appropriate searching technique for efficient retrieval of data stored location by applying **Design/Development of Solutions**	3
	PO 4	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying **Conduct Investigations of Complex Problems**	2
	PO 5	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying Computer software / simulation packages / diagnostic equipment / technical library resources / literature search toolsl	1

	PO 6	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying **reasoning informed by the contextual knowledge**	2
	PO 8	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of people in an organization	3
	PO 10	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	Identify**apply**appropriate searching technique for efficient retrieval of data stored location by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	Identify appropriate searching technique for efficient retrieval of data stored location in **search engines**	2
	PSO 2	Identify appropriate searching technique for efficient retrieval of data stored location in **mobile and web applications development**	2
	PSO 3	Identify appropriate searching technique for efficient retrieval of data stored location **in shipping real world software, using industry standard tools**	3
CO 2	PO 1	choose sorting technique to represent data in specified format to optimize data searching by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	choose sorting technique to represent data in specified format to optimize data searching by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	**Identify** choose sorting technique to represent data in specified format to optimize data searching by applying **Design/Development of Solutions**	3
	PO 4	**choose** sorting technique to represent data in specified format to optimize data searching by applying **Conduct Investigations of Complex Problems**	2
	PO 5	choose sorting technique to represent data in specified format to optimize data searching by applying Computer software / simulation packages / diagnostic equipment / technical library resources / **literature search toolsl**	1
	PO 6	choose sorting technique to **represent** data in specified format to optimize data searching by applying **reasoning informed by the contextual knowledge**	2

	PO 8	**choose** sorting technique to represent data in specified format to optimize data searching by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	choose sorting technique to **represent** data in specified format to optimize data searching by applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of people in an organization	3
	PO 10	choose**Apply** sorting technique to represent data in specified format to optimize data searching by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	**choose** sorting technique to **represent** data in specified format to optimize data searching by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	choose**Apply** sorting technique to represent data in specified format to optimize data searching in **search engines**	2
	PSO 2	choose**Apply** sorting technique to represent data in specified format to optimize data searching in **mobile and web applications development**	2
	PSO 3	choose**Apply** sorting technique to represent data in specified format to optimize data searching **in shipping real world software, using industry standard tools**	3
CO 3	PO 1	Make use of stacks and queues representation, operations and their applications to organize specified data by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	Make use of stacks and queues representation, operations and their applications to organize specified data by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	**Identify**, **Make use of** stacks and queues representation, operations and their applications to organize specified data by applying **Design/Development of Solutions**	3
	PO 4	Make use of **Apply**stacks and queues representation, operations and their applications to organize specified data by applying **Conduct Investigations of Complex Problems**	2
	PO 5	Make use of stacks and queues representation, operations and their applications to organize specified data by applying Computer software / simulation packages / diagnostic equipment / technical library resources / **literature search tools**	1

	PO 6	**Make use of** stacks and queues representation, operations and their applications to organize specified data by applying **reasoning informed by the contextual knowledge**	2
	PO 8	Make use of stacks and queues **representation**, operations and their applications to organize specified data by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	**Make use of** stacks and queues representation, operations and their applications to organize specified data by applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of people in an organization	3
	PO 10	Make use of stacks and queues representation, **operations and their applications** to organize specified data by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	Make use of stacks and queues **representation**, operations and their applications to organize specified data by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	Make use of stacks and queues **representation**, operations and their applications to organize specified data in **search engines**	2
	PSO 2	Make use of stacks and queues **representation**, operations and their applications to organize specified data **mobile and web applications development**	2
	PSO 3	Make use of stacks and queues **representation**, operations and their applications to organize specified data **in shipping real world software, using industry standard tools**	2
CO 4	PO 1	utilize linked lists to implement and perform operations for organizing specified data by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	utilize linked lists to implement and perform operations for organizing specified data by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	utilize**Apply** linked lists to **implement** and perform operations for organizing specified data by applying **Design/Development of Solutions**	3
	PO 4	utilize linked lists to **implement** and perform operations for organizing specified data by applying **Conduct Investigations of Complex Problems**	2

	PO 5	utilize linked lists to implement and perform operations for organizing specified data by applying Computer software / simulation packages / diagnostic equipment / technical library resources / **literature search toolsl**	1
	PO 6	utilize linked lists to implement and perform operations for organizing specified data by applying **reasoning informed by the contextual knowledge**	2
	PO 8	utilize linked lists to **implement** and perform operations for organizing specified data by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	utilize **Apply**linked lists to implement and perform operations for organizing specified data by applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of people in an organization	3
	PO 10	utilize linked lists to implement and **perform** operations for organizing specified data by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	utilize**Apply** linked lists to implement and perform operations for organizing specified data by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	utilize**Apply** linked lists to implement and perform operations for organizing specified in **search engines**	2
	PSO 2	utilize**Apply** linked lists to implement and perform operations for organizing specified in **mobile and web applications development**	2
	PSO 3	utilize**Apply** linked lists to implement and perform operations for organizing specified **in shipping real world software, using industry standard tools**	2
CO 5	PO 1	Construct tree to perform different traversal techniques by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	Construct tree to perform different traversal techniques by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	Construct**Apply** tree to **perform** different traversal techniques by applying **Design/Development of Solutions**	3
	PO 4	**Construct** tree to perform different traversal techniques by applying **Conduct Investigations of Complex Problems**	2

	PO 5	Construct tree to perform different traversal techniques by applying Computer software / simulation packages / diagnostic equipment / technical library resources / **literature search tools**	1
	PO 6	Construct tree to **perform** different traversal techniquesby applying **reasoning informed by the contextual knowledge**	2
	PO 8	ConstructApply tree to perform different traversal techniques by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	Construct tree to perform different traversal techniquesby applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of **people in an organization**	3
	PO 10	Construct tree to **perform** different traversal techniques by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	**Construct** tree to perform different traversal techniques by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	Construct tree to **perform** different traversal techniques in **search engines**	2
	PSO 2	Construct tree to **perform** different traversal techniques in **mobile and web applications development**	2
	PSO 3	Construct tree to **perform** different traversal techniques **in shipping real world software, using industry standard tools**	2
CO 6	PO 1	Select Appropriate graph traversal techniques to visit the vertices of a graph by applying the **principles of Mathematics and Engineering** , **Scientific principles and methodology**,**engineering disciplines to integrate / support study**	3
	PO 2	Select Appropriate graph traversal techniques to visit the vertices of a graph by applying Problem Analysis **Problem statement and system definition**,**Information and data collection**,**Solution development or experimentation / Implementation**	3
	PO 3	Select Appropriate graph traversal techniques to visit the vertices of a graph by applying **Design/Development of Solutions**	3
	PO 4	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by applying **Conduct Investigations of Complex Problems**	2
	PO 5	Select Appropriate graph traversal techniques to visit the vertices of a graph by applying Computer software / simulation packages / diagnostic equipment / technical library resources / **literature search tools**	1

	PO 6	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by applying **reasoning informed by the contextual knowledge**	2
	PO 8	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by applying **ethical principles** and commit to professional **ethics and responsibilities** and norms of the Engineering practice	3
	PO 9	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by applying Function **effectively** as an individual, and as a member or leader to get Ability to work with all levels of people in an organization	3
	PO 10	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by **Communicate effectively** on **complex Engineering activities**	3
	PO 12	**Select** Appropriate graph traversal techniques to visit the vertices of a graph by **Keeping current in CSE and advanced engineering concepts**	3
	PSO 1	**Select** Appropriate graph traversal techniques to visit the vertices of a graph in **search engines**	2
	PSO 2	**Select** Appropriate graph traversal techniques to visit the vertices of a graph in **mobile and web applications development**	2
	PSO 3	**Select** Appropriate graph traversal techniques to visit the vertices of a graph **in shipping real world software, using industry standard tools**	2

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

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	3	2	2	3	1	-	1	2	3	-	2	2	1	1
CO 2	1	2	2	2	3	1	-	2	3	3	-	2	1	1	1
CO 3	1	2	2	1	3	1	-	-	2	3	-	2	2	2	-
CO 4	1	2	1	1	3	1	-	-	2	3	-	2	2	1	1
CO 5	1	1	2	1	3	1	-	2	2	3	-	2	2	1	1
CO 6	1	1	2	1	3	1	-	1	3	3	-	2	2	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	**BASICS OF PYTHON**
	Write Python programs for the following: a. To find the biggest of given n numbers using control statements and lists b. To print the Fibonacci series using functions c. To find GCD of two numbers
WEEK II	**SEARCHING TECHNIQUES**
	Write Python programs for implementing the following searching techniques to arrange a list of integers in ascending order. a. Linear search b. Binary search
WEEK III	**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 IV	**IMPLEMENTATION OF STACK AND QUEUE**
	Write Python programs to for the following: a. Design and implement Stack and its operations using List. b. Design and implement Queue and its operations using List
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 operations on Single Linked List. (i) Creation (ii) insertion (iii) deletion (iv) traversal
WEEK VII	**IMPLEMENTATION OF CIRCULAR SINGLE LINKED LIST**
	Write Python programs for 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 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 a Python program to implement Stack using linked list.
WEEK X	**IMPLEMENTATION OF QUEUE USING LINKED LIST**
	Write a Python program to implement Linear 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 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. c. Count the number of nodes in the binary search tree

TEXTBOOKS

1. Rance D. Necaise, "Data Structures and Algorithms using Python", Wiley Student Edition.
2. Benjamin Baka, David Julian, "Python Data Structures and Algorithms", Packt Publishers, 2017.

REFERENCE BOOKS:

1. S. Lipschutz, "Data Structures", Tata McGraw Hill Education, 1st Edition, 2008.
2. Samanta, "Classic Data Structures", PHI Learning, 2nd Edition, 2004.Gottfried Byron,
3. "Schaum's Outline of Programming with Python", Tata Mc Graw Hill, 1st Edition, 2010.
4. Rance D. Necaise, "Data Structures and Algorithms using Python", Wiley, John Wiley and Sons, INC., 2011.
5. Benjamin Baka, David Julian, "Python Data Structures and Algorithms", Packt Publishing Ltd., 2017.

WEB REFERENCES:

1. https://docs.python.org/3/tutorial/datastructures.html
2. http://interactivepython.org/runestone/static/pythonds/index.html
3. http://www.tutorialspoint.com/data-structures-algorithms
4. http://www.geeksforgeeks.org/data-structures/
5. http://www.studytonight.com/data-structures
6. http://www.coursera.org/specializations/data-structures-algorithms
7. http://cse01-iiith.vlabs.ac.in/

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	Basics of Python	CO 1	T1
2	Searching Techniques.	CO 2	T1
3	Sorting Techniques	CO 2	T1,T2
4	Implementation of Stack and Queue	CO 3	T1,T2
5	Applications of Stack.	CO 3	T1, W1
6	Implementation of Single Linked List	CO 4	T1,W2

7	Implementation of Circular Single Linked List.	CO 4	T1,W3
8	Implementation of Double Linked List	CO 4	T2,W3
9	Implementation of Stack Using Linked List.	CO 3,CO 4	T2,W2
10	Implementation of Queue Using Linked List	CO 3,CO 4	T2,W5
11	Graph Traversal Techniques.	CO 6	T2,W2
12	Implementation of Binary Search Tree	CO 5	T1,W5

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Twin vortex formation:** Design a Data Structure SpecialStack that supports all the stack operations like push(), pop(), isEmpty(), isFull() and an additional operation getMin() which should return minimum element from the SpecialStack. All these operations of SpecialStack must be O(1). To implement SpecialStack, you should only use standard Stack data structure and no other data structure like arrays, list, . etc.
2	**Open channel:** In class, we studied binary search trees that do not allow us to insert duplicate elements. However, sometimes we do need to store duplicates. For example, a database of student marks might contain one record for every mark by every student; so if you've taken two courses, there will be two records with the same key (your student number) and different data (your two marks). To accomplish this, we might use a data structure called a "BST with duplicates", or BSTD
3	**Capillary action:** The variable tos in the Stack class is the index of the array element that would be filled the next time push() is called. Modify the code so that tos is the index of the top element actually in use. In other words, tos is to be the index of the top array element occupied by a value that has been "pushed" onto the stack. Write your changes on the code above. Don't forget to fix the comments. You do not need to add preconditions as in part-a.
4	**Buoyancy** Given an adjacency matrix representation of a graph, describe with pseudo code an algorithm that finds a single path, if one exists, between any two different vertices.
5	**Flow through pipes:** There is a garage where the access road can accommodate any number of trucks at one time. The garage is building such a way that only the last truck entered can be moved out. Each of the trucks is identified by a positive integer (a truck-id). Write a program to handle truck moves, allowing for the following commands: a) On-road (truck-id); b) Enter-garage (truck- id); c) Exit-garage (truck-id); d) Show-trucks (garage or road); If an attempt is made to get out a truck which is not the closest to the garage entry, the error message Truck x not near garage door
6	**Flow through pipes:** How many non-null links are there in a binary tree with N nodes?
7	**Flow through pipes:** How can we remove loops in a linked list? What are the functions of fast and slow pointers?

Signature of Course Coordinator **HOD,IT**
Mr.Ch.Suresh Kumar Raju, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
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COURSE DESCRIPTION

Department	MECHANICAL ENGINEERING				
Course Title	FLUID MECHANICS AND MACHINES				
Course Code	AMEB08				
Program	B. Tech.				
Semester	IV				
Course Type	Core				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	2	1
Course Coordinator	Mr. G Sarat Raju, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech.	AMEB03	III	Engineering Mechanics

II 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.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Fluid Mechanics and Machines	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
✓	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 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:

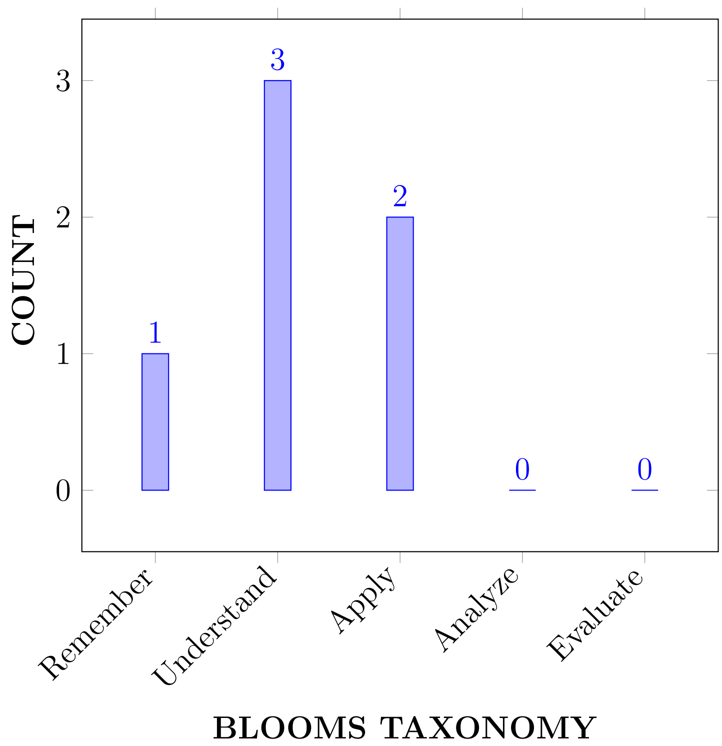
I	The fundamental knowledge of fluids, their properties and behaviour under various conditions of closed conduit and external flow systems.
II	The development of various static and dynamic fluid flow governing equations from the fundamental conservation laws of motion studied under basic physics and 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 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

Program Outcomes	
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.	3	SEE/CIA

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 creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	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	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
	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.	3
	PO 2	**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	**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 closed conduit flow for minimum losses.	3
	PO 2	**Understand** the given problem statement and **formulate** (complex) fluid flow engineering phenomena and system for **deriving** various governing equations of fluid flow through the pipes from the provided information.	3
CO 5	PO 1	**Apply** the basic principles of science for various phenomena of fluid systems and use mathematical principles for **deriving** the equations for power generation through the turbines by **understanding** the assumptions and limitations of fluid machines.	3
	PO 2	**Understand** the given problem statement and **formulate** fluid flow engineering phenomena and system for deriving various governing equations of fluid flow machines from the provided information.	2
CO 6	PO 1	**Apply** the principles of science for various phenomena of fluid pumps and use mathematical principles for **deriving** the equations for power transmission through the pipes by **understanding**the assumptions and limitations of fluid machines.	3
	PO 4	**Apply** the energy principles to enhance the performance characteristics of pumps by**design** and conduct research oriented experiments on different pumps using advanced methodologies.	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	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	3	-	-	-	-	-	-	-	-	-	-	-		-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	-	-	-	-	-	-	-	-	-	-	-	-	-	100
CO 3	66.6	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 4	100	30	-	-	-	-	-	-	-	-	-	-	-		-
CO 5	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	-	-	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	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-		-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	2	-	1	-		-	-	-	-	-	-	-	-	3
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:

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

XVIII 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. 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.

WEB REFERENCES:

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)			
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 2	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 2	T1:12.2 R2:13.1
15-16	Bernoulli equation for flow along a stream line and applications.	CO 2	T1:12.3
17-18	Measurement of flow.	CO 2	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 3	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.	CO4	T1:17.9 R2:16.11
28	Classification of water turbines, heads, efficiencies and Working principle of Pelton wheel turbine.	CO 5	T1:18.3 R2:17.2
29	Velocity triangles of Pelton wheel turbine.	CO 5	T1:18.10 R2:17.7
30-31	Working principle and velocity triangles of Francis turbine.	CO5	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. Geometric similarity, unit and specific quantities.	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. Cavitation, surge tank, water hammer	CO 6	T1:19.9 R1:18.11
40	Pumps: Theory of roto dynamic 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
42-43	Centrifugal pumps, velocity components at entry and exit of the rotor, velocity triangles.	CO 6	T1:19.3 R1:182
44	Performance curves and cavitation in pumps	CO 6	T1:19.4 R1:18.3
45	Indicator diagrams, Reciprocating pump–working principle.	CO 6	T1:19.5
PROBLEM SOLVING/ CASE STUDIES			
1	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
2	Water flows through a pipe AB 1.2 m dia. at 3m/s and then passes through pipe BC 1.5 m dia. At C the pipe branches, branch CD is 0.8 m dia. And carries 1/3 rd of the flow in AB the flow velocity in branch CE is 2.5 m/s. Calculate the volume rate of flow in AB, the velocity in BC, the velocity in CD and dia. of CE.	CO 2	T2:1.5 R2:2.4

3	A 300 mm diameter pipe carries water under a head of 20 m with a velocity of 3.5 m/s. If the axis of the pipe turns through 450, calculate the magnitude and the direction of the resultant force at the bend.	CO 2	T1:12.3
4	For the velocity profile 2(y/δ)- (y/δ)2, find the thickness of boundary layer at the end of the plate and the drag force on one side of a plate 1 m long and 0.8 m wide when placed in water flowing with a velocity of 150 mm/s. calculate the value of coefficient of drag also. Take µ for water as 0.01 poise.	CO 3	T2:12.3 R1:13.2
5	A crude oil of kinematic viscosity and 0.4 stoke is flowing through a pipe of diameter 300 mm at the rate of 300 lps. Find the head loss due to friction for a length of 50 m of the pipe.	CO 3	T1:16.7 R2:15.3
6	A horizontal pipe of diameter 500 mm is suddenly contracted to a diameter of 250 mm. The pressure intensities in the large and smaller pipe is given as 13.734 N/cm2 and 11.772 N/cm2 respectively. Find 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
7	A horizontal pipe line 40 m long is connected to a water tank at one end and discharges freely into the atmosphere at the other end. For the first 25 m of its length from the tank is 150 mm diameter and its diameter is suddenly enlarged to 300 mm. The height of water level in the tank is 8 m above the centre of the pipe. Considering all losses of head which occur, determine the rate of flow. Take f = 0.01 for both sections of the pipe, also draw HGL and TEL.	CO 4	T1:12.3
8	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. Find the rate of flow of oil of specific gravity 0.9 when the co-efficient of discharge of the meter = 0.64.	CO 3	T1:2.5 R2:2.6
9	A Pelton wheel having a mean bucket diameter of 1.0 m is running at 1000 r.p.m. the side clearance angle is 150 and discharge through the nozzle is 0.1m3/s, determine power available at the nozzle and hydraulic efficiency of the turbine.	CO 5	T1:18.10 R2:17.7
10	A Kaplan turbine develops 24647.6 KW power at an average head of 39 m. assuming speed ratio of 2, flow ratio of 0.6, diameter of the boss = 0.35 x diameter of the runner and an overall efficiency of 90%. Calculate the diameter, speed and specific speed of the turbine.	CO 5	T1:18.18 R1:17.11
11	A Francis turbine with an overall efficiency of 75% is required to produce 148.25 KW power. It is working under a head of 7.62 m. the peripheral velocity = 0.26 and the radial velocity of flow at inlet is 0.96 . The wheel runs at 150 rpm and the hydraulic losses in the turbine are 22% of the available energy. Assuming radial discharge determine; i. The guide blade angle, ii. The wheel vane angle at inlet and iii. Diameter of the wheel at inlet.	CO 5	T2:18.15 R2:17.9

12	A centrifugal pump is to discharge 0.118 m3/s at a speed of 1450 rpm against a head of 25 m. The impeller diameter is 250 mm, its width at outlet is 50 mm and manometric efficiency is 75%. Determine the vane angle at the outer periphery of the impeller.	CO 6	T1:19.3 R1:18.2
13	A double acting reciprocating pump running at 40 rpm is discharging 1 m3 of water per minute. The pump has a stroke of 400 mm. the diameter of the piston is 200 mm. the delivery and suction heads are 20 m and 5 m respectively. Determine the slip of the pump and the power required to drive the pump.	CO 6	T1:19.5
14	A single-acting reciprocating pump running at 30 r.p.m., delivers 0.012 m3/s of water. The diameter of the piston is 25 cm and stroke length 50 cm. Determine: i. The theoretical discharge of the pump ii. Co-efficient of discharge, and iii. Slip and percentage slip of the pump.	CO 6	T1:19.5
15	A single-acting reciprocating pump has a plunger of diameter 250 mm and stroke of 350 mm. if the speed of the pump is 60 rpm and it deliver 16.5 lps of water against a suction head of 5 m and a delivery head of 20 m. Determine the theoretical discharge, coefficient of discharge, the slip, the percentage of slip and the power required to drive the pump.	CO 6	T1:19.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	What is a Non- Newtonian fluid?	CO 1	T1:1.6
2	What are Eularian and Lagrangian approaches?	CO 2	T2:22.7
3	What is the separation of boundary layer?	CO 3	T2:12.3 R1:13.2
4	How thick is the boundary layer on a wing?	CO 4	T2:12.3 R1:13.2
5	Why priming is important in centrifugal pump?	CO 6	T1:19.3 R1:18.2
DISCUSSION OF QUESTION BANK			
1	Derive an expression specific speed of a centrifugal pump.	CO 6	T1:19.3 R1:18.2
2	How to govern the impulse turbines? Explain with a neat sketch.	CO 4	T1:18.3 R2:17.2
3	Derive the expression for the Coefficient of discharge through a Venturi meter.	CO 3	T1:2.5 R2:2.6
4	Classify the patterns of flow and Explain in detail with neat sketch the Streak line flow	CO 2	T1:22.7
5	Explain with a neat sketch the viscosity, newton's law of viscosity, and the effect of temperature and pressure on viscosity.	CO 2	T1:1.6

Signature of Course Coordinator **HOD, ME**

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

COURSE DESCRIPTION

Department	Mechanical Engineering				
Course Title	Applied Thermodynamics-I				
Course Code	AMEB09				
Program	B. Tech.				
Semester	IV				
Course Type	Core				
Regulation	R18				
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.	AMEB04	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-I	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
60 %	Understand
30%	Apply

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:

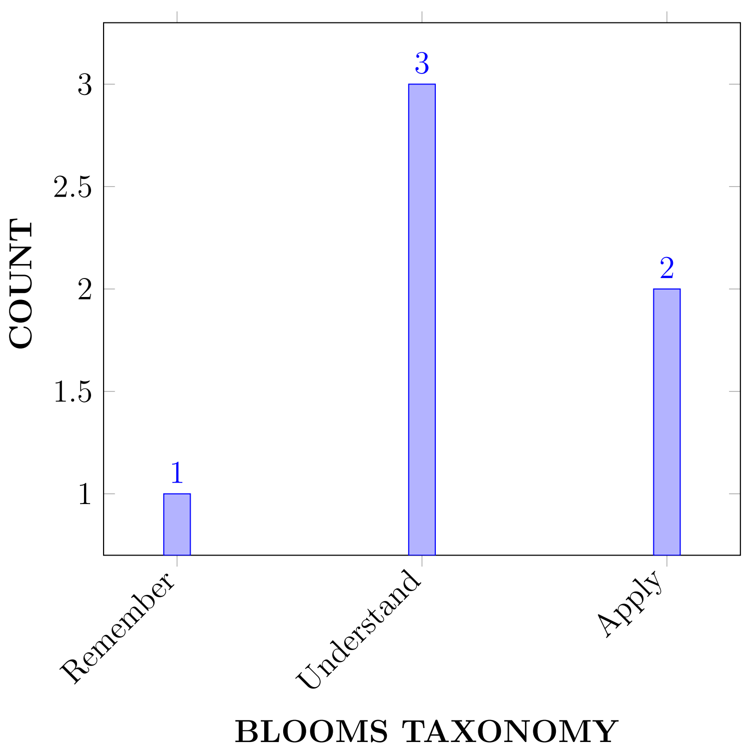
I	The concepts related to the operation of internal combustion engines based upon the fundamental engineering sciences of thermodynamics.
II	The techniques for improving the efficiencies and performance of compressors and refrigeration systems retained to practical applications such as irrigation, air 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.
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	-
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:

x	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

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	-	-
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

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**KINEMATICS OF MACHINES**				
Course Code	AMEB10				
Program	B.Tech				
Semester	IV	ME			
Course Type	Core				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr K Viswanath Allamraju, Professor				

I 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.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB002	II	Engineering Mechanics
B.Tech	AMEB001	II	Engineering Drawing

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Dynamics of Machinery	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
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 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:

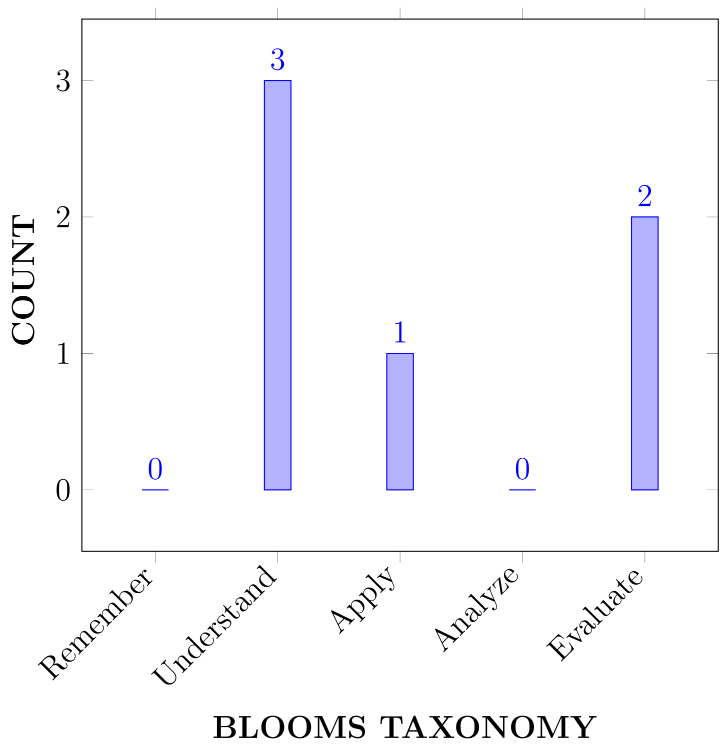
I	The basic concepts of Machine design to develop Mechanisms and Machines by using type synthesis , number synthesis and dimensional synthesis.
II	The Kinematics from the geometric point of view to determine mobility ,velocity and acceleration using graphical methods.
III	The Mechanisms with lower pairs 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 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	**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/ SEE /CIE, AAT, QUIZ

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	Quiz
PSO 2	Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining.	1	Quiz

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 Mathematics, Sciences and Engineering fundamentals principles** to classify various kinematic systems	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 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
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

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	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

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	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

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	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	36	6	-	-	6		-	-	-	-	2	3	3	-	-
AVERAGE	3	1	-	-	3		-	-	-	-	1	1	1 -	-	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1,PO 2, PO 3, PO 4	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	PO 1, PO 2, PO 3, PO 4				

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

XVII 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.

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 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.	CO7	T2:21.2
28	Condition for minimum number of teeth to avoid interference	CO7	T2:21.1
29	Problems on Condition for minimum number of teeth to avoid interference	CO7	T2:22.1
30	lenght of Path of contact	CO7	T2:22.2
31	Length of Arc of contact	CO7	R3 22.10
32	Contact ratio	CO7	R322.4
33	Pinion and Rack arrangements	CO7	R3 22.3
34	Introduction to Helical, Bevel and worm gearing.	CO7	R3 22.13
35	Types of gears	CO7	R3 22.12
36	Types of gear trains	CO8	T2.18.1
37	Epicyclic gear train.Methods of finding train value or velocity ratio of Epicyclic gear trains.	CO8	T2 18.6
38	Selection of gear box-Differential gear for an automobile.	CO8	R3 23.9
39	Problems on epicyclic gear train	CO8	R3 23.11
40	Tabular method	CO8	R3 23.4
41	Analytical method	CO8	R3 23.5
42	Equation of motion of gears	CO8	R3 23.12
43	Sun and Plant gears	CO8	R3 24.4
44	Annualr gear wheel	CO8	R3 24.5
45	Problems on sun and planet gear	CO8	R3 24.6
PROBLEM SOLVING/ CASE STUDIES			
46	Problems on annular gear.	CO8	R3 24.4
47	Problems on epicyclic gear train	CO9	R3 23.18
48	Applying velocity ratio in solving problems	CO9	R3 23.18
49	Law of gearing	CO9	R323.23
50	Applications of gear trains to real world problems	CO10	R3 23.14
DISCUSSION OF DEFINITION AND TERMINOLOGY			
51	Kinematic pairs.	CO8	R3 24.4
52	Straight line motion mechanisms	CO9	R3 23.18
53	Applying velocity ratio in solving problems	CO9	R3 23.18
54	Law of gearing	CO9	R323.23
55	Applications of gear trains to real world problems	CO10	R3 23.14
DISCUSSION OF QUESTION BANK			
1	Inversions	CO 1	R4:2.1
2	Velocity and Aceleration Mechanisms	CO 2	T4:7.3
3	Steering Gear Mechanisms	CO 3	R4:5.1
4	CAM profiles	CO 4	T1:7.5

5	Gears and Gear Trains	CO 5,6	T1: 4.1

Signature of Course Coordinator **HOD,ME**
Dr. K Viswanath Allamraju Professor

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

COURSE DESCRIPTION

Department	MECHANICAL ENGINEERING				
Course Title	MATERIALS AND MECHANICS OF SOLIDS				
Course Code	AMEB11				
Program	B. Tech				
Semester	FOUR				
Course Type	Core				
Regulation	IARE-R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	2	1
Course Coordinator	Dr. K Viswanath Allamraju, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB03	III	Engineering Mechanics

II COURSE OVERVIEW:

Materials and mechanics of solids course is a broad multidisciplinary approach to understand and manipulate the thermo-mechanical, electrical and magnetic properties of materials. This course provides key information of physical and chemical behavior of metallic elements, inter-metallic compounds and their mixtures, constitutive relations, normal stresses and computing deflection of various structures with different boundary and loading condition. The knowledge of the course leads to design the mechanical, aeronautical and civil structures.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Materials and Mechanics of Solids	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
✓	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 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 basic structure of materials at the molecular, microscopic, macroscopic scales, and discuss contemporary strategies of characterizing substances at every of those length scales.

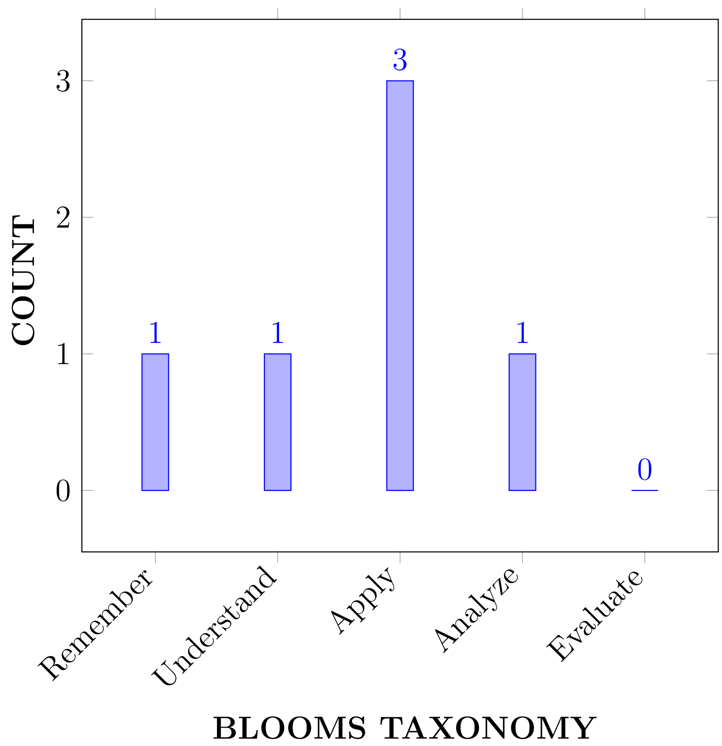
II	The fundamental knowledge of stress analysis, theories of failure, relationship between mechanical and metallurgical properties to design and analyse commonly used machine components.
III	The concepts of mechanics of deformable solids including stress – strain relations, methods for slope-deflection determination for structural applications.

VII COURSE OUTCOMES:

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

CO 1	**Relate** the structure of materials with the principles of Miller indices, and apply in inter disciplinary engineering applications.	Remember
CO 2	**Identify** the heat treatment process to determine mechanical and metallurgical properties with respect to phase changes of microstructures.	Apply
CO 3	**Compare** the concepts of stress and strain at a point as well as the stress-strain relationships for linear, elastic, homogeneous and isotropic materials.	Understand
CO 4	**Develop** the equations for principal stresses, maximum shearing stresses and angles acting on any arbitrary plane within a structural element.	Apply
CO 5	**Analyze** the shear force and bending moment diagrams for different types of loads on cantilever, simply supported and over hanging beams.	Analyze
CO 6	**Utilize** the Clerk-Maxwell's reciprocal theorem and its applications in design of beams by considering slope and deflections.	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	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

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 structure of materials with the principles of Miller indices and **apply** in inter disciplinary engineering.	3
	PO 2	**Identify, formulate and review research literature** available to explore structure of materials such as BCC, FCC, HCP, etc., **construct** lines, planes utilizing Miller indices.	5
	PO 12	**Recognize** the need for and having the preparation and **skill** to engage in independent and life-long learning in the context of technological changes in the **development** of smart materials from conventioal materials.	3
	PSO 1	**Formulate and evaluate** engineering concepts of crystallogrphy, crystallographic planes, miller indices, ASTM grain size numbers and concepts of grain boundaries in design of engineering materials.	2
CO 2	PO 1	**Apply** knowledge of science, engineering fundamentals to **understand** the phase diagrams, material properties and microstructures.	2
	PO 2	**Identify, formulate and analyse Identify** the heat treatment process to determine mechanical and metallurgical properties with respect to phase changes of microstructures.	5
	PO 12	**Recognize** the need for and having the preparation and **skill** to engage in independent and life-long learning in the context of technological changes in the **development** of microstructures of smart materials.	3
CO 3	PO 1	**Apply** knowledge of science, engineering fundamentals to **develop** the stress-strain relations for linear, elastic, homogeneous and isotropic materials.	2
	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
	PO 12	**Recognize** the need for and having the preparation and **skill** to engage in independent and life-long learning in the context of technological changes in the **development** of smart materials from conventioal isotropic materials.	3
	PSO 1	**Formulate and evaluate** engineering concepts of stress, strain, Poisons ratio, relationship between elastic constants in design of engineering materials.	2
CO 4	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
	PO 3	**Design** solutions for complex Engineering problems and design system components by **analyzing** principal stresses and strains that meet the specified needs with appropriate consideration for the societal and environmental considerations.	2
CO 5	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.	5
	PO 3	**Design** solutions for complex Engineering problems and design system components by **analyzing** shear force and bending moment for various beams that meet the specified needs with appropriate consideration for the societal and environmental considerations.	2
	PO 12	**Recognize** the need for and having the preparation and **skill** to engage in independent and life-long learning in the context of technological changes in the **development** of different types of beams with different cross sections.	3
	PSO 1	**Formulate and evaluate** engineering concepts of shear force, bending moment and the relation between SF, BM and load in design of beams.	2
CO 6	PO 1	**Apply** the knowledge of science, engineering fundamentals to **understand** Clerk-Maxwell's reciprocal theorem and applications in design engineering problems.	3
	PO 3	**Design** solutions for complex Engineering problems and design system components by **analyzing** slope and deflection for various beams that meet the specified needs with appropriate consideration for the societal and environmental considerations.	2
	PSO 1	**Formulate and evaluate** engineering concepts of slope, deflection and Clerk-Maxwell's reciprocal theorem and applications in design 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	5	-	-	-	-	-	-	-	-	-	3	2	-	-
CO 2	2	5	-	-	-	-	-	-	-	-	-	3	-	-	-
CO 3	2	4	-	-	-	-	-	-	-	-	-	3	2	-	-
CO 4	2	4	2	-	-	-	-	-	-	-	-	-	-		-
CO 5	3	5	2	-	-	-	-	-	-	-	-	3	2	-	-
CO 6	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	50	-	-	-	-	-	-	-	-	-	37.5	100	-	-
CO 2	66.7	50	-	-	-	-	-	-	-	-	-	37.5	-	-	-
CO 3	66.7	40	-	-	-	-	-	-	-	-	-	37.5	100	-	-
CO 4	66.7	40	20	-	-	-	-	-	-	-	-	-	-		-
CO 5	100	50	20	-	-	-	-	-	-	-	-	37.5	100	-	-
CO 6	66.7	-	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	2	-	-	-	-	-	-	-	-	-	1	3	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	1	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	1	3	-	-
CO 4	3	1	1	-	-	-	-	-	-	-	-	-	-		-
CO 5	3	2	1	-	-	-	-	-	-	-	-	1	3	-	-
CO 6	3	-	1	-	-	-	-	-	-	-	-	-	3	-	-
TOTAL	18	8	3	-	-		-	-	-	-	-	4	12	-	-
AVERAGE	3	1.6	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:

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

XVIII SYLLABUS:

MODULE I	**FUNDAMENTALS OF MATERIAL SCIENCE**
	Basic Crystallography Crystal structure BCC, FCC and HCP structure, unit cell, crystallographic planes and directions, miller indices. Crystal imperfections, point, line, planar and volume defects, grain size, ASTM grain size number. Frank Reed source of dislocation Elastic and plastic modes of deformation, slip and twinning, strain hardening, seasons cracking, Bauschingers effect, yield point phenomenon, cold/hot working, recovery, re-crystallization, and grain growth, strengthening of metals.
MODULE II	**ALLOYS AND PHASE DIAGRAMS**
	Constitution of alloys and phase diagrams; constitution of alloys, solid solutions, substitutional and interstitial. phase diagrams, isomorphous, eutectic, peritectic, eutectoid and peritectoid reactions. iron – iron carbide equilibrium diagram. Classification of steel and cast-iron microstructure, properties and application.
MODULE III	**SIMPLE STRESSES AND STRAINS, PRINCIPAL STRESSES**
	Hookes law, stress and strain- tension, compression and shear stresses elastic constants and their relations Volumetric, linear and shear strains principal stresses and principal planes, Mohrs circle.
MODULE IV	**SHEAR FORCE AND BENDING MOMENT DIAGRAMS, FLEXURAL STRESSES, SHEAR STRESSES**
	Beams and types transverse loading on beams shear force and bend moment diagrams types of beam supports, simply supported and over-hanging beams, cantilevers. theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads.
MODULE V	**SLOPE AND DEFLECTION**
	Moment of inertia about an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, $Maxwell's$ reciprocal theorems.

TEXTBOOKS

1. Sidney H Avner, “Introduction to Physical Metallurgy”, McGraw-Hill Education, 2nd Edition, 2008.
2. Donald R Askeland, Thomson, “Essentials of Material Science and Engineering”, Thomson Press, 1st edition, 2005.
3. 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.

WEB REFERENCES:

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	Basic crystallography and crystal structure.	CO 1	T2:2.3
3	BCC, FCC and HCP structure	CO 1	R1:2.6
4	Unit cell, crystallographic planes and directions, miller indices.	CO 1	T1:2.6
5-6	Crystal imperfections, point, line, planar and volume defects, Grain size, ASTM grain size number	CO 1	T2:2.7 R1:2.18
7	Frank Reed source of dislocation elastic and plastic modes of deformation.	CO 1	T2:2.22
8	Slip, twinning, strain hardening, seasons cracking.	CO 1	T2:2.25
9	Bauschingers effect, yield point phenomenon, Cold/hot working and recovery.	CO 1	T2:2.22
10-11	Re-crystallization, and grain growth, strengthening of metals, Constitution of alloys and solid solutions.	CO 2	T2:2.26 R1:2.55
12	Phase diagrams, Substitutional and interstitial.	CO 2	T2:3.14 R1:4.33
13-14	Iron – iron carbide equilibrium diagram. Classification of steel and cast-iron microstructure	CO 2	T2:3.18 R1:4.64
15	Properties and application	CO 2	T2:3.22
16	Introduction to mechanics of solids: Hook’s law	CO 2	T2:3.28 R1:4.67
17	Stress-strain diagrams for different materials,tension, compression and shear stresses .	CO 3	T2:4.3 R1:4.71

18-19	Elastic constants, derivations and relationship between elastic moduli.	CO 3	T2:4.15 R1:5.74
20	Volumetric, linear and shear strains	CO 3	T1:4.12 R2:5.75
21	Principal stresses, derivations	CO 4	T1:4.8 R1:5.72
22	Principal planes and problems	CO 4	T1:5.8 R1:5.73
23	Mohr's circle construction and problems	CO 4	T1:5.14 R1:6.78
24	Introduction to beams and types.	CO 5	T2:5.19 R1:6.81
25	Transverse loading on beams shear force, Bending moment diagrams	CO 5	T1:6.4 R2:6.8
26	types of beam supports and cantilever	CO 5	T1:7.12 R2:8.75
27	S.S.B and Over-hanging beams	CO 5	T1:8.8 R1:8.73
28-29	Theory of bending of beams and bending stress distribution, Neutral axis and shear stress distribution	CO 5	T2:9.19 R1:10.81
30	Moment of inertia about an axis and polar moment of inertia.	CO 5	T2:10.7 R1:12.74
31	Introduction to deflection of a beam using double integration method	CO 5	T1:11.12 R2:12.75
32	Deflection of a beam using double integration method: Cantilever	CO 6	T1:12.4 R2:13.68
33-34	Deflection of a beam using double integration method: Simply supported beam.	CO 6	T2:13.7 R1:14.74
35	Introduction to slope	CO 6	T1:14.12 R2:15.75
36-37	Derivations of cantilever and simply supported beams slope	CO 6	T2:9.19 R1:10.814
38-39	Deflection of beams and derivations.	CO 6	T1:10.4 R2:11.68
40	Maxwell's reciprocal theorems.	CO 6	T2:10.7 R1:12.74
PROBLEM SOLVING/ CASE STUDIES			
41	Miller indices, crystal plpanes and directions	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 2	T1:4.12 R2:5.75
44	Three elastic constants.	CO 2	T1:4.8 R2:4.68
45	Principal stresses	CO 3	T1:4.8 R1:5.72
46	Mohr's circle construction and problems	CO 4	T1:5.14 R1:6.78

47	Shear force and Bending moment diagrams	CO 5	T2:7.7 R1:7.74
48	Over-hanging beams and cantilevers.	CO 5	T1:8.8 R1:8.73
49	Deflection of a beam using double integration method: Cantilever	CO 6	T1:12.4 R2:13.68
50	Deflection of a beam using double integration method: Simply supported beam.	CO 6	T2:13.7 R1:14.74
51	Slope: Cantilever beams	CO 6	T2:9.19 R1:10.81
52	Slope: simply supported beams	CO 9, CO 6	T2:9.19 R1:10.81
53	Deflection: cantilever and simply supported beams	CO 6	T1:10.4 R2:11.68
54	Deflection: Over hanging beams	CO 6	T1:10.4 R2:11.68
55	Maxwell's reciprocal theorem Problems	CO 6	T2:10.7 R1:12.74
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Module I: Fundamentals of Material Science	CO 1	T2:2.3
57	Module II: Alloys and Phase Diagrams	CO 2	T2:3.14 R1:4.33
58	Module III: Simple Stresses and Strains, Principal Stresses	CO 3, CO 4	T2:4.2 R1:5.72
59	Module IV: Shear Force and Bending Moment Diagrams, Flexural Stresses, Shear Stresses	CO 5	T2:7.7 R1:7.74
60	Module V: Slope and Deflection	CO 6	T2:9.19 R1:10.81
DISCUSSION OF QUESTION BANK			
61	Module I: Fundamentals of Material Science	CO 1	T2:2.3
62	Module II: Alloys and Phase Diagrams	CO 2	T2:3.14 R1:4.33
63	Module III: Simple Stresses and Strains, Principal Stresses	CO 3, CO 4	T2:4.2 R1:5.72
64	Module IV: Shear Force and Bending Moment Diagrams, Flexural Stresses, Shear Stresses	CO 5	T2:7.7 R1:7.74
65	Module V: Slope and Deflection	CO 6	T2:9.19 R1:10.81

Signature of Course Coordinator **HOD, ME**

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">Optimization Techniques</td></tr>
<tr><td>Course Code</td><td colspan="5">AMEB12</td></tr>
<tr><td>Program</td><td colspan="5">B. Tech</td></tr>
<tr><td>Semester</td><td colspan="5">IV SEM</td></tr>
<tr><td>Course Type</td><td colspan="5">Core</td></tr>
<tr><td>Regulation</td><td colspan="5">R-18</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>-</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Dr A Naveen Krishna, Assistant Professor</td></tr>
</table>

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 optimization Techniques 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
Optimization Techniques	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:

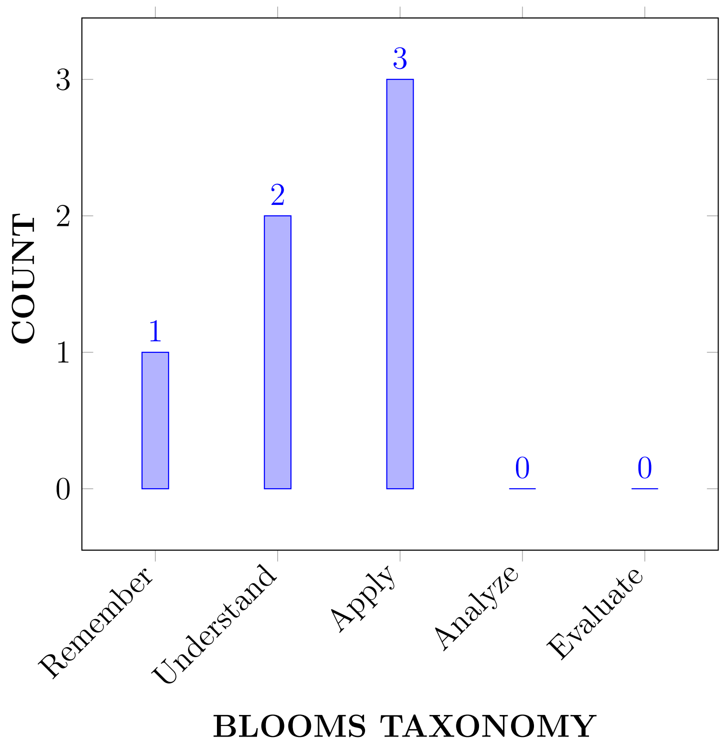
I	Operation research models using optimization techniques based upon the fundamentals of engineering mathematics (minimization and Maximization of objective function).
II	The problem formulation by using linear, dynamic programming, game theory and queuing models.
III	The stochastic models for discrete 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	**ENVIRONMENTAL SCIENCE**				
Course Code	AHSB07				
Program	B.Tech				
Semester	IV				
Course Type	FOUNDATION				
Regulation	R-18				
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	**Professional Skills:** The ability to understand, analyze and develop computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient design of computer-based systems of varying complexity	-	-
PSO 2	**Problem-Solving Skills:** The ability to apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success.	-	-
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.	-	-

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:

MODULE 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.
MODULE 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.
MODULE 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.
MODULE 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.
MODULE 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,AERO**

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

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**FLUID MACHINERY AND IC ENGINES LABORATORY**				
Course Code	AMEB13				
Program	B.Tech				
Semester	IV	ME			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. A Somaiah, Assistant Professor				

I COURSE OVERVIEW:

The Fluid Machinery and I.C. Engine 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 mechanics and thermodynamics, 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	AMEB03	III	Engineering Mechanics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Fluid Machinery and I.C Engine 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:

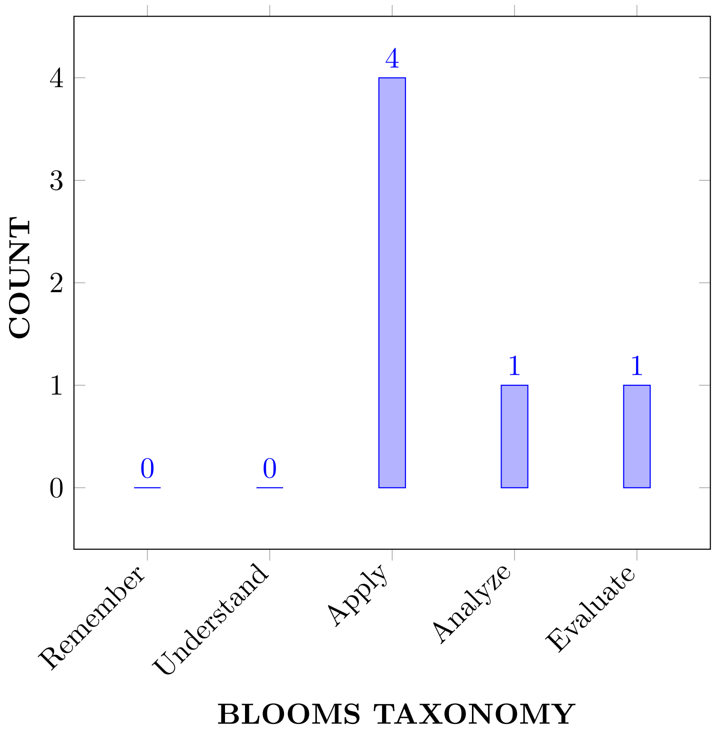
I	The types of fluids, properties and behaviour under static and dynamic conditions of closed conduit and external flow systems.
II	The operating principle of various turbo machinery and analyze their performance characteristics under various operating conditions.
III	The measurement of flow rate through 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	**Apply** the concepts of intercooling in multistage air compressor for minimum power input.	Apply
CO 6	**Determine** the performance parameters of internal combustion engines under variable input conditions for optimum fuel consumption.	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	**CALIBRATION OF FLOW METERS**
	Calibration of Venturimeter and Orifice meter.
WEEK II	**DETERMINATION OF FRICTION FACTOR**
	Determination of friction factor for a given pipe line.
WEEK III	**BERNOULLI'S THEOREM**
	Verification of Bernoulli's theorem.
WEEK IV	**PERFORMANCE TEST ON REACTION TURBINES**
	Performance Test on Francis and Kaplan Turbines.
WEEK V	**PERFORMANCE TEST ON IMPULSE TURBINE**
	Performance test on Pelton wheel turbine.
WEEK VI	**PERFORMANCE TEST ON POSITIVE DISPLACEMENT PUMP**
	Performance Test on Reciprocating Pump and generate various characteristic curves
WEEK VII	**PERFORMANCE TEST ON ROTODYNAMIC PUMPS**
	Performance Test on Centrifugal Pumps and generate various characteristic curves
WEEK VIII	**I.C Engines Valve/Port timing diagram**
	Drawing valve and port timing diagram for 4-stroke diesel and 2-stroke petrol engine respectively.
WEEK IX	**I.C Engine performance test for 4-stroke SI Engine**
	Performance test for 4-stroke SI engine and draw performance curves
WEEK X	**I.C Engine performance test on 4-Stroke CI engine**
	Performance Test on 4-stroke CI engine and to draw the performance curves
WEEK XI	**Performance Test on Air Compressor Unit**
	Volumetric Efficiency of Reciprocating Air compressor unit
WEEK XII	**Performance test on Variable Compression Ratio (VCR) engine**
	Performance Test on CI engine when the compression ratio is changing.

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	Determination of coefficient of discharge (Cd) and generation of various characteristic curves for water flowing through Venturi meter and Orifice meter.	CO 1, CO 2	T1:7.10
2	Determination of friction factor for a given pipe line.	CO 1, CO 2	T1:11.5
3	Verification of Bernoulli's theorem	CO 3	T1:7.7
4	Performance test on Francis turbine, Kaplan turbine and generate various characteristic curves.	CO 4, CO 5	T1:21.12
5	Performance test on Pelton wheel and generate various characteristic curves.	CO 5, CO 6	T1:21.5
6	Performance test on reciprocating pump and generate various characteristic curves.	CO 4, CO 6	T1:23.2
7	Performance test on centrifugal Pumps and generate various characteristic curves.	CO 4, CO 6	T1:24.3
8	Drawing valve and port timing diagram for 4 - stroke diesel and 2-stroke petrol engine respectively.	CO 6	R2:2.6
9	Performance test for 4 - stroke SI engine and draw performance curves.	CO 5, CO 6	T2:3.18
10	Performance Test on 4-stroke C.I engine and to draw the performance curves.	CO 5, CO 6	T2:3.18
11	Volumetric efficiency of reciprocating air compressor unit.	CO 5, CO 6	R2:7.12
12	Performance test on CI engine when the compression ratio is changing.	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. A Somaiah, Assistant Professor

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

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**MATERIALS AND MECHANICS OF SOLID LABORATORY**				
Course Code	AMEB14				
Program	B.Tech				
Semester	Four				
Course Type	Core				
Regulation	IARE-R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. A. Somaiah, Assistant Professor				

I COURSE OVERVIEW:

Materials and solid mechanics 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	AMEB03	III	Engineering Mechanics

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Materials and Mechanics of Solid 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
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

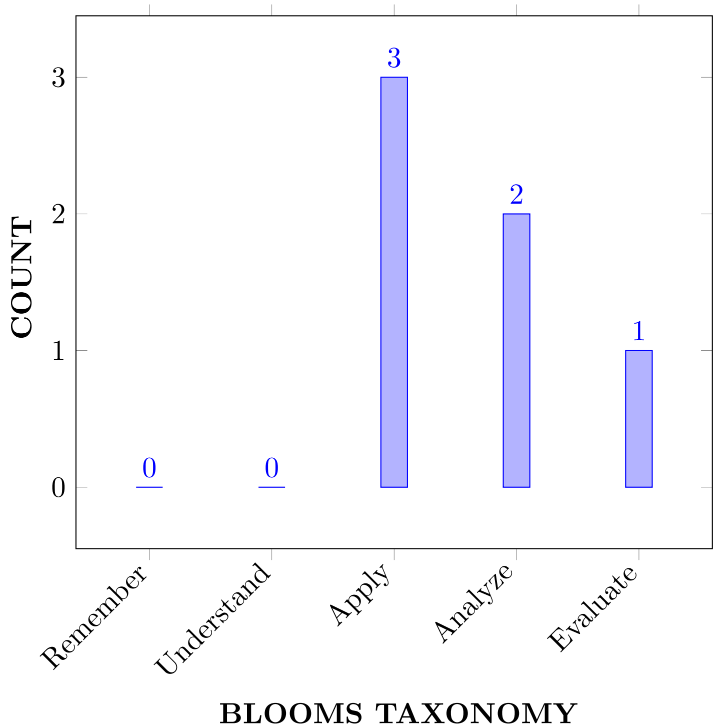
I	The processes of cold/hot working, re-crystallization, grain growth and micro structural properties of materials.
II	The parameters such as factor of safety, Poisson's ratio, three elastic moduli and their relationships in the selection and characterization of a material.
III	The theory of pure torsion, 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 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	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.	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	Focus on Ideation and Research towards Digital manufacturing in Product development using Additive manufacturing, Computer Numerical Control (CNC) simulation and high speed machining.	3	Lab Exercises
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	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
	PO 9	**Apply the knowledge of engineering and its principles** in the **feild** of Mechanical engineering to **function effectively** as an individual, and as a member or **leader** in **diverse teams towards the development** of organization, and in multidisciplinary systems.	7
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 **compare** the given material with different materials to **estimate** the variation of hardenability of a material and **draw** the hardenability curve.	6
	PO 9	**Apply the knowledge of engineering and its principles** in the **feild** of Mechanical engineering to **function effectively** as an individual, and as a member or **leader** in **diverse teams towards the development** of organization, and in multidisciplinary systems.	7
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.	3
	PO 9	**Apply the knowledge of engineering and its principles** in the **feild** of Mechanical engineering to **function effectively** as an individual, and as a member or **leader** in **diverse teams towards the development** of organization, and in multidisciplinary systems.	7
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
	PO 3	**Design** solutions for complex engineering problems and **development and analysis** of system components such as springs, carriages, etc. that satisfy the **demands** with suitable consideration for the safety, and the environmental considerations.	4
	PO 9	**Apply the knowledge of engineering and its principles** in the **feild** of Mechanical engineering to **function effectively** as an individual, and as a member or **leader** in **diverse teams towards the development** of organization, and in multidisciplinary systems.	7
CO 5	PO 1	**Apply** the knowledge of **science and engineering principles** to **analyze** the mechanical properties of materials by conducting Rockwell and Brinell hardness tests.	3

	PO 2	**Identify** the engineering materials, **determine and compare** the hardnes values with both Rockwell and Brinell test procedres.	3
	PO 9	**Apply the knowledge of engineering and its principles** in the **feild** of Mechanical engineering to **function effectively** as an individual, and as a member or **leader** in **diverse teams towards the development** of organization, and in multidisciplinary systems.	7
	PSO 1	**Formulate and evaluate** engineering concepts of design, thermal and production to provide solutions for technology aspects in digitalization of hardness testing.	2
CO 6	PO 1	**Apply** the knowledge of **science and engineering principles** to **analyze** the mechanical properties of materials by conducting Charpy and Izod impact tests.	3
	PO 9	**Apply the knowledge of engineering and its principles** in the **feild** of Mechanical engineering to **function effectively** as an individual, and as a member or **leader** in **diverse teams towards the development** of organization, and in multidisciplinary systems.	7
	PSO 2	**Formulate** and evaluate concepts of thermal analysis to provide solutions for inter disciplinary engineering applications.	1

XI COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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. R.Subramaniam, "The Strength of Materials", Oxford publishers, 4th Edition, 2018.
2. S. Ramamrutam, "Strength of Materials", Dhanpat Rai Publishing Company, 18th Edition, 2014.

REFERENCE BOOKS:

1. Robert J Asaro, Vlado Lubarda, “Mechanics of Solids and Materials”, Cambridge University Press, 4th Edition, 2006.
2. Vazirani, Ratwani, “Analysis of Structures”, Khanna Publishers, 19th Edition, 2014.

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	**OPTIMIZATION TECHNIQUES LABORATORY**				
Course Code	AMEB15				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Dr. K. Ch Apparao, Associate Professor				

I COURSE OVERVIEW:

The course covers developments of advanced optimization models and solution methods for technical and economical planning problems. Optimization Technique Lab 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. The main emphasis throughout this Lab will be on to develop and promote research interest in applying optimization techniques and reliability concepts in problems of Engineering and Technology by the use of advanced commercial software Python programming.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHSB02	I	Linear Algebra and Calculus	4
UG	AHSB11	II	Mathematical Transformation Techniques	4

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
OPTIMIZATION TECHNIQUES	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**

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

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		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	Lab Exercises
PO 2	**Problem Analysis:** An ability to analyze complex engineering problems to arrive at a relevant conclusion using knowledge of mathematics, science and engineering.	1	Lab Exercises/CIA/SEE
PO 3	**Design/Development of Solutions:** Competence to design a system, component or process to meet societal needs within realistic constraints.	1	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 modeling to complex engineering activities with an understanding of the limitations.	1	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 building career paths towards innovative start-ups, employability and higher studies.	2	Lab Exercises/CIA/SEE

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

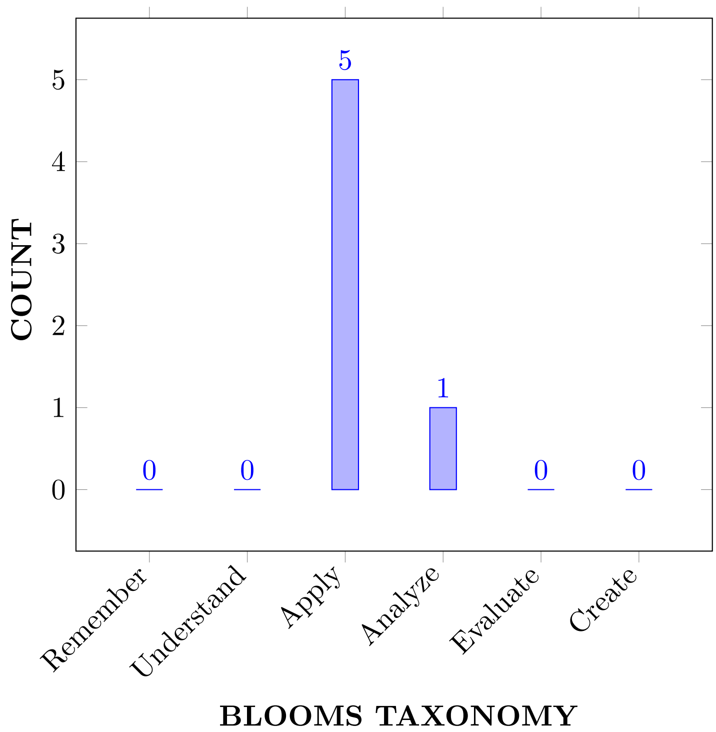
I	The theory of optimization methods and algorithms developed for solving various types of optimization problems by applying Python Programming.
II	Formulation of mathematical models for quantitative analysis of managerial problems in industry.
III	Application of quantitative methods and techniques for effective Decisions making; for solving business and industrial decision-making problems.

IX COURSE OUTCOMES:

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

CO No	Course Outcomes	Knowledge Level (Bloom's Taxonomy)
CO 1	**Apply** the basic principles and concepts of Python programming to formulate Linear Programming models for quantitative analysis of problems..	Apply
CO 2	**Apply** the Python Programing to solve LP problems using graphical, simplex and analytical methods for maximization and minimization problems.	Apply
CO 3	**Apply** the optimized material distribution schedule using transportation model **to** minimize total distribution cost by Python Programing.	Analyze
CO 4	**Identify** the appropriate algorithm for allocation of resources using Python Programing to optimize the process of assignment.	Apply
CO 5	**Apply** the python programming to formulate multi-server queuing model into L P problem to obtain the required number of servers and expected number of consumers in the system.	Apply
CO 6	**Apply** the python programming to formulate mathematical models for quantitative analysis of Inventory control practice in industry.	Apply

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	Understand various methods of optimization and the basic concepts of Python 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 5	Identify the various methods of optimization to solve specific real-world problem which are affecting them by using **appropriate techniques, modern Engineering and IT tools**	2
CO 2	PO 1	**Applty** Graphical and LPP methods for making effective decision on variables so as to optimize the objective function value by using the principles of **mathematics and engineering fundamentals.**	2
	PO 3	Problem analysis based on **principles of mathematics, engineering fundamentals** and **sciences** is essential to optimize the objective function value of Graphical and LPP methods for making effective decision on variables.	3
	PO 5	Identify the optimized material distribution schedule by Python programming to minimize total distribution cost by applying the **appropriate techniques, modern Engineering and IT tools**	2
CO 3	PO 1	Problem analysis based on **principles of mathematics, Manufacturing engineering fundamentals** and **sciences** is essential to identify and analyze the material distribution schedule to minimize total distribution cost	2
	PO 2	Selection of algorithm for assigning a suitable person to existing vacancy of jobs positions, need the knowledge of **science** and **engineering fundamentals**	2
	PO 5	Apply python programming to resolve decision for effective scheduling of Jobs for optimal values by applying **appropriate techniques, modern Engineering and IT tools**	2
CO 4	PO 1	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	3
	PO 2	Develop practical experience for solving the real time problem using **computational and experimental tools** in the field of Manufacturing process	2
	PSO 3	Make use of **computational and experimental tools** for creating innovative paths for optimized production process in the field of Manufacturing Process.	2

CO 5	PO 1	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	2
	PSO 3	Make use of **computational and experimental tools** for creating innovative paths for optimized production process in the field of Manufacturing Process.	2
CO 6	PO 1	Application of suitable inventory control system while manufacturing, can be used for **identifying, and analyzing complex problems**.	2
	PO 5	formulate mathematical models for quantitative analysis of Inventory control practice in industry by applying **appropriate techniques, modern Engineering and IT tools**	2
	PSO 3	Identify the stochastic models for discrete and continuous variables for **Qualitative and Quantitative methods** to their engineering problems.	2

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

Course Learning Outcomes	**Program Outcomes**												**Program Specific 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	$\surd$	-	-	-	$\surd$	-	-	-	-	-	-	-	-	-	-
CO 2	$\surd$	-	$\surd$	-	$\surd$	-	-	-	-	-	-	-	-	-	-
CO 3	$\surd$	$\surd$	-	-	$\surd$	-	-	-	-	-	-	-	-	-	-
CO 4	$\surd$	$\surd$	-	-	-	-	-	-	-	-	-	-	-	-	$\surd$
CO 5	$\surd$	-	-	-	-	-	-	-	-	-	-	-	-	-	$\surd$
CO 6	$\surd$	-	-	-	$\surd$	-	-	-	-	-	-	-	-	-	$\surd$

3 = High; 2 = Medium; 1 = Low

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

Course Outcomes	**Program Outcomes / No. of Key Competencies Matched**												**PSOs/ No. of key competencies**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
	3	**10**	**10**	**11**	**5**	**5**	**3**	**3**	**12**	**5**	**12**	**12**	**5**	**5**	**4**

CO 1	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO 3	2	3	-	-	2	-	-	-	-	-	-	-	-	-	-
CO 4	3	3	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	-	-	-	2	-	-	-	-	-	-	-	-	-	2

3 = High; 2 = Medium; 1 = Low

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

Course Out-comes	**Program Outcomes / No. of Key Competencies Matched**												**PSOs/ No. of key competencies**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
	3	**10**	**10**	**11**	**5**	**5**	**3**	**3**	**12**	**5**	**12**	**12**	**5**	**5**	**4**
CO 1	100	00.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 2	100	00.0	30.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 3	66.7	30.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 4	100	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
CO 5	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	0.0	50.0
CO 6	100	00.0	0.00	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0

XIV COURSE ARTICULATION MATRIX (CO-PO/PSO MAPPING)

COs and POs and COs and PSOs 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 – ??≤ ??≤ 5% –No correlation; **2** – 40 % <??< 60% –Moderate.
1 – 5 <??≤ 40% – Low/ Slight; **3** – 60% ≤ ??< 100% – Substantial /High

Course Outcomes	**Program Outcomes**												**Program Specific Out-comes**		
	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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	-	-	-	1	-	-	-	-	-	-	-	-	-	2
TOTAL	18	2	1	-	4	-	-	-	-	-	-	-	-	-	4
AVERAGE	**3.0**	**1.0**	**1.0**	-	**1.0**	-	-	-	-	-	-	-	-	-	**2.0**

XV ASSESSMENT METHODOLOGY - DIRECT:

CIE Exams	PO 1, PO 2	SEE Exams	PO 1,PO 2,PO 3, PO 5, PSO 3	Assignments	-	Seminars	-
Laboratory Practices	PO 1,PO 2, PO 3, PO 5, PSO 3	Student Viva	PO 1,PO 2, PO 3, PO 5, PSO 3	Mini Project	-	Certification	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

XVII SYLLABUS:

WEEK 1	**Matrix Operations**
	Write a Python program to find out when given an array of size N, the task is to partition the given array into two subsets such that the average of all the elements in both subsets is equal. If no such partition exists print -1. Otherwise, print the partitions.
WEEK 2	**Matrix Operations**
	Write a Python program to find out when given an array of positive elements, you have to flip the sign of some of its elements such that the resultant sum of the elements of array should be minimum non-negative (as close to zero as possible).
WEEK 3	**Minimum Cost Path**
	Write a Python program to find out when given a two-dimensional grid, each cell of which contains integer cost which represents a cost to traverse through that cell. The task is to find the maximum cost path from the bottom-left corner to the top-right corner.
WEEK 4	**Finding Maximum Number in An Array**
	Write a Python program to find out when given an array of non-negative integers arr[], the task is to find a pair (n, r) such that nPr is maximum possible and .
WEEK 5	**Array Sorting**
	Write a Python program to find out when given an array of non-negative integers arr[], the task is to find a pair (n, r) such that nPr is maximum possible and .
WEEK 6	**Linear Programming Problem**

	A store sells men's and women's tennis shoes. It makes a profit of \$1 per pair of men's shoes and \$1.20 per pair of women's shoes. It takes two minutes of a salesperson's time and two minutes of a cashier's time to sell a pair of men's shoes. It takes three minutes of a salesperson's time and one minute of a cashier's time per pair of women's shoes. The store is open eight hours per day, during which time there are two salespersons and one cashier on duty. How many pairs of shoes of each type should the store sell in order to maximize profit each day?
WEEK 7	**Queuing Problem**
	A super market has two girls ringing up sales at the counters. If the service time for each customer is exponential with mean 4 minutes, and if people arrive 3 in a poison fashion at the 10/hour.
WEEK 8	**Sequencing Problem**
	We have five jobs each of which must go through two machines in the order BA, processing times are given in the table. Determine a sequence for the five jobs that will minimize the total elapsed time. Also compute idle times for each of the machine
WEEK 9	**Game Theory**
	Using the dominance property obtain the optimal strategy for both the players and determine the value of game. The payoff matrix for player A is given
WEEK 10	**Assignment Problem**
	A Company has three plants at locations A, B and C which supply to warehouses located at D,E,F,G and H. monthly plant capacities are 800,500 and 900 respectively. Monthly warehouse requirements are 400, 500,400 and 800 units respectively. Unit transportation cost in rupees is given below Determine an optimum distribution for the company in order to minimize the total transportation cost
WEEK 11	**Dynamic Programming Problem**
	Given an array arr of N integers, the task is to sort the array in non-decreasing order by performing the minimum number of operations. In a single operation, an element of the array can either be incremented or decremented by 1. Print the minimum number of operations required.
WEEK 12	**Inventory Problem**
	A dealer supplies you the following information with regards to a product that he deals in annual demand =10,000 units, ordering cost Rs.10/order, Price Rs.20/unit. Inventory carrying cost is 20% of the value of inventory per year. The dealer is considering the possibility of allowing some back orders to occurs. He has estimated that the annual cost of back ordering will be 25% of the value of inventory. a. What should be the optimum no of units he should buy in 1lot? b. What qty of the product should be allowed to be backordered c. What would be the max qty of inventory at any time of year Would you recommend to allow backordering? If so what would be the annual cost saving by adopting the policy of backordering.

TEXTBOOKS:

1. J. K. Sharma, "Operations Research", Macmillan, 5th Edition, 2012.
2. R. Pannerselvan, "Operations Research", 2nd Edition, PHI Publications, 2006.

REFERENCE BOOKS:

1. A. M. Natarajan, P. Balasubramani, A. Tamilarasi, "Operations Research", Pearson Education, 2013.
2. Maurice Saseini, Arhur Yaspan, Lawrence Friedman, "Operations Research: Methods & Problems", 1st Edition, 1959.

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
1	Matrix Operations	CO 1, CO 2	T2: 3.1 R2: 2.4
2	Matrix Operations	CO 1, CO 2	T1: 4.1 R1:6.3
3	Minimum Cost Path	CO 1, CO 3	T2: 3.4 R2:6.3
4	Finding Maximum Number in An Array	CO 1, CO 3	T1: 4.4
5	Array Sorting	CO 1, CO 2	T1: 14.1
6	Linear Programming Problem	CO 2	T2: 9.1
7	Queuing Problem	CO 4	T2: 9.5
8	Sequencing Problem	CO 5	T1: 9.6 R2:6.3
9	Game Theory	CO 6	T1: 17.1 R2:13.2
10	Assignment Problem	CO 3	T1: 17.3 R2:13.3
11	Dynamic Programming Problem	CO 7	T1: 17.4 R2:15.3
12	Inventory Problem	CO 8, CO 9	T1: 12.1 R2:15.3

XIX EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Analyze the practical limitations to formulate real world problems in to Linear Programming Model.
2	Determination of optimum no of units to be shipped from plants to warehouses.
3	Determine the sequence of n jobs processed on two machines A, B in the order AB

4	Obtain the best replace period of equipment considering no money value for a given initial cost, operational costs
5	Determine the best replacement period considering 'money value' for given a initial cost, scrap value, operational costs
6	Determination of Economic Order Quantity by MRP to enhance better inventory control by reduced costs and improved schedule to meet the customer satisfaction
7	Determination of queuing performance parameters for the model (M/M/I: infinite/fico)

Prepared by: **HOD,ME**
Dr. K. Ch Apparao, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
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Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**MANUFACTURING TECHNOLOGY**				
Course Code	AMEB16				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	R-18				
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	AMEB05	III	Manufacturing Processes

II COURSE OVERVIEW:

Manufacturing Technology 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
Manufacturing Technoloy	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	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%	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	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 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 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:

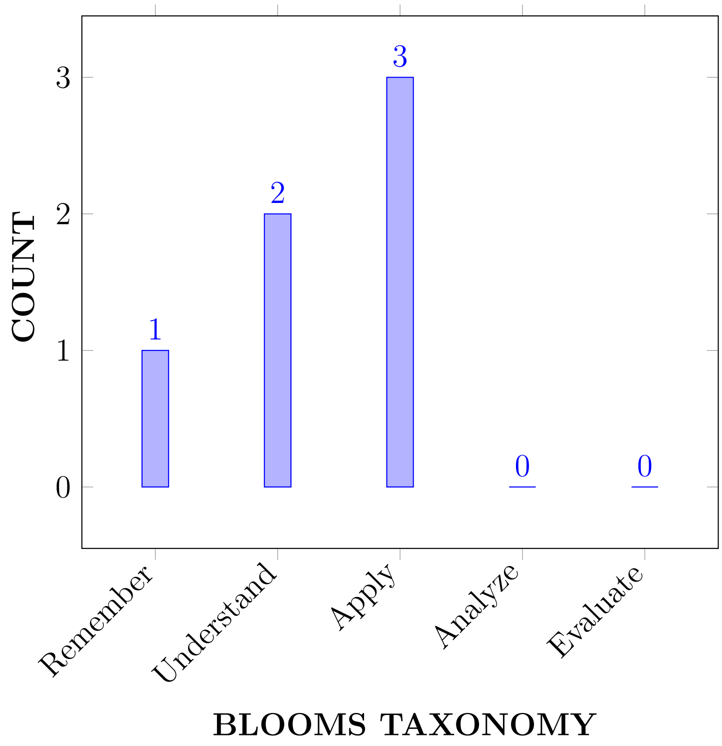
I	The fundamental concepts of the metal cutting principles to study the behavior of various machining processes.
II	The importance of tool materials, cutting parameters, cutting fluids and tool wear mechanisms for optimized machining.
III	The principles of linear and angular measuring instruments for 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/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/Quiz/ AAT/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/Quiz/ AAT/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.	1	CIA/Quiz/ AAT/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.	1	CIA/Quiz/ AAT/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.	1	CIA/Quiz/ AAT/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.	1	CIA/Quiz/ AAT/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	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	✓	Open Ended Experiments	✓
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

X	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 Machines**				
Course Code	AMEB17				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	R18				
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 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 of precision, static and dynamic forces of planer mechanisms by neglecting friction of aero planes, sea vessels, auto mobiles and various force members.

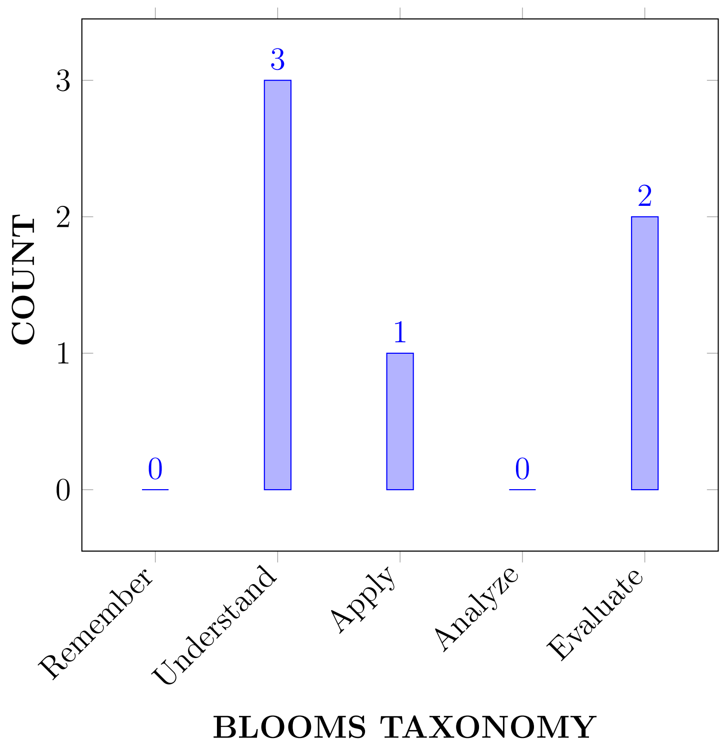
II	The knowledge of engineering mechanics for identifying the coefficient of friction and engine speed of the various contact bodies (Clutches and Brakes) and speed controlled devices, variations of torques and fluctuation of speeds of IC engines.
III	The magnitude and direction of balanced mass for 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.
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 find the gyroscopic effect	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 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
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

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 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
	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	**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, 9th Edition, 2021
3. R. L. Norton, "Kinematics and Dynamics of Machinery", McGraw-Hill, 1st Edition, 2022.
4. P.L. Balleny, "Theory of Machines and Mechanisms", Khanna publishers, 2021.

REFERENCE BOOKS:

1. J. S. Rao, R.V. Dukkipati, "Mechanism and Machine Theory", New Age Publication, 8th Edition, 2021.
2. Uiker, Penock, Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 10th Edition,2021.

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	CO6	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 DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**Applied Thermodynamics-II**				
Course Code	AMEB18				
Program	B. Tech.				
Semester	V				
Course Type	Core				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	1	3	-	-
Course Coordinator	Mr. A. Venu Prasad, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB04	III	Thermodynamics
B.Tech	AMEB09	IV	Applied Thermodynamics-I

II COURSE OVERVIEW:

Thermal Engineering is science intended to introduce concepts and working principles of boilers, turbines, condensers and nozzles which are widely used in different industrial applications such as automobile, agriculture, industry for transport, water pumping, electricity generation, earth moving and for supply mechanical power. This course also deals with working principles of aircraft systems such as propulsion systems and rockets in various fields of engineering.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Applied Thermodynamics-II	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). 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
16%	Remember
50%	Understand
33%	Apply
0%	Analyze
0 %	Evaluate

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:

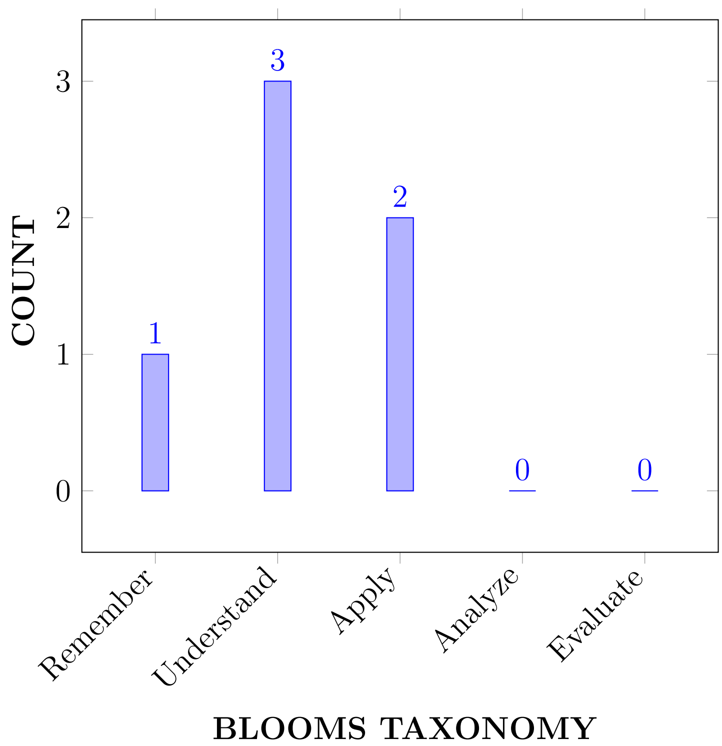
I	The usage of fundamental knowledge on thermodynamic cycles and fluid dynamics phenomena present in turbomachinery and combustion for producing electric and mechanical energy/power.
II	The operational concepts, principles, features, procedures and detailed thermodynamic analyses related to components of power cycles, rocket propulsion as well as steam and power generators.
III	The 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** the thermodynamic processes, working and analyses of combustion, vapor power cycles for electrical and mechanical power.	Remember
CO 2	**Interpret** various concepts, principles of operation, theories and phenomena related to the boilers and nozzles.	Understand
CO 3	**Develop** 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	**Demonstrate** the principles of operation, classification, working, accessories and mountings of various steam generators and condensers.	Understand
CO 5	**Identify** the working principles and analyses of combustion, gas power cycles for producing electrical and mechanical power.	Apply
CO 6	**Demonstrate** 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

Program Outcomes	
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/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	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	CIE/SEE

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.	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.	2	CIE/SEE
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	2	CIE/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.	2.5	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	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	Identify and formulate the thermodynamic properties using **first principles** of mathematics, natural sciences, and engineering sciences.	1
	PSO 2	Evaluate the thermodynamic properties using the concepts of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary** Engineering Applications.	2
CO 2	PO 1	Explain the concept and working principle of boilers and nozzles using the knowledge of **mathematics**, **science** and **engineering fundamental**.	3
	PO 2	Understand working principle of boilers and nozzles using **first principles** of mathematics, natural sciences, and engineering sciences.	1
	PSO 2	Analyze the working principle of boilers and nozzles using the concepts of **Thermo-Fluid Systems** to provide solutions for **Inter Disciplinary** Engineering Applications.	2
CO 3	PO 1	Explain the concept and working principle of steam turbines using the knowledge of **mathematics**, **science** and **engineering fundamental**.	3
	PO 7	Understand the impact of steam turbines in **societal** and **environmental** contexts, and demonstrate the knowledge of, and need for **sustainable** development.	3
CO 4	PO 1	Explain the concept and working principle of steam condensers using the knowledge of **mathematics**, **science** and **engineering fundamental**.	3
	PO 2	Understand working principle of steam **condensers** using **first principles** of **mathematics**, **natural sciences**, and **engineering sciences**.	5
	PO 3	Explain the solutions for **complex** Engineering problems and identify the properties of steam **condensers** used for the **public health**, **society**, and **environment**.	5
	PO 6	Apply the working principles of steam condensers in physical systems to assess **societal**, health, safety, legal and **cultural issues** and the consequent responsibilities relevant to the professional **engineering practice**.	3

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 concept and working principle of gas power cycles using the knowledge of **mathematics**, **science** and **engineering fundamental**.	3
	PSO 2	Analyze the working principle of gas power cycles using the concepts of **Thermo-Fluid Systems** to provide solutions for Inter Disciplinary Engineering Applications.	1
CO 6	PO 1	Explain the working principle of turbomachines and rockets using the knowledge of **mathematics**, **science** and **engineering fundamental**.	3
	PO 4	Explain the working principle of **turbomachines** and rockets in physical systems 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**.	7
	PO 12	Recognize the major components of the **turbomachines** and **ability** to take part in **independent** and **life-long learning** in the broadest context of **technological** change.	5
	PSO 2	Analyze the working principle of turbomachines and rockets using the concepts of **Thermo-Fluid Systems** to provide solutions for Inter Disciplinary Engineering Applications.	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	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 3	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	3	5	5	-	-	3	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 6	3	-	-	7	-	-	-	-	-	-	-	5	-	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	10	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 2	100	10	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 3	100	-	-	-	-	-	100	-	-	-	-	-	-	-	-
CO 4	100	50	50	-	-	60	-	-	-	-	-	-	-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 6	100	-	-	63	-	-	-	-	-	-	-	41	-	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	1	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 3	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 4	3	2	2	-	-	2	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	-	-	3	-	-	-	-	-	-	-	2	-	2	-
TOTAL	18	4	2	3	-	2	3	-	-	-	-	2	-	10	-
AVERAGE	3	1	2	3	-	2	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:

x	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.
MODULE II	**BOILERS AND STEAM NOZZLES**
	Boilers: Classification, working principles with sketches, boilers mountings and accessories. Basics of compressible flow, Isentropic flow of a perfect gas through nozzle, subsonic, supersonic and choked flow- normal shocks, flow of steam 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, actualcycle, 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. R. K. Rajput, "Thermal Engineering", Lakshmi Publications, 11th Edition, 2020.
2. V. Ganeshan "Gas turbines", Tata McGraw-Hill, 3rd Edition, 2017.

REFERENCE BOOKS:

1. P. Khajuria, S. P Dubey, "Gas Turbines and Propulsive systems", Dhanpat Rai Publishers., 1st Edition, 2012
2. P.L. Ballaney, "Thermal Engineering", Khanna Publishers, 5th Edition, 2017.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112103275

COURSE WEB PAGE:

https://www.iare.ac.in/sites/default/files/Courses-description/MECH-Applied-Thermodynamics-II-Syllabus.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	Rankine cycle - Schematic layout	CO 1	T1 1.1
3-4	Thermodynamic Analysis	CO 1	T1 1.2
5-6	Concept of Mean Temperature of Heat addition	CO 1	T1 1.3
7	Methods to improve cycle performance	CO 1	T1 1.4
8-9	Regeneration and reheating	CO 1	T1 1.5
10-12	BOILERS : Classification – Working principles	CO 2	T1 2.1, R1
13-14	Boilers mountings and accessories	CO 2	T1 2.2, R1

15	Function of nozzle – applications- types	CO 2	T1 2.3, R2
16	Flow through nozzles	CO 2	T1 2.4, R1
17	Thermodynamic analysis of nozzle	CO 2	T1 2.5, R1
18	Steam Turbines: Classification	CO 3	T1 3.1, R2
19	Impulse turbine; Mechanical details	CO 3	T1 3.2, R2
20	Velocity diagram – effect of friction – power developed, axial thrust, blade or diagram efficiency	CO 3	T1 3.2, R2
21	condition for maximum efficiency	CO 3	T1 3.3, R2
22	Reaction Turbine: Mechanical details – principle of operation	CO 3	T1 3.4, R2
23	Thermodynamic analysis of a stage, degree of reaction	CO 3	T1 3.5, R2
24	Velocity diagram Parson's reaction turbine – condition for maximum efficiency	CO 3	T1 3.5,R2
25	Steam Condensers : Requirements of steam condensing plant	CO 4	T1 3.6, R1
26	Classification of condensers, working principle of different types	CO 4	T1 3.7, R1
27-29	Gas Turbines: Simple gas turbine plant, Ideal cycle, essential components – parameters of performance, actual cycle	CO 5	T1 4.1, R3
30-32	Regeneration, inter cooling and reheating	CO 5	T1 4.2, R3
33	Closed and Semi-closed cycles – merits and demerits	CO 5	T1 4.3, R3
34	Brief concepts of combustion chambers of gas turbine plant	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 6	T1 4.4, R3
37	Thrust, Thrust Power and Propulsion Efficiency	CO 6	T1 4.5, R3
38-39	Turbo jet engines – Needs and Demands met by Turbo jet – Schematic Diagram, Thermodynamic Cycle, and Performance Evaluation	CO 6	T1 4.7, R3
40	Rockets: Application – Working Principle – Classification – Propellant Type – Thrust, Propulsive Efficiency – Specific Impulse	CO 6	T1 4.9, R3
41	Solid and Liquid propellant Rocket Engines.	CO 6	T1 4.11, R3

PROBLEM SOLVING/ CASE STUDIES			
42	A Rankine cycle operates between pressures of 80 bar and 0.1 bar. The maximum cycle temperature is 600°C. If the steam turbine and condensate pump efficiencies are 0.9 and 0.8 respectively, calculate the specific work and thermal efficiency.	CO 1	T1 1.1
43	A simple Rankine cycle works between pressures 28 bar and 0.06 bar, the initial condition of steam being dry saturated. Calculate the cycle efficiency, work ratio and specific steam consumption.	CO 1	T1 1.2
44	A steam power plant operates on a theoretical reheat cycle. Steam at boiler at 150 bar, 550°C expands through the high pressure turbine. It is reheated at a constant pressure of 40 bar to 550°C and expands through the low pressure turbine to a condenser at 0.1 bar. Draw T-s and h-s diagrams. Find: (i) Quality of steam at turbine exhaust; (ii) Cycle efficiency ; (iii) Steam rate in kg/kWh.	CO 1	T1 1.3
45	Steam is expanded in a set of nozzles from 10 bar and 200ºC to 5 bar. What type of nozzle is it ? Neglecting the initial velocity find minimum area of the nozzle required to allow a flow of 3 kg/s under the given conditions. Assume that expansion of steam to be isentropic.	CO 2	T1 2.4
46	Steam is expanded in a set of nozzles from 10 bar and 250° C to 5 bar. What type of nozzle is it? Assume the expansion to be isentropic.	CO 2	T1 2.4
47	In a steam nozzle, the steam expands from 4 bar to 1 bar. The initial velocity is 60 m/s and the initial temperature is 200°C. Determine the exit velocity if the nozzle efficiency is 92 percent.	CO 2	T1 2.5
48	The velocity of steam exiting the nozzle of the impulse stage of a turbine is 400 m/s. The blades operate close to the maximum blading efficiency. The nozzle angle is 20°. Considering equiangular blades and neglecting blade friction, calculate for a steam flow of 0.6. kg/s, the diagram power and the diagram efficiency.	CO 3	T1 3.4
49	A single stage steam turbine is supplied with steam at 5 bar, 200°C at the rate of 50 kg/min. It expands into a condenser at a pressure of 0.2 bar. The blade speed is 400 m/s. The nozzles are inclined at an angle of 20° to the plane of the wheel and the outlet blade angle is 30°. Neglecting friction losses, determine the power developed, blade efficiency, and stage efficiency.	CO 3	T1 3.5
50	Steam enters a condenser at 36°C and with barometer reading 760 mm. If the vacuum of 695 mm is produced find the vacuum efficiency.	CO 4	T1 3.7
51	A gas turbine plant receives air at 1 bar and 290 K and compresses it to 5 bar, If the temperature of air after compression is 1000 K ; find the thermal efficiency of the turbine.	CO 5	T1 4.1

52	A simple closed cycle gas turbine plant receives air at 1 bar and 15° C, and compresses it to 5 bar and then heats it to 800° C in the heating chamber. The hot air expands in a turbine back to 1 bar. Calculate the power developed per kg of air supplied per second. Take Cp for the air as 1 kJ/kg K.	CO 5	T1 4.3
53	A gas turbine plant consists of two stage compressor with perfect intercooler and a single stage turbine. If the plant works between the temperature limits of 300 K and 1000 K and 1 bar and 16 bar, determine the net power of the plant per kg of air. Take specific heat constant pressure as 1 kJ/kg K.	CO 5	T1 4.1
54	A turbojet is flying with a velocity of 320 m/s at an altitude of 9150m, where the ambient conditions are 32 kPa and -32°C. The pressure ratio across the compressor is 12, and the temperature at the turbine inlet is 1400 K. Air enters the compressor at a rate of 40 kg/s, and the jet fuel has a heating value of 42,700 kJ/kg. Assuming ideal operation for all components and constant specific heats for air at room temperature, determine: a) the temperature and pressure at the turbine exit, b) the velocity of the exhaust gases, c) the propulsive power developed	CO 6	T1 4.9
55	An aircraft flies at a speed of 520 kmph at an altitude of 8000 m. The diameter of the propeller of an aircraft is 2.4 m and flight to jet speed ratio is 0.74. density is 0.525 kg/m3.Find the following: (i) The rate of air flow through the propeller, (ii) Thrust produced, (iii) Specific thrust, (iv) Specific impulse, (v) Thrust power	CO 6	T1 4.9
56	A turbo-jet engine travels at 216 m/s in air at 0.78 bar and – 7.2°C. Air first enters diffuser in which it is brought to rest relative to the unit and it is then compressed in a compressor through a pressure ratio of 5.8 and fed to a turbine at 1110°C. The gases expand through the turbine and then through the nozzle to atmospheric pressure (i.e., 0.78 bar). The efficiencies of diffuser, nozzle and compressor are each 90 percent. The efficiency of turbine is 80 percent. Pressure drop in the combustion chamber is 0.168 bar. Determine: (i) Air-fuel ratio, (ii) Specific thrust of the unit, (iii) Total thrust, if the inlet cross-section of diffuser is 0.12 m2. Assume calorific value of fuel as 44150 kJ/kg of fuel.	CO 6	T1 4.9
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Rankine cycle, thermodynamic analysis, regeneration, reheating	CO 1	T1 1.1
58	Boilers, steam nozzles, compressible flow, Isentropic flow, thermodynamic analysis of nozzle	CO 2	T1 2.2
59	Impulse turbine, Reaction turbine, velocity diagrams, Steam Condensers	CO 3, 4	T1 3.1
60	Simple gas turbine plant, ideal cycle, closed and semi-closed cycles, combustion chambers	CO 5	T1 4.1
61	Turbo jet engines, thrust, thrust power, propulsion efficiency solid and liquid propellant rocket engines	CO 6	T1 4.9

DISCUSSION OF QUESTION BANK			
62	Module I: Basic concepts, Rankine cycle	CO 1	T1 1.1
63	Module II: Boilers and steam nozzles	CO 2	T1 2.2
64	Module III: Steam turbines and steam condensers	CO 3, 4	T1 3.1
65	Module IV: Gas turbines: Simple gas turbine plant	CO 5	T1 4.1
66	Module V: Jet propulsion and rockets	CO 6	T1 4.9

Signature of Course Coordinator **HOD, ME**
Mr. A. Venu Prasad, Assistant Professor

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

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**BUSINESS ECONOMICS AND FINANCIAL ANALYSIS**				
Course Code	AHSB14				
Program	B.Tech				
Semester	V	ME			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. S. Sivasankara Rao, Associate Professor				

I 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.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Business Economics and Financial Analysis	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOCs
✓	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 Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50%	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 (AAT).

Component	**Theory**			**Total Marks**
Type of Assessment	CIE Exam	Quiz	ATT	
CIA Marks	20	05	05	30

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 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 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 centre. 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.

5 Minutes Video	Assignment	Tech-talk	Seminar	Open Ended Experiment
30	30	30	10	0

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.

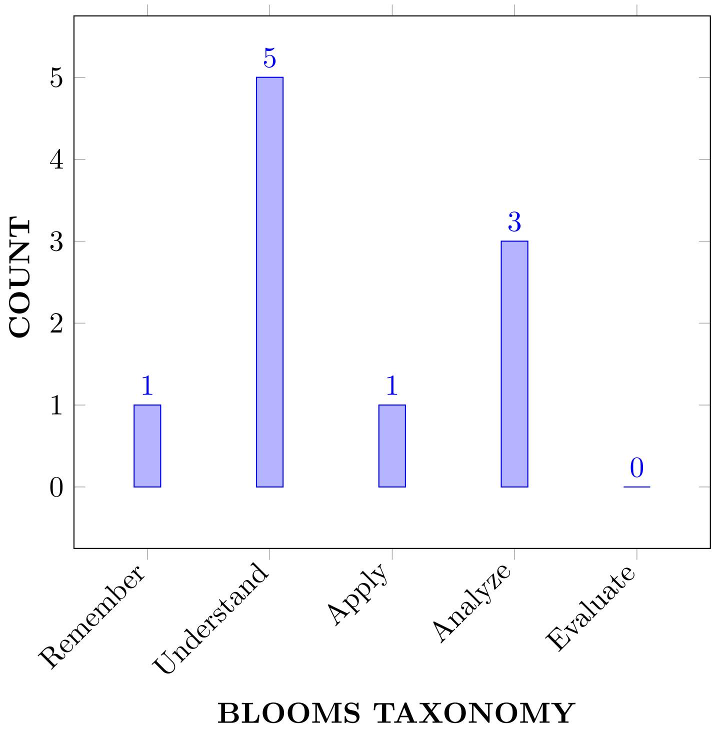
VII COURSE OUTCOMES:

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

CO 1	**Recall** the objectives, nature and scope of business economics to understand the real time house hold issues.	Understand
CO 2	**Outline** the significance of demand, its analysis, measurement of demand and its forecasting to know the current status of goods and services.	Understand
CO 3	**Explain** the production function and it's determinates to know the economies of scale, diseconomies of scale in manufacturing sector.	Understand
CO 4	**Examine** cost functions with the help of mathematical equations and by developing graphical solutions through business applications.	Analyze
CO 5	**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 6	**Compare** various types of business organizations and discuss their implications for resource allocation to strengthen the market environment.	Analyze
CO 7	**Analyse** different project proposals by applying capital budgeting techniques to know the strengths and weaknesses of the projects.	Analyze
CO 8	**List** out capital budgeting methods and tools to interpret and analyze the real problems in various business projects.	Remember

CO 9	**Develop** the ability to use a basic accounting systemto create (record, classify, and summarize) the data needed to solve a variety of business problems.	Apply
CO 10	**Apply** different types of financial ratios for knowing liquidity and profitability positions of business concern.	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	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	1	Seminar/ Conferences
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	Assignments/ Discussion

PO 10	**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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	2	Seminar
PSO 3	Make use of modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	Guest Lectures

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	-	-	-	-	-	-	-	✓	✓	-	-	-	-	-	✓
CO 7	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-
CO 8	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-	-
CO 9	-	✓	-	-	-	-	-	-	-	-	✓	-	-	-	✓
CO 10	-	✓	-	-	-	-	-	-	-	-	✓	-	-	-	✓

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	**Recall** (knowledge) the scientific fundamentals of economic activities performed by the businessmen in the business for profit earning.	2
	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
	PSO 3	**Find** (knowledge) the economical practices and practical experiences that are using in the IT industry.	1
CO 2	PO 1	**Understand** the fundamentals and scientific significance of demand, its analysis, measurement of demand and its forecasting to the solution of complex engineering problems.	2
	PO 2	**Interpret** and identify the demand and its analysis with the mathematical and natural principles of demand forecasting methods.	6
	PSO 2	**Illustrate** the applications development and learn the emerging technologies and frameworks in demand with employers and contemporary challenges.	1
CO 3	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 8	**Relate** (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 production management principles.	5
	PSO 3	**Select** the economies of scale using in the production function and collaboration techniques in IT industry.	1
CO 4	PO 2	(**Demonstrate**) (Knowledge) the different cost concepts and determine the significance of Break Even Analysis.	5
	PO 11	**Outline**the Break Even Analysis knowledge and understanding 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	7

CO 5	PO 8	**List** (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 6	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
	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
	PSO 3	**Examine**the establishment of organizations with industry standard tools and collaboration techniques that will equip to secure.	1
CO 7	PO 11	**Interpret** the allocation and sources of capital which plays a vital role in a business organization to manage projects and in multidisciplinary environments.	8
CO 8	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.	7
CO 9	PO 2	**Explain** the accounting concepts and conventions and analyse complex engineering problems reaching substantiated conclusions using first principles of accounts.	6
	PO 11	**Illustrate** the accounting methods and procedures and accounting principles to manage the financial aspects in a project.	8
	PSO 3	**Outline** the financial position of business by applying accounting procedures using in the industries with standard accounting techniques and tools.	2
CO 10	PO 2	**Apply** the ratio analysis to assess the operating efficiency and profitability of business in concluding the financial position of the organizations.	6
	PO 11	**Make use of** various ratios to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	8
	PSO 3	**Organize** the ratio analysis methods, standard tools and collaboration techniques that will equip to secure and succeed in analysing the financial position of the organization.	1

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
	3	10	10	1	5	5	3	3	12	5	12	12	2	2	2
CO 1	2	-	-	-	-	-	-	1	5	-	6	-	-	-	1
CO 2	2	6	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 3	2	-	-	-	-	-	-	2	6	-	5	-	-	1	-
CO 4	-	5	-	-	-	-	-	-	-	-	7	-	-	-	-
CO 5	-	-	-	-	-	-	-	2	6	-	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	2	6	-	-	-	-	-	1
CO 7	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-
CO 8	1	-	-	-	-	-	-	-	-	-	7	-	-	-	-
CO 9	-	6	-	-	-	-	-	-	-	-	8	-	-	-	2
CO 10	-	6	-	-	-	-	-	-	-	-	8	-	-	-	1

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

COURSE OUT COMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	3	10	10	1	5	5	3	3	12	5	12	12	2	2	2
CO 1	66.7	-	-	-	-	-	-	33.3	41.6	-	-	-	-	-	50.0
CO 2	66.7	60.0	-	-	-	-	-	-	-	-	-	-	-	50.0	-
CO 3	66.7	-	-	-	-	-	-	66.7	50.0	-	41.6	-	-	50.0	-
CO 4	-	50.0	-	-	-	-	-	-	-	-	58.3	-	-	-	-
CO 5	-	-	-	-	-	-	-	66.7	50.0	-	-	-	-	-	-

CO 6	-	-	-	-	-	-	-	66.7	50.0	-	-	-	-	-	50.0
CO 7	-	-	-	-	-	-	-	-	-	-	66.6	-	-	-	-
CO 8	33.3	-	-	-	-	-	-	-	-	-	58.3	-	-	-	-
CO 9	-	60.0	-	-	-	-	-	-	-	-	66.6	-	-	-	100
CO 10	-	60.0	-	-	-	-	-	-	-	-	66.6	-	-	-	50.0

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
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
	3	10	10	1	5	5	3	3	12	5	12	12	2	2	2
CO 1	3	-	-	-	-	-	-	1	2	-	2	-	-	-	2
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 3	3	-	-	-	-	-	-	3	2	-	2	-	-	2	-
CO 4	-	2	-	-	-	-	-	-	-	-	2	-	-	-	-
CO 5	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-
CO 6	-	-	-	-	-	-	-	3	2	-	-	-	-	-	2
CO 7	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
CO 8	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-
CO 9	-	2	-	-	-	-	-	-	-	-	3	-	-	-	3
CO 10	-	2	-	-	-	-	-	-	-	-	3	-	-	-	2
TOTAL	10	9	-	-	-	-	-	10	9	-	17	-	-	4	9
AVERAGE	2.5	2.25	-	-	-	-	-	2.5	2.25	-	2.48	-	-	2	2.25

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	Assignments	PO 9	Seminars	PO 8
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

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. 1. Aryasri, "Managerial Economics and Financial Analysis", TMH publications, 4thEdition,2012.
2. 2. M. KasiReddy, Saraswathi, "Managerial Economics and Financial Analysis", PHI Publications, New Delhi, 2ndEdition,2012.
3. 3. Varshney, Maheswari, "Managerial Economics", Sultan Chand Publications, 11thEdition,2009.

REFERENCE BOOKS:

1. 1. D.N. Dwivedi, "Managerial Economics", Vikas Publication House Pvt.Ltd, 2ndEdition,2012.
2. 2. S.N. Maheshwari & S.K.Maheshwari, "Financial Accounting", Vikas Publication House Pvt.Ltd,4thEdition, 2012.
3. 3. R.NarayanaSwamy, "Financial Accounting- A managerial Perspective", Pearson publications, 1stIndian Reprint Edition,2012.

XVIII COURSE PLAN:

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

Lecture No	Topics to be covered	COs	Reference
1-2	Explain about managerial economics according to the business	CO 1	T1- 1.3-1.8 R1-1.5-1.7
3-4	Describe about demand analysis, the Law of Demand and Demand Function.	CO 2	T1-2.2-2.11 R1-3.3-3.20
5-6	Understand elasticity of the demand of the product, different types, Measurement of Elasticity of Demand and Factors influencing on Elasticity of Demand.	CO 2	T1-3.3-3.20 R1- 5.29-6.8
7	State different methods of Demand Forecasting and the factors governing Demand Forecasting.	CO 2	T1-4.6-4.19

8 - 9	Demonstrate the Production function, features of Iso-Quants and Iso-Costs, different types of Internal Economies, External Economies and Law of Returns.	CO 3	T1- 5.3-5.18 R1- 5.29-6.8
10 - 12	Different types of Internal Economies, External Economies ad Law of Returns with appropriate examples.	CO 4	T1- 5.3-5.18
13-14	Illustrate different types of costs	CO 4	T1- 5.29-6.8
15-16	Explain the Significance and Limitations of Break-Even Analysis	CO 4	T1- 7.13-7.14
17-18	Calculate Break-Even Point (Simple Problems)	CO 4	T1- 7.1-7.12
19-20	Illustrate the features, price-output determination under Perfect Competition, Monopoly and Monopolistic competition Markets.	CO 5	T1- 8.4-8.16 R2- 5.29-6.8
21-23	Demonstrate the Objectives, Policies and Methods of Pricing Strategies and Price Methods.	CO 5	T1- 8.21-8.25
24-25	Describe Features of business, Definitions of Various forms of Business Units.	CO 6	T1-9.3-9.15
26-29	State the Merits & Demerits of Different types of Public Enterprises and Changing Business Environment to Post Liberalization Scenario.	CO 6	T1-9.2-10.23 R1- 8.21-8.25
30-31	Explain the significance and classification of capital, Methods and Sources of Raising Finance.	CO 7	T1-9.2-10.23
32-33	Demonstrate the concept of capital budgeting and allocations of the resources through capital budgeting methods and compute simple problems.	CO 8	T1-11.3-11.5 R2-12.3-12.5
34-36	Illustrate the Significance of Financial Accounting, Double Entry, Accounts, Accounting Concepts and Conventions	CO 9	T1-12.1-12.26
37-39	Explain the meaning, advantages and Limitations of the Journal, Ledger and Trial Balance and Final Accounts and Solve simple Problems.	CO 9	T1-13.4-13.15 R2-11.3-11.5
40-41	Describe Meaning, Definitions and Limitations of Ratio Analysis	CO 10	T1-13.4-13.15 R2-11.7-11.8
42-43	Compute different types of Financial Ratios (Problems)	CO 10	T1-13.5-13.68

Signature of Course Coordinator **HOD MBA**
Dr. S. Sivasankara Rao, Associate Professor

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

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**AUTOMOBILE ENGINEERING**				
Course Code	AMEB33				
Program	B.Tech				
Semester	V	ME			
Course Type	Elective				
Regulation	IARE-R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. G Aravind Reddy, 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	AMEB09	IV	Applied Thermodynamics-I
B.Tech	AMEB10	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
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70 %	Apply
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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:

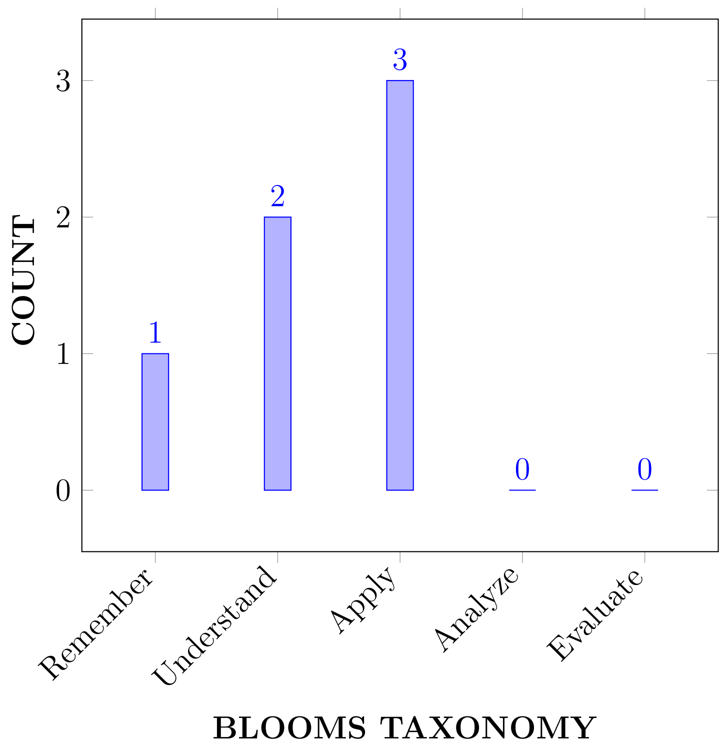
I	The need and scope of automobile engineering in the field of automotive industry.
II	The basic concepts and working principles of various automobile systems.
III	The mechanisms associated with the power transmission from engine to rear axles by using the concepts of kinematics of machines.
IV	The automobile 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 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	-	-	-	-	-	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 - $0 \leq C \leq 5\%$ – 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	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	**EMISSIONS 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: Introdcution	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 Aravind Reddy, Assistant Professor

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

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Airframe Structural Design**				
Course Code	AAEB54				
Program	B.Tech				
Semester	V				
Course Type	Open Elective - I				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. Athota Rathan Babu, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB08	IV	Fluid Mechanics and Fluid Machines
B.Tech	AMEB11	IV	Materials and Mechanics of solids

II COURSE OVERVIEW:

This course deals with fundamental aspects of an anatomy of aircraft and the current trends in airframe design. It includes the evolution of the aircraft and space industry, aerodynamics and performance of the aircraft with their applications. It compares and contrasts various thrust vector control mechanisms of different aircraft propulsion systems. It discusses various materials and its properties that are used for manufacturing different parts of an aircraft. This course enriches the knowledge of connection between theoretical and practical methods for performing the airframe design exercises

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Airframe Structural 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 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
10 %	Understand
80 %	Apply
10 %	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 concepts of various airframe designs, aircraft propulsion systems and aerodynamic forces/moments acting on the aircraft and spacecraft under static and dynamic load conditions.

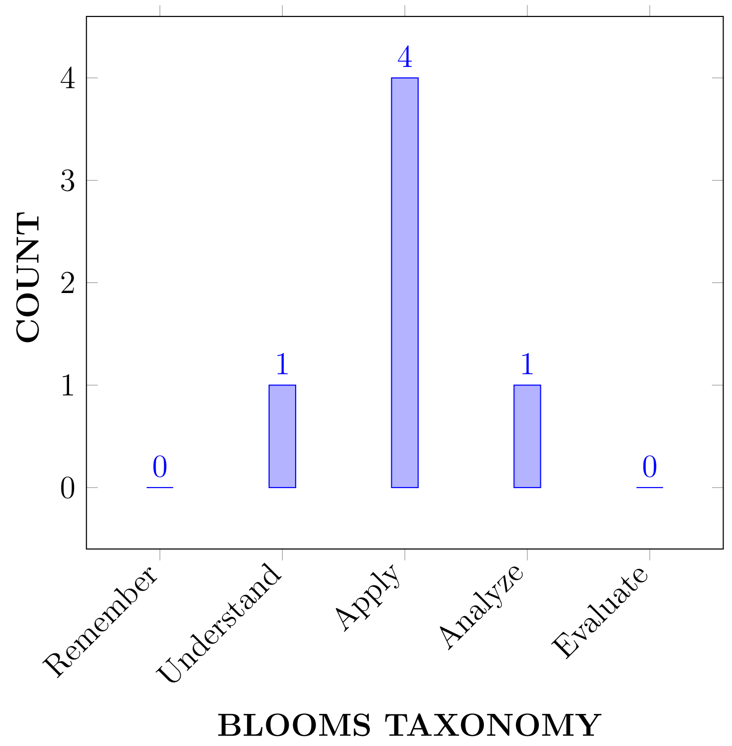
II	The characteristics of stability and performance of an aircraft and the role of primary and secondary controls in longitudinal and lateral stability.
III	The properties of different materials that are used in industries for manufacturing various components of an aircraft and spacecraft.
IV	The mathematical modelling of tailless aircraft, flapping wing aircraft and innovative designs in modern aircraft for future requirements.

VII COURSE OUTCOMES:

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

CO 1	**Understand** the theoretical knowledge behind the design and development of aircrafts and spacecraft for distinguishing them based on the mission requirements.	Understand
CO 2	**Apply** Newton's law of motion to determine the governing equations, for interpreting the physics of flow over an aircraft and spacecraft.	Apply
CO 3	**Identify** the performance parameters of an aircraft and spacecraft based on the aerodynamic forces and moments acting on the body.	Apply
CO 4	**Classify** different types of aircraft propulsion systems and the effect of operating variables on its performance.	Analyze
CO 5	**Choose** an appropriate airframe design to withstand all types of loads in different flight conditions .	Apply
CO 6	**Design** the advanced UAVS models like and flapping wing models and micro-aerial vehicles.	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	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	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
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	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 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	CIE/Quiz/AAT

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.	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	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical including air traffic controls standards.	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 the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to classify various types of flying bodies such as aircraft, spacecraft, UAV, etc,.	3
	PO 2	**Identify the problem statement** (mission requirement), select the appropriate aircraft and spacecraft required for carrying the payload by reviewing the literature (information and data collection) suitable to mission requirement	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and derive the range and endurance of an aircraft at different flight conditions	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Analyze the performance parameters and various forces acting on the for an aircraft and spacecraft using the **first principles of Mathematics and engineering sciences.**	2
CO 3	PO 1	Identify the role of different parts of an aircraft and spacecraft **using principles of mathematics, science, and engineering fundamentals.**	3
	PSO 1	Analyze different types of wings used for a fighter aircraft using **using principles of mathematics, natural science, and engineering fundamentals.**	2
CO 4	PO 1	Apply the knowledge of different forces and moments (**scientific Principles and mathematical principles**) for an aircraft and spacecraft .	3
	PO 2	Determine the performance parameters for an aircraft and spacecraft **using first principles and Mathematics and Engineering sciences.**	2
	PO 5	Illustrate Load vs time graph for an aircraft and spacecraft flying at different flight conditions using modern Engineering and IT tools (Matlab) to **solve complex engineering problems.**	1
CO 5	PO 1	Understand the advantages of Metallic & non-metallic materials, use of aluminum alloy, titanium, stainless steel and composite materials to determine the desirable properties such as stiffness, strength to weight ratio using thel **using the fundamentals of engineering and mathematical equations**	3
CO 6	PO 1	Analyze different Engine cycles used for the propulsion system of an aircraft and spacecraft **using fundamentals of science &and engineering fundamentals.**	3
	PO 2	Categorize the concept of Pyrotechnics based on its physical state and its usage in **complex engineering problems.**	3
	PO 3	Investigate and define a problem and identify constraints of Pyrotechnics including **environmental and sustainability limitations, health and safety and risk assessment issues** when dealing with manufacturing of different components of aircraft and spacecraft.	2
	PSO 1	Describe (Knowledge) different types of wings used for a conventional transport and fighter aircraft using **using principles of mathematics, natural science, and engineering fundamentals.**	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	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 4	3	2	-	-	1	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	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	50	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	50	-	
CO 4	100	50	-	-	30	-	-	-	-	-	-		-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	100	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	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 4	3	2	-	-	1	-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	3	2	-	-	-	-	-	-	-	-		2	-	-
TOTAL	18	9	2	-	1	-	-	-	-	-	-	-	4	-	-
AVERAGE	3	2.25	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:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**HISTORY OF FLIGHT AND SPACE ENVIRONMENT**
	Balloons and dirigibles, heavier than air aircraft, commercial air transport; Introduction of jet aircraft, helicopters, missiles; Conquest of space, commercial use of space; Different types of flight vehicles, classifications exploring solar system and beyond, a permanent presence of humans in space; Earth's atmosphere, the standard atmosphere; The temperature extremes of space, laws of gravitation, low earth orbit, microgravity, benefits of microgravity; Environmental impact on spacecraft, space debris; Planetary environments
MODULE II	**INTRODUCTION TO AERODYNAMICS**
	Anatomy of the airplane, helicopter; Understanding engineering models; Aerodynamic forces on a wing, force coefficients; Generating lift, moment coefficients; Aerodynamic forces on aircraft – classification of NACA airfoils, aspect ratio, wing loading, mach number, centre of pressure and aerodynamic centre aerofoil characteristics-lift, drag curves; Different types of drag.
MODULE III	**FLIGHT VEHICLE PERFORMANCE AND STABILITY**
	Performance parameters, performance in steady flight, cruise, climb, range, endurance, accelerated flight symmetric maneuvers, turns, sideslips, takeoff and landing. Flight vehicle Stability, static stability, dynamic stability; Longitudinal and lateral stability; Handling qualities of the airplanes
MODULE IV	**INTRODUCTION TO AIRPLANE STRUCTURES AND MATERIALS, POWER PLANT**
	General types of construction, monocoque, semi-monocoque; Typical wing and fuselage structure; Metallic & non-metallic materials, use of aluminum alloy, titanium, stainless steel and composite materials; Basic ideas about engines, use of propellers and jets for thrust production; Principles of operation of rocket, types of rockets.

MODULE V	**SATELLITE SYSTEMS ENGINEERING HUMAN SPACE EXPLORATION**
	Satellite missions, an operational satellite system, elements of satellite, satellite bus subsystems; Satellite structures, mechanisms and materials; Power systems; Communication and telemetry; Propulsion and station keeping; Space missions, mission objectives. Goals of human space flight missions, historical background, the Soviet and US missions; The mercury, Gemini, Apollo (manned flight to the moon), Skylab, apollo-soyuz, space Shuttle; International space station, extravehicular activity; The space suit; The US and Russian designs; Life support systems, flight safety; Indian effort in aviation, missile and space technology.

TEXTBOOKS

1. Newman D, "Interactive Aerospace Engineering and Design", McGraw-Hill, 1st Edition, 2002
2. Anderson J. D, "Introduction To Flight", McGraw-Hill Education, 5th Edition,2002.
3. Etkin, B and Reid, L.D., "Dynamics of Flight", 3rd Edn., John Wiley, 1998, ISBN0-47103418-5.

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1. Kermode. A. C, "Flight without Formulae", McGraw Hill, 4th Edition, 1997.
2. McCormick, B.W., "Aerodynamics, Aeronautics, and Flight Mechanics", Wiley India, 2nd Edition, 1995, ISBN 97

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1. https://nptel.ac.in/courses/112/105/112105045/
2. https://nptel.ac.in/courses/112/106/112106294/
3. https://ocw.mit.edu/courses/mechanical-engineering/2-29-numerical-fluid-mechanics-spring-2015/lecture-notes-and-references/

COURSE WEB PAGE:

1. https://www.iare.ac.in/sites/default/files/R18/Computational_Aerodynamics.pdf
2. https://lms.iare.ac.in/index?route=course/details&course_id=455

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)			
1	Introduction of jet aircraft, helicopters, missiles.	CO 1& CO 2	T2: 1.1-1.5, T1: 4.1
2	Conquest of space, commercial use of space, exploring the solar system and beyond, a permanent presence of humans in space.	CO 1	T2: 2.1-2.2, R1: 3.1
3	Earth's atmosphere, standard atmosphere, temperature extremes of space.	CO 1	T2: 2.3-2.4
4	Laws of gravitation, low earth orbit, microgravity, benefits of microgravity.	CO 1	T2: 2.5-2.6
5	The near earth radioactive environment. The magnetosphere. Environmental impact on spacecraft.	CO 4	T2: 3.3 R1: 3.3
6	Anatomy of the launch vehicles and space vehicles, Meteoroids and micrometeoroids, space debris. Planetary environments.	CO 3	T2: 3.4
7	Understanding engineering models aerodynamic forces on a wing, force coefficients. Generating lift.	CO 5	T2: 3.3
8	Moment coefficients, center of pressure, aerodynamic of wings. Sources of drag.	CO 3	T2: 4.2
9	Thrust for flight, the propeller and the jet engine, governing equations, rocket engines.	CO6	T2: 5.1
10	Performance parameters, performance in steady flight.	CO 6	T2: 5.2 R3: 2.1
11	Cruise, climb, range, endurance, accelerated flight symmetric maneuvers, turns, sideslips, takeoff and landing.	CO 3	T2: 4.5 R3: 2.3
12	Flight vehicle Stability, static stability, dynamic stability. Longitudinal and lateral stability, handling qualities of the airplanes.	CO 3	T1: 4.1
13	General types of construction, monocoque, semi-monocoque.	CO 7	T1: 4.2
14	Typical wing and fuselage structure.	CO 4	T1: 4.3
15	Metallic & non-metallic materials.	CO2	T2: 5.2
16	Use of aluminum alloy, titanium, stainless steel.	CO 2	T2: 5.2
17	Basic ideas about engines, use of propellers and jets for thrust production. Principles of operation of rocket, types of rockets.	CO3	T2: 5.2

18	Satellite missions, an operational satellite system, elements of satellite, satellite bus subsystems.	CO 3	T1: 7.2 R2:7.2
19	Satellite structures, mechanisms and materials. Propulsion and station keeping. Space missions. Mission objectives. Case studies.	CO5	T1: 7.5 R2:7.2
20	The Mercury, Gemini, Apollo (manned flight to the moon), Skylab, Apollo-Soyuz, Space Shuttle. International Space Station, extravehicular activity.	CO5	T1: 7.5 R2:7.5
21	Inferderivatives of axial, normal force components and pitching moment with respect to the velocity, angle of attack, angle of attack rate, pitch rate, elevator angle.	CO6	T1: 6.4
22	Identify Principle modes of motion characteristics, mode shapes and significance, time constants.	CO 1	T1: 6.5
23	Interpret undamped natural frequency and damping ratio, mode shapes, significance.	CO 1	T1: 7.1
24	Recall One degree of freedom, two degree of freedom approximations- constant speed (short period).	CO6	T1: 7.2
25	State and apply Constant angle of attack (long period) approximations-solutions.	CO 1	T1: 7.3
26	Calculate longitudinal and lateral stability from coefficients of characteristic equation.	CO 2	T1: 7.4, R2:4.1-4.4
27	Explain Stability and lateral stability from coefficients of characteristics equation-stability criteria.	CO6	T1: 7.5, R2:7.3
28	Apply the concept of aircraft spin- entry, balance of forces in steady spin.	CO 2	T1: 7.6
29	Apply the concept of recovery methods, pilot techniques for recovery.	CO 2	T1: 7.7
30	Cruise, climb, range, endurance, accelerated flight symmetric maneuvers, turns, sideslips, takeoff and landing.	CO 3	T2: 4.5 R3: 2.3
31	Flight vehicle Stability, static stability, dynamic stability. Longitudinal and lateral stability, handling qualities of the airplanes.	CO 3	T1: 4.1
32	General types of construction, monocoque, semi-monocoque.	CO 7	T1: 4.2
33	Typical wing and fuselage structure.	CO 4	T1: 4.3
34	Metallic & non-metallic materials.	CO2	T2: 5.2
35	Use of aluminum alloy, titanium, stainless steel.	CO 2	T2: 5.2
36	Basic ideas about engines, use of propellers and jets for thrust production. Principles of operation of rocket, types of rockets.	CO3	T2: 5.2
37	Satellite missions, an operational satellite system, elements of satellite, satellite bus subsystems.	CO 3	T1: 7.2 R2:7.2
38	Satellite structures, mechanisms and materials. Propulsion and station keeping. Space missions. Mission objectives. Case studies.	CO5	T1: 7.5 R2:7.2
39	The Mercury, Gemini, Apollo (manned flight to the moon), Skylab, Apollo-Soyuz, Space Shuttle. International Space Station, extravehicular activity.	CO5	T1: 7.5 R2:7.5

40	Inferderivatives of axial, normal force components and pitching moment with respect to the velocity, angle of attack, angle of attack rate, pitch rate, elevator angle.	CO6	T1: 6.4
PROBLEM SOLVING/ CASE STUDIES			
1	Explain how the continuity equation derived from these flow models can be converted from conservative to non-conservative form.	CO 1	T2:5.6 R1:1.12.3
2	Explain and Differentiate shock fitting and shock capturing methods with the suitable diagram.	CO 1	T2:5.6 R1:1.12.3
3	Illustrate the non-conservative form of governing equations. Derive continuity equation in non-conservation form using infinitesimal small fluid element moving in space.	CO 1	T2:5.6 R1:1.12.3
4	Explain the mathematical and physical nature of flows governed by parabolic Equations with an illustration of a steady boundary layer flow.	CO 1	T2:5.10 R1:1.15
5	Explore the boundary layer flow for the parabolic equation by considering the nose region with the neat sketch.	CO 2	T2:5.18 R2:1.13.2
6	Explicit the general behavior of the different classes of partial differential equation – impact on physical and computational fluid dynamics with suitable example for each.	CO 2	T2:5.20 R1:1.17.1
7	Elucidate the domain and boundaries for the solution of hyperbolic equations for the three dimensional steady flow.	CO 3	T2:6.3 R1:2.6.1
8	Discuss the domain and boundaries for the solution of hyperbolic equations for the one and two dimensional unsteady flow with the suitable diagram.	CO 3	T2:6.3 R1:2.6.1
9	Illustrate the physical behavior of flows governed by hyperbolic equations with an example of steady, inviscid supersonic flow over a two dimensional circular arc airfoil.	CO 5	T2:6.5 R1:2.6.2
10	Illustrate the physical behavior of flows governed by parabolic equations with an example of steady boundary layer flows. Explain PNS model for high speed flows and explain its merits.	CO 5	T2:7.7 R1:2.10
11	Explain the Parabolized Navier-Stokes equations and well-posed problems.	CO 4	T2:7.7 R1:2.10
12	Write short notes on the following properties of numerical solutions of fluid flows: i) Stability ii) Consistency iii) Accuracy iv) Convergence.	CO 5	T2:7.11 R1:2.32
13	Illustrate the time marching solution for constructing the explicit finite difference module by considering one-dimensional heat conduction equation which is parabolic partial differential solution.	CO 4	T2:15.13 R1:8.7.2
14	Explain the difference equation by considering unsteady, one-dimensional heat conduction equation with constant thermal diffusivity with the neat sketch.	CO 6	T2:5.20 R1:1.17.1
15	Illustrate a stable case by comparing the numerical domain include the entire analytical domain and does not include the entire analytical domain with the neat sketch.	CO 6	T2:7.3 R1:2.8

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Effect of aileron deflection and tail incidence angle	CO 1	T2:5.6 R1:1.12.3
2	Different types of rocket tests before operational use.	CO 2	T2:5.18 R2:1.13.2
3	Classification of Missile based on launch mode	CO 4,5	T2:6.5 R1:2.6.2
4	What is Time-dependent density functional theory?	CO 5	T2:7.11 R2:2.10.2
5	How does a multi-stage rocket like the Delta II ?	CO 5	T2:6.3 R3:2.6.1
DISCUSSION OF QUESTION BANK			
1	The concept of monoplane with a neat sketch	CO 1,2,3	T2:5.10 R1:1.15
2	Effect of Reynolds number on lift and drag curves	CO 2,3	T2:6.1 R1:2.3
3	Aircraft and label its parts and write down about functions of each part	CO 4,5	T2:7.3 R1:2.8
4	Helicopter and label its parts and write down about functions of each part.	CO 5,6	T2:7.11 R1:2.32
5	Discuss the major contribution of European space agencies to develop a space program	CO 4,6	T2:6.3 R3:2.6.1

Signature of Course Coordinator **HOD,ME**
Mr. A Rathan Babu Assistant Professor

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

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**MANUFACTURING TECHNOLOGY LABORATORY**				
Course Code	AMEB19				
Program	B.Tech				
Semester	V	ME			
Course Type	CORE				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
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
MANUFACTURING 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 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:

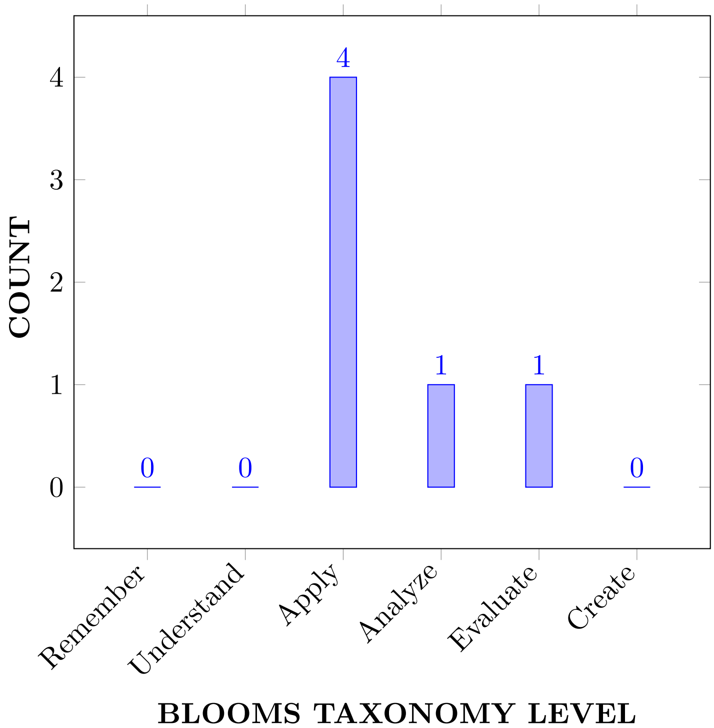
I	The empirical knowledge on machine tools so that they can identify, manipulate and control various process parameters during machining processes in the manufacturing industry.
II	The details related to thermal aspects during machining for defect free manufacturing components.
III	The mechanics of machining 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

<table>
<tr><td>Course Title</td><td colspan="5">THEORY OF MACHINES LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">AMEB20</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 - R18</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>2</td><td>1</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Ms. V. Lakshmi prasanna, Assistant Professor</td></tr>
</table>

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
B.Tech	AMEB14	IV	Materials and Mechanics of Solids Laboratory

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:

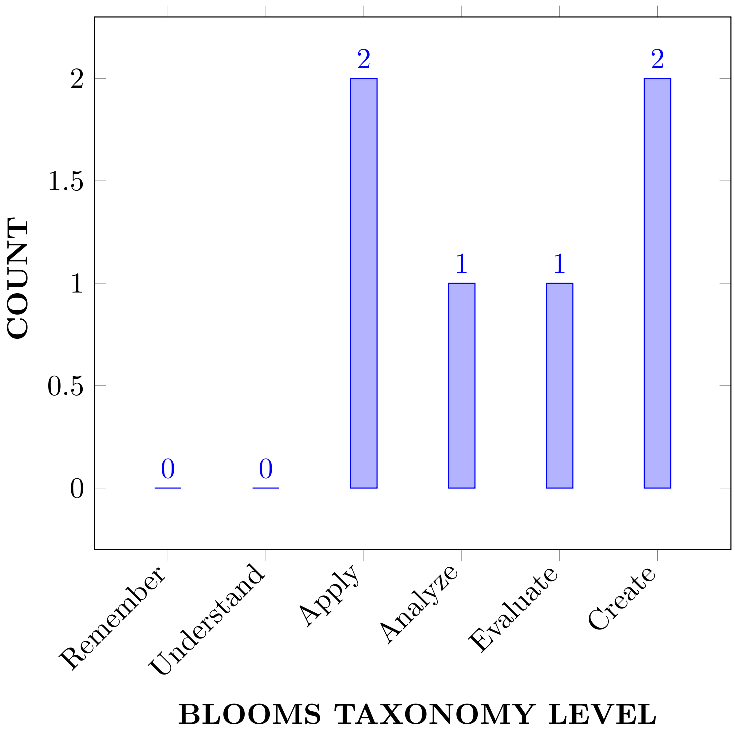
I	The Importance of theory of machines and mechanism involved in the day-to-day life, and study of basic mechanisms and inversion mechanisms to form a machine.
II	The information related design and analysis of mechanisms for a specific type of motion in a machine.
III	The developmental use of rigid bodies 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
e	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	✓	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	**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.

Signature of Course Coordinator **HOD, ME**
Ms. V. Lakshmi Prasanna,, Assistant professor

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(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">HEAT TRANSFER</td></tr>
<tr><td>Course Code</td><td colspan="5">AMEB21</td></tr>
<tr><td>Program</td><td colspan="5">B. Tech</td></tr>
<tr><td>Semester</td><td colspan="5">SIX</td></tr>
<tr><td>Course Type</td><td colspan="5">Core</td></tr>
<tr><td>Regulation</td><td colspan="5">R-18</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>-</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Dr. K. Ch Apparao, Associate Professor</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB04	III	Thermodynamics
B.Tech	AMEB08	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	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 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:

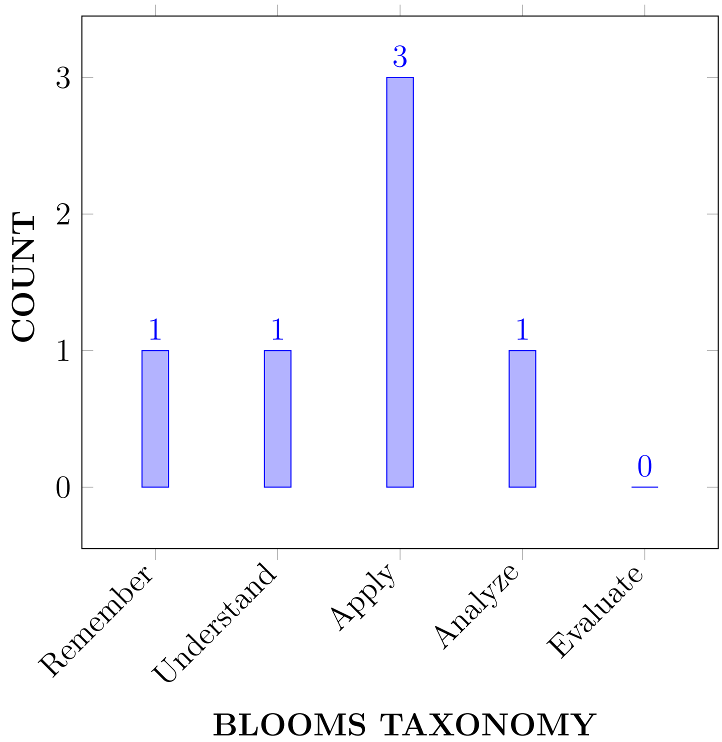
I	The governing equations and performance relations of various modes of heat transfer using the three types of coordinate systems.
II	The concepts for validating heat transfer parameters during internal and external flows based on non-dimensional numbers and convective mode heat transfer.
III	The performance 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.
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
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:

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	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

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	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 HEAT TRANSFER**
	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.
MODULE V	**HEAT EXCHANGERS AND PHASE CHANGE**
	Classification of heat exchangers, overall heat transfer Coefficient and fouling factor, Concepts of LMTD and NTU methods, Problems using LMTD and NTU methods. 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.

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

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**Finite Element Methods**				
Course Code	AMEB22				
Program	B.Tech				
Semester	VI	ME			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	1	3	-	-
Course Coordinator	Mr. M Prashanth Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB11	IV	Materials and 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 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:

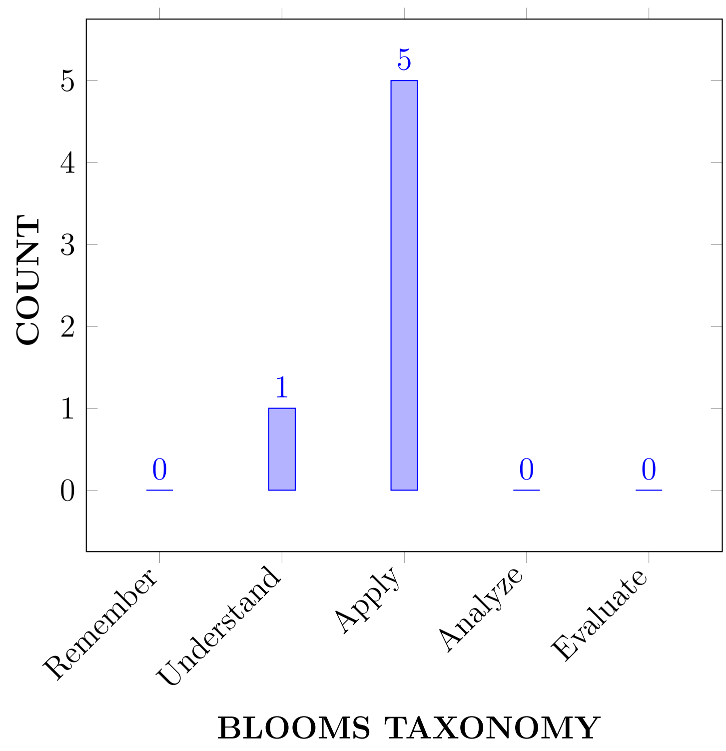
I	The basic concepts of Finite Element methods and its applications to complex engineering problems.
II	The characteristics and selection of different finite elements used in finite element methods.
III	The equilibrium equations and stress-strain relations for different boundary conditions encountered 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	Program Outcomes/ No. of Key Competencies												PSO'S		
OUTCOMES	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	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	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	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	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

COURSE DESCRIPTOR

Department	**MECHANICAL ENGINEERING**				
Course Title	**DESIGN OF MACHINE ELEMENTS**				
Course Code	AMEB23				
Program	B.Tech.				
Semester	VI				
Course Type	CORE				
Regulation	IARE -R18				
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:

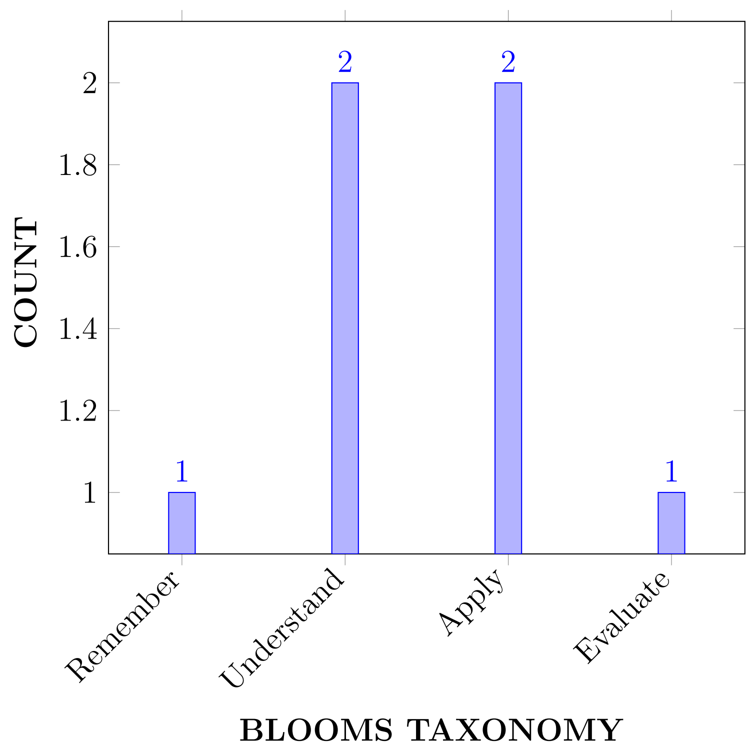
I	The machine element design process that achieves desired constraints for strength, rigidity and reliability
II	The nature of loading for the application of theories of failure for mechanical machine elements under different loading conditions.
III	The various permanent and temporary joints in engineering 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

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

MECHANICALL ENGINEERING

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**COMPUTATIONAL FLUID DYNAMICS**				
Course Code	AMEB35				
Program	B.Tech.				
Semester	VI				
Course Type	ELECTIVE				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms. N santhisree, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Course Name
B.Tech	AMEB08	IV	Fluid Mechanics and Machines

II COURSE OVERVIEW:

Computational Fluid Dynamics mainlyfocuses on complex engineering fluid dynamics and heat transfer analysis using numerical methods which are provided with advanced engineering mathematics(Fourier series, partial differential equations). This course also describes the computationalsimulation tools required for the analysis of thermal engineering problems in the emerging technologies of interdisciplinary applications like aerospaceand medical fields of research.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	✓	Tech talk	✓	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
0%	Remember
50 %	Understand
33 %	Apply
17 %	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.

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:

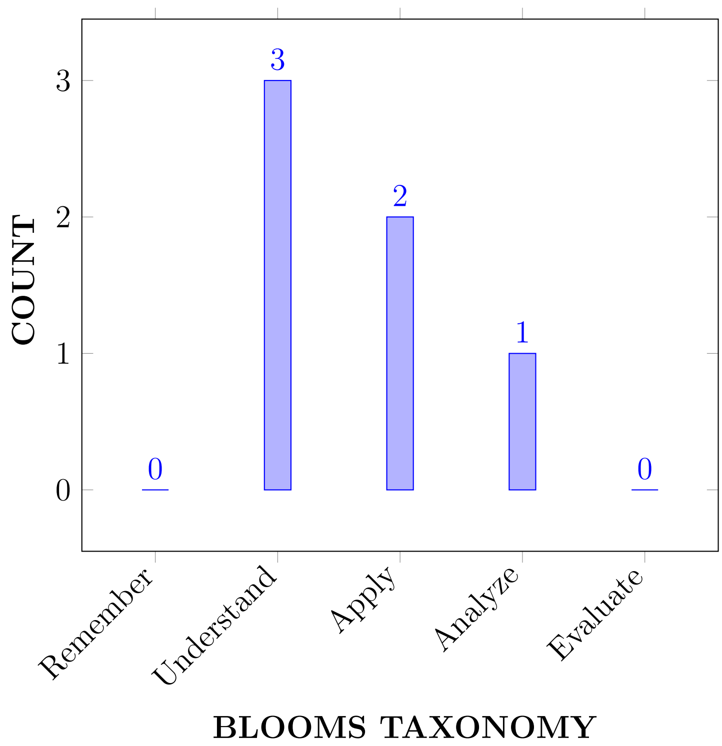
I	The evolution of the major theories, approaches, methodologies and programming techniques in Computational fluid dynamics.
II	The development of various fluid flow governing equations from the conservation laws of motion and Fluid mechanics.
III	The rigorous and comprehensive treatment of numerical methods in fluid flow and heat transfer problems in engineering applications.
IV	The environment and usage of commercial Computational Fluid Dynamics packages and carry out research in interdisciplinary applications.

VII COURSE OUTCOMES:

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

CO 1	**Summarize** the concepts of computational fluid dynamics and its applications in various industries as a tool for fluid and heat flow analysis.	Understand
CO 2	**Select** the appropriate fundamental physical principles and a suitable flow model to derive the governing equations for CFD analysis.	Apply
CO 3	**Apply** shock fitting and shock capturing methods for CFD analysis of time marching and space marching problems.	Apply
CO 4	**Classify** the partial differential equations into hyperbolic, parabolic and elliptical forms with the understanding of their mathematical behaviour.	Understand
CO 5	**Distinguish** various grid generation and transformation techniques in the implementation of finite difference useful in solving complex fluid flow problems.	Analyze
CO 6	**Outline** the concepts of finite volume method and its difference from finite difference method to solve basic fluid flow modelin the real world applications.	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, engineeringfundamentals, 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 complexengineering 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 anddesign 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/Quiz/AAT
PO 4	**Conduct Investigation 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
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	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 interdisciplinary engineering applications.	3	AAT
PSO 3	Make use of computational and experimental tools for building career paths towards innovative start-ups, employability and higher studies.	3	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	Summarize the history, basics of computational fluid dynamics **(Knowledge)** and its importance in solving complex engineering problems by applying **mathematics** (partial differentials) and principles of engineering **fluid sciences.**	3
CO 2	PO 1	Select an appropriate fundamental physical principles and a suitable flow model for numerical formulations from the fundamentals of **mathematics, sciences and engineering knowledge.**	3
	PO 2	Formulate the **problem statement** and identify the fundamental physical principles and a suitable flow model to obtain substantiated conclusions by the **interpretation of results.**	2

	PSO 2	Select an appropriate fundamental physical principles and a suitable flow model for numerical method relevant to **physical systems** in design of fluid thermal systems and **provide solutions in interdisciplinary applications.**	2
CO 3	PO 1	Identify the shock fitting and shock capturing methods for CFD analysis from **mathematical knowledge, principles and engineering fluid thermal sciences.**	3
	PO 2	Identify the shock fitting and shock capturing methods for fluid flow problems related to various governing equations in the CFD from partial differential equations **(mathematics)** and fluid **thermal sciences to develop solution.**	2
CO 4	PO 1	Select the partial differential equations in hyperbolic, parabolic and elliptical forms by understanding the basic **engineering fundamentals, mathematics and fluid thermal sciences.**	3
	PO 2	Identify the governing equations in different form applied in thermal problemsand analyseby describing the characteristics of fluid flow to **develop solution** by using **(mathematics)** (partial differential equations).	2
	PO 4	Identify the available partial differential equations (analytical methods) for engineering fluid flow problems and apply computer software (CFD) to **develop solution** by analysing the processes.	1
	PSO 2	Select the partial differential equations for fluid flow relevant to **physical systems** in design of thermal systems and **provide solutions in interdisciplinary applications.**	2
	PSO 3	Outline the governing equations in different formadopted in computational techniques for simulationof fluid thermal systems for **innovative career** path in industry for **modern tool** usage	2
CO 5	PO 1	Identify finite difference techniques to solve analytical problems by using the **fundamentals of engineering knowledge, science and mathematics**.	3
	PO 2	Formulate the appropriate CFD technique by using **first principles of mathematics** (Partial differential equations) to get analytical in order to **validate results.**	2
	PO 3	Select the **customer requirement** and identify the proper finite difference method for complex thermal systems used in **various applications.**	2
	PO 4	Knowledge and understandingthe basic finite difference method to solve **complex problems** in analysis to provide numerical solution in order to minimise the error.	1

	PO 5	Apply **appropriate** finite difference technique to solve the complex thermal problems.	1
	PSO 2	Formulate the **physical systems** with appropriate design to **provide solutions** for fluid systems.	2
	PSO 3	Make use of **computational** simulation techniques for the analysis of **thermal problems** in the career path of modern engineering start up industries..	2
CO 6	PO 1	Analyse the finite volume method for solving thermal problems by using **engineering fundamentals, fluid sciences and mathematical equations**.	3
	PO 2	Identify the finite volume method methods to analyse the stability of fluid system in the aspect of **design** the problems experimentally and numerically to recognize the significance of them in **solving various engineering problems to create solutions for thermal systems.**	2
	PO 4	Recognize **(Knowledge)** the characteristics of various fluid flow processesrelatedto different methods of CFD and analyse the basic parameters influencing the flow by incorporating commercial CFD codes.	1
	PO 5	Select an appropriate technique of finite volume methods to solve the fluid flow of **real world problems**.	1
	PSO 3	Make use of **computational techniques** and simulation methods for the analysis of **thermal problems** in the career path of modern engineering start up industries..	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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	1	-	-	-	-	-	-	-	-	-	2	2
CO 5	3	2	2	1	1	-	-	-	-	-	-	-	-	2	2
CO 6	3	2	-	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	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	20	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 3	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	20	-	10	-	-	-	-	-	-	-		-	100	100
CO 5	100	20	20	10	10	-	-	-	-	-	-	-	-	100	100
CO 6	100	20	-	10	10	-	-	-	-	-	-		-	-	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	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	1	-	-	-	-	-	-	-	-	-	3	3
CO 5	3	1	1	1	1	-	-	-	-	-	-	-	-	3	3
CO 6	3	1	-	1	1	-	-	-	-	-	-	-	-	-	3
TOTAL	18	5	-	3	2		-	-	-	-	-	-	-	9	9
AVERAGE	3	1	1	1	1	-	-	-	-	-	-	-	-	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:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS**
	Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Numerical Methods Programming fundamentals, simple coding techniques for numerical problems.
MODULE II	**GOVERNING EQUATIONS OF FLUID FLOW AND HEAT TRANSFER**
	Governing Equations of Fluid Dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions.
MODULE III	**PARTIAL DIFFERENTIAL EQUATIONS AND ITS NUMERICAL BEHAVIOUR**
	The Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching problems. Mathematical Behavior of Partial Differential Equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.
MODULE IV	**DISCRETIZATION AND NUMERICAL METHODS OF PDEs**
	Basic aspects of Discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, uniform and unequally spaced grid points. Grids With Appropriate Transformation: General transformation of the equations, Metrics and Jacobians. Stability Analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion; Grid Generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, and Parabolic Grid Generation.
MODULE V	**SOLUTION METHODS AND APPLICATIONS OF NUMERICS TO SIMPLE PROBLEMS**
	Parabolic Partial Differential Equations: Finite difference formulations, Explicit methods – FTCS, Richardson. Implicit methods – Lasonen and Crank-Nicolson; Finite Volume Method For Structured and Unstructured Grids: Advantages, Cell Centred and Nodal point Approaches, Numerical Solution of Quasi 1D Flow equation and 2D heat conduction equation.

TEXTBOOKS

1. J.D. (Jr) Anderson, "Computational Fluid Dynamics", McGraw-Hill Book Company, 1st Edition, 1995.
2. K.A. Hoffman, S.T. Chiang, "Computational Fluid Dynamics", Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
3. D.A. Anderson, J.C. Tannehill, R.H. Pletcher, "Computational Fluid Mechanics and Heat Transfer", McGraw Hill Book Company, 2002.

REFERENCE BOOKS:

1. T.J. Chung, "Computational Fluid Dynamics", Cambridge University Press, 2003.
2. K. Muralidhar, Sundararajan "Computational Fluid Flow and Heat Transfer", 2009.

WEB REFERENCES:

1. https://nptel.ac.in/courses/112/105/112105045/
2. https://nptel.ac.in/courses/112/107/112107080/

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:
OBE DISCUSSION			
1	Introduction to Outcome Based Education		
CONTENT DELIVERY (THEORY)			
2-3	Introduction to CFD as design and research tool	CO1	T1:1
4	History, Philosophy of computational fluid dynamics	CO1	T1:2
5-6	Applications of computational fluid dynamics	CO 1	T1:4.1-4.5
7	Numerical Methods Programming fundamentals	CO 1	T1:6
8-9	Simple coding techniques for numerical problems.	CO 1	T1:6
10	Models of the flow	CO 2	T1:2.2
11-12	The substantial derivative, Physical meaning of the divergence of velocity	CO 2	T1:2.3,2.4
13-14	The continuity equation, The momentum equation	CO2	T1:2.5 R1:2.55
15	The energy equation	CO2	T1:2.7 R1:2.61
16	Navier stokes equations for viscous flow	CO2	T1:2.8 R1:2.58
17-18	Euler equations for in viscid flow, Physical boundary conditions.	CO 2	T2:2.9 R1:4.29

19	The Forms of the governing equations suited for CFD	CO 2	T1:2.10 R1:4.31
20	Conservation form of the equations	CO2	T1:2.10 R1:4.33
21	shock fitting and shock capturing	CO 3, CO 4	T1:2.10
22	Time marching and space marching problems	CO 3, CO 4	T1:2.10 R1:4.64
23	Classification of quasi-linear partial differential equations,	CO3	T2:3.2
24	Methods of determining the classification	CO 3, CO 4	T1:3.3 R1:4.67
25	General behavior of Hyperbolicequations	CO 3, CO 4	T1:4.1
26	General behavior of Parabolic equations	CO 3, CO 4	T1:4.2 R1:4.71
27	General behavior of Elliptic equations	CO 3, CO 4	T1:4.3
28	Basic aspects of Discretization	CO5	T1:4.1 R1:5.74
29	Introduction to finite differences, Finite difference equations using Taylor series expansion	CO4	T1:4.2 R2:5.75
30	Finite difference equations using polynomial expansion	CO5	T1:4.3 R1:5.72
31	Explicit and implicit approaches	CO5	T2:4.4 R1:5.73
32	Uniform and unequally spaced grid points.	CO5	T1:5.14 R1:6.78
33	General transformation of the equations, Metrics and Jacobians.	CO5	T2:5.1 R1:6.81
34	Stability Analysis-stability criterion , von Neumann Stability analysis	CO5	T2:4.4 R2:6.8
35	Error analysis, Artificial dissipation and dispersion	CO5	T1:4.5 R1:7.74
36	Elliptic, Hyperbolic, and Parabolic Grid Generation	CO5	T1:5.7 R2:8.75
37	Parabolic Partial Differential Equations	CO6	T1:6.1 R1:8.72
38-39	Explicit methods – FTCS, Richardson	CO6	T1:6.2 R1:8.73
40-41	Implicit methods –Crank-Nicolson	CO6	T1:6.3 R1:10.78
42	Finite Volume Method	CO 6	T3: 4.4 R1:10.814

43	Finite Volume Method For Structured and Unstructured Grids:	CO 6	T3: 4.4 R2:11.68
44	Cell Centered and Nodal point Approaches	CO6	T3: 4.4 R1:12.74
45	Numerical Solution of Quasi 1D Flow equation and 2D heat conduction equation.	CO6	T3:4.4 R2:12.75
PROBLEM SOLVING/ CASE STUDIES			
1	Problems on Programming fundamentals-FDM	CO 4	T1:6
2	Problems on Programming fundamentals-FVM	CO 6	T1:6
3	Problems on Navier Stokes equations for viscous flow	CO 2	T1:2.8 R1:2.58
4	Problems on Navier Stokes equations for non-viscous flow	CO 2	T1:2.8 R1:2.58
5	Problems on Hyperbolic equations	CO 3, CO 4	T1:4.1
6	Problems on parabolic equations	CO 3, CO 4	T1:4.2 R1:4.71
7	Problems on elliptical equations	CO 3, CO 4	T1:4.3
8	Problems on experimental errors	CO 5	T1:4.5 R1:7.74
9	Problems on error propagation.	CO 5	T1:4.5 R1:7.74
10	Problems on heat transfer analysis	CO 6	T3:4.4 R2:12.75
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Density, Continuity Equation, body force, surface force, Uniform and non-uniformFlow,Newtonian and non-Newtonian fluids, convective derivative, boundary conditions, control volume	CO 1, CO 2	T2:2.1
2	Fundamental equations, Newton's Law, fundamentals laws of physics, integral form of equations, conservation form of the equations, physical principle for continuity equation	CO 2	T2:3.1
3	Ordinary differential equation, partial differential equation ,quasi linear system, Hyperbolic, parabolic, elliptic, Compatibility equation, Parabolized Navier-Stokes equation, condition for the equation to be parabolic	CO 3, CO 4	T1:5.1
4	Grid points, Discretization, Methods of finite differences, Discretization error, Round off error, Courant number, adaptive grid, Zonal grids, Explicit methods, implicit methods, Euler method, backward Euler method	CO 5	T1:7.1

5	LAX wendroff technique, McCormack's technique, Jacobi method, Gauss-Seidel method,successive over-relaxation, Under-Relaxation, Artificial viscosity, Crank Nicolson scheme, High-resolution schemes, finite volume method	CO 6	T1: 11.12
DISCUSSION OF QUESTION BANK			
1	Module I: Introduction to Computational Fluid Dynamics	CO 1	T1:1
2	Module II: Governing equations of fluid flow	CO 2	T1:2.8
3	Module III: Partial differential equations	CO 3, CO 4	T1:2.10
4	Module IV: Discretization and Numerical Methods Of PDEs	CO 5	T1:4.1
5	Module V: Solution methods and applications of numerics to simple problems	CO 6	T1:6.1

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	**Design for Manufacturing**				
Course Code	AMEB48				
Program	B.Tech				
Semester	VI				
Course Type	Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr M.Sunil Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB16	V	Manufacturing Technology

II COURSE OVERVIEW:

Design for manufacturing is an engineering methodology that focuses on reducing time-to-market and total production costs by prioritizing both the ease of manufacture for the product parts and the simplified assembly of those parts into final product. The main objective of this course is to design a product for part minimization, Qunatative analysis of a design efficiency, critique product design for ease of assembly and the importance of involving production engineering in DFMA analysis.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Design for Manufacturing	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	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 below Table.

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
20 %	Understand
70%	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:

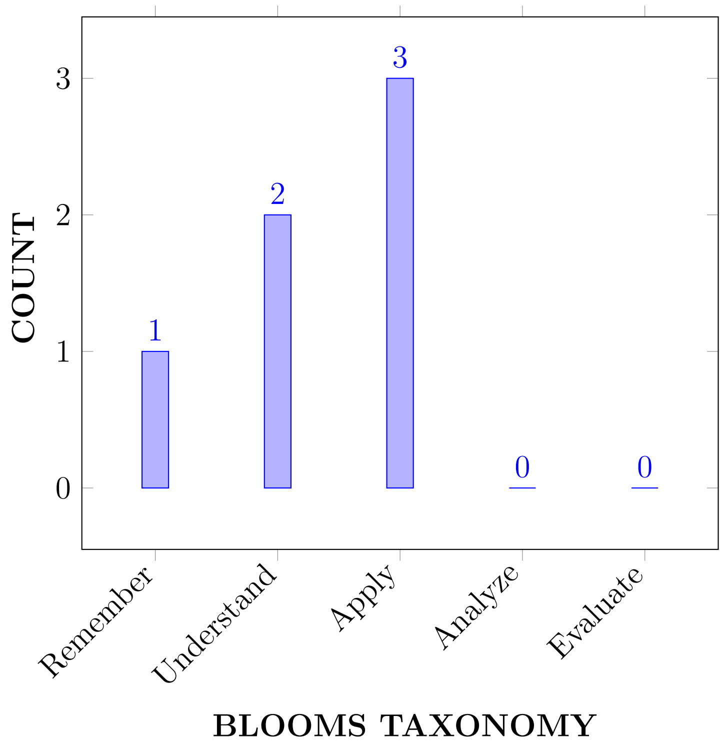
I	Understand the design principles of design for manufacturing processes.
II	Understand the various factors influencing the manufacturability of components.
III	Estimates the cost of dies, molds and machined components based on die life
IV	Application of this study to various casting, welding and machining processes.

VII COURSE OUTCOMES:

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

CO 1	**Select** the appropriate material selection criteria for economical production.	Apply
CO 2	**Compare** various machining process guidelines for complex products used in the industry.	Understand
CO 3	**Select** the appropriate casting process guidelines for efficient of automotive industry	Remember
CO 4	**Make use of** simulation software for optimal casting process.	Apply
CO 5	**Demonstrate** the various joining process for their application in real world examples.	Understand
CO 6	**Identify** vairous sheet metal process and poweder metallurgy techniques in automobiles, aerospace domain.	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, AAT, 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	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.	1	SEE
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	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.	2	CIE, AAT
PSO 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications.	1	CIE, 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	Explain the design for manufacturing for innovative product and service design using the **mathematics** and **engineering fundamentals.**	2
	PO 2	Determine the material selection of material for **Problem identification** for **Problem statement** and **system definition**, also analyse the **Information** and **data collection** using the **principles of mathematics** and **engineering sciences**.	7
	PO 3	Determine the material selection of material for **Investigate and define a problem** for **Understand customer and user needs and the importance of considerations such as aesthetics** and **Knowledge of management techniques** which may be used to achieve engineering objectives.	3
	PO 5	Determine the material selection of material for **Problem identification** for **Problem statement** and **system definition**, also analyse the **Information** and **data collection** using the **principles of mathematics** and **engineering sciences**.	7
	PO 7	Determine the material selection of material for **Socio economic** for **Environmental** and using the **principles of mathematics** and **engineering sciences**.	3
	PSO 1	Compute systematic selection of process and materials, with the help of the **knowledge** of selection of materials.	1
	PSO 2	Understand the design guidelines for designing innovative product, with the help of the **knowledge** of service design.	1
CO 2	PO 1	Apply the knowledge of **mathematics, engineering fundamentals** for machining process and obtain dimensional tolerance and surface roughness.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Formulates the problem** on machining for **general design recommendations** for machined parts to find cutting forces and **analyse the complex engineering problems** using the **principles of mathematics** and **engineering sciences**.	5
	PO 3	Design solution for complex engineering problems and design machined parts for **Investigate and define a problem** for **Understand customer and user needs and the importance of considerations such as aesthetics** and **Knowledge of management techniques** which may be used to achieve engineering objectives.	3
	PO 5	select machined tool geometry by using **simulation packages** for **diagnostic equipment** and **technical library resources**, also analyse the **Information** and **data collection** using the **principles of mathematics** and **engineering sciences**.	7
	PO 7	Understand the impact of machining **Socio economic** for **Environmental** and using the **principles of mathematics** and **engineering sciences**.	3
	PSO 1	Understands the machining parameters, with the help of the **knowledge** of relationship between the speed, depth of cut, feed parameters.	1
	PSO 2	Understands the machining thermal effects , with the help of the **knowledge** of relationship between the speed, depth of cut, feed parameters.	1
CO 3	PO 1	Apply the knowledge of maetallurgy in the casting process by using **mathematics, engineering fundamentals** for preparing defect free casting.	2
	PO 2	**Formulate the problem** on determinate beams for **development of solution** to find strength and stress distribution and **analyse the complex engineering problems** using the **principles of mathematics** and **engineering sciences**.	5
	PO 3	Design solution for complex engineering problems and defect free castings and **Investigate and define a problem** for **Understand customer and user needs and the importance of considerations such as aesthetics** and **Knowledge of management techniques** which may be used to achieve engineering objectives	3
	PO 5	Select simulation by using **simulation packages** for **diagnostic equipment** and **technical library resources**, also analyse the **Information** and **data collection** using the **principles of mathematics** and **engineering sciences**.	7
	PO 7	Understand the impact **Socio economic** for **Environmental** and using the **principles of mathematics** and **engineering sciences**.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	Design the recommendation for redesigning of casting **knowledge** of design guidelines.	1
	PSO 2	Identify newer castings methods to **validation and interpretation** by using simulation softwares **information and data collection** conditions.	2
CO 4	PO 1	Apply the concepts of dimensional tolerances for designing defect free casting **principles of mathematics** and **engineering fundamentals.**	2
	PO 2	**Formulate the problem** on effect defect free casting and **development of solution** to stresses and **analyse the complex engineering problems** using the **principles of mathematics** and **engineering sciences**.	5
	PO 3	Design solution for complex engineering problems and casting processes and **Investigate and define a problem** for **Understand customer and user needs and the importance of considerations such as aesthetics** and **Knowledge of management techniques** which may be used to achieve engineering objectives	3
	PO 5	Select simulation by using **simulation packages** for **diagnostic equipment** and **technical library resources**, also analyse the **Information** and **data collection** using the **principles of mathematics** and **engineering sciences**.	7
	PO 7	Understand the impact **Socio economic** for **Environmental** and using the **principles of mathematics** and **engineering sciences**.	3
	PSO 1	Design the casting with the help of the **knowledge** of product design rules for casting.	1
	PSO 2	Identify casting process for design using **knowledge** simulation in casting design.	1
CO 5	PO 1	Apply the concepts of metal joining using the pre and post welding to make weld joint **principles of mathematics** and **engineering fundamentals.**	2
	PO 2	**Formulate the problem** on effect of thermal stresses and **development of solution** to stresses and **analyse the complex engineering problems** using the **principles of mathematics** and **engineering sciences**.	5
	PO 3	Design solution for complex engineering problems and extrusion processes and **Investigate and define a problem** for **Understand customer and user needs and the importance of considerations such as aesthetics** and **Knowledge of management techniques** which may be used to achieve engineering objectives	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 5	Select simulation by using **simulation packages** for **diagnostic equipment** and **technical library resources**, also analyse the **Information** and **data collection** using the **principles of mathematics** and **engineering sciences**.	7
	PO 7	Understand the impact **Socio economic** for **Environmental** and using the **principles of mathematics** and **engineering sciences**.	3
	PSO 1	Design the extruded section with the help of the **knowledge** of design for extruded section.	1
	PSO 2	Identify forming process for design using **knowledge** Keeler Goodman Forming line diagram.	1
CO 6	PO 1	Apply the basic knowledge of powder metallurgy and develop new materials for assessment of behavior of materials under external loads, with the help of the **principles of mathematics** and **engineering fundamentals.**	2
	PO 2	Apply the basic knowledge of powder metallurgy and develop new materials for assessment of behavior of materials under external loads, with the help of the **principles of mathematics** and **engineering fundamentals.**	2
	PO 3	Recognize the importance of strength and stability of structural members, under varying load conditions and tries to **enhance design skill** for improving the strength and stability of existing structures towards **future advancement** and **lifelong learning.**	3
	PO 5	Recognize the importance powder metallurgy **Computer software** for improving the strength and stability of existing structures towards **simulation packages** and **technical library resources.**	3
	PO 7	Recognize the importance of powder metallurgy for **enhance design skill** for improving the strength and stability of existing materials towards **future advancement** and **environmental.**	3
	PSO 1	Make use of **enhance the performance** of newer powder metallurgy **safety and serviceability** conditions.	2
	PSO 2	Devise new methods to **enhance the performance** of newer powder metallurgy for satisfying **safety and serviceability** conditions.	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	7	3	-	7	-	4	-	-	-	-		1	1	-
CO 2	2	5	3	-	7	-	4	-	-	-	-	-	1	1	-
CO 3	2	5	3	-	7	-	4	-	-	-	-	-	1	1	-
CO 4	2	5	3	-	7	-	4	-	-	-	-		1	1	-
CO 5	2	5	3	-	7	-	4	-	-	-	-	-	1	1	-
CO 6	2	2	3	-	3	-	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	70	30	-	70	-	100	-	-	-	-		50	50	-
CO 2	66.6	50	30	-	70	-	100	-	-	-	-	-	50	50	-
CO 3	66.6	50	30	-	70	-	100	-	-	-	-	-	50	50	
CO 4	66.6	50	30	-	70	-	100	-	-	-	-		50	50	-
CO 5	66.6	50	30	-	70	-	100	-	-	-	-	-	50	50	
CO 6	66.6	20	30	-	30	-	100	-	-	-	-		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	3	3	1	-	3	-	3	-	-	-	-	-	2	2	-
CO 2	3	2	1	-	3	-	3	-	-	-	-	-	2	2	-
CO 3	3	2	1	-	3	-	3	-	-	-	-	-	2	2	-
CO 4	3	2	1	-	3	-	3	-	-	-	-	-	2	2	-
CO 5	3	2	1	-	3	-	3	-	-	-	-	-	2	2	-
CO 6	3	1	1	-	3	-	3	-	-	-	-	-	3	3	-
TOTAL	18	12	6	-	18	-	18	-	-	-	-	-	13	13	-
AVERAGE	3.0	2.0	1.0	-	3.0	-	3.0	-	-	-	-	-	2.1	2.1	-

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	**INTRODUCTION**
	Overview of the course, Design for manufacturing, Typical Case studies, Innovative product and service designs. Material Selection: Requirements for material selection, systematic selection of processes and materials, ASHBY charts
MODULE-II	**MACHINING PROCESS**
	Machining process: Overview of various machining processes, general design rules for machining, dimensional tolerance and surface roughness, design for machining, ease, redesigning of components for machining ease with suitable examples, general design recommendations for machined parts.
MODULE- III	**METAL CASTING:**
	appraisal of various casting processes, selection of casting process, general design considerations for casting; Casting tolerances, use of solidification simulation in casting design, product design rules for sand casting.
MODULE-IV	**METAL JOINING**
	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; forging, design factors for Forging, closed dies forging design, parting lines of dies 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 SHEET METAL WORKING POWDER METAL PROCESSING**
	Design for Sheet metal working: Press selection, press brake operations, design rules, design for powder metal processing: Powder metallurgy, tooling and presses for compaction, sintering, materials, heat treatments, design guidelines.

TEXTBOOKS

1. Geoffrey Boothroyd, Dewhurst.P, Knight.W, "Product Design for Manufacture and Assembly", CRC press, 2002.

2. George E Dieter, "Engineering Design- A Material Processing Approach", McGraw hill international, 5th Edition. 2003.

REFERENCE BOOKS:

1. Surender Kumar and Goutham Sutradhar, "Design and Manufacturing", Oxford and IBH Publishing Co. Pvt .Ltd., New Delhi, 1998.
2. ASM Handbook, Design for manufacture, 2000. 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 Outcome Based Education and PO and CO's		
CONTENT DELIVERY (THEORY)			
2	Module-I: Introduction: Overview of the course Design for manufacturing.	CO1	T2: 1.1
3	Typical Case studies.	CO1	T2: 1.1
4	Innovative product and service designs.	CO1	T2: 1.1
5	Material Selection: Requirements for material selection.	CO1	T2: 1.1
6	Systematic selection of processes and materials.	CO1	T2: 1.1
7	ASHBY charts	CO1	T2: 1.1
8	Module II: Machining process: Overview of various machining processes.	CO 2	T2: 1.1
9	General design rules for machining.	CO 2	T2: 1.1
10	Dimensional tolerance and surface roughness,	CO 2	T2: 1.1
11	Design for machining,	CO 2	T2: 1.1
12	ease, redesigning of components for machining ease with suitable examples,	CO 2	T2: 1.1
13	General design recommendations for machined parts.	CO 2	T2: 1.1
14	Module III: Metal casting, appraisal of various casting processes.	CO 3	T2: 1.1
15	Selection of casting process, general design considerations for casting.	CO 3	T2: 1.1
16	Casting tolerances,	CO 3	T2: 1.1
17	use of solidification simulation in casting design	CO 3	T2: 1.1
18	Product design rules for sand casting.	CO 3	T2: 1.1
19	Module-IV Metal joining: Appraisal of various welding processes.	CO 4	T2: 1.1
20	Factors in design of weldments, general design guidelines.	CO 4	T2: 1.1
21	Pre and post treatment of welds.	CO 4	T2: 1.1
22	Effects of thermal stresses in weld joints.	CO 5	T2: 1.1

23	Design of brazed joints.	CO 5	T2: 1.1
24	Forging, design factors for Forging.	CO 5	T2: 1.1
25	closed dies forging design, parting lines of dies drop forging die design, general design recommendations;	CO 5	T2: 1.1
26	Extrusion and sheet metal work: design guidelines for extruded sections.	CO 5	T2: 1.1
27	Design principles for punching, Blanking, bending, deep drawing	CO 5	T2: 1.1
28	Keeler Goodman Forming line diagram; component design for blanking.	CO 5	T2: 1.1
29	Module V: Design for Sheet metal working, Press selection, press brake operations, design rules.	CO 6	T2: 1.1
30	Design for powder metal processing.	CO 6	T2: 1.1
31	Powder metallurgy, tooling and presses for compaction.	CO 6	T2: 1.1
32	sintering, materials	CO 6	T2: 1.1
33	heat treatments, design guidelines.	CO 6	T2: 1.1
PROBLEM SOLVING/ CASE STUDIES			
1	Module-I Introduction	CO 1	R4:2.1
2	Module-II Machining Process	CO 2	T4:7.3
3	Module-III Metal Casting	CO 3, 4	R4:5.1
4	Module-IV Metal Joining	CO 5	T1:7.5
5	Module-V Design of Sheet metal working and powder metal processing	CO 6	T1: 4.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Module-I Introduction	CO 1	R4:2.1
2	Module-II Machining Process	CO 2	T4:7.3
3	Module-III Metal Casting	CO 3, 4	R4:5.1
4	Module-IV Metal Joining	CO 5	T1:7.5
5	Module-V Design of Sheet metal working and powder metal processing	CO 6	T1: 4.1
DISCUSSION OF QUESTION BANK			
1	Module-I Introduction	CO 1	R4:2.1
2	Module-II Machining Process	CO 2	T4:7.3
3	Module-III Metal Casting	CO 3, 4	R4:5.1
4	Module-IV Metal Joining	CO 5	T1:7.5
5	Module-V Design of Sheet metal working and powder metal processing	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	**Unconventional Machining Processes**				
Course Code	AMEB50				
Program	B.Tech				
Semester	VI				
Course Type	Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	0	0
Course Coordinator	M.Sunil Kumar, Assistant Professor.				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB16	V	Manufacturing Technology

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 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:

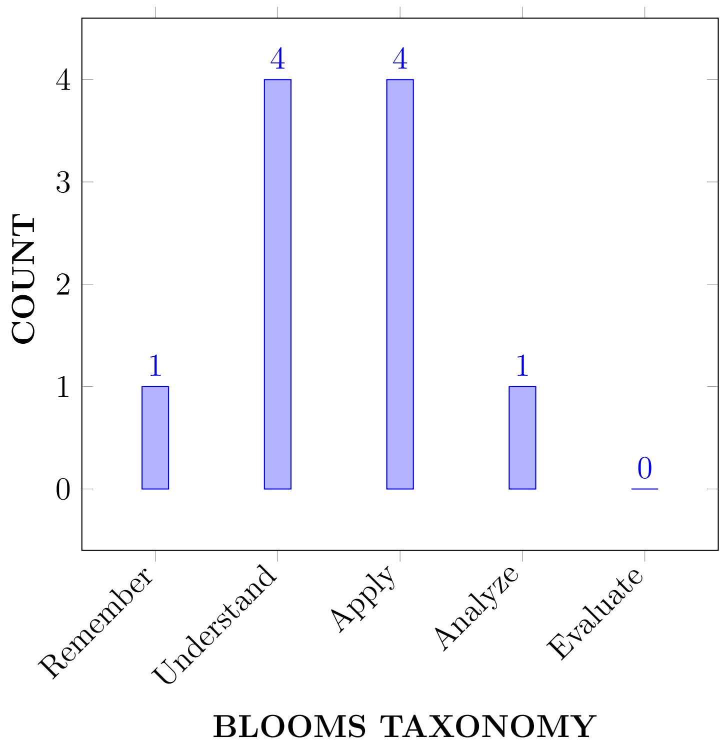
I	Understand the need and importance of non-traditional machining methods and process selection.
II	Gain the knowledge to remove material by thermal evaporation, mechanical energy process.
III	Apply the knowledge to remove material by chemical and electro chemical methods.
IV	Analyze various material 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.

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	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

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	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
	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
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	-
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	✓	SEE 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:

https://iare.ac.in/sites/default/files/NewRegulationsSyllabi/R18/MECH-R18-Autonomous-Regulations-and-Syllabus.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
OBE DISCUSSION			
1	OBE Discussion		
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

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**HEAT TRANSFER LABORATORY**				
Course Code	AMEB24				
Program	B. Tech				
Semester	SIX				
Course Type	Core				
Regulation	IARE-R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
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:

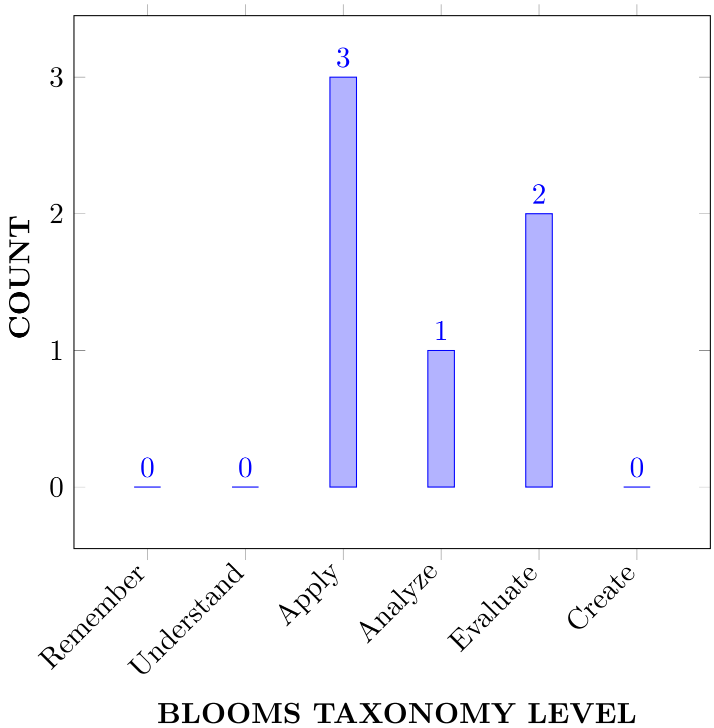
I	The information for validating heat transfer parameters during internal and external flows based on non-dimensional numbers and convective mode heat transfer.
II	Enhance the performance and analysis of heat exchangers for real-time applications using logarithmic mean temperature difference and number 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:
Dr.K.China Apparao, Associate Professor

HOD,ME

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**Fluid Thermal, Modelling and Simulation Laboratory**					
Course Code	AMEB25					
Program	B.Tech					
Semester	VI	ME				
Course Type	Core					
Regulation	IARE - R18					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	-	-	-	2	1	
Course Coordinator	Mr. P Venkata Mahesh, 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:

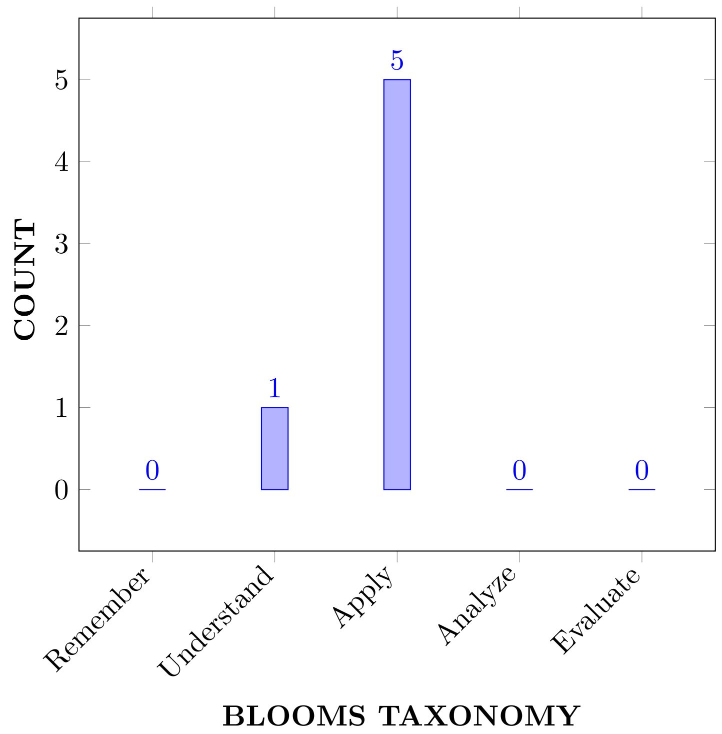
I	Analyze the Internal and External fluid flow problems.
II	Apply FEM techniques to fluid flow problems.
III	Evaluate the thermal stresses in real time problems.

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**
Mr. P Venkata Mahesh, Assistant Professor

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

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**CAD-CAM**				
Course Code	AMEB26				
Program	B.Tech				
Semester	VII				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. M V Aditya Nag, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB22	VI	Finite Element Methods

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 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
0%	Remember
34%	Understand
66%	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 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.

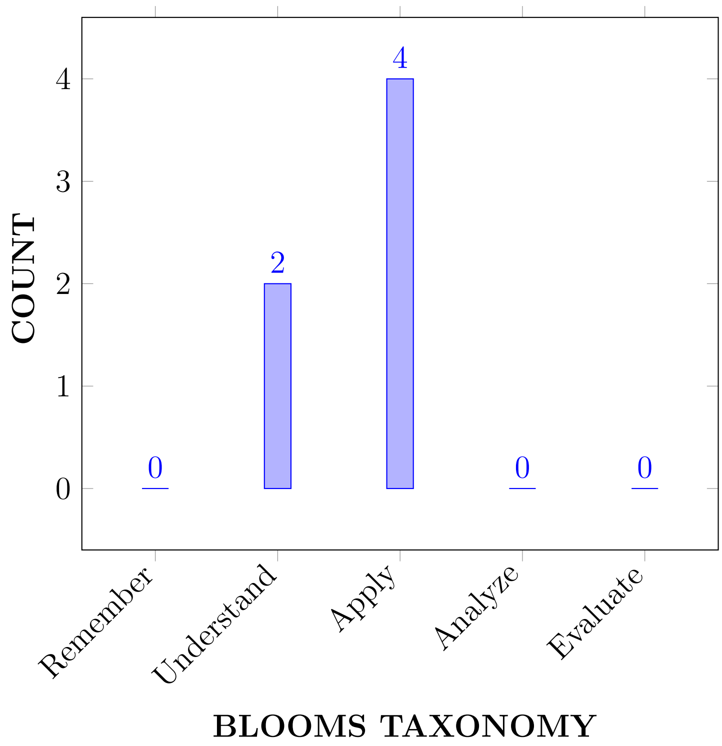
IV	Identify the quality parameters by adopting the contact and non-contact type of inspection techniques.

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.	Understand
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.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyse 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 modeling 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 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:

MODULE I	**FUNDAMENTAL CONCEPTS IN CAD**
	Fundamentals of CAD/CAM, Design process, Application of computers for design, Product cycle-CAD/CAM approach, Benefits of CAD, computer peripherals, Graphics terminal CAD software, Definition of system software and application software, Functions of Graphics package, Graphics packages in present industry, CAD database and structure.
MODULE II	**GEOMETRICAL MODELLING AND DRAFTING SYSTEMS**

	Wire frame modeling- wire frame entities and their definitions, interpolation andapproximation of curves, concepts of parametric and non-parametric representation, curve fitting techniques, Characteristics of Bezier and B-spline curves, NURBS. Surface modeling: Surface modeling entities,Blending functions,Parameterization of surface patch, sub dividing. Applications of Surface Modeling. Solid modeling:Solid modeling entities-Boolean operations, sweep representation,Constructive Solid geometry, Boundary representation, Hybrid Modeling. Applications of Solid Modeling
MODULE 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.
MODULE 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, noncontact inspection methods-optical, noncontact inspection methods-non-optical, computer aided testing, integration of CAQC with CAD/CAM.
MODULE V	**COMPUTER INTEGRATED MANUFACTURING SYSTEMS**
	Flexible Manufacturing System: FMS Equipment, FMS layouts Benefits of FMS, Computer Aided Quality Control: Automated inspection, Contact and non-contact Inspection methods, co-ordinate measuring machines, machine vision, Computer Integrated Manufacturing: CIM systems, Benefits of CIM.

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

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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

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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
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	Fundamentals of CAD/CAM, Design process, Application of computers for design	CO 1	T2:1,T1:1
3	Product cycle-CAD/CAM approach	CO 1	T2:23
4	Benefits of CAD	CO 1	T2:3
5	Computer peripherals	CO 1	T2:3
6	Graphics terminal CAD software	CO 1	T2:11
7	Definition of system software and application software, Functions of Graphics package	CO 1	T3:5
8	Graphics packages in present industry	CO 1	T3:5
9	CAD database and structure	CO 1	T3:5
10	Wire frame modeling- wire frame entities and their definitions, interpolation and approximation of curves	CO 2	T3:8
11	concepts of parametric and non-parametric representation, curve fitting techniques	CO 2	T3:8
12	Characteristics of Bezier and B-spline curves, NURBS	CO 2	T3:8
13	Surface modeling: Surface modeling entities,Blending functions,Parameterization of surface patch, sub dividing. Applications of Surface Modeling	CO 2	T2:7
14	Solid modeling:Solid modeling entities-Boolean operations, sweep representation	CO 2	T2:9
15	Constructive Solid geometry	CO 2	T3:10
16	Boundary representation, Hybrid Modeling. Applications of Solid Modeling	CO 2	T3:10
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	Flexible Manufacturing System: FMS Equipment, FMS layouts Benefits of FMS	CO 6	T3:21
36	Computer Aided Quality Control: Automated inspection	CO 6	T3:17
37	Contact and non-contact Inspection methods	CO 6	T3:17
38	Co-ordinate measuring machines, machine vision	CO 6	T3:17
39	Computer Integrated Manufacturing: CIM systems	CO 6	T3:22
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	Module I: Fundamental concepts in CAD	CO 1	T1,T2,T3, R1,R2
57	Module II: Geometrical modelling and drafting systems	CO 2	T1,T2,T3, R1,R2
58	Module III: Computer Aided Manufacturing	CO 3,4	T1,T2,T3, R1,R2
59	Module IV: Group Technology, CAPP and CAQC	CO 5	T1,T2,T3, R1,R2
60	Module V: Computer Integrated Manufacturing Systems	CO 6	T1,T2,T3, R1,R2
DISCUSSION OF QUESTION BANK			
61	Module I: Fundamental concepts in CAD	CO 1	T1,T2,T3, R1,R2
62	Module II: Geometrical modelling and drafting systems	CO 2	T1,T2,T3, R1,R2
63	Module III: Computer Aided Manufacturing	CO 3,4	T1,T2,T3, R1,R2

64	Module IV: Group Technology, CAPP and CAQC	CO 5	T1,T2,T3, R1,R2
65	Module I: Fundamental concepts in CAD	CO 6	T1,T2,T3, R1,R2

Signature of Course Coordinator **HOD,ME**
Mr. M V Aditya Nag, Assistant Professor

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**INSTRUMENTATION AND CONTROL SYSTEMS**				
Course Code	AMEB27				
Program	B.Tech				
Semester	VII				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	3	1.5
Course Coordinator	Mr M.Sunil Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AMEB08	IV	Fluid Mechanics and 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	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
70%	Understand
20%	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:

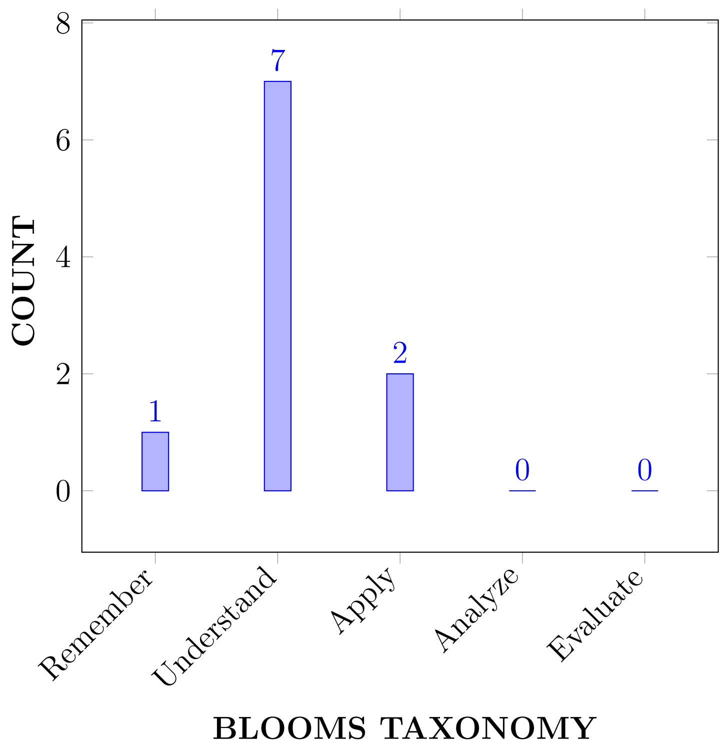
I	The fundamental knowledge of measuring principles, configuration and functional description of instruments with static, dynamic inputs and error control.
II	The concepts and working of instrumentation devices for displacement, flow, dynamic and other mechanical measurement applications.
III	Instrumentation 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 performance characteristics of an instrument when the device is exposed to measure dynamic inputs and error control	Remember
CO 2	**Categorize** the measuring instruments based on the principle of working with the physical parameters such as displacement, temperature and pressure.	Understand
CO 3	**Make use of** appropriate instrument for measuring Speed, Acceleration and Vibration by considering different aspects.	Understand
CO 4	**Apply** relevant control systems for speed, position and control processes in practical applications.	Apply
CO 5	**Demonstrate** the concepts for measurement of Stress, Strain, Humidity and their application for finding stress, strain, and humidity.	Understand
CO 6	**Describe** the control systemsfor temperature, speed and position control systems to industrial applications.	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.	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.	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 2	Formulate and Evaluate concepts of Thermo-Fluid Systems to provide solutions for Inter Disciplinary Engineering Applications..	2	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 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
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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
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	2	-	-	-	-	-	-	-	-	-	-		-	2	-
CO 2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	4	-	-	-	-	-	-	-	-	-		-	2	-
CO 5	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
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	66.7	-	-	-	-	-	-	-	-	-	-		-	100	-
CO 2	66.7	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	40	-	-	-	-	-	-	-	-	-		-	100	-
CO 5	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
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	-	-	-	-	-	-	-	-	-	-		-	3	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-		-	3	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	-	-	-	-	-	-	-	-	-		-	-	-
TOTAL	18	5	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:

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

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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.

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COURSE WEB PAGE:

https://www.iare.ac.in/?q=node/3763

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 1	T1: 1.16,
6-7	Dynamic performance characteristics.	CO 1	T1: 1.16,
8	Sources of error, Classification of errors.	CO 1	T1: 1.16
9	Classification of errors, elimination of error and calibration.	CO 1	TT1: 1.16
10	Zero order, 1st order 2nd order systems.	CO 1	T1: 1.12-1.16
11-12	Classification of transducers, Theory and construction of LVDT, Resistance, Inductive transducer for measurement of displacement.	CO 2	T1: 14.1-14.2
13	Theory and construction of capacitance transducer for measurement of displacement.	CO 2	T1: 14.1-14.2
14	Theory and construction of Piezo electric and photo electric transducer transducers for measurement of displacement.	CO 2	T1: 14.1-14.2
15	Theory and construction of Ionization and Photo electric transducer for measurement of displacement.	CO 2	T1: 14.1-14.2
16	Hall effect Transducer, LDR.	CO 2	T1: 14.1-14.2
17	Measurement of Temperature: Classification – Ranges.	CO 2	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 3	T1: 18.1-18.3
27	Thermal conductivity gauges.	CO 3	T1: 18.1-18.3
28	Ionization pressure gauges, Mcleod pressure gauge	CO 3	R2:7.5
29	Measurement of Level: Direct method – Indirect methods	CO 3	T1: 24.1-24.2
30	Capacitive, ultrasonic level measurement.	CO 3	T1: 24.1-24.2
31	Magnetic, cryogenic fuel level indicator.	CO 3	T1: 24.1-24.2
32	Bubbler level indicatorss	CO 3	T1: 24.1-24.2
33	Flow Measurement: Rotameter, magnetic flow meter	CO 3	R2:7.5
34	Ultrasonic, Turbine flow meter	CO 3	T1: 21.1-21.2
35	Hot – wire anemometer, Laser Doppler Anemometer (LDA)	CO 3	R2:7.5
36	Measurement of Speed: Mechanical Tachometers	CO 4	R2:7.5
37	Electrical tachometers	CO 4	R2:7.5
38	Noncontact type of tachometer , Stroboscope.	CO 4	R2:7.5
39	Measurement of Acceleration and Vibration: Different simple instruments.	CO 4	R2:7.5
40	Principles of Seismic instruments	CO 4	R2:7.5
41-42	Vibrometer and accelerometer using this principle.	CO 4	R2:
43-44	Stress Strain Measurements: Various types of stress and strain measurements.	CO 5	R2:7.61
45	Electrical strain gauge.	CO 5	R2:7.63
46	gauge factor – method of usage of resistance strain gauge for bending compressive and tensile strains.	CO 5	R2:7.65
47	usage for measuring torque, Strain gauge Rosettes.	CO 5	R2:7.68
48	Measurement of Humidity: Moisture content of gases, sling psychrometer.	CO 5	R2:7.69
49	Absorption psychrometer, Dew point meter.	CO 6	R2:7.0
50	Measurement of Force , and Elastic force meters.	CO 6	R2:7.1
51	Measurement of Torque.	CO 6	R2:7.2
52	load cells, Torsion meters.	CO 6	R2:7.3
53-54	Measurement of Power, Dynamometers	CO 6	R2:7.5
55	Elements of Control Systems: Introduction, Importance, Classification.	CO 6	R2:7.5
PROBLEM SOLVING/ CASE STUDIES			
56	Module I:measuring instruments examples, dynamic performance characteristics	CO 1	R4:2.1

57	Module II:Measurement of temperature: Classification ranges, various principles of measurement, expansion, electrical resistance, thermistor, thermocouple, pyrometers, temperature indicators;	CO 2	T4:7.3
58	Module III: Measurement of Speed: Mechanical tachometers, electrical tachometers, stroboscope	CO 3	R4:5.1
59	Module IV:Measurement of Humidity: Moisture content of gases, sling psychrometer.	CO 4, CO5	T1:7.5
60	Module V:Elements of Control Systems: Introduction, Importance, Classification.	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
61	Module I:measuring instruments examples, dynamic performance characteristics	CO 1	R4:2.1
62	Module II:Measurement of temperature: Classification ranges, various principles of measurement, expansion, electrical resistance, thermistor, thermocouple, pyrometers, temperature indicators;	CO 2	T4:7.3
63	Module III: Measurement of Speed: Mechanical tachometers, electrical tachometers, stroboscope	CO 3	R4:5.1
64	Module IV:Measurement of Humidity: Moisture content of gases, sling psychrometer.	CO 4, CO 5	T1:7.5
65	Module V:Elements of Control Systems: Introduction, Importance, Classification.	CO 6	R2:7.5
DISCUSSION OF QUESTION BANK			
1	Module I:measuring instruments examples, dynamic performance characteristics	CO 1	R4:2.1
2	Module II:Measurement of temperature: Classification ranges, various principles of measurement, expansion, electrical resistance, thermistor, thermocouple, pyrometers, temperature indicators;	CO 2	T4:7.3
3	Module III: Measurement of Speed: Mechanical tachometers, electrical tachometers, stroboscope	CO 3	R4:5.1
4	Module IV:Measurement of Humidity: Moisture content of gases, sling psychrometer.	CO 4	T1:7.5
5	Module V:Elements of Control Systems: Introduction, Importance, Classification.	CO 6	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	**Advanced Machine Design**				
Course Code	AMEB42				
Program	B.Tech.				
Semester	VII				
Course Type	Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr S Sathees Kumar, 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	AMEB03	III	Engineering Mechanics
B.Tech	AMEB11	IV	Materials and Mechanics of solids
B.Tech	AMEB23	VI	Design of Machine Elements

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Advanced 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 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
50 %	Understand
50 %	Apply
0 %	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.

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:

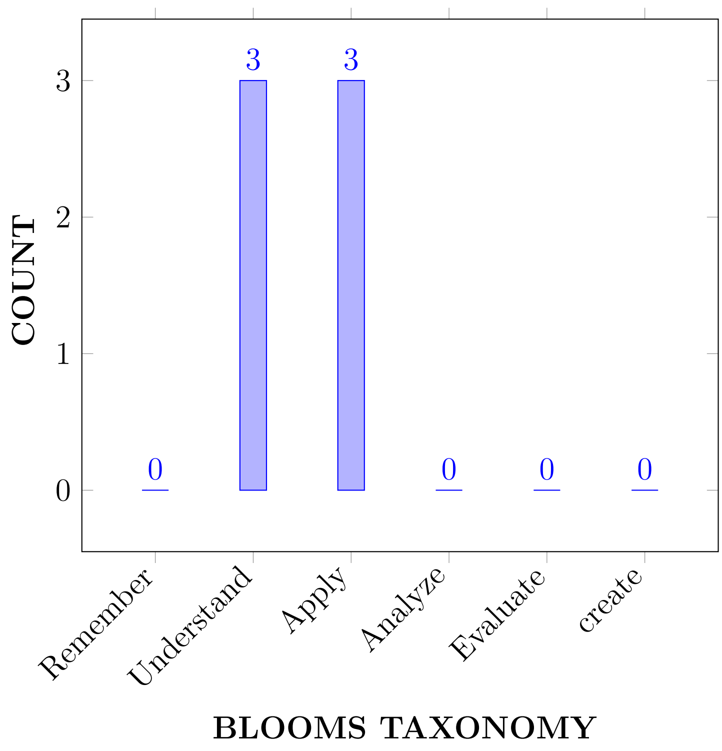
I	The ability to evaluate mechanical element behaviour under various loads.
II	The design of various automobile transmission elements.
III	The importance of ability to interpret mechanical elements

VII COURSE OUTCOMES:

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

CO 1	**Identify** static and dynamic loads for sliding and rolling contact bearings to calculate the life of bearings.	Apply
CO 2	**Select** the specific design methodology for automobile components like connecting rod, piston , and crank shaft under combined loading for feasible solutions as per the IS design standards.	Apply
CO 3	**Utilize** different power transmission systems for computing the efficiency in respective drives such as flat belts, V- belts and ropes.	Apply
CO 4	**Outline** the design process of power transmission using pulleys and chain drives for the given specifications.	Understand
CO 5	**Explain** various types of gears, their typical design features and performance characteristics for efficient power transmission.	Understand
CO 6	**Illustrate** standard fasteners used for various applications based on their efficiency and theories of failures.	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/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.	1	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	1	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.	1	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/Quiz/AAT

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	AAT
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
CO1	PO1	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
	PO2	**Identify** the materials, types of bearings, and **analyse** the functions of different bearings with various loads	2
	PO3	**Design** ball,roller bearings and **develop** the solutions according to their the functions and applications	2
	PO11	**Apply** the knowledge of suitable materials and cost of bearings.	1
	PO12	**Ability** to identify the suitable gears for various applications.	1
	PSO1	**Product development** based on bearing life under static and dynamic loads	1
	PSO3	Make use of creatinginnovative career paths to be an **entrepreneur** and desire for **higher studies.**	2
CO2	PO 1	Apply the knowledge of **science, engineering and mathematical** fundamentals to demonstrate the working process and evaluate the forces acting on the various components in automobiles.	3
	PO2	**Analyse** the different forces acting on the connecting rod, piston, crankshafts and **formulate** the design of different components in automobiles	2
CO3	PO 1	Apply the knowledge of **science, engineering and mathematical** fundamentals to identify the power transmission drives for various applications	3
	PO2	**interpret** the design of rope, belt drives and **identify** the transmission efficiencies according to their applications	2
CO 4	PO 1	Apply the knowledge of **science, engineering and mathematical** fundamentals to identify the chain drives for various applications	3
	PO2	**interpret** the design of chain drives and **identify** the transmission efficiencies according to their applications	2
CO 5	PO 1	Apply the knowledge of **science, engineering and mathematical** fundamentals to identify the types of gears for various applications.	3
	PO2	**interpret** the various types of gears and **analyse** the compressive and bending strength	2

	PO3	**Design** spur,helical, bevel , worm gears and **develop** the solutions according to diferent load factors	2
	PO5	**Create** and **apply** appropriate modern design techniques/tools for gear design.	2
	PO11	**Apply** the knowledge of suitable materials and cost of gears.	1
	PO12	**Ability** to identify the suitable gears for various applications.	1
CO 6	PSO1	**Product development** based on under static and dynamic loads	1
	PSO3	Make use of creatinginnovative career paths to be an **entrepreneur** and desire for **higher studies.**	2
	PO 1	Apply the knowledge of **science, engineering and mathematical** fundamentals to identify the possible failure of power screws	3
	PO2	**interpret** the compound, differential, ball screw and **analyse** the possible failures	2
	PO3	**Design** of screw, nut, and **develop** the solutions according to the failures	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	2	2	-	-	-	-	-	-	-	1	1	1	-	2
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	2	-	2	-	-	-	-	-	1	1	1	-	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	100	20	20	-	-	-	-	-	-	-	8	8	50	-	100
CO 2	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-

CO 4	100	20	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	100	20	20	-	18	-	-	-	-	-	8	8	50	-	100
CO 6	100	20	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
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	1	-	-	-	-	-	-	-	1	1	2	-	3
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	1	-	1	-	-	-	-	-	1	1	2	-	3
CO 6	3	1	1	-	-	-	-	-	-	-	-		-	-	-
TOTAL	18	6	3	-	1	-	-	-	-	-	2	2	4	-	6
AVERAGE	3	1	1	-	1	-	-	-	-	-	1	1	2	-	3

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	AAT	✓	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	**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.

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	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 1	T2:5.11
8	Heat dissipation in bearing	CO 1	T2:7.3 R3:3.21
9	Bearing materials, Journal bearing design	CO 1	T1:7.63 R3:6.11
10-11	Types of rolling contact bearings	CO 1	T1:7.89 R4:6.4
12-14	Selection of bearing type	CO 1	T1:7.9 R3:6.20
15-17	Static and dynamic loading of ball and roller bearings	CO 1	T1:11.2 R3:11.6
18	Thrust in Connecting Rod	CO 2	T2:11.9 R1:11.12
19	Stress due to Whipping action on Connecting rod ends.	CO 2	T2:11.21 R1:11.7
20	Cranks and crankshafts, Strength and proportions of crankshafts	CO 2	T1:12.1
21	Design of Piston, Forces acting on piston	CO 2	T2:9.9 R3:13.8
22-24	Construction design and proportions of piston	CO 2	T1:12:10 R3:12.4
25	Transmission of power by belt drives	CO 3	T1:9.2 R3:9.8
26	Construction of rope drives	CO 3	T1:9.5 R3:9.14
27-28	Belts-Flat and V belts	CO 3	T1:10.6 R4:10.17
29-30	Transmission efficiencies.	CO 3, CO4	T2:8.3 R4:9.21
31	Pulleys for belt and rope drives, materials	CO 4	T1:11.9 R4:11.16

32	Design of Chain drives	CO 4	T2:11.5 R4:11.10
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
35-37	Surface compressive strength-bending strength	CO 5	T1:13.2 R3:14.6
38	Design analysis of spur gear	CO 5	T1:13.8, R3:14.11
39-40	Estimation of center distance, module and face width, check for plastic deformation	CO 5	T1:13.9 R3:14:13
41	Check for dynamic and wear considerations	CO 5	T2:15.1 R3:14.16
42-43	Helical and Bevel Gear Drives: Load concentration factor-dynamic factor	CO 5	T2:15.2. R2: 12.6
44	Design analysis of Helical and Bevel gear	CO 5	T2:9.24 R2: 12.8
45	Check considerations for dynamic strength	CO 5	T2:9.30
46	Design of Worm gears: worm gear- properties of worm gears-selections of materials	CO 5	T2:16.2 R3:23.8
47	Strength and wear rating of worm gears- force analysis	CO 5	T2:10.3 R4:23.18
48	Friction in worm gears-thermal considerations	CO 5	T2:10.5
49-50	Design of power screws : Design of screw	CO 6	T2:10.10
51-52	Square, ACME, Buttress screws	CO 6	T2:10.15
53	Design of ball Screw	CO 6	T2:10.17
54	Possible failures of screws	CO 6	T2:10.18
55	Design of nuts	CO 6	T2:10.21
PROBLEM SOLVING/ CASE STUDIES			
1	Design a journal bearing for a centrifugal pump with the following data: Diameter of the journal = 150 mm Load on bearing = 40 KN Speed of journal = 900 rpm	CO1	T11:13
2	A 150mm diameter shaft supporting a load of 10KN has a speed of 1500rpm.The shaft run in whose bearing length is 1.5 times the shaft diameter. If the diametric clearance of bearing is 0.15mm and the absolute viscosity of the oil at the operating temperature is 0.011 Kg/m-s. Find the power wasted in friction	CO1	T1:11.12
3	A 75 mm journal bearing 100 mm long is subjected to 2.5 kN at 600 r.p.m. If the room temperature is 24°C, what viscosity of oil should be used to limit the bearing surface temperature at 55°C. D/c = 1000.	CO1	T1:11.14

4	Design a trunk piston for an IC engine. The piston is made of cast iron with an allowable stress of 38.5 MPa. The bore of the cylinder is 200 mm and the maximum explosion pressure is 0.4 MPa. The permissible bending stress of the gudgeon pin is100 MPa. The bearing pressure in the gudgeon pin bearing of the connection rod is to be taken as 200 MPa	CO2	T1:12.17
5	Design a side or overhung crankshaft for a 500x600mm gas engine. The weight of the flywheel is 85KN and the explosion pressure is $2.5N/mm^2$. The gas pressure at the maximum torque is 0.95 N/mm^2, when the crank angle is 30° from I.D.C. the connecting rod is 4.5 times the crank radius.	CO2	T1:12.16
6	Connecting rod is required to be designed for a high speed, four stroke I.C. engine. The following data are available.Diameter of piston = 75mm; Mass of reciprocating parts=1.6kg; Length of connecting rod (centre to centre) =350 mm; Stroke = 125 mm; R.P.M=2200 (when developing 50kW); Possible over speed=3000r.p.m; Compression ratio = 6.8:1 (approximately); Probable maximum explosion pressure (assumed shortly after dead centre, say at about 30) = $4.5N/mm^2$.	CO2	T1:12.18
7	A compressor is to run by a motor pulley running at 1440rpm, Speed ratio 2.5. Choose a flat belt crossed drive. Centre distance between pulleys is 3.6m. Take belt speed as 16 m/s. Load factor is 1.3. Take a 5- ply, flat Dunlop belt. Power to be transmitted is 12 KW. High speed load rating is 0.0118 KW/ply/mm, width at v = 5 m/s. Determine the width and length of the belt.	CO3	T1:10.12
8	A Stone crushing machine receives power from motor rated at 50 kw at 1800 rpm by means of a flat belt pulley dia are 200 mm and 700 mm distance between pulley is 4 m design the belt drive the direction or rotation of 2 pulley opposite to each other.	CO3	T1:10.14
9	A bucket elevator is to be driven by geared motor and a roller chain drive with the information given below. Motor out – put – 3KW, speed of motor shaft – 100 rpm, elevator drive shaft speed – 42rpm, load – even. Distance between centres of sprockets approximately = 1.2 m, period of operation 16 hour / day. Geared motor is mounted on an auxiliary bed for centre distance adjustments. Design the chain drive.	CO4	T2:11.13

10	The transporter of a heat treatment furnace is driven by a 4.5kW, 1440rpm induction motor through a chain drive with a speed reduction ratio 2.4. The transmission is horizontal with bath type of lubrication. Rating is continuous with 3 shifts per day. Design the complete chain drive. Assume center distance as 500mm and service factor as 1.5.	CO4	T2:11.17
11	Design a spur gear drive required to transmit 45 KW at a pinion speed of 800 rpm. The velocity ratio is 3.5:1. The teeth are 20° involute with 18 teeth on the pinion. Both the pinion and gear are made of steel with a maximum safe static stress of 180 N/mm^2. Assume medium shock conditions	CO5	T2:12.17
12	Design a straight bevel gear drive between two shafts at right angles to each other. Speed of the pinion shaft is 360 rpm and the speed of the gear. Wheel shaft is 120 rpm. Pinion is of steel and wheel of cast iron. Each gear is expected to work 2 hours / day for 10 years. The drive transmits 9.35 KW.	CO5	T2:10.14
13	A hardened steel worm rotates at 1440 rpm and transmits 12kW to a phosphor bronze gear. The speed of the worm wheel should be 60 rpm. Design the worm gear drive if an efficiency of atleast 82 percentage is desired.	CO5	T2:10.19
14	A vertical screw with single start square threads of 50 mm mean diameter and 12.5 mm pitch is raised against a load of 10 kN by means of a hand wheel, the boss of which is threaded to act as a nut. The axial load is taken up by a thrust collar which supports the wheel boss and has a mean diameter of 60 mm. The coefficient of friction is 0.15 for the screw and 0.18 for the collar. If the tangential force applied by each hand to the wheel is 100 N, find suitable diameter of the hand wheel.	CO6	T2:10.24
15	The cutter of a broaching machine is pulled by square threaded screw of 55 mm external diameter and 10 mm pitch. The operating nut takes the axial load of 400 N on a flat surface of 60 mm and 90 mm internal and external diameters respectively. If the coefficient of friction is 0.15 for all contact surfaces on the nut, determine the power required to rotate the operating nut when the cutting speed is 6 m/min. Also find the efficiency of the screw	CO6	T2:10.23
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Bearing materials, types and modes of lubrication	CO1	T1:11.2
2	Materials and loads acting on automobile parts	CO2	T1:12.4
3	Transmission of belts , chains, rope drives and their efficiencies	CO3,CO4	T1:10.7 T2:11.3

4	Selection of materials for different types of gears	CO5	T2:10.5
5	Applications of various screws and nuts	CO 6	T2:10.8
DISCUSSION OF QUESTION BANK			
1	MODULE I : Bearings	CO1	T1:11.12
2	MODULE II : Design of IC Engine parts	CO2,	T1:12.15
3	MODULE III : Power Transmission systems, Pulleys	CO3,CO4	T1:10.16 T2:11.18
4	MODULE IV : Spur Gear	CO5	T2:10.16
5	MODULE V : Design of Power Screws	CO6	T2:10.23

Course Coordinator **HOD,ME**

Dr S Sathees Kumar, Associate Professor

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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**ROBOTICS**				
Course Code	AMEB49				
Program	B.Tech				
Semester	VII				
Course Type	Professional Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. A.Anudeep Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB11	II	Mathematical Transform Techniques

II COURSE OVERVIEW:

Robotics is recognised 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 development of robot geometry, sensors and actuators to meet the kinematic requirements and trajectory planning of the manipulaotr. 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 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
16%	Remember
50 %	Understand
34 %	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:

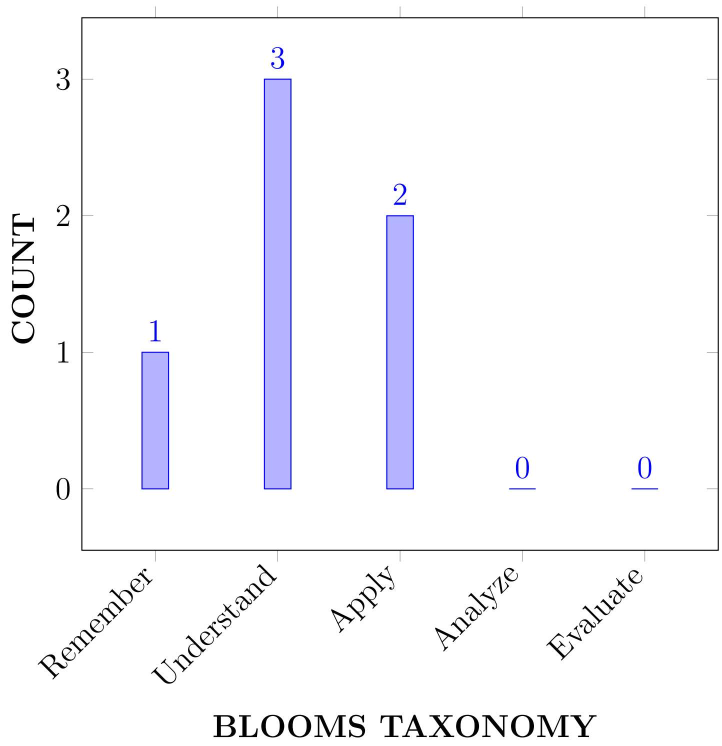
I	The fundamental concepts of various configurations of the robot manipulators and their working principles used in the industries.
II	The circuit design and operation for generation of high DC, AC and impulse voltages.
III	The path planning of a robot manipulator for given polynomial equation and how 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	**Develop** the mechanism for solving forward and inverse kinematics of simple robot manipulators.	Apply
CO 3	**Develop** an ability to obtain the Jacobian matrix and use it to identify singularities.	Apply
CO 4	**Outline** the differential kinematics methods used to study the motion of robot manipulators.	Understand
CO 5	**Explain** an ability to generate the trajectory for given application of robot manipulator.	Understand
CO 6	**Recall** the working of electric actuators and applications of robot inx manufacturing, material handling, assembly and inspections.	Remember

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

Program Outcomes	
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	1	CIE/Quiz/AAT

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	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
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.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
CO3	PO4	Investigate prototype models based on constraint including Environmental sustainability, Health and safety risks assessment issues and define specific problem.	3
CO4	PO3	Design the solution for problems of voltage doublers and multiplier circuits.	2
CO5	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
	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
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
	PO2	Understand the given problem statement and apply data validation techniques to solve (complex) specific engineering problems related to design.	5
	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	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	2	-	-	-	-	-	-	-	-		-	-	-
CO 5	-	5	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	5	-	-	-	-	-	-	-	-	-		-	-	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	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	-	-	27	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	20	-		-	-	-	-	-	-		-	-	-
CO 5	-	50	-	-	-	-	-	-	-	-	-	-	-	-	100
CO 6	100	50	-	-		-	-	-	-	-	-		-	-	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	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	2	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	3
TOTAL	9	6	5	7	-	-	-	-	-	-	-	-	-	-	6
AVERAGE	3.0	2.0	2.0	3.0	-	-	-	-	-	-	-	-	-	-	3.0

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 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 II	**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.
4. Mark W. Spong, M. Vidyasagar, I. John, “Robot Dynamics & Control”, John Wiley & Sons, 1st Edition, 2013.

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)			
2	Introduction to robotics and automation, an over view of robotics – Prerequisites.	CO1	T2: 1.1-1.5, T1: 4.1
3	Classification of robots by coordinate system and control systems. Components of the industrial robotics.	CO1	T2: 1.1-1.5, T1: 4.1
4	Degrees of freedom (DOF) End effectors and types	CO1	T2: 1.1-1.5, T1: 4.1
5	Types of grippers in robots. Mechanical gripper, magnetic vacuum cup and other types of grippers	CO1	T2: 1.1-1.5, T1: 4.1
6	General consideration on gripper selection and design	CO1	T2: 1.1-1.5, T1: 4.1
7	Robot actuators -types and working.	CO1	T2: 1.1-1.5, T1: 4.1
8	Robot sensors-types and working	CO1	T2: 1.1-1.5, T1: 4.1
9	Control systems in robotics.	CO1	T2: 1.1-1.5, T1: 4.1
10	Intelligent robots. Precision of movement (or) parameters of robot.	CO1	T2: 1.1-1.5, T1: 4.1
11	Motion analysis: Robot Kinematics, Basic rotation matrices, composite rotation matrices.	CO2	T2: 1.1-1.5, T1: 4.1
12	Position representation of forward and inverse kinematics of a robotic arm	CO2	T2: 1.1-1.5, T1: 4.1
13	Forward and Inverse Transformation of a 2-Degree of Freedom Arm	CO2	T2: 1.1-1.5, T1: 4.1
14	Adding Orientation: A 3-Degree of Freedom Arm in Two Dimensions	CO2	T2: 1.1-1.5, T1: 4.1

15	A 4-Degree of Freedom Manipulator in Three Dimensions	CO2	T2: 1.1-1.5, T1: 4.1
16	Homogeneous Transformations and Robot Kinematics	CO2	T2: 1.1-1.5, T1: 4.1
17	Kinematic Equations Using Homogeneous Transformations	CO2	T2: 1.1-1.5, T1: 4.1
18	Solving the Kinematic Equations	CO2	T2: 1.1-1.5, T1: 4.1
19	D-H notations, joint coordinates and world coordinates,	CO2	T2: 1.1-1.5, T1: 4.1
20	Differential kinematics of planar and spherical manipulators.	CO2	T2: 1.1-1.5, T1: 4.1
21	Jacobians matrix formation and problems	CO2	T2: 1.1-1.5, T1: 4.1
22	Robot dynamics: Lagrange, Euler formulations	CO2	T2: 1.1-1.5, T1: 4.1
23	Newton-Euler formulations	CO2	T2: 1.1-1.5, T1: 4.1
24	Problems on planar two link manipulators.	CO2	T2: 1.1-1.5, T1: 4.1
25	Denavit–Hartenberg convention.	CO3	T2: 1.1-1.5, T1: 4.1
26	Denavit–Hartenberg parameters.	CO3	T2: 1.1-1.5, T1: 4.1
27	Trajectory planning: joint space scheme.	CO3	T2: 1.1-1.5, T1: 4.1
28	Cubic polynomial fit, avoidance of obstacles.	CO3	T2: 1.1-1.5, T1: 4.1
29	Types of motion: Slew motion, joint interpolated motion, straight line motion.	CO3	T2: 1.1-1.5, T1: 4.1
30	Problems on slew motions	CO3	T2: 1.1-1.5, T1: 4.1

31	Robot actuators and feedback components	CO4	T2: 1.1-1.5, T1: 4.1
32	Actuators: pneumatic, hydraulic and pneumatic.	CO4	T2: 1.1-1.5, T1: 4.1
33	Robot application in Material handling assembly and inspection, work cell design	CO5	T2: 1.1-1.5, T1: 4.1
34	Electric actuators: DC servo motors	CO5	T2: 1.1-1.5, T1: 4.1
35	Feedback components: position sensors	CO5	T2: 1.1-1.5, T1: 4.1
36	Working of a potentiometers	CO5	T2: 1.1-1.5, T1: 4.1
37	Working of a Resolvers	CO6	T2: 1.1-1.5, T1: 4.1
38	Working of a Encoders	CO6	T2: 1.1-1.5, T1: 4.1
39	Working of a Velocity sensors	CO6	T2: 1.1-1.5, T1: 4.1
40	Working of a Tactile sensors	CO6	T2: 1.1-1.5, T1: 4.1
PROBLEM SOLVING/ CASE STUDIES			
1	Numerical Examples working of resolvers and optical encoder	CO 1	R2:7.5
2	Numerical examples on transformation matrix in robot kinematics	CO 2	R2:7.5
3	Numerical examples on transformation matrix in robot kinematics	CO 2	R2:7.5
4	Numerical examples on transformation matrix in robot kinematics	CO 2	R2:7.5
5	Solving the Kinematic Equations using transformation robotics	CO 2	R2:7.5
6	Solving the Kinematic Equations using transformation robotics	CO 3	R2:7.5
7	Solving the Kinematic Equations using transformation robotics	CO 3	R2:7.5
8	Solving the Jacobian matrix to find the motion analysis of an arm	CO 3	R2:7.5
9	Solving the Jacobian matrix to find the motion analysis of an arm	CO 3	R2:7.5

10	Solving the Jacobian matrix to find the motion analysis of an arm	CO 4	R2:7.5
11	Solving the Jacobian matrix to find the motion analysis of an arm	CO 4	R2:7.5
12	Problems on slew motions	CO 5	R2:7.5
13	Problems on joint interpolated motion motions	CO 5	R2:7.5
14	Problems on straight line motions	CO 6	R2:7.5
15	Problems on slew motions	CO 6	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definitions and Terminology of robotics and automation.	CO 1	R4:2.1
2	Definitions and Terminology of motion analysis of robots.	CO 2	R4:2.1
3	Definitions and Terminology of differential kinematics.	CO 3,4	R4:2.1
4	Definitions and Terminology of trajectory planning	CO 5	R4:2.1
5	Definitions and Terminology of electric drives in robots	CO 6	R4:2.1
DISCUSSION OF QUESTION BANK			
1	Discussion on question bank of robotics and automation	CO 1	R4:2.1
2	Discussion on question bank of motion analysis of robots	CO 2	T4:7.3
3	Discussion on question bank of differential kinematics	CO 3,4	R4:5.1
4	Definitions and Terminology of trajectory planning	CO 5	T1:7.5
5	Discussion on question bank of electric drives in robots	CO 6	T1: 4.1

Mr. A. Anudeep Kumar Assitant Professor **HOD,ME**

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

MECHANICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**CAD/CAM LABORATORY**				
Course Code	AMEB28				
Program	B.Tech				
Semester	VII	ME			
Course Type	Lab				
Regulation	IARE - R18				
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:

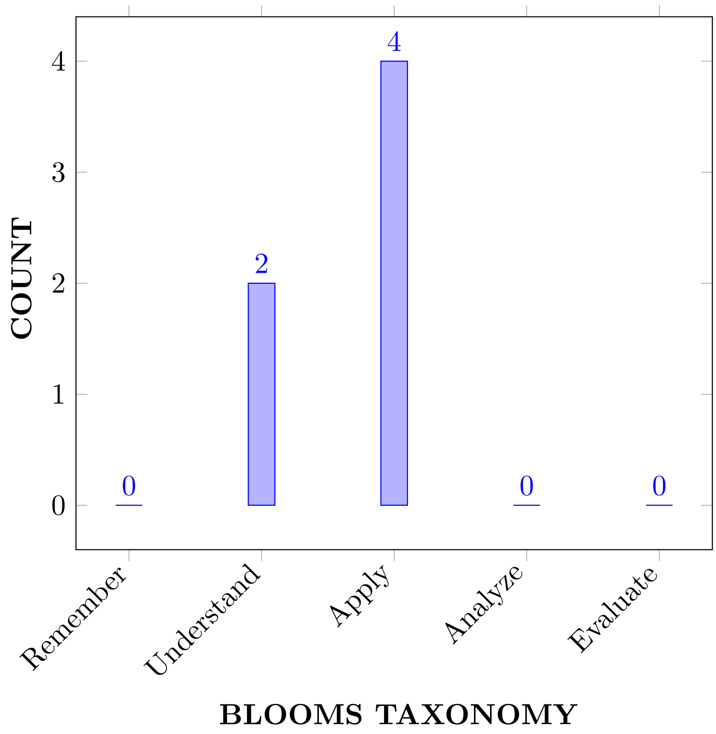
I	Understand the features and specifications of CNC and 3D printing machines.
II	Develop the process planning sheets and tool layouts.
III	Use the CAM software and prepare CNC part programs.

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	**ICS AND PDP LABORATORY**				
Course Code	AMEB29				
Program	B.Tech				
Semester	VII	ME			
Course Type	CORE				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
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	AMEB19	V	Manufacturing Technology Laboratory	3

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Instrumentation and Control Systems and PDP 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 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

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.

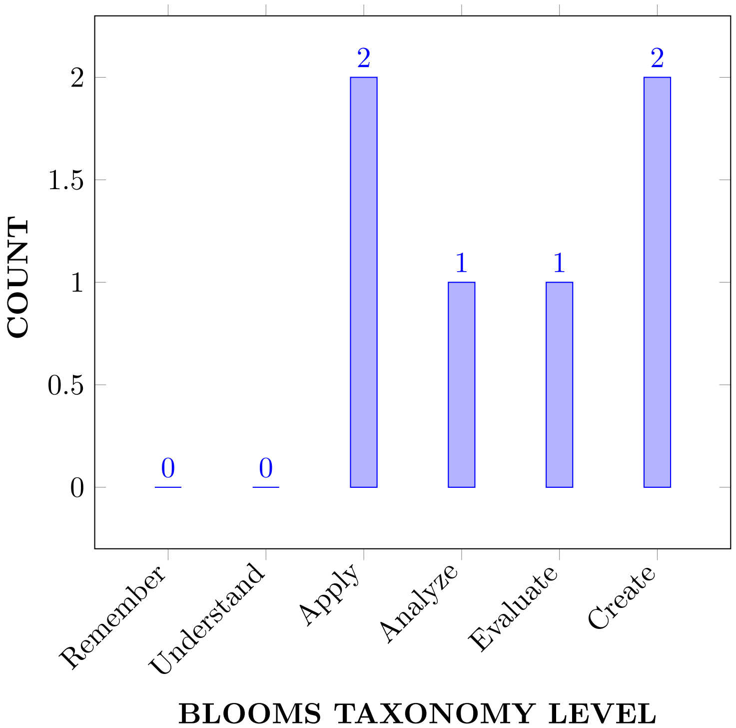
IX COURSE OUTCOMES:

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 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 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 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	**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	**RESISTANCE TEMPERATURE DETECTOR**
	Calibration of thermistor, thermocouple, resistance temperature detector.
WEEK-4	**CALIBRATION OF PRESSURE GUAGE AND VACCUM**
	Calibration of Pressure gauges ,Study and calibration of Mcleod gauge for low pressure.

WEEK-5	**CALIBRATION OF STRAIN GUAGE**
	Calibration of strain gauge for temperature measurement.
WEEK-6	**CALIBRATION OF PHOTO AND MAGNETIC SPEED PICKUP**
	Study and calibration of photo and magnetic speed pickups for the measurement of speed.
WEEK-7	**CALIBRATION OF ROTAMETER**
	Study and calibration of rotameter for flow measurement.
WEEK-8	**CALIBRATION OF VIBROMETER**
	Study and use of a Seismic pickup for the measurement of vibration amplitude of an engine bed at various loads.
WEEK-9	**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-10	**LIMTS FITS AND TOLERANCES AND FORM AND POSITIONAL TOLERANCES**
	Limits, Fits and Tolerances: Types of fits, exercises involving selection, interpretation of fits and estimation of limits from tables; Introduction and indication of form and position tolerances on drawings;
WEEK-11	**SURFACE ROUHNESS AND ITS INTRODUCTION, DETAILED AND PART DRAWINGS**
	Definition, types of surface roughness indication surface roughness obtainable from various manufacturing processes, recommended surface roughness on mechanical components
WEEK-12	**DETAILED AND PART DRAWINGS**
	Drawing of parts from assembly drawings with indications of size, tolerances, roughness, form and position errors, Part drawings using computer aided drafting by CAD software.
WEEK-13	**EXAMINATIONS**

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.

3. K.L. Narayana, P. Kannaiah, "Production Drawing", New Age publishers, 3rd Edition, 2009.

REFERENCE BOOKS:

1. GouthamPohit, Goutham Ghosh, "Machine Drawing with Auto CAD", Pearson, 1st Edition, 2004.

2. 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	CAPACTIVE TRANSDUCER	CO1, CO 5	T1:2.1.5 T2:2.3
2	CALIBRATION OF LVDT	CO1, CO 5	T2:2.1.5 R1:2.6
3	RESISTANCE TEMPERATURE DETECTOR	CO 1, CO 4, CO 5, CO 6	T1:2.6 R3:3.6.5
4	CALIBRATION OF PRESSURE GUAGE AND VACCUM	CO 2, CO 6	T2:2.7 R2:2.18
5	CALIBRATION OF STRAIN GUAGE	CO 2, CO 6	T2:2.22 R3:3.1.1
6	CALIBRATION OF PHOTO AND MAGNETIC SPEED PICKUP	CO 2, CO 6	T1:2.5.1 T2:2.25
7	CALIBRATION OF ROTAMETER	CO 3, CO 6	T2:2.26 R3:2.55
8	CALIBRATION OF VIBROMETER	CO 3, CO 6	T2:2.3 R3:2.6
9	CONVENTIONAL REPRESENTATION OF MATERIALS	CO 3, CO 6	T2:2.3 R1:2.6
10	LIMTS FITS AND TOLERANCES AND FORM AND POSITIONAL TOLERANCES	CO 4, CO 6	T1:2.6
11	SURFACE ROUHNESS AND ITS INTRODUCTION, DETAILED AND PART DRAWINGS	CO 4, CO 6	T2:2.8 R1:2.18
11	DETAILED AND PART DRAWINGS	CO 4, CO 6	T2:2.7 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

COURSE DESCRIPTION

Department	**MECHANICAL ENGINEERING**				
Course Title	**PRODUCTION PLANNING AND CONTROL**				
Course Code	AMEB52				
Program	B.Tech				
Semester	VIII				
Course Type	Professional Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr R. Srinivas, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	**Course Code**	**Semester**	**Prerequisites**
B.Tech	AMEB05	III	Manufacturing Process
B.Tech	AMEB16	V	Manufacturing Technology

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 man power, 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 and Control	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
10%	Remember
30%	Understand
60%	Apply
0 %	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	5	5	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.

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:

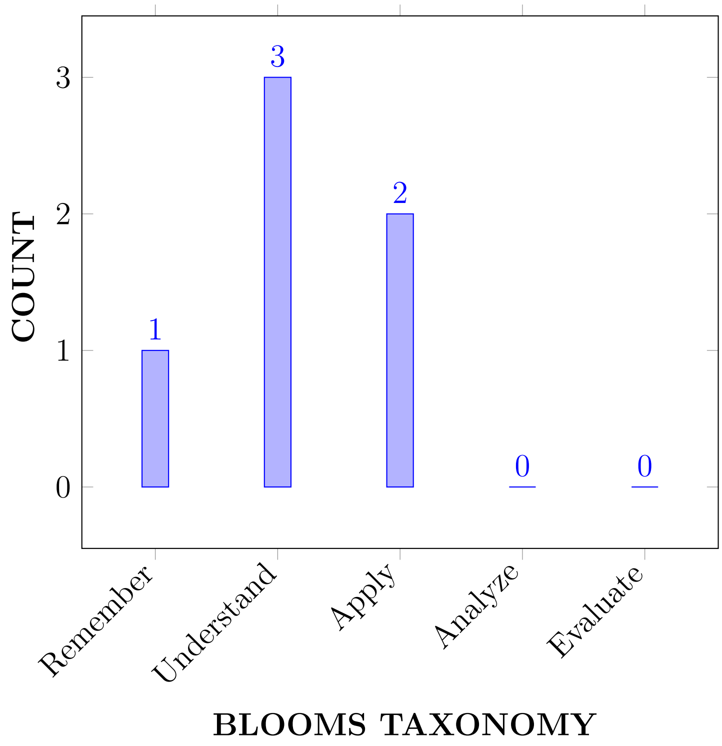
I	To develop, manage and control all aspects of an effective and efficient manufacturing planning and control system which is a key component to the success of any product manufacturing company.
II	The Methodology and models related to forecasting, business operations and productivity in supply chain 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	**Define** different inventory methods in Production Planning that empower manufacturers to enhance smarter and optimized production process. Show 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 quantity for minimizing the operation cost. Master Production Schedule and a resultant Materials Requirement Plan (MRP)for a complete production facility.	Understand
CO 4	**Identify** the forecasting models and errors associated with production to develop business enterprise for product demand, profits, sales, material requirements and 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 enterprise Apply forward and backward scheduling policies to analyze different job shop schedules with reference to prioty rules.	Apply
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.	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.	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	1	SEE/CIA
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	SEE/CIA
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.	1	SEE/CIA
PSO 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	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	2	Discussion /AAT
PSO 3	Make use of computational and experimental tools for building career paths towards innovative startups, employability and higher studies.	1	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	Define 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 ofEngineering 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	3
	PO 3	Forging techniques for the development of critical products for public **health and safety**, and the **cultural, societal** and **Environmental considerations**	3
CO 4	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 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.	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
	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

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 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	2	3	3	-	-	-	-	-	-	-	2	-	-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	3	3	-		-	-	-	-	-	-	2	1	-	2
CO 5	-	3	3	-	-	-	-	-	-	-	2	-	1	-	-
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	66	30	30	-	-	-	-	-	-	-	16	-	-	-	-
CO 2	66	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	30	30	-		-	-	-	-	-	-	-	-	-	-
CO 4	-	30	30	-	-	-	-	-	-	-	-	16	50	-	100
CO 5	-	30	30	-		-	-	-	-	-	16	-	50	-	-
CO 6	-	20	-	-	-	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	3	1	1	-	-	-	-	-	-	-	1	-	-	-	
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	1	1	-	-	-	-	-	-	-	-	1	2	-	3

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	-	1	1	-	-	-	-	-	-	-	1	-	2	-	-
CO 6	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-
TOTAL	6	5	4	-	-	1	-	-	-	-	2	1	4	-	3
AVERAGE	3	1	1	-	-	1	-	-	-	-	1	1	2	-	1

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	**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**
	Forecasting: Importance of forecasting, types of forecasting, their uses, general principles of forecasting, forecasting techniques, qualitative methods and quantitive methods; Inventorymanagement, functions of inventories relevant inventory costs ABC analysis, VED analysis, EOQ model, inventory control systems, P-Systems and Q-Systems.
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	-	-
CONTENT DELIVERY (THEORY)			
S.No	**Topics to be covered**	**CO's**	**Reference T1: 4.1**
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**

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

COURSE DESCRIPTION

Department	**Mechanical Engineering**				
Course Title	**Microprocessors and Interfacing**				
Course Code	AECB55				
Program	B.Tech				
Semester	VIII				
Course Type	Open Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms B.Veena, Assistant Professor				

I COURSE OVERVIEW:

This course introduces the architecture and signal description of Intel microprocessor and microcontrollers. The instruction set and assembly language programming along with input output and memory interfacing techniques are covered. The main applications of microprocessors are automatic testing of products, speed control of motors and software developement.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Microprocessors and Interfacing	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Tech talk	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
0%	Remember
50 %	Understand
33 %	Apply
17 %	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), 10 marks for Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	AAT	
CIA Marks	20	10	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.

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, techtalk, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), concept video, MOOCs etc. The AAT chosen for this course is given in table .

Concept Video	Tech-talk	Complex Problem Solving
50%	50%	-

VI COURSE OBJECTIVES:

The students will try to learn:

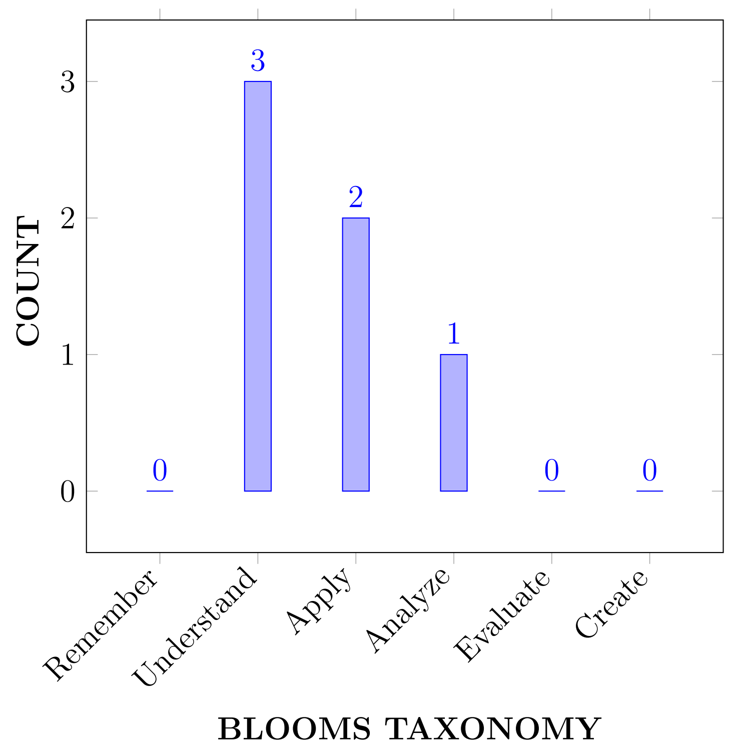
I	The signal descriptions along with functional architecture and hardware interfacing skills using microprocessors and microcontrollers.
II	The instruction set and logic to build assembly language programs for arithmetic, logic and automated electronic systems.
III	The essential concepts of development through a practical hands-on approach on advanced ARM processors and Internet of Things based systems.

VII COURSE OUTCOMES:

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

CO 1	**Outline** the functional components of microprocessors and microcontrollers for understanding the operation of architectures.	Understand
CO 2	**Apply** the instruction set and addressing modes of a microprocessor to write an assembly language program.	Apply
CO 3	**Demonstrate** the internal architecture and modes of operation of peripheral devices for interfacing memory and I/O devices.	Understand
CO 4	**Illustrate** the interrupt handling mechanism in microprocessors and microcontrollers using interrupt controller.	Understand
CO 5	**Choose** an appropriate data transfer scheme and hardware for data transfer between the devices.	Apply
CO 6	**Analyze** the interfacing concept of programmable interfacing modules with microprocessors and microcontrollers for real time applications.	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.

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	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

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	SEE, CIE, 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.	1	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.	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
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
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	Describe the features and architectures of Intel 8086 processor and Intel 8051 microcontroller (knowledge) by applying the knowledge of **mathematics, Engineering fundamentals,**and electronics **engineering specialization** for understanding the operation.	3
	PO 10	Explain the functional components of microprocessors and microcontrollers by **giving effective presentations and receive clear instructions** for understanding the operation of architectures.	1
CO 2	PO 1	Illustrate instructions from the set library (knowledge) for efficient assembly level programming by applying the knowledge of **science, engineering fundamentals and mathematics.**	3
	PO 2	Select proper instructions from the instruction set by **Information and data collection** for **Solution development** by writing assembly language level programming efficient and **Interpretation of results**	3
	PO 3	**Manage the design process** and make use of **creativity to establish solutions** by selecting proper mnemonics to write the assembly language level programming by **Understanding of the requirement for engineering activities to promote sustainable development.**	3
	PO 10	Utilize addressing modes and instruction set of target microprocessors and microcontrollers microcontrollers by **giving effective presentations and receive clear instructions** for writing an assembly language programs to perform a task .	1
	PSO 1	Make use of addressing modes and instruction set of target microprocessors and microcontrollers microcontrollers and do **research towards digital manufacturing in Product development** by writing an assembly language programs to perform a task.	2
CO 3	PO 1	Illustrate the internal architecture and modes of operation of peripheral devices like PPI, DMA controller, PIC, USART by applying the principles of **mathematics, engineering fundamentals, electronics engineering specialization** for the solution of complex engineering problems.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Explain the **Problem statement and system definition** for interfacing devices with microprocessor and microcontroller by **Information and data collection** using peripheral devices like PPI, DMA controller, PIC, USART for **Solution development** and **Interpret the results**	4
	PO 3	**Manage the design process and evaluate outcomes** by interfacing devices with microprocessor and microcontroller using Programmable Peripheral Interface (PPI) and Interrupt Controllers **to establish innovative solutions** by**Understanding of the requirement for engineering activities to promote sustainable development**	3
	PO 10	Describe the internal architecture and modes of operation of peripheral devices by **giving effective presentations and receive clear instructions** for interfacing memory and I/O devices.	1
CO 4	PO 2	Explain the functionality of various types of interrupts and their structure with **Information and data collection** for controlling the processor or controller with program execution flow and**Interpret the results** for **solution development** using interrupt controller.	3
	PO 3	**Understand the requirement for engineering activities to promote sustainable development** in Interrupt handling and **use creativity to establish innovative solutions** using interrupt controller by **Managing the design process and evaluate outcomes**	3
	PO 10	Explain the interrupt handling mechanism in microprocessors and microcontrollers by **giving effective presentations and receive clear instructions** using interrupt controller.	1
CO 5	PO 2	Formulate and analyze (Problem analysis) **complex Engineering problems** by differentiating synchronous & asynchronous communication with **Information and data collection** for data transfer between the devices using first principles of **mathematics and Engineering sciences** and then **Interpret the results**	4
	PO 3	**understand the customer and user needs** and select an appropriate data transfer scheme and hardware by **Managing the design process and evaluate outcomes** to **promote sustainable development** for data transfer between the devices **using creativity to establish innovative solutions**	4
	PO 10	Select an appropriate data transfer scheme and hardware by **giving effective presentations and receive clear instructions** for data transfer between the devices.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	Build (Apply)necessary hardware and software interface using microcomputer based systems to provide solution for real world problems by applying **knowledge of mathematics, engineering fundamentals, engineering specialization.**	3
	PO 2	**Identify problem** and Choose necessary hardware and software interface **(information and data collection)** and conduct **experimental design** with **model translation** to provide **solution development** for real world problems **by interpreting results.**	6
	PO 3	Organize necessary hardware and software interface **based on user needs and importance of considerations** for **innovative solutions, of the problem including all aspects to manage design process** , in microcomputer based systems **by applying different techniques, to achieve required sustained development, with legal requirements governing engineering activities, including personnel, health, safety, and risk issues.**	6
	PO 10	Build microprocessor and microcontroller based applications using necessary input and output devices and **give effective presentations and receive clear instructions.**	1
	PSO 1	**Focus on Ideation and Research towards Digital manufacturing in Product development** and develop microprocessor and microcontroller based applications using necessary input and output devices.	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
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	3	3	-	-	-	-	-	-	1		-	2	-	-
CO 3	3	4	3	-	-	-	-	-	-	1	-	-	-	-	-
CO 4	-	3	3	-	-	-	-	-	-	1	-	-	-	-	-
CO 5	-	4	4	-	-	-	-	-	-	1	-	-	-	-	-
CO 6	3	6	6	-	-	-	-	-	-	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
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	100	-	-	-	-	-	-	-	-	20	-	-	-	-	-
CO 2	100	30	30	-	-	-	-	-	-	20	-	-	100	-	-
CO 3	100	40	30	-	-	-	-	-	-	20	-	-	-	-	-
CO 4	-	30	30	-	-	-	-	-	-	20	-	-	-	-	-
CO 5	-	40	40	-	-	-	-	-	-	20	-	-	-	-	-
CO 6	100	60	60	-	-	-	-	-	-	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	-	-	-	-	-
CO 2	3	1	1	-	-	-	-	-	-	1	-	-	3	-	-
CO 3	3	2	1	-	-	-	-	-	-	1	-	-	-	-	-
CO 4	-	1	1	-	-	-	-	-	-	1	-	-	-	-	-
CO 5	-	2	2	-	-	-	-	-	-	1	-	-	-	-	-
CO 6	3	3	3	-	-	-	-	-	-	1	-	-	3	-	-
TOTAL	**12**	**9**	**8**	-	-	-	-	-	-	**6**	-	-	**6**	-	-
AVERAGE	**3**	**1.8**	**1.6**	-	-	-	-	-	-	**1**	-	-	**3**	-	-

XVI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	-
Quiz	-	Tech - Talk	✓	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practices	-	5 Minutes Video / Concept Video	✓	Open Ended Experiments	-
Micro Projects	-	-	-	-	-

XVII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✓	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO 8 BIT AND 16 BIT MICROPROCESSOR**
	An over view of 8085, Architecture of 8086 Microprocessor, register organization of 8086, 8086 flag register. Addressing modes of 8086, Instruction set of 8086. Assembler directives, procedures, and macros. Assembly language programs involving logical, Branch & Call instructions, sorting, evaluation of arithmetic expressions, string manipulation.
MODULE II	**OPERATION OF 8086 AND INTERRUPTS**
	Pin diagram of 8086-Minimum mode and maximum mode of operation with Timing diagrams. Interrupt structure of 8086: Vector interrupt table, Interrupt service routines. Introduction to DOS and BIOS interrupts.
MODULE III	**INTERFACING WITH 8086**
	Memory interfacing to 8086 (Static RAM & EPROM). Need for DMA, DMA data transfer Method, Interfacing with 8237/8257. 8259 PIC Architecture and interfacing cascading of interrupt controller and its importance. Serial data transfer schemes: Asynchronous and Synchronous data transfer schemes. 8251 USART architecture and interfacing. TTL to RS 232C and RS232C to TTL conversion.
MODULE IV	**ADVANCED MICROPROCESSORS**
	Introduction to 80286, Salient Features of 80386, Real and Protected Mode Segmentation & Paging, Salient Features of Pentium, Branch Prediction, and Overview of RISC Processors.
MODULE V	**8051 MICROCONTROLLER ARCHITECTURE**
	Microcontroller Architecture, Register set of 8051, Modes of timer operation, Serial port operation, Interrupt structure of 8051, Memory and I/O interfacing with 8051.

TEXTBOOKS

1. A.K.Ray and K.M.Bhurchandi, —Advanced Microprocessor and Peripherals‖, TMH, 2000.

2. Deshmukh, Micro Controllers‖, Tata McGraw Hill Edition, TMH, 2000

REFERENCE BOOKS:

1. Douglas U, —Micro Processors & Interfacing‖, Hall, 2007.

2. By Liu, GA Gibson, —Micro Computer System 8086/8088 Family Architecture, Programming and Design‖, PHI, 2nd Edition, 2007.

WEB REFERENCES:

1. http://www.daenotes.com/electronics/digital-electronics/Intel-8085 8 bit microprocessor axzz2I9yUSe7I

2. https://www.smartzworld.com/notes/microprocessors-and-microcontrollers-mpmc/

3. http://www.iare.ac.in

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index?route=course/details&course_id=135

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			
0	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	https://lms.iare.ac.in/index?route=course/details&course_id=135
CONTENT DELIVERY (THEORY)			
1	An over view of 8085 Microprocessor	CO 1	T1:1.1 R2:1.3
2	Architecture of 8086 Microprocessor	CO 1	T1:1.2 R2:1.2.2
3	Register organization of 8086 Microprocessor	CO 1	T1:1.1 R2:1.1,6.1
4	Flag Register of 8086 Microprocessor	CO 1	T1:1.1 R2:2.3
5	Addressing modes of 8086 Microprocessor	CO 2	T1:2.2,1.6,1.7
6	Instruction Set Of 8086 Microprocessor: Data transfer instructions	CO 2	T1:2.3 R2:6.3
7	Instruction Set Of 8086 Microprocessor: Arithmetic and Logical instructions	CO 2	T1:2.3 R2:6.4
8	Instruction Set Of 8086 Microprocessor: Program control transfer instructions	CO 2	T1:2.3 R2:3.1
9	Instruction Set Of 8086 Microprocessor: Machine Control Instructions and Flag manipulation instructions	CO 2	T1:2.3 R2:1.4
10	Instruction Set Of 8086 Microprocessor: Shift and rotate instructions	CO 2	T1:2.3 R2:3.2
11	Instruction Set Of 8086 Microprocessor: String instructions	CO 2	T1: 2.3 R2:3.4,3.5
12	Assembler Directives	CO 2	T1: 2.4 R2:3.3
18	Pin Diagram of 8086 Microprocessor	CO 1	T1: 1.3 R2:3.7
19	Operation of 8086 microprocessor in minimum mode with timing diagrams	CO 1	T1: 1.8 R2:3.6

20	Operation of 8086 microprocessor in maximum mode with timing diagrams	CO 1	T1: 1.9 R2:4.1
21	Interrupts and interrupt cycle of 8086	CO 4	T1:4.3, 4.4 R2:2.2
22	Vector interrupt table and interrupt service routines	CO 4	T1:4.3,3.2,3.3 R2:2.1
23	Introduction to DOS And BIOS Interrupts	CO 4	R2:4.1,4.2
26	Need for DMA and DMA data transfer method	CO 3	T1:7.1 R2:8.1
27	Pin Configuration of 8257 DMA Controller	CO 3	T1:7.1 R2:8.2
28	Block Diagram of 8257 DMA Controller	CO 3	T1:7.2
29	Pin Configuration Of 8259 PIC	CO 4	T1:6.2
30	Architecture Of 8259 PIC	CO 4	T1:6.2 R2:9.2
31	Serial Data Transfer Schemes, Asynchronous And Synchronous Data Transfer Schemes	CO 5	T1:6.4 R2:9.3
32	Pin Configuration Of 8251 USART	CO 5	T1:6.4 R2:9.8,9.9
33	8251 USART Architecture	CO 5	T1:6.4 R2:9.11
34	TTL To RS 232C And RS232C To TTL Conversion	CO 5	T1:6.4
35	80286 Microprocessor	CO 1	T1:9.1, 9.2, 9.3 R2:10.3
36	80386 Microprocessor	CO 1	T1:10.1, 10.2, 10.3 R2:10.3
37	Real mode and Protected mode	CO 1	T1:10.6, 10.7 R2:10.2
38	Segmentation	CO 1	T1:10.8 R2:11.3
39	Paging	CO 1	T1:10.9 R2:11.6
40	Salient features of Pentium processor, Branch Prediction	CO 1	T1:11.1 R2:20.1
41	overview of RISC processors	CO 1	T1:13
42	Introduction to 8051 Microcontroller	CO 1	T1:17.1 R2:19.9
43	8051 Microcontroller Architecture	CO 1	T1:17.2 R2:19.10
44	Pin Configuration Of 8051 Microcontroller	CO 1	T1:17.3 R2:20.3,20.4
45	I/O port structure of 8051 Microcontroller	CO 1	T1:17.6 R2:20.6
46	Register Set of 8051 Microcontroller	CO 1	T1:17.4 R2:20.5

47	Modes of Timer operation	CO 3	T1:18.2 R2:20.5
48	Serial Port Operation	CO 5	T1:18.4 R2:20.5
49	Interrupt Structure Of 8051 Microcontroller	CO 4	T1:18.3 R2:20.5
	PROBLEM SOLVING/ CASE STUDIES		
50	Assembly Language Programs For Sorting Of Numbers using 8086 microprocessor	CO 2	T1:3.4 R2:1.1
51	Assembly Language Programs For Multibyte Addition and Subtraction, sum of squares using 8086 microprocessor	CO 2	T1:3.4 R2:4.7
52	Assembly Language Programs For String Manipulations using 8086 microprocessor	CO 2	T1:3.4 R2:4.7
53	Assembly Language Programs For Code Conversions using 8086 microprocessor	CO 2	T1:3.4 R2:4.1
54	Physical Address Calculation	CO 1	T1:1.2 R2:4.4,4.5
55	Memory Interfacing To 8086 (Static RAM)	CO 3	T1:5.1 R2:12.2,12.3
56	Memory Interfacing To 8086 (EPROM)	CO 3	T1:5.2 R2:12.4
57	Interfacing 8257 With 8086 Microprocessor	CO 3	T1:7.3 R2:9.8,9.9
58	Cascading Of Interrupt Controller And its Importance, Interfacing 8259 PIC With 8086 Microprocessor	CO 3	T1:6.2 R2:9.11
59	Interfacing 8251 USART With 8086 Microprocessor	CO 3	T1:6.4 R2:10.3,10.4
60	Memory And I/O Interfacing With 8051 Microcontroller	CO 3	T1:17.6 R2:10.2
61	Assembly language programming using data transfer, arithmetic, logical and branch instructions	CO 2	T1:17.10 R2:19.3
62	Real world interfacing of 8051 microcontroller with external memory	CO 6	T1:18.6 R2:20.2
63	Interfacing 8051 microcontroller with LCD	CO 6	T1:18.6 R2:21.3
64	Interfacing 8051 microcontroller with ADC and DAC	CO 6	T1:18.6 R2:21.1
	DISCUSSION OF DEFINITION AND TERMINOLOGY		
65	Introduction to 8 and 16 bit microprocessors	CO 1, CO 2	T1, R2
66	Operation of 8086 microprocessor and Interrupts	CO 3, CO 4	T1, R2
67	Interfacing with 8086 microprocessor	CO 3, CO 4, CO 5, CO 6	T1, R2

68	Advanced Microprocessors	CO 1, CO 2, CO 3	T1, R2
69	8051 Microcontroller Architecture	CO 1, CO 3, CO 4, CO 5, CO 6	T1, R2
DISCUSSION OF QUESTION BANK			
70	Introduction to 8 and 16 bit microprocessors	CO 1, CO 2	T1, R2
71	Operation of 8086 microprocessor and Interrupts	CO 3, CO 4	T1, R2
72	Interfacing with 8086 microprocessor	CO 3, CO 4, CO 5, CO 6	T1, R2
73	Advanced Microprocessors	CO 1, CO 2, CO 3	T1, R2
74	8051 Microcontroller Architecture	CO 1, CO 3, CO 4, CO 5, CO 6	T1, R2

Signature of Course Coordinator
Ms B.Veena, Assistant Professor **HOD, ME**