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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**ENGLISH**				
Course Code	AHSB01				
Program	B. Tech				
Semester	I				
Course Type	Foundation				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	2	-	-
Course Coordinator	Dr. Jetty Wilson, 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:

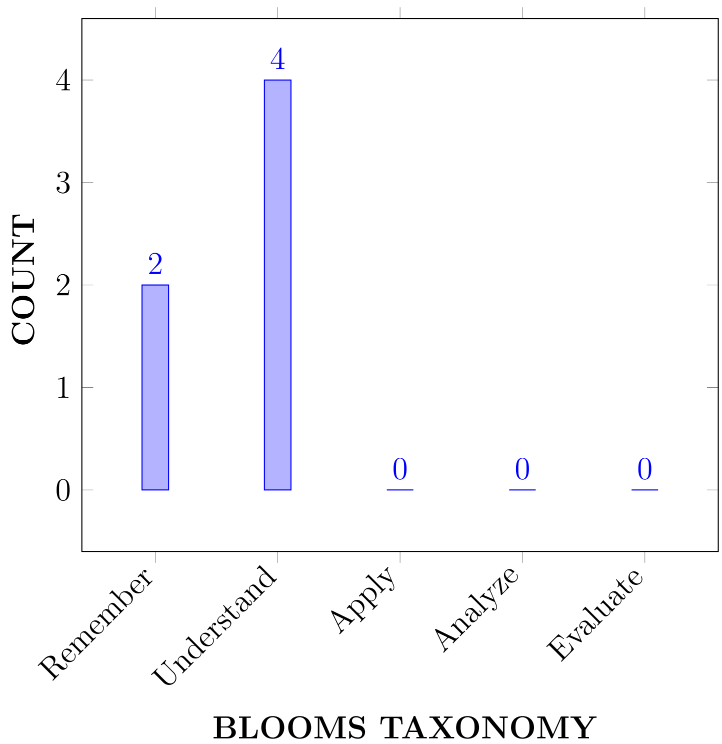
I	Communicate in an intelligible English pronunciation to meet the global standards.
II	Effectively use of four language skills (listening skill, speaking skill, reading skill and writing skill) in day-to-day affairs.
III	A critical aspect of speaking and reading for interpreting in-depth meaning between 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	-	-	-	-	-	-	-	-	-	✓ -	-	-	-	-	-

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

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

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

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

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

TEXTBOOKS

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

REFERENCE BOOKS:

1. 1. Norman Whitby, Business Benchmark: Pre-Intermediate to Intermediate – BEC Preliminary, Cambridge University Press, 2nd Edition,2008.
2. Devaki Reddy, Shreesh Chaudhary, Technical English, Macmillan, 1st Edition,2009.
3. Rutherford, Andrea J, Basic Communication Skills for Technology, Pearson Education,2nd Edition, 2010.
4. Raymond Murphy, Essential English Grammar with Answers, Cambridge University Press, 2nd Edition,2010.
5. Dr. N V Sudershan, President Kalam's Call to the Nation, Bala Bharathi Publications, Secunderabad, 1st Edition,2003

XIX COURSE PLAN:

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

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

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

DISCUSSION OF QUESTION BANK			
62	Soft Skills for difficult situations in terms of reassurance and reliability.	CO 3	TI:9,10
63	Verbal and non-verbal communication.	CO 2	TI: 34,35
64	Honesty, Respect, Self-Control and Accountability their role in building long lasting interpersonal skills?	CO 3	TI: 9,10
65	Etiquette and manners. Its importance in social, personal and professional communication.	CO 23	TI: 9,10
66	Problem solving and decision making.	CO 3	TI: 9,10

Signature of Course Coordinator **HOD**

INSTITUTE OF AERONAUTICAL ENGINEERING
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COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS 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:

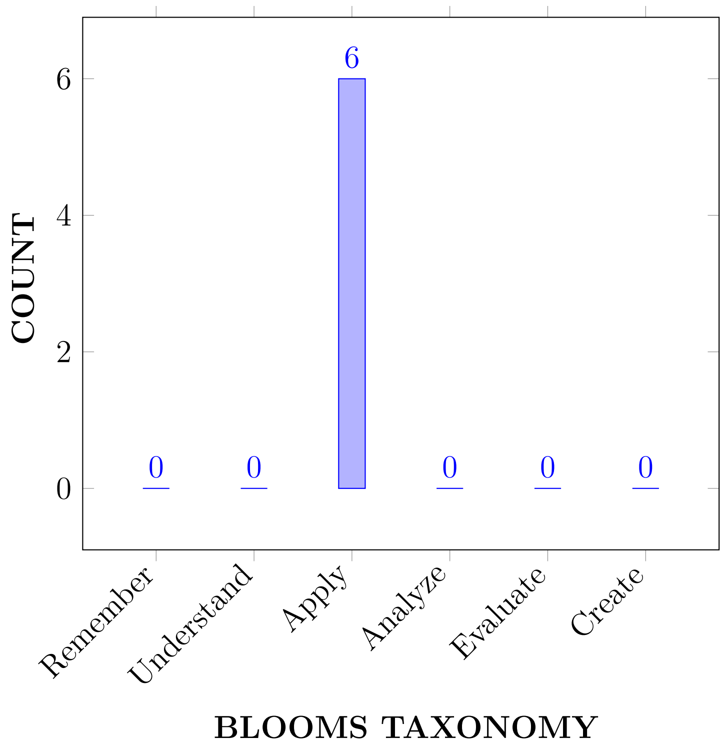
I	Apply and solve linear system of equations by using elementary transformations.
II	Determine the maxima and minima of functions of several variables by using partial differential coefficients.
III	Apply second and higher order linear differential equations to solve electrical circuits.
IV	Apply multiple 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	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	-	-
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	-	-
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.	-	-

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	✓	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	**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, EEE**
Mr. P Shantan Kumar, Assistant Professor

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

COURSE DESCRIPTION

<table>
<tr><td>Department</td><td colspan="5">ELECTRICAL AND ELECTRONICS ENGINEERING</td></tr>
<tr><td>Course Title</td><td colspan="5">ENGINEERING CHEMISTRY</td></tr>
<tr><td>Course Code</td><td colspan="5">AHSB03</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td colspan="5">I</td></tr>
<tr><td>Course Type</td><td colspan="5">FOUNDATION</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>1</td><td>4</td><td>3</td><td>1.5</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Dr V Anitha Rani, Associate Professor</td></tr>
</table>

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:

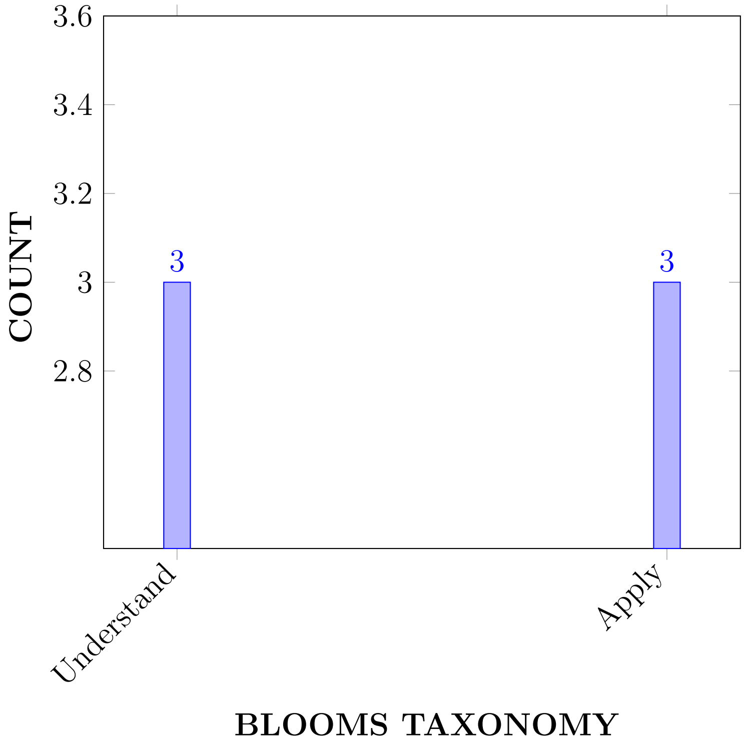
I	The concepts of electrochemical principles and causes of corrosion in the new development and breakthroughs efficiently in engineering and technology.
II	The different parameters to remove causes of hardness of water and their reactions towards the complexometric method.
III	The microscopic chemistry 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	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	-	-
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development..	-	-
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..	-	-

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO3	PO1	Explain the concept of corrosion processes in metals by exposing to acidic environment for solving engineering problems by applying the principles of science	3
	PO2	Identify the problem and formulate for finding the hardness of water in terms of CaCO3 equivalents with given information and data by applying principles of science.	2
CO4	PO1	Explain the formation of molecular orbitals by linear combination of atomic orbitals, splitting of d orbitals for formation of octahedral, tetrahedral and square planar complexes for solving engineering problems by applying the principles of science.	2
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

Signature of Course Coordinator **HOD,EEE**

Dr V Anitha Rani, Associate Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	ENGLISH LANGUAGE AND COMMUNICATION SKILLS LABORATARY				
Course Code	AHSB08				
Program	B.Tech				
Semester	I	EEE			
Course Type	Foundation				
Regulation	R 18				
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, pre-sending techniques of writing, participating role plays, telephonic etiquettes, asking and giving direction, 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
10+2	-	-	Basic principles of communication skills and concepts of functional English grammar.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
English Language and CommunicationSkills 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 assessmentand 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 emphases on the experiments is broadly based on the following criteria given in Table: 1

	Software 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 germination, elision andassimilation.
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. **Software 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.

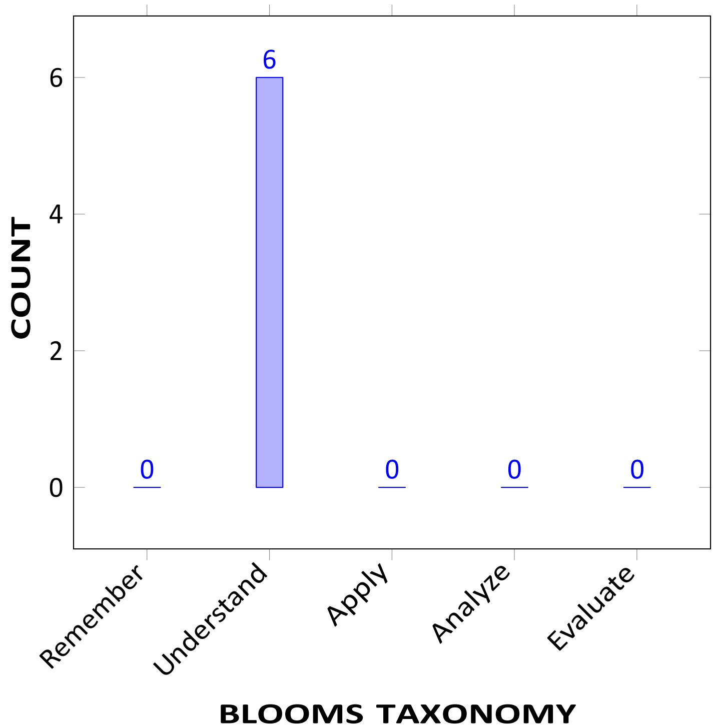
II	The critical aspect of speaking and reading for interpreting in-depth meaning of the sentences.
III	Use language appropriately for social interactions such as public speaking, group discussions and interviews.
IV	Habituate using English speech sounds, word accent, intonation and rhythm.

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	Design next-generation computer systems, networking devices, search engines, soft computing and intelligent systems, web browsers, and knowledge discovery tools.	-	-
PSO 2	Focus on mobile and web applications development and learn the emerging technologies and frameworks in demand with employers and contemporary challenges.	-	-
PSO 3	Practical experience in shipping real world software, using industry standard tools and collaboration techniques will equip to secure and succeed in first job upon graduation in IT industry.	-	-

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 aswell 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.**
	Expressions 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 PublicAddress 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, Expressions In Various Situations.	CO 2	R2: 39-42
9	Neutralization Of Mother Tongue Influence (MT), 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	Listening Comprehension, Etiquettes	CO 5	R1:44-48
12	Techniques And Methods To Write Summaries And Reviews Of Videos, Writing Messages, Leaflets And Notices Etc.	CO 4	R1:107-110
13	Common Errors, Resume Writing.	CO 4	R1:7.3
14	Introduction To Word Dictionary, Group Discussions –Video Recording – Feedback.	CO 5	R1:7.3
15	Introduction To Conversation Skills, Mock Interviews.	CO 6	R1: 54-58

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

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

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

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTOR

Course Title	**ENGINEERING CHEMISTRY LABORATORY**					
Course Code	AHSB03					
Program	B. Tech					
Semester	I	EEE				
Course Type	Foundation					
Regulation	IARE – R18					
Course Structure	**Theory**			**Practical**		
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**	
	3	1	4	3	1.5	
Course Coordinator	Mr. G Mahesh Kumar, Assistant Professor					

I. COURSE OVERVIEW:

The primary objective of an Engineering Chemistry laboratory is to develop the analytical ability of the students by better understanding the concepts experimental chemistry. The experiments carried out like conductometry, potentiometry, physical properties like adsorption of acetic acid on charcoal, viscosity and surface tension of liquids. The analytical experiments like determination of hardness of water, chloride content in the water and hydrolysis of ester cartelized by an acid can be carried out in the laboratory.

II. COURSE PRE-REQUISITES:

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

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Engineering Chemistry Laboratory	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	Chalk & Talk	✘	Quiz	✘	Assignments	✘	MOOCs
✔	LCD / PPT	✘	Seminars	✘	Mini Project	✔	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

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

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

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

20 %	To test the preparedness for the experiment.
20 %	To test the performance in the laboratory.
20 %	To test the calculations and graphs related to the concern experiment.
20 %	To test the results and the error analysis of the experiment.
20 %	To test the subject knowledge through viva – voce.

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

Table 1: Assessment pattern for CIA

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

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

Preparation	**Performance**	**Calculations and Graph**	**Results and Error Analysis**	**Viva**	**Total**
2	2	2	2	2	10

VI. COURSE OBJECTIVES :

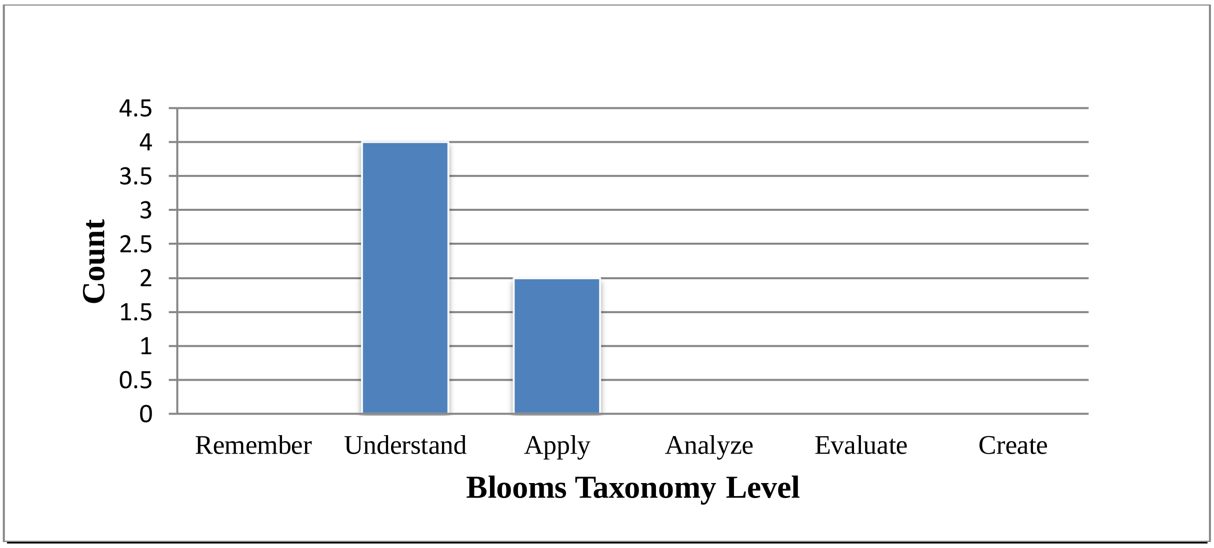
The students will try to learn:	
I	The basic principles involved in chemical analysis and mechanism of synthetic organic reactions.
II	The need and importance of quality of water for industrial and domestic use.
III	The measurement of physical properties like surface tension and viscosity
IV	The fundamental knowledge on chromatographic and adsorption techniques.

VII. COURSE OUTCOMES :

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

	Course Outcomes	Knowledge Level (Bloom's Taxonomy)
CO 1	**Explain** the mechanism of chemical reactions for synthesizing drug molecules.	Understand
CO 2	**Identify** the total hardness, amount of chloride content 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	**Compare** different types of liquids for finding the surface tension and viscosity of lubricants.	Understand
CO 5	**Explain** the rate of chemical reactions for understanding the control of reaction conditions to increase the production of reaction products.	Understand
CO 6	**Relate** the importance of adsorption techniques, chromatography for separating the components of a reaction mixture.	Understand

COURSE KNOWLEDGE COMPETENCY LEVELS



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	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	-	-
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	-	-
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.	-	-

3 = High; 2 = Medium; 1 = Low

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

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	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	POs / PSOs	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**	**Compare** 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 rate of chemical reactions for understanding the control of reaction conditions to increase the production of reaction products by applying **mathematical** expressions by using **principles of science** for solving **engineering** problems.	**3**
CO 6	**PO 1**	**Relate** the importance of adsorption techniques, chromatography for separating the components of a reaction mixture by applying **mathematical** expressions by using **principles of science** for solving **engineering** problems.	**3**

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	1	5	3	3	12	5	12	12	2	2	2
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	2	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

Course Outcomes	Program Outcomes / No. of key competencies												PSOs / No. of key competencies		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	3	10	10	11	1	5	3	3	12	5	12	12	2	1	2
CO 1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	20.0	-	-	-	-	66.6	-	-	-	-	-	-	-	-
CO 3	100	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100		-	-	-	-	-	-	-	-	-	-	-	-	-

XIV. COURSE ARTICULATION MATRIX (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 – **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												Program Specific Outcomes		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	-	-	-	-	3	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	4	-	-	-	-	-	-	-	-	-	-	-	-	-
AVERAGE	**3**	**1**	-	-	-	-	**3**	-	-	-	-	-	-	-	-

XV. ASSESSMENT METHODOLOGY - DIRECT

CIE Exams	PO 1,PO 2 PO 7	SEE Exams	PO 1,PO 2 PO 7	Assignments	-	Seminars	-
Laboratory Practices	PO 1,PO 2 PO 7	Student Viva	PO 1,PO 2 PO 7	Mini Project	-	Certification	-
Term Paper	--						

XVI. ASSESSMENT METHODOLOGY - INDIRECT

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

XVII. SYLLABUS

LIST OF EXPERIMENTS	
Week-1	**PREPARATIONS OF ORGANIC COMPOUNDS**
Synthesis of Aspirin	
Week-2	**VOLUMETRIC ANALYSIS**
Determination of total hardness of water by complexometric method using EDTA	
Week-3	**CONDUCTOMETRIC TITRATIONS**
Estimation of an HCl by conductometric titrations.	

Week-4	**POTENTIOMETRIC TITRATIONS**
Estimation of HCl by potentiometric titrations.	
Week-5	**CONDUCTOMETRIC TITRATIONS**
Estimation of Acetic acid by Conductometric titrations.	
Week-6	**POTENTIOMETRIC TITRATIONS**
Estimation of Fe^{2+} by Potentiometry using $KMnO_4$ titrations.	
Week-7	**PHYSICAL PROPERTIES**
Determination of surface tension of a given liquid using stalagmometer.	
Week-8	**PHYSICAL PROPERTIES**
Determination of viscosity of castor oil and ground nut oil by using Ostwald's viscometer	
Week-9	**VOLUMETRIC ANALYSIS OF ARGENTOMETRY**
Determination of chloride content of water by Argentometry.	
Week-10	**CHEMICAL KINETICS**
Determination of rate constant of acid catalyzed hydrolysis of methyl acetate.	
WeeK-11	**ADSORPTION TECHNICS**
Verification of freundlich adsorption isotherm-adsorption of acetic acid on charcoal	
Week-12	**CHROMOGRAPHY TECHNICS**
Thin layer chromatography calculation of R_f values.	
Text Books:	
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.	
Web References:	
1. http://www.iare.ac.in 2. https://en.wikipedia.org/wiki/Chemistry	

XVIII. COURSE PLAN:

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

Week No	Topics to be covered	Course Outcomes	Text (T) book / Reference (R) book
1	Synthesis of Aspirin	CO1	R1,R2
2	Determination of total hardness of water by complexometric method using EDTA	CO 2	R1,R2
3	Estimation of an HCl by conductometric titrations.	CO 3	R1,R2
4	Estimation of HCl by potentiometric titrations.	CO 3	R1,R2
5	Estimation of Acetic acid by Conductometric titrations.	CO 3	R1,R2
6	Estimation of Fe^{2+} by Potentiometry using $KMnO_4$ titrations.	CO 3	R1,R2
7	Determination of surface tension of a given liquid using stalagmometer.	CO 4	R1,R2
8	Determination of viscosity of castor oil and ground nut oil by using Ostwald's viscometer	CO 4	R1,R2
9	Determination of chloride content of water by Argentometry.	CO 2	R1,R2
10	Determination of rate constant of acid catalyzed hydrolysis of methyl acetate.	CO 5	R1,R2
11	Verification of freundlich adsorption isotherm-adsorption of acetic acid on charcoal	CO 6	R1,R2
12	Thin layer chromatography calculation of R_f values.	CO 6	R1,R2

Prepared by:
Mr.G Mahesh Kumar, Assistant Professor **HOD, EEE**

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS 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.

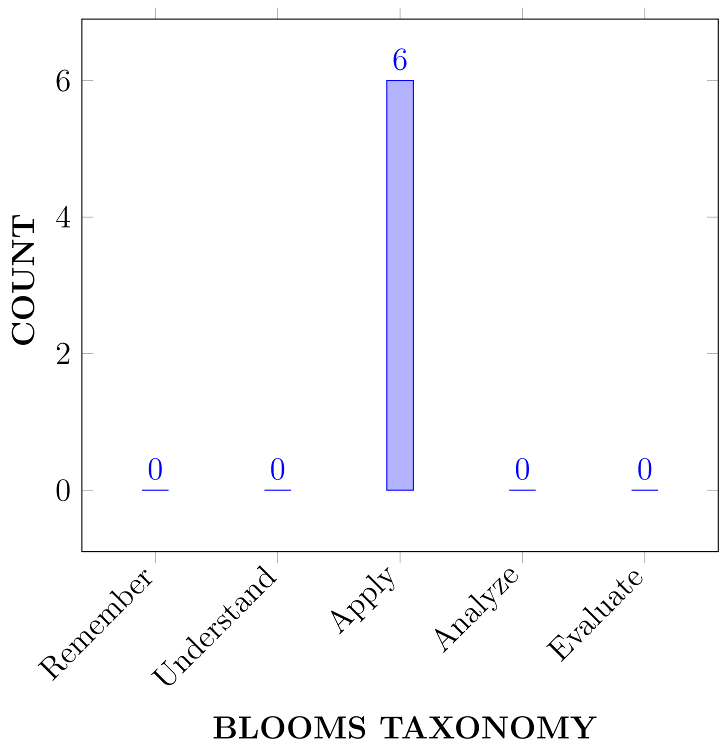
III	The transformation of ordinary differential equations in Laplace field and its applications
IV	The partial differential equation for solving non-linear equations

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	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	2	Seminar/ Conferences/ Research Papers
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	-	-
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.	-	-

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≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ 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

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION

Course Title	**WAVES AND OPTICS**				
Course Code	AHSB04				
Program	B.Tech				
Semester	II	EEE/CE			
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:

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 below.

Percentage of Cognitive Level	Blooms Taxonomy Level
0 %	Remember
60 %	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) and 10 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 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 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:

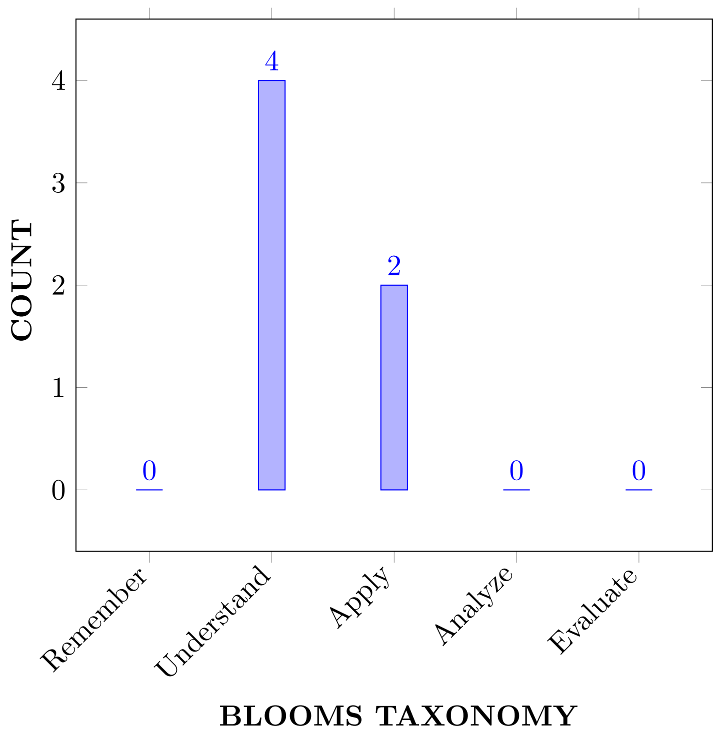
I	Basic formulations in wave mechanics for the evolution of energy levels and quantization of energies for a particle in a potential box with the help of mathematical description.
II	Fundamental properties of semiconductors including the band gap, charge carrier concentration, doping and charge carrier 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.	Apply
CO 2	**Demonstrate** the classification of solids and important aspects of semiconductors in terms of carrier concentration and Fermi level.	Understand
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.
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/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/AAT/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	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	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
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
	PSO 1	**Make use of** the knowledge of **charge transport mechanism** in semiconductors **to build Electrical systems**.	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
	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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	4	-	2	-	-	-	-	-	-	-	-	1	-	-
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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	40	-	18	-	-	-	-	-	-	-	-	35	-	-
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	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	1	-	-	-	-	-	-	-	-	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	**COMPUTER SCIENCE AND ENGINEERING**					
Course Title	PROGRAMMING FOR PROBLEM SOLVING USING C					
Course Code	ACSB01					
Program	B.Tech					
Semester	II					
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:

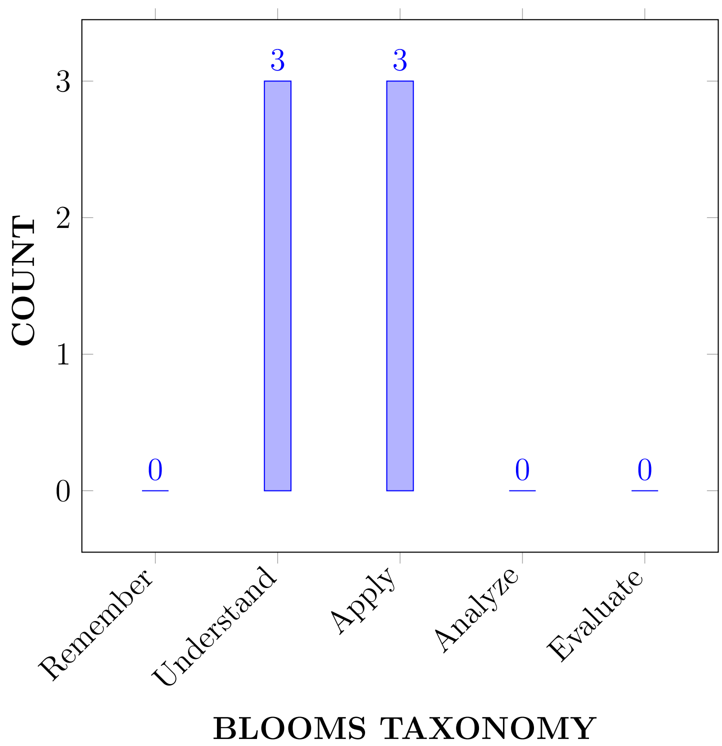
I	Learn adequate knowledge by problem solving techniques.
II	Understand programming skills using the fundamentals and basics of C Language.
III	Improve problem solving skills using arrays, strings, and functions.
IV	Understand the dynamics of memory by pointers.
V	Study files creation process with access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

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

COMPUTER SCIENCE AND ENGINEERING

COURSE DESCRIPTION

Course Title	**PROGRAMMING FOR PROBLEM SOLVING LABORATORY**				
Course Code	ACSB02				
Program	B.Tech				
Semester	II	CSE |IT |ECE |EEE |MECH |AERO			
Course Type Regulation	Foundation IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. P 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	I	-

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:

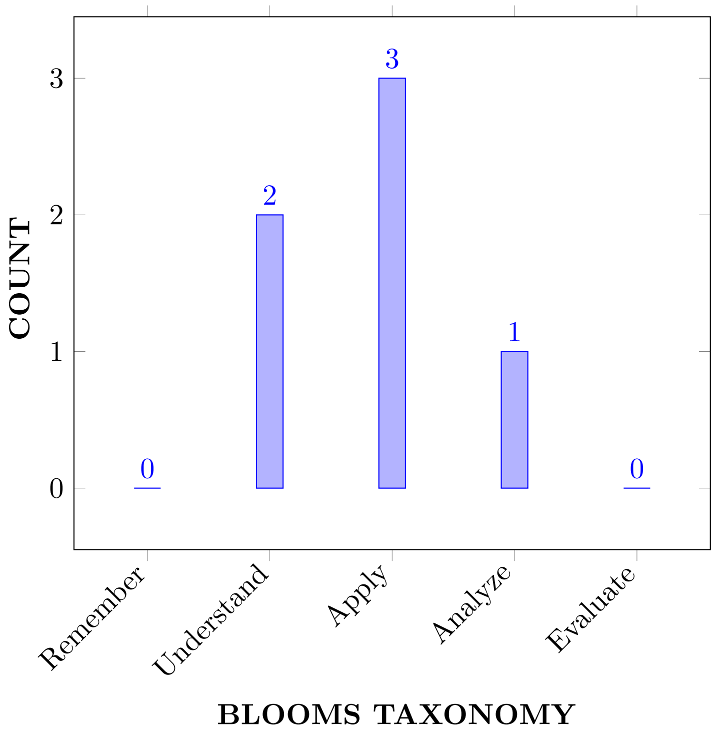
I	The hands on experience in design, develop, implementation and evaluation by using Asymptotic notation.
II	The demonstration knowledge of basic abstract data types (ADT) and associated algorithms for organizing programs into modules using criteria that are based on the data structures of the program.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

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

COURSE OUTCOMES	PROGRAM OUTCOMES				
	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	4	2	
CO 2	3	4	5	2	
CO 3	3	3	4	2	3
CO 4	3	3	3	2	2
CO 5	2	4	5	4	2
CO 6	3	5	3	3	2

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, ,PO 2, PO 3, PSO 1	SEE Exams	PO 1,PO 3, PO 5, PSO 1	Seminars	-
Laboratory Practices	PO 1,PO 2, PO 3, PO 5,PO 10, PSO 1	Student Viva	PO 1, PO 5	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**OPERATORS AND EVALUATION OF EXPRESSIONS**
	a. Write a C program to check whether a number is even or odd using ternary operator. b. Write a C program to perform the addition of two numbers without using + operator. c. Write a C program to evaluate the arithmetic expression ((a + b / c * d - e) * (f - g)). Read the values a, b, c, d, e, f, g from the standard input device. d. Write a C program to find the sum of individual digits of a 3 digit number. e. Write a C program to read the values of x and y and print the results of the following expressions in one line: i. (x + y) / (x - y) ii. (x + y)(x - y)
WEEK II	**CONTROL STRUCTURES**
	a. Write a C program to find the sum of individual digits of a positive integer. b. A Fibonacci sequence is defined as follows: The first and second terms in the sequence are 0 and 1.Subsequent terms are found by adding the preceding two terms in the sequence. Write a C program to generate the first n terms of the sequence. c. Write a C program to generate all the prime numbers between 1 and n, where n is a value supplied by the user. d. A character is entered through keyboard. Write a C program to determine whether the character entered is a capital letter, a small case letter, a digit or a special symbol using if- else and switch case. The following table shows the range of ASCII values for various characters. Characters ASCII values A – Z 65 – 90 a – z 97 – 122 0 – 9 48 – 57 Special symbols 0 – 47, 58 – 64, 91 – 96, 123 – 127 If cost price and selling price of an item is input through the keyboard, write a program to determine whether the seller has made profit or incurred loss. Write a C program to determine how much profit or loss incurred in percentage.
WEEK III	**CONTROL STRUCTURES**
	a. Write a C program to find the roots of a quadratic equation. d. Write a C program to check whether a given 3 digit number is Armstrong number or not. e. Write a C program to print the numbers in triangular form 1 1 2 1 2 3
WEEK IV	**ARRAYS**
	a. Write a C program to find the second largest integer in a list of integers. b. Write a C program to perform the following: i. Addition of two matrices ii. Multiplication of two matrices c. Write a C program to count and display positive, negative, odd and even numbers in an array. d. Write a C program to merge two sorted arrays into another array in a sorted order. e. Write a C program to find the frequency of a particular number in a list of integer.
WEEK V	**STRINGS**

	a. Write a C program that uses functions to perform the following operations: i. To insert a sub string into a given main string from a given position. ii. To delete n characters from a given position in a given string. b. Write a C program to determine if the given string is a palindrome or not. c. Write a C program to find a string within a sentence and replace it with another string. d. Write a C program that reads a line of text and counts all occurrence of a particular word. e. Write a C program that displays the position or index in the string S where the string T begins, or 1 if S doesn't contain T. .
WEEK VI	**FUNCTIONS**
	a. Write C programs that use both recursive and non-recursive functions i. To find the factorial of a given integer. ii. To find the greatest common divisor of two given integers. b. Write C programs that use both recursive and non-recursive functions i. To print Fibonacci series. ii. To solve towers of Hanoi problem. c. Write a C program to print the transpose of a given matrix using function. d. Write a C program that uses a function to reverse a given string. .
WEEK VII	**POINTERS**
	a. Write a C program to concatenate two strings using pointers. b. Write a C program to find the length of string using pointers. c. Write a C program to compare two strings using pointers. d. Write a C program to copy a string from source to destination using pointers. e. Write a C program to reverse a string using pointers. .
WEEK VIII	**STRUCTURES AND UNIONS**
	a. Write a C program that uses functions to perform the following operations: i. Reading a complex number ii. Writing a complex number iii. Addition and subtraction of two complex numbers iv. Multiplication of two complex numbers. Note: represent complex number using a structure. b. Write a C program to compute the monthly pay of 100 employees using each employee's name, basic pay. Print the employees name and gross salary. c. Create a Book structure containing book id, title, author name and price. Write a C program to pass a structure as a function argument and print the book details. d. Create a union containing 6 strings: name, home address, hostel address, city, state and zip. Write a C program to display your present address. e. Write a C program to define a structure named DOB, which contains name, day, month and year. Using the concept of nested structures display your name and date of birth. .
WEEK IX	**ADDITIONAL PROGRAMS**

	a. Write a C program to read in two numbers, x and n, and then compute the sum of this geometric progression: 1+x+x2+x3+... +xn . For example: if n is 3 and x is 5, then the program computes1+5+25+125. Print x, n, the sum. Perform error checking. For example, the formula does not make sense for negative exponents if n is less than 0. Have your program print an error message if n¡0, then go back and read in the next pair of numbers of without computing the sum. Are any values of x also illegal? If so, test for them too. b. 2s complement of a number is obtained by scanning it from right to left and complementing all the bits after the first appearance of a 1. Thus 2's complement of 11100 is 00100. Write a C program to find the2 s complement of a binary number. c. Write a C program to convert a Roman numeral to its decimal equivalent. E.g. Roman number CD is equivalent to 400. .
WEEK X	**PREPROCESSOR DIRECTIVES**
	a. Define a macro with one parameter to compute the volume of a sphere. Write a C program using this macro to compute the volume for spheres of radius 5, 10 and 15 meters. b. Define a macro that receives an array and the number of elements in the array as arguments. Write a C program for using this macro to print the elements of the array. c. Write symbolic constants for the binary arithmetic operators +, -, *, and /. Write a C program to illustrate the use of these symbolic constants.
WEEK XI	**FILES**
	a. Write a C program to display the contents of a file. b. Write a C program to copy the contents of one file to another. c. Write a C program to reverse the first n characters in a file, where n is given by the user. d. Two files DATA1 and DATA2 contain sorted lists of integers. Write a C program to merge the contents of two files into a third file DATA i.e., the contents of the first file followed by those of the second are put in the third file. e. Write a C program to count the no. of characters present in the file
WEEK XII	**COMMAND LINE ARGUMENTS**
	a. Write a C program to read arguments at the command line and display it. b. Write a C program to read two numbers at the command line and perform arithmetic operations on it. c. Write a C program to read a file name at the command line and display its contents.

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

COMPUTER SCIENCE AND ENGINEERING

COURSE DESCRIPTION

Course Title	**ENGINEERING PHYSICS LABORATORY**				
Course Code	AHSB10				
Program	B.Tech				
Semester	II	CSE			
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:

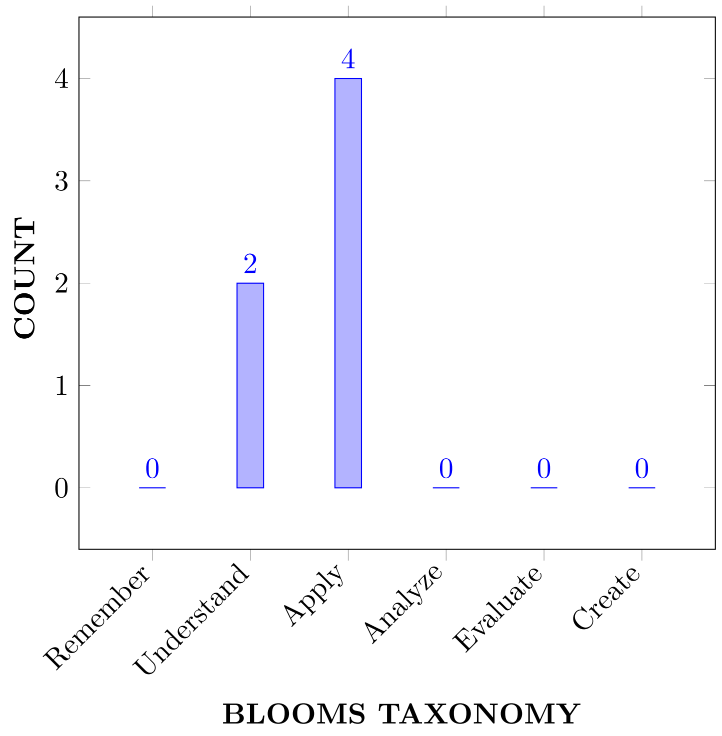
I	To familiarize with the lab facilities, equipment, standard operating procedures.
II	About the different kinds of functional electric and magnetic materials which paves a way for them to use in various technical and engineering applications.
III	The analytical techniques and graphical analysis to study 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 **HOD,CSE**
Mr.K Saibaba, Assistant Professor

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

COURSE DESCRIPTION

<table>
<tr><td>Department</td><td colspan="5">Electrical and Electronics Engineering</td></tr>
<tr><td>Course Title</td><td colspan="5">Network Analysis</td></tr>
<tr><td>Course Code</td><td colspan="5">AEEB09</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td colspan="5">III</td></tr>
<tr><td>Course Type</td><td colspan="5">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>1</td><td>4</td><td>3</td><td>2</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Dr. D Shobha Rani, Professor, EEE</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHB02	I	Linear Algebra and Ordinary Differential Equations
B.Tech	AHSB11	II	Mathematical Transform Techniques
B.Tech	AEEB02	II	Electrical Circuits

II COURSE OVERVIEW:

This course introduces the basic concepts of net work theory which is the foundation for all subjects of the electrical engineering discipline. The emphasis of this course is laid on the basic analysis of circuits which includes three phase circuits, transient analysis of DC and AC circuits, network functions, and two port net work parameters, Fourier analysis of AC circuits, design and analysis of filters.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Network Analysis	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

<table>
<tr><td>✓</td><td>Power Point Presentations</td><td>✓</td><td>Chalk & Talk</td><td>✓</td><td>Assignments</td><td>x</td><td>MOOC</td></tr>
<tr><td>x</td><td>Open Ended Experiments</td><td>x</td><td>Seminars</td><td>x</td><td>Mini Project</td><td>x</td><td>Videos</td></tr>
<tr><td>x</td><td colspan="7">Others</td></tr>
</table>

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
66.66 %	Understand
33.3 %	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
50%	50%	-

VI COURSE OBJECTIVES:

The students will try to learn:

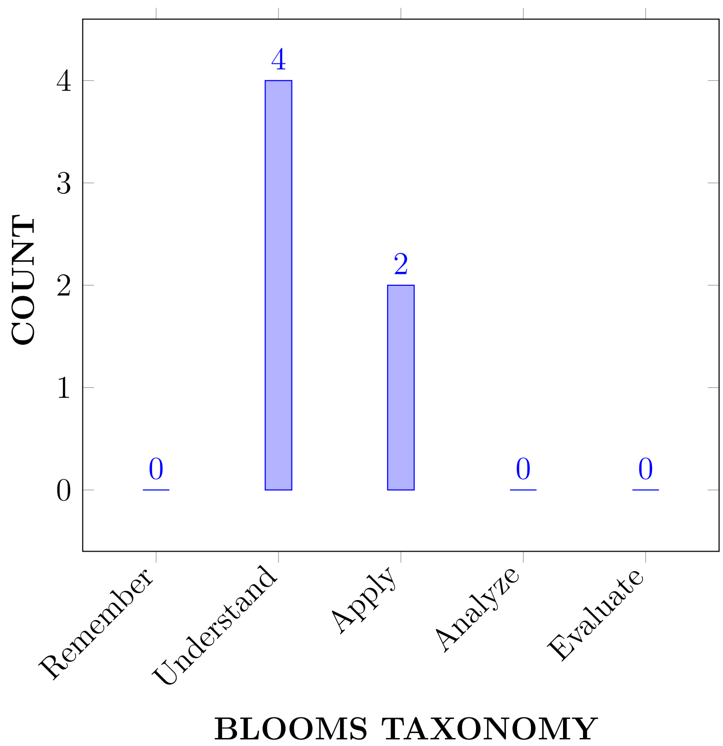
I	Analyse three phase star and delta connected circuits to calculate the active and reactive power.
II	Understand the transient response of series and parallel RL, RC and RLC circuits for DC and AC excitations.
III	Discuss the concepts of locus diagram, network functions and to calculate the two port network parameters.
IV	Design different types of filters and perform the digital simulation of electric circuits.

VII COURSE OUTCOMES:

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

CO 1	**Understand** the relation between line and phase quantities of three phase star and delta connected systems to analyze balanced and unbalancedcircuits.	Understand
CO 2	**Demonstrate** the operation of wattmeter to measure the three-phase active and reactive power in three phase systems.	Understand
CO 3	**Understand** the concept of initial conditions of RLC elements to determine the transient response of first and second order electric circuits using differential equation approach and Laplacetransform technique.	Understand
CO 4	**Illustrate** the locus diagram for series and parallel circuits and describe the network functions in time domain and frequency domain approach.	Understand
CO 5	**Solve** the various two port network parameters and determine their inter relationships,outline the concepts of interconnections of two port networks.	Apply
CO 6	**Develop** the various types of active filters and understand their characteristics, execute digital simulation using MATLAB.	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	AAT/CIE/SEE

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	AAT/CIE/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	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 the engineering sciences** to understand sline and phase quantities of three phase star and delta connected systems	3
CO 2	PO 1	**Recall the engineering sciences** to understand three-phase active and reactive power in three phase systems	3
	PO 2	Develop the equation for measure the three-phase active and reactive power in three phase systems with help of basic mathematics and engineering sciences.	2
CO 3	PO 1	**Recall the engineering sciences** to understand the concept of initial conditions of RLC elements to determine the transient response	3
	PO 2	Develop the solutions for initial conditions of RLC elements to determine the transient response of first and second order electric circuits with help of basic mathematics and engineering sciences.	2
CO 4	PO 1	**Recall the engineering sciences** to understand locus diagram for series and parallel circuits	3
	PO 2	Develop the the network functions in time domain and frequency domain approach using which complex engineering problems can be solved with help of basic mathematics and engineering sciences.	2
	PSO 2	Understand the locus diagram for series and parallel circuits	1
CO 5	PO 1	**Recall the engineering sciences** to understand the concepts of interconnections of two port networks.	3
	PSO 2	Understand the various two port network parameters and their inter relationships	1
CO 6	PO 1	**Recall the engineering sciences** to understand the filter characteristics	3
	PO 2	Develop the various types of active filters using which complex engineering problems can be solved with help of basic mathematics and engineering sciences.	2
	PSO 2	Understand the active filters characteristics, execute digital simulation using MATLAB	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	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	50	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	50	-	-		-	-	-	-	-	-		-	50	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	50	-
CO 6	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	-	-	-	-	-	-	-	-	-	-	-	-	-	
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-
TOTAL	18	8	-	-	-	-	-	-	-	-	-	-	-	6	-
AVERAGE	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback
-	Assessment of activities/Modelling and Experimental Tools in Engineering by Experts		

XVIII SYLLABUS:

MODULE I	**THREE PHASE CIRCUITS**
	Three phase circuits: Star and delta connections, phase sequence, relation between line and phase voltages and currents in balanced systems(both Y), three phase three wire and three phase four wire systems, analysis of balanced and unbalanced three phase circuits, measurement of active and reactive power.
MODULE II	**SOLUTION OF FIRST AND SECOND ORDER NETWORKS**
	Transient response: Initial conditions, transient response of RL, RC and RLC series and parallel circuits with DC and AC excitations, differential equation and Laplace transform approach
MODULE III	**LOCUS DIAGRAMS AND NETWORKS FUNCTIONS**
	Locus diagrams: Locus diagrams of RL, RC, RLC circuits; Network Functions: The concept of complex frequency, physical interpretation, transform impedance, series and parallel combination of elements, terminal ports, network functions for one port and two port networks, poles and zeros of network functions, significance of poles and zeros, properties of driving point functions and transfer functions, necessary conditions for driving point functions and transfer functions, time domain response from pole-zero plot.
MODULE IV	**TWO PORTNETWORK PARAMETERS**
	Two port network parameters: Z, Y, ABCD, hybrid and inverse hybrid parameters, conditions for symmetry and reciprocity, inter relationships of different parameters, interconnection (series, parallel and cascade) of two port networks, image parameters
MODULE V	**FILTERS**
	Filters: Classification of filters, filter networks, classification of pass band and stop band, characteristic impedance in the pass and stop bands, constant-k low pass filter, high pass filter, m-derived T-section, band pass filter and band elimination filter.

TEXTBOOKS

1. A Chakrabarthy, “Electric Circuits”, Dhanpat Rai Sons, 6th Edition, 2010.

2. A Sudhakar, Shyammohan S Palli, “Circuits and Networks”, Tata McGraw-Hill, 4th Edition, 2010

3. M E Van Valkenberg, “Network Analysis”, PHI, 3rd Edition, 2014.

4. Rudrapratap, “Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers”, Oxford University Press, 1st Edition, 1999.

REFERENCE BOOKS:

1. John Bird, “Electrical Circuit Theory and technology”, Newnes, 2nd Edition, 2003

2. C L Wadhwa, “Electrical Circuit Analysis including Passive Network Synthesis”, New Age International, 2nd Edition, 2009.

3. David A Bell, “Electric Circuits”, Oxford University Press, 7th Edition, 2009.

WEB REFERENCES:

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

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courses/electrical-and-electronics-engineering-autonomous/network-analysis

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			
0	OBE DISCUSSION		
CONTENT DELIVERY (THEORY)			
1	Interpret three phase circuits, its generation and connections.	CO 1	T2:9.3 R1:19.1
2	Discriminate three phase circuits when connected in star and delta.	CO 1	T2: 9.6 R2:19.4
3	Analyze the three phase loads	CO 1	T2: 9.7 R2:19.5
4	Discuss voltage and current of three phase unbalanced loads.	CO 1	T2: 9.10 R2:19.6
5	Determine the active power in a three phase circuit and the effect of power factor on Wattmeter readings.	CO 1	T2: 9.11 R2:19.8
6	Determine the reactive power in a three phase circuit	CO 1	T2: 9.11 R2:19.8
7	Observe the Transient behavior of R, L and C elements in a circuit.	CO 2	T2 - 11.1 R2 :17.1
8	Compute initial conditions and time response for current and voltage in first order R-L and R-C circuits	CO 2	T2 :11.2 R2 :17.3
9	Analyze and solve problems on complicated RC and RL circuits	CO 2	T2 :11.2 R2:17.12
10	Describe the AC Transient analysis of a series RC, RL circuits	CO 2	T2:11.5 R2:17.5
11	Analyze Transient behavior of a series RLC circuits to AC excitation	CO 2	T2 - 11.7 R2:17.6
12	Analyze the Transients using Laplace transform method	CO 2	T2 :11.7 R2:17.10
13	Discuss the concepts of locus diagram	CO 3	T2 – 8.13 R2:15.12
14	Learn about complex frequency	CO 3	T2 – 15.1 R2:15.1
15	Design Transform Impedance and Transform Circuits	CO 3	T2 – 15.3 R2:15.1

16	Learn terminal pairs or ports	CO 3	T2 – 15.5 R2:15.1
17	Study the significance of poles and zeros	CO 3	T2 – 15.8 R2:15.1
18	Understand the properties of Transfer functions, Necessary conditions for driving point functions	CO 3	T2 :15.14 R2:15.1
19	Study the Necessary conditions for transfer functions, time domain response from pole zero plot	CO 3	T2 :15.14 R2:15.1
20	Discuss about network parameters	CO 4	T1 :13.6 R2:16.3
21	Obtain Z parameters and Y parameters	CO 4	T1 :13.6 R2:16.4
22	Analyze problems on Z and Y parameters	CO 4	T1 :13.9 R2:16.5
23	Design h parameters and ABCD parameters	CO 4	T1 :13.6
24	Analyze problems on h and ABCD parameters	CO 4	T1 :13.6 R2:16.7
25	Interrelate Z, Y, H , T parameters	CO 4	T1 :13.7 R2:16.8
26-28	Study the Cascade, series, parallel connection of Networks	CO 4	T1 :13.14 R2:16.9
28	Understand the Low Pass filter characteristics and design	CO 5	T1: 18.6 R2:19.12
29	Design the High Pass filter and study its characteristics	CO 5	T1 :18.8 R2:19.2
30	Analyze and Design Band Pass filter	CO 5	T1 :18.8 R2:19.3
31-32	Understand the characteristics of Band Elimination filter	CO 5	T1 :18.14 R2:19.4
33	Design of Active filters	CO 5	T1 :18.17 R2:19.3
34-37	Observe the simulation of RL,RC,RLC circuits	CO 5	T2 :11.7 R2:14.3
38-40	Demonstrate different properties of Fourier transforms	CO 5	T2 :12.1 R2:14.5
PROBLEM SOLVING/ CASE STUDIES			
41	Analyze the three phase loads	CO 1	T2: 9.7 R2:19.5
42	Discuss voltage and current of three phase unbalanced loads.	CO 1	T2: 9.10 R2:19.6
43	Determine the active power in a three phase circuit and the effect of power factor on Wattmeter readings.	CO 1	T2: 9.11 R2:19.8
44	Compute initial conditions and time response for current and voltage in first order R-L and R-C circuits	CO 2	T2 :11.2 R2 :17.3
45	Analyze and solve problems on complicated RC and RL circuits	CO 2	T2 :11.2 R2:17.12
46	Describe the AC Transient analysis of a series RC, RL circuits	CO 2	T2:11.5 R2:17.5

47	Design Transform Impedance and Transform Circuits	CO 3	T2 – 15.3 R2:15.1
48	Learn terminal pairs or ports	CO 3	T2 – 15.5 R2:15.1
49	Study the significance of poles and zeros	CO 3	T2 – 15.8 R2:15.1
50	Analyze problems on h and ABCD parameters	CO 4	T1 :13.6 R2:16.7
51	Interrelate Z, Y, H , T parameters	CO 4	T1 :13.7 R2:16.8
52	Study the Cascade, series, parallel connection of Networks	CO 4	T1 :13.14 R2:16.9
53	Design the High Pass filter and study its characteristics	CO 5	T1 :18.8 R2:19.2
54	Analyze and Design Band Pass filter	CO 5	T1 :18.8 R2:19.3
55	Understand the characteristics of Band Elimination filter	CO 5	T1 :18.14 R2:19.4
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Discriminate three phase circuits when connected in star and delta.	CO 1	T2: 9.6 R2:19.4
57	Observe the Transient behavior of R, L and C elements in a circuit.	CO 2	T2 - 11.1 R2 :17.1
58	Discuss the concepts of locus diagram	CO 3	T2 – 8.13 R2:15.12
59	Obtain Z parameters and Y parameters	CO 4	T1 :13.6 R2:16.4
60	Analyze and Design Band Pass filter	CO 5	T1 :18.8 R2:19.3
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	R4:5.1
4	Module IV	CO 4	T1:7.5
5	Module V	CO 5	T1: 4.1

Signature of Course Coordinator **HOD,EEE**

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**					
Course Title	**Electromagnetic Fields**					
Course Code	AEEB10					
Program	B.Tech					
Semester	III					
Course Type	CORE					
Regulation	R-18					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	1	4	-	-	
Course Coordinator	Dr.Sayanti Chatterjee, Associate Professor					

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC02	I	Linear Algebra Calculus
B.Tech	AHSC03	I	Engineering Physics

II COURSE OVERVIEW:

This course will equip the students with good understanding of underlying principles and laws in electromagnetic fields and waves. The concepts of vector algebra, principles and basic laws of electrostatics, characteristics and properties of conductors and dielectrics, behavior of static magnetic field and application of Ampere's law, determination of force in magnetic field and magnetic potential, concept of time varying fields and propagation of electro-magnetic waves.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
EMF	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
0%	Remember
50 %	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:

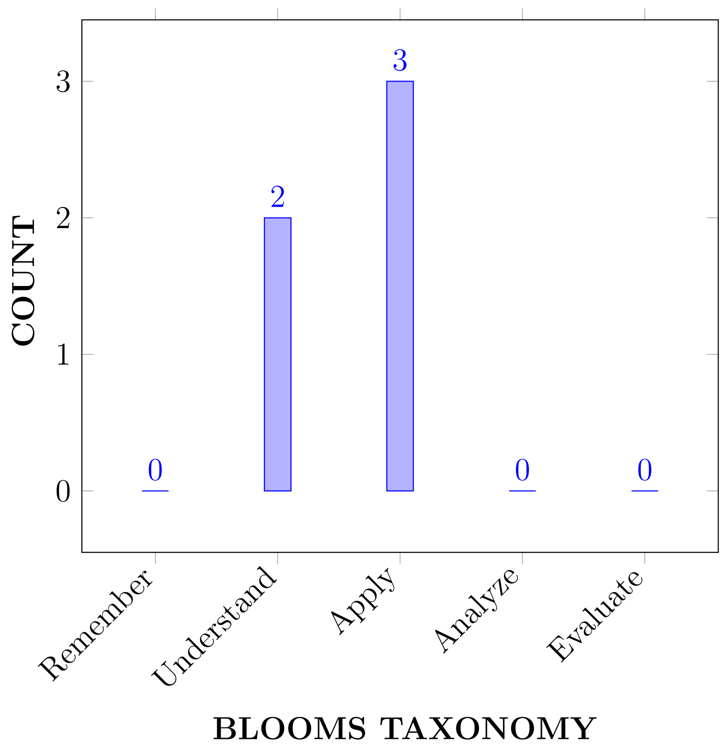
I	The behavior of charge under rest with static electric field in terms of electric field intensity, electric displacement and electric potential.
II	The charge distribution in conductors, dielectrics and condensers.
III	The sources to study the effect of static and dynamic fields in terms of magnetic field intensity, displacement and potential.
IV	The nature of electromagnetic wave propagation in free space, conductors and dielectric materials.

VII COURSE OUTCOMES:

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

CO 1	**Make use of** Vector Calculus, Coulomb's Law and Gauss Law for obtaining electric field intensity, Potential and behavior of electrostatic field	Apply
CO 2	**Calculate** the capacitance of different physical configuration based on the behavior of the conductors and dielectric materials.	Apply
CO 3	**Demonstrate** Biot-Savart law and Ampere circuital law for derivation of magnetic field intensity due to different current carrying conductors.	Understand
CO 4	**Predict** the force due to moving charge/current in the static magnetic field, thereby obtaining the inductance for different configurations of wires and energy stored in the coil	Understand
CO 5	**Apply** the Faraday's law of Electromagnetic induction and Maxwell Equations to produce a wave equation for the free- space, insulators and conductors for propagation of electromagnetic waves.	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 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 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	CIE/Quiz/AAT
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 SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	3	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recollect the basics of matter , types of charge distribution and vector analysis for solving the force and electric field intensity using **the knowledge of mathematics, science, and engineering fundamentals.**	3
	PO 2	Determine the standard expressions for electric filed intensity , torque, Potential due to line, surface and volume charge distributions **to analyze complex engineering problems using principles of mathematics and engineering sciences.**	10
	PO 3	Design the basic electrical components using **principles and laws of electromagnetic to meet the required specifications**	5
	PO 4	Understand the knowledge of electric field and potential **to analyze complex engineering problems using principles of mathematics and engineering sciences for future research.**	2
	PO 10	Students are given teck-talk and concept video **to improve their communication skills towards scientific discussion.**	1
	PO 12	Vector algebra, electromagnetic field and poential helps **in lifelong learning in significant skills.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	Make use of Coloumb's law in structuring the principles of electrostatic instruments using in system for **generation, transmission and distribution of power.**	1
CO 2	PO 1	Understand the behavior of conductors and dielectrics with the **knowledge of mathematics, science and engineering fundamentals** for capacitance calculation.	3
	PO 2	Derive the standard expression for different configured capacitors to **analyse complex engineering problems be framed using basics of mathematics and engineering sciences**	10
	PO 3	Determine capacitance of power system equipments to design electrical components at specifications of **different stages to meet the required**	5
	PO 4	Understand the knowledge of current ,conductor and dielectric **to analyze complex engineering problems using principles of mathematics and engineering sciences for future research.**	8
	PO 10	Students are given teck-talk and concept video **to improve their communication skills towards scientific discussion.**	1
	PO 12	Capacitor, dielectric etc. helps **in lifelong learning in significant skills.**	4
	PSO 1	Recognize the importance of conductors and dielectrics in **generation, transmission and distribution of power.**	1
CO 3	PO 1	**Use the basics of mathematics, science and engineering fundamentals** for obtaining magnetic field intensity and magnetic flux density	3
	PO 2	Standard expressions of magnetic field intensity and density with helps in **solving complex engineering problems.** 7	
	PO 3	Design the characteristics of magnetic field using bio savart and ampere laws which helps in **obtaining the desired specifications of electrical components.**	5
	PO 4	Understand the knowledge of magnetic field intensity and magnetic flux density **to analyze complex engineering problems using principles of mathematics and engineering sciences for future research.**	2
	PO 10	Students are given teck-talk and concept video **to improve their communication skills towards scientific discussion.**	1
	PO 12	characteristics of magnetic field using bio savart and ampere laws which helps in **tin lifelong learning in significant skills.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	Understand the characteristics of magnetic field the structure using **principles of electrical equipment in power systems.**	1
CO 4	PO 1	Type of force due to different configured conductors and their inductances with the help of **basic fundamentals of mathematics science and engineering fundamentals.**	3
	PO 2	Develop the standard expressions of self and mutual inductance for different shaped coils by **identifying different coil configuration**	7
	PO 3	Solve the self and mutual inductance of complex engineering problems **to obtain the desired specifications of electrical component in power system.**	5
	PO 4	Understand the knowledge of magnetic field intensity and magnetic flux density **to analyze complex engineering problems using principles of mathematics and engineering sciences for future research.**	2
	PO 10	Students are given teck-talk and concept video **to improve their communication skills towards scientific discussion.**	1
	PO 12	characteristics of magnetic field using bio savart and ampere laws which helps in **tin lifelong learning in significant skills.**	2
	PSO 1	Summarize the features of coils their by constructing the various **types of windings for required output from electrical machines in power system.**	1
CO 5	PO 1	Make use of expressions obtained during analysis of electrostatics and magneto statics fields their deducing the same for time varying fields using **knowledge of mathematics , science and engineering fundamentals.**	3
	PO 2	Interpret the solution of complex problems on time varying fields and obtain some standard conclusion on properties of time varying fields using **to analyse the behaviour of time varying field**	7
	PO 3	Obtain the standard expressions for electromagnetic wave propagation in free space, insulators and conductors to conclude solution of complex engineering problems to **develop the solutions of different medium**	7
	PO 4	Understand the knowledge of electromagnetic field intensity and magnetic flux density **to analyze complex engineering problems using principles of mathematics and engineering sciences for future research.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 10	Students are given teck-talk and concept video **to improve their communication skills towards scientific discussion.**	1
	PO 12	characteristics of electromagnetic field using Faraday and Maxwell's laws which helps in **tin lifelong learning in significant skills.**	2
	PSO 1	Build the electrical machinery and components based on **Faraday's law of electromagnetic induction, Maxwell's Law and wave propagation, at different modes of power system.**	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	10	5	2	-	-	-	-	-	1	-	2	2	-	-
CO 2	3	10	5	8	-	-	-	-	-	1	-	4	2	-	-
CO 3	3	7	7	6	-	-	-	-	-	1	-	4	2	-	-
CO 4	3	7	5	6	-	-	-	-	-	1	-	4	2	-	-
CO 5	3	7	7	8	-	-	-	-	-	1	-	2	2	-	-
-															

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	100	50	18	-	-	-	-	-	20	-	25	50	-	-
CO 2	100	100	50	72	-	-	-	-	-	20	-	25	50	-	-
CO 3	100	70	70	54	-	-	-	-	-	20	-	50	50	-	-
CO 4	100	70	50	54	-	-	-	-	-	20	-	50	50	-	-
CO 5	100	70	70	80	-	-	-	-	-	20	-	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 - $0 \leq C \leq 5\%$ – 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	1	-	-	-	-	-	1	-	1	2	-	-
CO 2	3	3	2	3	-	-	-	-	-	1	-	2	2	-	-
CO 3	3	3	3	2	-	-	-	-	-	1	-	2	2	-	-
CO 4	3	3	2	2	-	-	-	-	-	1	-	2	2	-	-
CO 5	3	3	3	3	-	-	-	-	-	1	-	1	2	-	-
TOTAL	15	15	12	11	-	-	-	-	-	5	-	8	10	-	-
AVERAGE	3	3	2.4	1.2	-	-	-	-	-	1	-	1.6	2	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1, PO2, PO3 ,PO 4	SEE Exams	PO 1, PO2, PO3 ,PO 4	Seminars	PO 1, PO 2, PO 3 ,PSO 2
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 1, PO2, PO3 ,PO 4	Open Ended Experiments	PSO 1, PSO 2, PSO 3
Assignments					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**ELECTROSTATICS**
	Introduction to Cartesian, cylindrical and spherical co-ordinates. Conversion of one type of coordinates to another; Electrostatic fields: Coulomb's law, electric field intensity due to line and surface charges, work done in moving a point charge in an electrostatic field, electric potential, properties of potential function, potential gradient, Gauss's law, application of Gauss's law, Maxwell's first law, Laplace's and Poisson's equations, solution of Laplace's equation in one variable
MODULE II	**CONDUCTORS AND DIELECTRICS**
	Dipole moment, potential and electric field intensity due to an electric dipole, torque on an electric dipole in an electric field, behavior of conductors in an electric field, electric field inside a dielectric material, polarization, conductor and dielectric, dielectric boundary conditions, capacitance of parallel plate and spherical and coaxial capacitors with composite dielectrics, energy stored and energy density in a static electric field, current density, conduction and convection current densities, Ohm's law in point form, equation of continuity.
MODULE III	**MAGNETOSTATICS**

	Biot-Savart's law, magnetic field intensity, magnetic field intensity due to a straight current carrying filament, magnetic field intensity due to circular, square and solenoid current carrying wire, relation between magnetic flux, magnetic flux density and magnetic field intensity, Maxwell's second equation, div(B)=0. Magnetic field intensity due to an infinite sheet of current and a long current carrying filament, point form of Ampere's circuital law, Maxwell's third equation, Curl (H)=Jc, field due to a circular loop, rectangular and square loops.
MODULE IV	**FORCE IN MAGNETIC FIELD AND MAGNETIC POTENTIAL**
	Moving charges in a magnetic field, Lorentz force equation, force on a current element in a magnetic field, force on a straight and a long current carrying conductor in a magnetic field, force between two straight long and parallel current carrying conductors, magnetic dipole and dipole moment, a differential current loop as a magnetic dipole, torque on a current loop placed in a magnetic field; Vector magnetic potential and its properties, vector magnetic potential due to simple configurations, Poisson's equations, self and mutual inductance, Neumann's formula, determination of selfinductance of a solenoid, toroid and determination of mutual inductance between a straight long wire and a square loop of wire in the same plane, energy stored and density in a magnetic field, characteristics and applications of permanent magnets.
MODULE V	**TIME VARYING FIELDS AND WAVE PROPAGATION**
	Faraday's laws of electromagnetic induction, integral and point forms, Maxwell's fourth equation, statically and dynamically induced EMFs, modification of Maxwell's equations for time varying fields, displacement current. Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in loss dielectrics, Propagation in good conductors, Skin effect. Poynting theorem.

TEXTBOOKS

1. K.B. MadhuSahu, " Eelectromagnetic Fields", Scitech Ltd., 2nd Edition.
2. David J Griffiths, "Introduction to Electrodynamics" Pearson Education Ltd., 4th Edition, 2014.
3. Sunil Bhooshan, "Fundamentals of Engineering Electromagnetics", Oxford University Press, st Edition, 2012.
4. E Kuffel, W S Zaengl, J Kuffel, "High Voltage Engineering Fundamentals", Newnes, 2nd Edition, 2000.

REFERENCE BOOKS:

1. Matthew N O Sadiku, S V Kulkarni, "Principles of Electromagnetics", Oxford University Press,6th Edition, 2015.
2. AS Mahajan , AA Rangwala "Electricity And Magnetism", McGraw Hill Publications, 1st Edition, 2000.
3. MS Naidu, V Kamaraju "High Voltage Engineering", McGraw Hill Publications, 3rd Edition, 2013.

4. William H Hayt, John A Buck, “Problems and Solutions in Electromagnetics”, McGraw Hill Publications, 1st Edition, 2010.

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO’s	Reference T1: 4.1
OBE DISCUSSION			
1			
CONTENT DELIVERY (THEORY)			
1	Introduction to vector algebra	CO1	T1: 1.12, RR4:1.1-1.8
2	Analysis and conversion of different types of co-ordinates	CO1	T1: 2.4-2.5, R2:2.9-3.3
3	Introduction to electro static fields and coulomb’s Law	CO1, CO3	T1:2.16-2.17, R2:2.9-2.10
4	Derive the work done in moving a point charge in an electrostatic field	CO2, CO3	T1:2.13-2.14, R2:2.11
5	State Gauss’s law and application of Gauss’s law.	CO1	T1:2.20-2.21, R2:3.5
6	Deduce Maxwell’s first law.	CO1	T1: 3.1-3.4,R2: 3.7
7	Determine the solution of Laplace’s equation in one variable	CO1	T1:4.1-4.5, R2:4.1,5.1
8	Derive the Laplace’s and Poisson’s equations.	CO2	T1:4.3.2,4, 3.3, R2:5.2
9	Study behavior of conductors in an electric field.	CO2	T2: T1:4.6, R2:5.4
10	Understand electric field inside a dielectric material.	CO2	T1:3.5.2-3.5.5 R2:4.3-4.5
11	Discuss on polarization, conductor and dielectric.	CO2	T1:4.7-4.8 R2:6.1

12	Derive dielectric boundary conditions.	CO2,	T1:4.9-4.10, R2:6.2
13	Calculate capacitance of parallel plate and spherical and coaxial capacitors with composite dielectrics	CO2	T1: 5.4-5.7,R2:7.4
14	Define current density, conduction and convection current densities.	CO2	T1:5.8 R2:7.3
15	Define current density, conduction and convection current densities.	CO2	T1:5.8 R2:7.3
16	Calculation of Electric field intensity due to line and surface charges.	CO3	TT1:6.1-6.5. R2:7.7-7.8
17	Derive the work done in moving a point charge in an electrostatic field.	CO3	T1:6.2 R2:6.3 R2:7.3
18	Introduction to static magnetic fields.	CO3	T1:6.3-6.4 R2:7.8
19	State Biot-Savart's law and magnetic field intensity	CO3	T1:7.5-7.7, R2:8.6
20	Find magnetic field for square and solenoid current carrying wire.	CO4	T1:7.8-7.9, R2:8.6-8.7
21	Relation between magnetic flux, magnetic flux density and magnetic field intensity.	CO3	T1:8.2, R2:7.12-7.13
22	Deduce Maxwell's second equation, div (B)=0.	CO3	T1:8.3-8.4, R2:9.4-9.5
23	State point form of Ampere's circuital law	CO3	T1:8.3-8.8 R2:9.4-9.5
24	Deduce Maxwell's third equation, Curl (H)=Jc	CO3	T1:9.2,9.4 R2:9.1
25	Estimate field due to a circular loop, rectangular and square loops.	CO3	T1:4.1-4.5, R2:4.1,5.1
26	Expression for force due to Moving charges in a magnetic field, Lorentz force equation, magnetic dipole.	CO3	T1:4.3.2,4, 3.3, R2:5.2
27	Define vector magnetic potential and its properties.	CO4	T2: T1:4.6, R2:5.4

28	Explain Poisson's equations, self and mutual inductance.	CO4	T1:3.5.2-3.5.5 R2:4.3-4.5
29	Derive Neumann's formula, determination of self inductance of a solenoid, toroid.	CO4	T1:4.7-4.8 R2:6.1
30	State Faraday's laws of electromagnetic induction.	CO5	T1:4.9-4.10, R2:6.2
31	Deduce integral and point forms.	CO5	T1: 5.4-5.7,R2:7.4
32	Derive Maxwell's fourth equation..	CO5	T1:5.8 R2:7.3
33	Derive , statically and dynamically induced emf.	CO5	T1:5.8 R2:7.3
34	Modification of Maxwell's equations for time varying fields.	CO5	TT1:6.1-6.5. R2:7.7-7.8
35	Define displacement current.	CO 5	T1:6.2 R2:6.3 R2:7.3
36	Analysis of wave equation in phasor form	CO5	T1:6.3-6.4 R2:7.8
37	Behavior of plane waves in homogeneous material.	CO5	T1:7.5-7.7, R2:8.6
38	Explain wave equation in conductors and dielectrics.	CO5	T1:7.8-7.9, R2:8.6-8.7
39	Deducing wave equation in conductors and dielectrics.	CO5	T1:8.2, R2:7.12-7.13
40	State skin effect and derive pointing theorem	CO5	T1:8.3-8.4, R2:9.4-9.5
PROBLEM SOLVING/ CASE STUDIES			
1	Vector Algebra	CO1	T1:3.5.2-3.5.5 R2:4.3-4.5
2	Problem on co ordinate conversion	CO1	T1:3.5.2-3.5.5 R2:4.3-4.5

3	Problem on application of coulomb's law	CO1	T1:3.5.2-3.5.5 R2:4.3-4.5
4	Problems on Field intensity calculation	CO1	T1:3.5.2-3.5.5 R2:4.3-4.5
5	Problems on Electrical potential calculation	CO1	T1:4.1-4.5, R2:4.1,5.1
6	Deduce on Laplace and Poisson's Equation	CO1	T1:4.3.2,4,3.3, R2:5.2
7	Deduce the dipole moment and torque	CO2	T2: T1:4.6, R2:5.4
8	Calculation of capacitance	CO2	T1:3.5.2-3.5.5 R2:4.3-4.5
9	Using Bio-Savart's law find the expression for magnetic field intensity inside a long solenoid carrying current I.	CO2	T1:4.7-4.8 R2:6.1
10	Calculation of energy stored in capacitance	CO2	T1:4.9-4.10, R2:6.2
11	Ampere circuital law for infinitely long current carrying conductor and infinite sheet	CO3	T1: 5.4-5.7,R2:7.4
12	Problems on force calculation of current carrying conductor	CO3	T1:5.8 R2:7.3
13	Problem on self and mutual inductance calculation	CO4	T1:4.204.21, R2:4.5
14	Problems on magnetic dipole moment calculation	CO4	TT1:6.1-6.5. R2:7.7-7.8
15	Problems on emf calculation of time varying field	CO5	T1:6.2 R2:6.3 R2:7.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Co ordinate Point charge, unit vector, field intensity, permittivity of Medium, charge distribution	CO1	T1:1.5-1.7, R2:1.1-1.6
2	Electric Dipole, electric dipole moment, potential and toque due to electric dipole.	CO2	T1:2.1-2.8 R2:3.6-8.7

3	Magnetostatics. Magnetic field, magnetic field intensity permeability of core intensity of magnetization.	CO3	T1:4.5-4.10, R2:3.12-3.13
4	magnetic dipole. magnetic dipole moment. torque due to magnetic dipole.	CO4	T1:6.1-6.5. R2:7.7-7.8
5	Dynamically and statistically induced induced emf., time varying field, total current density, displacement and conduction current density. types of emf induced in coil.	CO5	T1:8.3-8.4, R2:9.4-9.5
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	R4:5.1
4	Module IV	CO 4	T1:7.5
5	Module V	CO 5	T1: 4.1

Signature of Course Coordinator **HOD,EEE**

Dr. Sayanti Chatterjee, Associate Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF(s)
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change **(Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**ANALOG ELECTRONICS**				
Course Code	AECB02				
Program	B.Tech				
Semester	III				
Course Type	CORE				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms.L Babitha,Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB03	II	Electrical Circuits
B.Tech	AHSB04	II	Waves and Optics

II COURSE OVERVIEW:

This course introduces the fundamentals and principles of semiconductor devices and circuits. Apply the characteristics of diodes, bipolar, uni-polar transistors and operational amplifiers for designing rectifiers, clippers, clampers, amplifiers, oscillators and waveform generators. It provides skills for analyzing amplifier circuits using small signal model and hybrid pi model.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Analog Electronics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	x	Seminars	x	Mini Project	✓	Concept 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
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) 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:

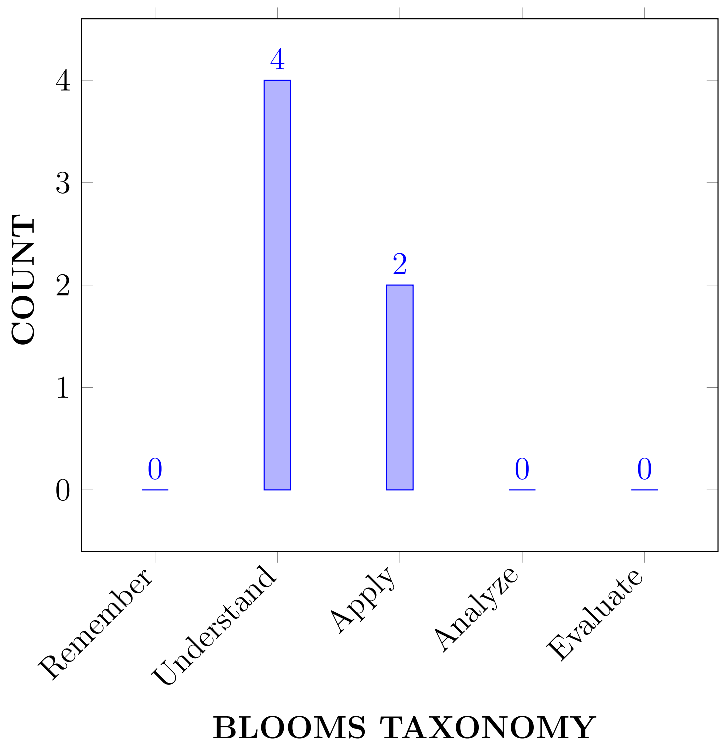
I	The operational principles of analog electronic circuits such as feedback amplifiers and operational amplifiers.
II	The analog circuits fundamental theory to build signal conversion circuits, filter circuits, Data converters and Automatic Gain Control.
III	The analog circuits applications in the advanced fields power electronics such as power factor monitoring circuits, power quality measurement, SMPS and battery controls..

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the principle of operation of pn diode for the diode applications such as rectifiers, clippers, and clampers.	Understand
CO 2	**Illustrate** the principle of operation of bipolar and uni polar transistor for operating in different regions of operation.	Understand
CO 3	**Explain** differential amplifiers and power amplifiers using transistor high frequency model.	Understand
CO 4	**Estimate** feedback amplifiers parameters based on sampling and mixer circuits.	Apply
CO 5	**Calculate** frequency of oscillations for the RC, LC, Hartley and Colpits oscillators.	Apply
CO 6	**Utilize** inverting and non inverting amplifiers as waveform generators and in IC related real time 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		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 modeling to complex engineering activities with an understanding of the limitations.	3	Assignments/ SEE /CIE, AAT, QUIZ
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	4	Assignments/ SEE /CIE, AAT, QUIZ

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz

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	Illustrate**(understand)** the volt ampere characteristics**(knowledge)** of P N diode and identify, formulate**(apply)** to derive mathematical model for diode current, static and dynamic resistance and state a (complex) **problem** to **develop**(apply) solutions to the diode applications such as rectifier ,clipper and clamper for **complex engineering problems** by applying the principles of **mathematics, science to interpret** the result.	3
	PO 2	Understand the given the diode application **problem statement** and finding the **solution implementation** of clipper, clamper and rectifier circuits by **analyzing complex engineering problems.**	4
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling the basic electronic circuits using P-N junction diode by **complex Engineering activities** with an understanding of the limitations.	1
	PO 10	**Describe** the principle of operation of pn diode for the diode applications such as rectifiers, clippers, and clampers **to make effective presentations, and give clear instructions .**	2
	PSO 1	**Demonstrate** and Develop the capability to **analyze and design** simple circuits like electrical systems containing nonlinear elements such as transistors using the concepts of load lines, operating points and incremental anlysis.	1

CO 2	PO 1	**Recall** the concept of transistor operation and **understand** the input and output characteristics of a transistor and **apply** the small signal equivalent model to common emitter, common base and common collector to transistor circuit with the use of the principles of **science to engineering problems.**	3
	PO 10	**Describe** the principle of operation of of bipolar and uni polar transistor for operating in different regions of operation. **to make effective presentations, and give clear instructions .**	2
CO 3	PO 1	Estimate (Knowledge) the characteristic parameters of BJT amplifier circuits for negative feedback amplifiers for **solving complex engineering problems** by applying **mathematics, science and engineering fundamentals.**	3
	PO 10	**Describe** differential amplifiers and power amplifiers using transistor high frequency model **to make effective presentations, and give clear instructions .**	2
CO 4	PO 1	Determine **(understand)** the Common Emitter configuration Hybrid - model to **find** the unity gain bandwidth and gain bandwidth product by principles of **mathematics, science to the solutions of complex engineering problems.**	3
	PO 2	Analyze high frequency signal analysis **problem statements** of BJT, FET amplifier circuits using **mathematics principles.**	6
	PO 10	**Describe** feedback amplifiers parameters based on sampling and mixer circuits **to make effective presentations, and give clear instructions .**	2
CO 5	PO 1	**Recall** and **understand** the amplifier characteristics to **design** (knowledge) the various oscillator circuits for stable operation by applying **mathematics, science and engineering fundamentals for complex engineering problems.**	3
	PO 2	**Design** (knowledge) and **demonstrate**(understand) the various oscillator circuits amplifier circuits and **identify, formulate**(apply) for stable operation to develop solution using appropriate general characteristics in certain areas of communication(problems) by applying **mathematics, science and engineering fundamentals for complex engineering problems.**	6
	PO 10	**Describe** inverting and non inverting amplifiers as waveform generators and in IC related real time applications **to make effective presentations, and give clear instructions .**	2

CO 6	PO 1	**Recall** and **understand** the op-amp characteristics to **analyze** the applications like inverting amplifier, non-inverting amplifier, integrator, differentiator and waveform generators using Op-Amp in **complex problem analysis using mathematics.**	3
	PO 2	**Design** (knowledge) and **demonstrate**(understand) the various operational amplifier circuits and **identify, formulate**(apply) for stable operation to develop solution using appropriate general characteristics in certain areas of communication**(problems)** by applying **mathematics, science and engineering fundamentals for complex engineering problems.**	6
	PO 3	Design solutions for **complex Engineering problems** and **design system components** ofop-amp **applications** that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	5
	PO 5	Create, select, and **apply** appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling the basic electronic circuits using P-N junction diode complex Engineering activities with an understanding of the limitations.	1
	PO 10	**Describe** inverting and non inverting amplifiers as waveform generators and in IC related real time applications **to make effective presentations, and give clear instructions .**	2
	PSO 1	**Demonstrate** and Develop the capability to **analyze and design** simple circuits like electrical systems containing nonlinear elements such as op-amp using the concepts of load lines, operating points and incremental analysis.	1

Note:Refer annexure to check the mapping of program outcomes.

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	1	2	3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	3	4	-	-	1	-	-	-	-	2	-	-	1	-	-
CO 2	3	-	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 4	3	6	-	-	-	-	-	-	-	2	-		-	-	-
CO 5	3	6	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 6	3	6	5	-	1	-	-	-	-	2	-	-	1	-	-

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	40	-	-	100	-	-	-	-	40	-	-	50	-	-
CO 2	100	-	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 4	100	60	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 5	100	60	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 6	100	60	50	-	100	-	-	-	-	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
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	-	-	3	-	-	-	-	2	-		2	-	-
CO 2	3	-	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 4	3	3	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 5	3	3	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 6	3	3	2	-	3	-	-	-	-	2	-	-	2	-	-
TOTAL	18	11	2	-	6	-	-	-	-	12	-	-	4	-	-
AVERAGE	3	1.81	0.33	-	1	-	-	-	-	2	-	-	0.6	-	-

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
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**DIODE CIRCUITS**
	P-N junction diode, I-V characteristics of a diode; review of half-wave and full-wave rectifiers, clamping and clipping circuits. Input output characteristics of BJT in CB, CE, CC configurations, biasing circuits, Load line analysis, common emitter, common base and common collector amplifiers; Small signal equivalent circuits.
MODULE II	**MOSFET CIRCUITS**
	MOSFET structure and I-V characteristics. MOSFET as a switch. small signal equivalent circuits - gain, input and output impedances, small-signal model and common-source, common-gate and common-drain amplifiers, trans conductance, high frequency equivalent circuit.
MODULE III	**MULTI-STAGE AND POWER AMPLIFIERS**
	Classification of Amplifiers, Distortion in amplifiers, Different coupling schemes used in amplifiers, Frequency response and Analysis of multistage amplifiers, Cascade amplifier, Darlington pair. Transistor at High Frequency: Hybrid - model of Common Emitter transistor model, fα, β and unity gain bandwidth, Gain band width product. Differential Amplifiers, Power amplifiers - Class A, Class B, Class C, Class AB.
MODULE IV	**FEEDBACK AMPLIFIERS**
	Concepts of feedback: Classification of feedback amplifiers, general characteristics of Negative feedback amplifiers, effect of feedback on amplifier characteristics, voltage series, voltage shunt, current series and current shunt feedback configurations, simple problems; Oscillators: Condition for Oscillations, RC type Oscillators RC phase shift and Wien-bridge Oscillators, LC type Oscillators, generalized analysis of LC Oscillators, Hartley and Colpitts oscillators.
MODULE V	**OPERATIONAL AMPLIFIERS**
	Ideal op-amp, Output offset voltage, input bias current, input offset current, slew rate, gain bandwidth product, Inverting and non-inverting amplifier, Differentiator, integrator, Square-wave and triangular-wave generators.

TEXTBOOKS

1. Jacob Millman, Christos C Halkias, “Integrated Electronics”, McGraw Hill Education, 2nd Edition 2010.

2. Ramakanth A Gayakwad, “Op-Amps & Linear ICS”, PHI, 1st Edition, 2003.

REFERENCE BOOKS:

1. Electronic Devices – Conventional current version – Thomas L Floyd, 2015, Pearson

2. J Millman and A Grabel, “Microelectronics”, McGraw Hill Education, 1988.
3. P Horowitz and W Hill, “The Art of Electronics”, Cambridge University Press, 1989.
4. P. R Gray, R.G. Meyer and S. Lewis,”Analysis and Design of Analog Integrated Circuits”, John Wiley & Sons, 2001.

WEB REFERENCES:

1. https://www.mdp.eng.cam.ac.uk/web/library/enginfo/electrical/hong1.pdf
2. https://www.archive.org/details/ElectronicDevicesCircuits
3. https://www.nptel.ac.in/courses/webcourse-contents/IIT-ROORKEE/BASICELECTRONICS/home_page.htm
4. http://notes.specworld.in/pdc-pulse-and-digital-circuits/.

E-TEXT BOOKS:

1. https://www.mdp.eng.cam.ac.uk/web/library/enginfo/electrical/hong1.pdf
2. https://nptel.ac.in/courses/122106025
3. http://www.freebookcentre.net/electronics-ebooks-download/Electronic-Devices-and-Circuits-(PDF-313p).html
4. http://www.introni.it/pdf/Millmam-Taub-Pulse and Digital Switching Waveforms 1965.pdf
5. https://www.jntubook.com/pulse-digital-circuits-textbook-free-download/

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	CO 1	T1:4.1
	CONTENT DELIVERY (THEORY)		
1-5	Understand the P-N junction diode-FB & RB using V-I characteristics	CO 1	T2:1.1-1.8, 2.2
6-7	Analysis of half-wave rectifiers-Vac, Irms, PIV, Efficiency, Ripple factor..	CO 1	T2:1.10,
8	Analysis of full-wave rectifiers.	CO 1	T2:2.7
9-10	Analysis of Clipping circuits. Analysis of Clamping circuits.	CO 1	T2:2.8
11-12	Analysis of Input output characteristics of BJT in CB,CE,CC configurations. Design the different biasing circuits- Fixed bias, Emitter follower bias Self bias.	CO 1	T2:2.8
15-16	Understand the Load line analysis. Analysis of CE,CB,CC amplifiers.	CO 2	T2:3.1-3.2
17-18	Design the Small signal equivalent circuits. Understand the MOSFET structure, I-V characteristics, MOSFET as a switch.	CO 2	T2:3.3-3.7

19-21	Determine the gain, input and output impedances. Apply small-signal model to MOSFET.	CO 2	T2:4.2,7.1-7.4
22-25	Apply small-signal model to MOSFET. Analyze the CS,CG and CD amplifiers. Determine the Trans conductance.	CO 2	T2: 7.6 7.7, 8.9-8.10
26-27	Understand the classification of Amplifiers. Understand the distortion in amplifiers.	CO 3	T3:1.1 R3:1.1-1.4
28-30	Analyze the different coupling schemes-Direct coupled Analyze the different coupling schemes- Transformer coupled.	CO 3	T3:1.1-1.2 R3:1.5-1.7
31-32	Analyze the frequency response and Analysis of multistage amplifiers. Analyze the Cascade amplifier.	CO 4	T3:1.3 R3:1.7,7.4
33-35	Analyze the Darlington pair circuit. Analyze the Hybrid -pi model of Common Emitter transistor model, fα, β.	CO 4	T3:3.1-3.4 R3:2.1-2.4
36-37	Analyze the Hybrid - pi model of Common Emitter transistor model, fα, β Understand the unity gain bandwidth, Gain band width product.	CO 5	T3:3.3-3.5 R3:2.6
38-39	Analyze the Differential Amplifiers-DIBO, DIUO, SIBO andSIUO. Analyze the Class A, Class B, Class C , Class AB Power amplifiers.	CO 5	T3:5.1-5.3 R3:2.8,3.7-3.8
40-43	Understand the Concepts of feedback, Classification of feedback amplifiers. Understand the general characteristics of Negative feedback amplifiers. Analyze the effect of feedback on amplifier characteristics Analyze the voltage series, Voltage shunt feedback configuration.	CO 5	T4:5.1.-5.10 R3:3.6
44-45	Analyze the current series and current shunt feedback configurations. Distinguish the constructional features and operation of feedback amplifiers and oscillators.	CO 6	T3:4.4-4.6 T4: 5.11 R3:3.10
46-47	Understand the Condition for Oscillations, RC phase shift Oscillator, Wien-bridge Oscillator. Analyze the Generalized analysis of LC Oscillators, Hartley and Colpitts oscillators	CO 6	T4:6.1,6.4 R3:4.1-4.5
48-49	Understand the concept of Ideal op-amp. Determine the Output offset voltage, input bias current, input offset current, slew rate and gain bandwidth product.	CO 6	T4:6.2-6.3,6.7 R3:4.8,4.11
50-51	Analyze the Inverting and non-inverting amplifier. Analyze the Differentiator and integrator.	CO 6	T4:6.3,6.10 R3:4.9-4.10
52-54	Discuss the classifications of data converters	CO 4	R2:7.5

55	Discuss and Analyze DAC techniques and characteristics.	CO 6	T4:7.1 R3:5.2-5.3
56-58	Discuss and Analyze ADC techniques and characteristics	CO 6	T4:7.2-7.6 R3:5.4-5.5
59-60	classification amplifiers	CO 5	T4:7.7-7.10 R3:5.5
61	feedback amplifiers	CO 4	T4:8.1-8.3 R3:6.1-6.2 R3:5.5
62	design of op amp applications	CO 6	T4:8.4-8.7 R3:6.3-6.5
PROBLEM SOLVING/ CASE STUDIES			
9	Static, dynamic resistances Clampers	CO 1	T1: 1.1
10	Rectifiers	CO 1	R3: 1.7
18	Clippers.	CO 1	T1: 2.1-2.6
19	Clampers	CO 2	T1: 6.1-6.6
30	CE,CC amplifiers.	CO 2	T1: 2.7-2.12
31	CB amplifier.	CO 2	T1: 2.7-2.12
32	CS,CG amplifier	CO 3	T1: 3.7-3.12
42	CD amplifier	CO 4	T1: 7.7-7.12
43	and Transition, diffusion capacitances	CO 5	T3: 1.7
44	Derive the specifications of analog to digital.	CO 5	T3: 1.7
51	Design the programmable logic devices using memories	CO 6	R4: 4.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Diode circuits	CO 1	T1:4.1
57	Transistors	CO 2	T2:4.1
58	Multi stage amplifiers	CO 3	T3:2.1
59	Feedback amplifiers.	CO 4	R4: 4.2
60	Operational amplifiers	CO 5	T2:6.1

DISCUSSION OF QUESTION BANK			
61	Analysis of Transistor.	CO 1	T1:4.1
62	Analysis of Transistor Analysis of amplifiers	CO 2	T2:4.1
63	Analysis of multistage amplifiers.	CO 3	T3:2.1
64	Feedback amplifiers.	CO 5	R4: 4.2
65	Op-amp applications.	CO 6	T2:6.1

Signature of Course Coordinator **HOD,ECE**
Ms. L Babitha, Assistant Professor

ANNEXURE

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4.	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

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).** "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**
PO11	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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO12	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 (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

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INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**DIGITAL ELECTRONICS**				
Course Code	AEC019				
Program	B.Tech				
Semester	FOUR				
Course Type	CORE				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms.V.Bindusree,Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	-	-	-

II COURSE OVERVIEW:

This course intended to logic gates, various logic families. Design of digital circuits using logic gates, combinational circuits and sequential circuits. Apply op-amp characteristics to design analog to digital converters and digital to analog converters. Classification and characteristics of memories such as Read-only memory, Random access memory and programmable logic devices such as programmable logic array and programmable array logic.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Digital Electronics	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). 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
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) 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:

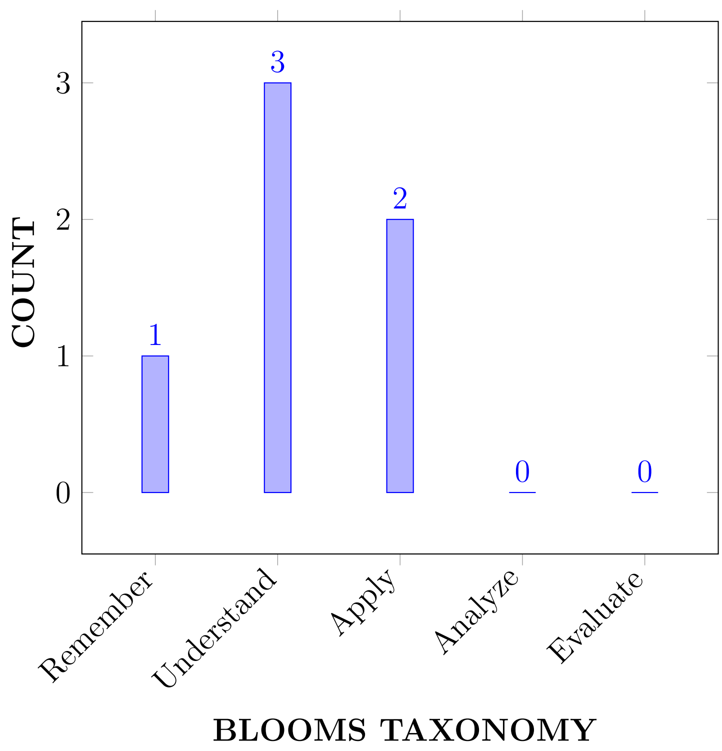
I	The Fundamentals of number systems, Boolean algebra and representation of switching functions using Boolean expressions and their minimization techniques.
II	The combinational and sequential logic circuits to design various complex switching devices, and their realizations.
III	The programmable logic devices, Semiconductor memories and their use in realization of switching functions.
IV	Analog to Digital and Digital to Analog converters applicable in the field of microprocessors, microcontrollers and VLSI

VII COURSE OUTCOMES:

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

CO 1	**Understand** the different forms of number representations and binary codes in digital logic circuits.	Remember
CO 2	**Make use of** Boolean postulates, theorems and k-map for obtaining minimized Boolean expressions.	Apply
CO 3	**Utilize** the functionality and characteristics of flip-flops and latches for designing sequential circuits.	Understand
CO 4	**Construct** the synchronous and asynchronous modules using flip-flops used for memory storing applications.	Apply
CO 5	**Choose** an appropriate A/D and D/A converters for signal processing applications.	Undersatnd
CO 6	**Extend** the knowledge of memories and programmable logic devices for understanding the architectural blocks of FPGA.	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		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	1	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz

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	Understand the number systems, binary addition and subtraction, 2's complement representation and operations, complements of numbers, codes- binary codes, BCD code by applying its **mathematical principles** and **engineering problems.**	2
	PO 2	Illustrate the minimization techniques for **validation** of Boolean expressions apply for basic theorems and properties.	1
	PO 10	Demonstrate the ability to convert the analog signal to digital signal to **communicate** effectively	1
CO 2	PO 1	Demonstrate the design procedures of half and full Adders, subtractors, serial and parallel adders, BCD Adder for fundamental block realization in any processor **complex engineering problems** by applying **mathematical principles**	2
	PO 2	Identify the importance of SOP and POS canonical forms in the **optimization** of conventional Boolean formulas in general and digital circuits	1
	PSO1	Analyze the basic theorems and its properties, switching functions, canonical and standard form by applying its **mathematical models**	1
CO 3	PO 1	Understand the sequential circuits **methodology** and the **principles** of flipflops, latches	2
	PO 2	Identify the bi-stable elements like latches, flip-flop and excitation tables of different flip flops for **implementing** the **memory storage elements.**	2
	PO 3	Design **solutions** for different type of counters using excitation table of flip flops by **applying engineering problems** and design system components.	3
CO 4	PO 1	Implement the bidirectional and universal shift registers using the **principles** of shift registers for organization of data applications **methodology**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Compare the Asynchronous counters using **design** procedure of sequential circuit and excitation tables of flip– flops for **memory harvesting applications**.	2
	PO 3	Design **solutions** for different type of counters using excitation table of flip flops by **applying engineering problems** and design system components.	3
CO 5	PO 1	Understand the **fundamentals** of analog to digital converter and **develop** the **different techniques** of analog to digital converter	3
	PO 2	Design the different techniques of digital to analog converters and **implement** the different specifications of converters.	2
CO 6	PO 1	Design the **solution** of PLA and PLDs and **implement** combinational and sequential logic circuits using PLA and PLDs	2
	PO 3	Design the different memory **techniques** of memories. **memories**	2
	PSO 1	Understand the memory organization and implement the **Fundamental blocks** of CAM, FPGA.	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	-	-	-	-	-	-	-	1	-		-	-	-
CO 2	2	1	-	-	-	-	-	-	-	1	-	-	1	-	-
CO 3	2	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	2	3	-		-	-	-	-	-	-		-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	2	1	-	-	-	-	-	-	-	-		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
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	66.6	10	-	-	-	-	-	-	-	10	-		-	-	-
CO 2	66.6	10	-	-	-	-	-	-	-	10	-	-	100	-	-
CO 3	66.6	20	100	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	20	100	-		-	-	-	-	-	-		-	-	-
CO 5	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.6	20	33.3	-		-	-	-	-	-	-		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 ≤ C≤ 5% – No correlation

1 -5 <C≤ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% ≤ 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	1	-	-	-	-	-	-	-	1	-	-	1	-	-
CO 3	3	1	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	3	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	6	7	-	-	-	-	-	-	-	-	-	1	-	-
AVERAGE	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					

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**FUNDAMENTALS OF DIGITAL SYSTEMS AND LOGICFAMILIES**
	Digital signals, digital circuits, AND, OR, NOT, NAND, NOR and Exclusive-OR operations, Boolean algebra, examples of IC gates, number systems-binary, signed binary, octal hexadecimal number, binary arithmetic, ones and two's complements arithmetic, codes, error detecting and correcting codes, characteristics of digital lCs, digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-state logic

MODULE II	**COMBINATIONAL DIGITAL CIRCUITS**
	Standard representation for logic functions, K-map representation, and simplification of logic functions using Kmap, minimization of logical functions. Dont care conditions, Multiplexer, DeMultiplexer, Decoders, Adders, Sub tractors, BCD arithmetic, carry look ahead adder, serial ladder, ALU, elementary ALU design, popular MSI chips, digital comparator, parity checker/generator, code converters, priority encoders, decoders, drivers for display devices, Q-M method of function realization.
MODULE III	**SEQUENTIAL CIRCUITS AND SYSTEMS**
	1-bit memory, the circuit properties of Bi-stable latch, the clocked SR flip flop, J- K-T and D types flip flops, applications of flip flops, shift registers, applications of shift registers. Serial to parallel converter: Parallel to serial converter, ring counter, sequence generator, ripple (Asynchronous) counters, synchronous counters, counters design using flip flops, special counter IC's, asynchronous sequential counters, applications of counters.
MODULE IV	**A/D AND D/A CONVERTERS**
	Digital to analog converters: weighted resistor, converter, R-2R Ladder D/A converter, specifications for D/A converters, examples of D/A converter lCs, sample and hold circuit, analog to digital converters: quantization and encoding, parallel comparator A/D converter, successive approximation A/D converter, counting A/D converter, dual slope A/D converter, A/D converter using voltage to frequency and voltage to time conversion, specifications of A/D converters, example of A/D converter ICs.
MODULE V	**SEMICONDUCTOR MEMORIES AND PROGRAMMABLE LOGIC DEVICES**
	Memory organization and operation, expanding memory size, classification and characteristics of memories, sequential memory, read only memory (ROM), read and write memory(RAM), content addressable memory (CAM), charge de coupled device memory (CCD), commonly used memory chips, ROM as a PLD, Programmable logic array, Programmable array logic, complex Programmable logic devices (CPLDS), Field Programmable Gate Array (FPGA).

TEXTBOOKS

1. P Jain, "Modern Digital Electronics", McGraw Hill Education, 2009.

2. M M Mano, "Digital logic and Computer design", Pearson Education India, 2016.

REFERENCE BOOKS:

1. A Kumar, "Fundamentals of Digital Circuits", Prentice Hall India, 2016.

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
0	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	CO 1	T1:4.1
CONTENT DELIVERY (THEORY)			
1-5	Understand the need for digital systems, review of number systems, number base conversion	CO 1	T2:1.1-1.8, 2.2
6-7	Complements of numbers, codes-binary codes, BCD code and its Properties.	CO 1	T2:1.10,
8	Unit distance code, alphanumeric codes, and error detecting and correcting codes	CO 1	T2:2.7
9-10	Design and analyze the combinational circuits using TTL/CMOS logic	CO 1	T2:2.8
11-12	Design and analyze the sequential circuits using TTL/CMOS logic.	CO 1	T2:2.8
15-16	SIdentify basic building blocks of digital systems and Minimization using three variables; four variables; five variable K-Maps; Don't Care Conditions.	CO 2	T2:3.1-3.2
17-18	Design functions using universal gates. NAND and NOR Implementation; Other Two-Level Implementation; Exclusive –OR function. .	CO 2	T2:3.3-3.7
19-21	Combinational design, arithmetic circuits- adders, subtractors.	CO 2	T2:4.2,7.1-7.4
22-25	Design different combinational logic circuits comparators Multiplexers,	CO 2	T2: 7.6 7.7, 8.9-8.10
26-27	Demultiplexer, Decoder	CO 3	T3:1.1 R3:1.1-1.4
28-30	Understand the elementary ALU design	CO 3	T3:1.1-1.2 R3:1.5-1.7
31-32	popular MSI chips	CO 4	T3:1.3 R3:1.7,7.4
33-35	Combinational and sequential circuits, the binary cell, the Fundamentals of sequential machine operation.	CO 4	T3:3.1-3.4 R3:2.1-2.4
36-37	Flip-flop	CO 5	T3:3.3-3.5 R3:2.6

38-39	D-Latch Flip-flop.	CO 5	T3:5.1-5.3 R3:2.8,3.7-3.8
40-43	Clocked T Flip-flop.	CO 5	T4:5.1.-5.10 R3:3.6
44-45	Clocked JK Flip-flop.	CO 6	T3:4.4-4.6 T4: 5.11 R3:3.10
46-47	Shift Registers	CO 6	T4:6.1,6.4 R3:4.1-4.5
48-49	Synchronous, Asynchronous Counters	CO 7	T4:6.2-6.3,6.7 R3:4.8,4.11
50-51	Excitation tables of Flip-flops	CO 7	T4:6.3,6.10 R3:4.9-4.10
52-54	Discuss the classifications of data converters	CO 8	R2:7.5
55	Discuss and Analyze DAC techniques and characteristics.	CO 9	T4:7.1 R3:5.2-5.3
56-58	Discuss and Analyze ADC techniques and characteristics	CO 9	T4:7.2-7.6 R3:5.4-5.5
59-60	classification and characteristics of memories, sequential memory, read only memory (ROM), read and write memory (RAM),	CO 10	T4:7.7-7.10 R3:5.5
61	Discuss and analyze PLA, PAL, PLD	CO 11	T4:8.1-8.3 R3:6.1-6.2 R3:5.5
62	FPGA	CO 12	T4:8.4-8.7 R3:6.3-6.5
PROBLEM SOLVING/ CASE STUDIES			
9	Problems on number conversions	CO 1	T1: 1.1
10	Problems on Hamming code	CO 1	R3: 1.7
18	Derive the Boolean theorems and properties.	CO 1	T1: 2.1-2.6
19	Problems on 3 and 4 variable k-maps.	CO 2	T1: 6.1-6.6
30	Design the Decoder,Encoder.	CO 2	T1: 2.7-2.12

31	Design the multplexer and demultiplexer.	CO 2	T1: 2.7-2.12
32	Construct the registers using flipflops	CO 3	T1: 3.7-3.12
42	Design and construct the counters using flipflops.	CO 4	T1: 7.7-7.12
43	Design the analog to digital and digital analog converter	CO 5	T3: 1.7
44	Derive the specifications of analog to digital.	CO 5	T3: 1.7
51	Design the programmable logic devices using memories	CO 6	R4: 4.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Hamming code	CO 1	T1:4.1
57	Multiplexer and demultiplexer	CO 2	T2:4.1
58	Twisted ring counter	CO 3	T3:2.1
59	Analog to digital converter specifications.	CO 4	R4: 4.2
60	Programmable logic devices.	CO 5	T2:6.1
DISCUSSION OF QUESTION BANK			
61	Solve the given 8bit data word 01011011, generate the 12-bit composite word for the hamming code that corrects and detects single errors.	CO 1	T1:4.1
62	implify the following 3 variable expression using Boolean algebra Y = M(3, 5, 7)	CO 2	T2:4.1
63	Explain the working of 2 to 4 decoder and also implement a 2 to 4 decoder using 1 to 2 decoders.	CO 3	T3:2.1
64	Design a synchronous counter using JKFF to count the following sequence 0, 2, 5, 6 undesired states 1,3,4,7must go to 0 on the next clock pulse.	CO 5	R4: 4.2
65	Compare logic families of CMOS,TTL and ECL with their specifications.	CO 6	T2:6.1

Signature of Course Coordinator **HOD,ECE**
Ms.V.Bindusree,Assistant Professor

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Electrical Machines - I**				
Course Code	AEEB11				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	1.5
Course Coordinator	Mr. A Sathish Kumar				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS006	II	Engineering Physics
B.Tech	AEEB10	III	Electrical Circuits

II COURSE OVERVIEW:

This course deals with the basic theory, construction, operation, performance characteristics and application of electromechanical energy conversion devices such as DC generators and motors. It also gives an in-depth knowledge on the operation of single phase and three phase transformers and it's testing. It also focus on the auto transformers, on-load, off-load tap changers which are widely used in real time applications.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
DC Machines and Transformers	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	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
7%	Remember
57%	Understand
14%	Apply
21 %	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	-	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.

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
50%	50%	-

VI COURSE OBJECTIVES:

The students will try to learn:

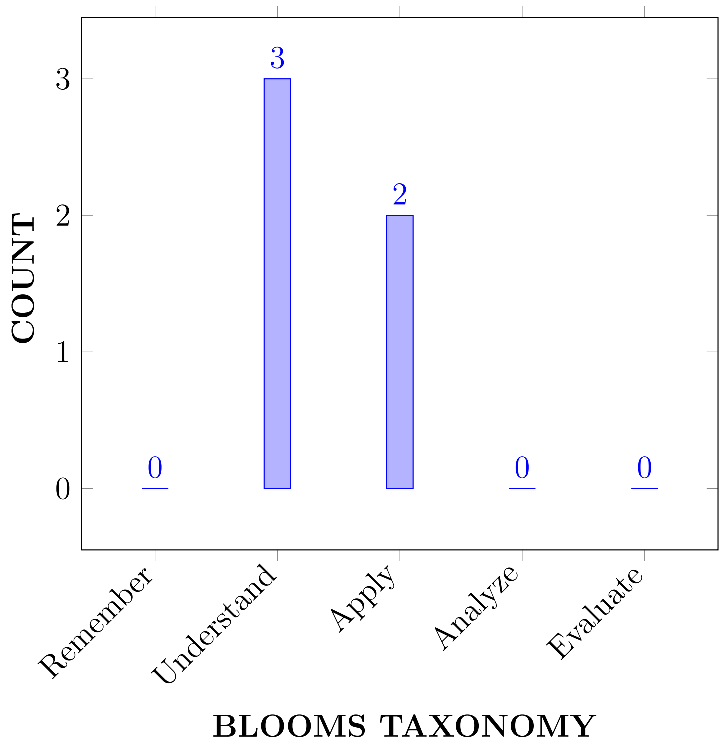
I	The principles of single excited and multiple excited systems leading to the energy balance equations.
II	The construction, working and operation of self and separately excited DC machines
III	The performance characteristics of different DC machines when they are under no load and load conditions.
IV	The energy transformation using single and poly phase transformers under no load and load conditions.

VII COURSE OUTCOMES:

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

CO 1	**Use** the concepts of complex algebra, phasor operations, principles of electromagnetism and circuit theory . for analysing the performance related issues in electrical machines.	Apply
CO 2	**Demonstrate** the working of linear machine as generator, motor and transformer by applying electromagnetic laws and its mathematical models under different loading conditions.	Understand
CO 3	**Identify** various control strategies for calculating the performance parameters and voltage regulation of electrical machines .	Apply
CO 4	**Illustrate** the equivalent circuits and connections of three phase transformers and auto transformers for power system analysis.	Understand
CO 5	**Describe** the load sharing capabilities and reliability of electrical machines using parallel operation under various loading conditions.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	-

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Recall the engineering sciences** to principles of electromagnetisim and circuit theory for analysing the performance related issues in electrical machines	2
	PO 2	Validate the principles of electrical devices and design the electric machines from obtained principles using **fundamentals of mathematics and engineering sciences**	7
	PO 3	**Understand** the constructional features of DC machines using components or processes that meet the specified needs with appropriate consideration, safety considerations.	5
CO 2	PO 1	Demonstrate electromagnetic laws for the operation of DC machines with **engineering sciences**	2
	PO 2	**Understand** the operation of DC motor and DC generator using engineering sciences	4
CO 3	PO 1	Determine voltage regulation, speed control, torque and efficiency of DC machines with the knowledge of mathematics and engineering sciences	3
	PO 2	Solve the complex problems related to voltage regulation, speed control, torque and efficiency of DC machines and validate specifications of DC machines with **basics of engineering sciences and mathematics.**	5
CO 4	PO 1	Understand the connection of three phase transformer and autotransformers with the **knowledge of mathematics and engineering sciences.**	3
	PO 2	Solve the equivallent circuit parameers and voltage, current realtions of three phase transformer with the **first principles of mathematics, natural sciences, and engineering sciences.**	5
	PSO 1	Understand the connections of three phase transformer and autotransformers for smooth operation of power system	2
CO 5	PO 1	Demonstrate how load sharing of DC machine happens with their parallel operation to increase rating of power system with **knowledge of mathematics of engineering sciences.**	3
	PO 2	Calculate the electrical parameters involved in load sharing of DC machines for solving the complex problems related to parallel operation of DC machines **first principles of mathematics, natural sciences, and engineering sciences**	5

Note: For Key Attributes refer **Anexure-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	7	5	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	5	-	-		-	-	-	-	-	-		2	-	-
CO 5	3	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	66.6	70	50	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.6	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.6	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.6	50	-	-		-	-	-	-	-	-		66.6	-	-
CO 5	66.6	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	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	-		-	-	-	-	-	-		3	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	**15**	**11**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**
AVERAGE	**3**	**2.2**	**0.4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.6**	**0**	**0**

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	**MAGNETIC FIELDS AND MAGNETIC CIRCUITS**
	Review of magnetic circuits: MMF, flux, reluctance, inductance; Visualization of magnetic fields produced by a bar magnet and a current carrying coil through air and through a combination of iron and air, influence of highly permeable materials on the magnetic flux lines; Electromechanical energy conversion: Forces and torque in magnetic systems, energy balance, energy and force in a singly excited and multi excited magnetic field systems, determination of magnetic force, co- energy
MODULE II	**DC GENERATORS**
	DC generators: Principle of operation, construction, armature windings, lap and wave windings, simplex and multiplex windings, problems, use of laminated armature, commutator, EMF equation, types of DC generators, voltage buildup, critical field resistance and critical speed, causes for failure to self-excite and remedial measures; Armature reaction: Cross magnetization and demagnetization, ampere turns per pole, compensating winding, commutation, reactance voltage, methods of improving commutation; Characteristics: Open circuit characteristics, critical field resistance and critical speed. Load characteristics of shunt, series and compound generators; Parallel operation: Principle of parallel operation, load sharing, and use of equalizer bars, cross connection of field windings, problems.
MODULE III	**DC MOTORS AND TESTING**
	DC motors: Principle of operation, back EMF, torque equation, condition for maximum power developed, types of DC motors, armature reaction and commutation, characteristics, methods of speed control, types of starters, numerical problems; Losses and efficiency: Types of losses, calculation of efficiency, condition for maximum efficiency Testing of DC machines: Swinburnes test, brake test, regenerative testing, Hopkinsons test, fields test, retardation test and separation of stray losses, problems.
MODULE IV	**SINGLE PHASE TRANSFORMERS**
	Single phase transformers: Principle of operation, construction, types of transformers, EMF equation, concept of leakage flux and leakage reactance, operation of transformer under no load and on load, phasor diagrams, equivalent circuit, efficiency, regulation and all day efficiency; Testing of transformers: objective of testing, polarity test, measurement of resistance, OC and SC tests, back to back test, heat run test, parallel operation, problems.
MODULE V	**POLY PHASE TRANSFORMERS**
	Three phase transformer: Principle of operation, star to star, delta to delta, star to delta, delta to star, three phase to six phase, open delta connection, Scott connection; Auto transformers: Principles of operation, equivalent circuit, merits and demerits, no load and on load tap changers, harmonic reduction in phase voltages, cooling methods of transformers problems.

TEXTBOOKS

1. A E Fitzgerald and C Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
2. P S Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
3. I J Nagrath and D P Kothari, "Electric Machines", McGraw Hill Education, 2010.

REFERENCE BOOKS:

1. M G Say, "Alternating Current Machines", Pitman Publishing Ltd, 4th Edition, 1976.
2. P C Sen, "Principles of Electric Machines and Power Electronics", John Wiley & Sons, 2007.
3. S K Bhattacharya, "Electrical Machines", TMH publication, 2nd Edition, 2006.

WEB REFFERENCES

1. https://www.electricaltechnology.org
2. https://www.cet.edu.in
3. https://gndec.ac.in

COURSE WEB PAGE:

1. https://www.iare.ac.in/sites/default/files/Courses-description/EEE - Electrical machines -I

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	Presentation on Outcome based education		
CONTENT DELIVERY (THEORY)			
1	Review of magnetic circuits and basic definitions.	CO 2	T1:4.1-4.2
2	Visualization of magnetic fields produced by a bar magnet and a current carrying coil through air and through a combination of iron and air.	CO 2	T1:4.1-4.2
3	Forces and torque in magnetic systems, energy and force in a singly excited magnetic field systems, determination of magnetic force, co- energy.	CO 2	T1:4.1-4.2
4	Understand principle of operation of DC generator.	CO 2	T1:4.1-4.2
5	Know the different parts in a DC machine and understand the functioning of each component..	CO 1	T1:4.3
6	Know the different types of windings used in DC generators.	CO 1	T1:4.4-4.9

7	Understand why the core of a DC machine is laminated and functioning of commutator	CO 1	T1:4.3
8	Derive the equation of EMF induced in a DC generator and solve the simple problems	CO 1	T1:4.10
9	Distinguish the different types of DC generators and know how the voltage is buildup in DC generators	CO 1	T1:6.1-6.2
10	Distinguish the different types of DC generators and know how the voltage is buildup in DC generators.	CO 1	T1:6.1-6.2
11	Problems on the different types of DC generators.	CO 1	T1:6.1-6.2
12	Problems on the different types of DC generators.	CO 1	T1:6.1-6.2
13	Understand the concept of critical field resistance and critical speed.	CO 3	T1:6.7-6.12
14	Understand the different causes for the failure of excitation in DC generators and know the remedies to solve the problem	CO 3	T1:6.13-6.14
15	Understand the concept of armature reaction in DC generator	CO 1	T1:5.1-5.2
16	Understand the concept of cross magnetization and demagnetization in DC generator	CO 1	T1:5.3
17	Solve the problems on armature reaction	CO 1	T1:5.7
18	Understand the concept of commutation, and know different methods used for improving the commutation	CO 1	T1:5.4-5.6
19	Draw the different types of characteristics for DC generators	CO 3	T1:6.5-6.11
20	Understand the basic principle of operating the generators in parallel	CO 5	T1:7.1 -7.4
21	Understand the function of equalizer bar and its usage	CO 1	T1:7.2
22	Solve the different types of numerical problems related to DC generators.	CO 1	T1:4.1-7.4
23	Understand the basic principle of dc motor and its function	CO 1	T1:8.2
24	Understand how the back EMF is induced in DC motor and derive the torque equation.	CO 1	T1:8.4-8.6
25	Know different types of motors and solve simple problems.	CO 1	T1:8.7.1-8.7.5
26	Understand the occurrence of armature reaction and study the commutation techniques	CO 1	T1:8.16
27	Draw the performance characteristics of DC motors	CO 3	T1:8.18-8.23
28	Understand the methods of speed control	CO 3	T1:9.1-9.3
29	Know why starters are used and different types of starters	CO 3	T1:9.4-97
30	Understand the differ types of losses that are occurred in a DC motor.	CO 1	T1:10.1-10.4
31	Solve different numerical problems related to efficiency of DC motor	CO 3	T1:10.1-10.4

32	Conduct the Swinburnes test and Brake test on DC motor and compare the two methods	CO 3	T1:10.7
33	Conduct the regenerative test, Hopkinsons test and determine the efficiency of DC motor	CO 3	T1:10.8
34	Conduct the fields test on DC series motor, and retardation test on DC shunt motor	CO 3	T1:10.9-10.1
35	Summarize the different types of losses and separate the each loss from total losses	CO 3	T4:10.10
36	Solve the different types of numerical problems related to DC motors testing	CO 1	T1:8.2-10.10
37	Explain the operation, construction and types of single phase transformer	CO 1	T1:1.1-1.4, T1:1.24
38	Derive the equation of EMF induced in transformer and understand the concept of leakage flux and reactance	CO 1	T1:1.5-1.6
39	Discuss the operation of transformer under no load and on load with the phasor diagrams	CO 1	T1:1.8-1.12
40	Draw the equivalent circuit of single phase transformer and study the concept of regulation and all day efficiency	CO 3	T1:1.13-1.18
41	Solve the Numerical problems on EMF equation and draw the phasor diagrams	CO 3	T1:1.1-1.18
42	Understand the objectives of testing, and kwon how to conduct polarity test and how to measure resistance	CO 3	T1:1.19.1-1.19.2
43	Conduct OC and SC tests on transformer and determine the efficiency and regulation at different loads	CO 3	T1:1.193-1.195
44	Conduct back to back test / heat run test and determine the efficiency and regulation	CO 3	T1:1.19.6
45	Solve the problems on transformer testing	CO 3	T1:1.19.1-1.19.6
46	Understand the necessity and importance of parallel connection of transformers	CO 5	T1:10.3.1
47	Solve the different types of numerical problems related to single phase transformers	CO 1	T1:1.1-2.11
48	Understand the principle of operation of three phase transformers	CO 4	T1:2.1-2.2
49	Analyze the different connections of three phase transformers	CO 4	T1:2.3.1-2.3.2
50	Solve the problems on three phase transformer connections	CO 4	T1:2.1-2.3.2
51	Analyze how a transformer can work on open delta connection	CO 4	T1:2.4.1-2.4.2
52	Describe how scott connection is performed to convert three phase supply to two phase and vice versa	CO 4	T1:2.5
53	Understand the principle of operation auto transformers	CO 4	T1:2.12
54	Draw the equivalent circuit and explain the merits and demerits of auto transformers	CO 4	T1: 2.12.2
55	Solve the problems on Autotransformers	CO 4	T1: 2.12.2

56	Understand the operation of no load and on load tap changers	CO 4	T1:1.17.1-2.17.2
57	Know how to reduce the harmonics in phase voltages	CO 4	T1:2.62
DISCUSSION OF DEFINITION AND TERMINOLOGY)			
58	Discussion on Question bank and definition terminology of magnetic Fields and Magnetic Circuits	CO 2	T1:4.4-4.9
59	Discussion on Question bank and definition terminology of DC Generators	CO 1, CO 2, CO 3, CO 5	T1:8.2-10.10
60	Discussion on Question bank and definition terminology of DC motors andTesting	CO 1, CO 2, CO 3, CO 5	T1:1.1-1.18
61	Discussion on Question bank and definition terminology of single phase transformers	CO 1, CO 2, CO 3, CO 5	T1:2.4.1-2.4.2
62	Discussion on Question bank and definition terminology of poly phase transformers	CO 4	T1:1.17.1-2.17.2
DISCUSSION OF QUESTION BANK			
63	Module I	CO 2	T2: 3.2-3.3
64	Module -II	CO 1, 2, 3, 5	T3: 6.9-6.14
65	Module - III	CO 1, 2 ,3 , 5	T2: 5.1-5.20
66	Module - IV	CO 1, 2 ,3 ,5	T2: 7.1-7.20
67	Module - V	CO 4	T3:36.8

Course Coordinator **HOD,EEE**
Mr A Sathish Kumar, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

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

ELECTRONICS AND COMMUNICATION ENGINEERING

COURSE DESCRIPTION

Course Title	**ANALOG AND DIGITAL ELECTRONICS LABORATORY**				
Course Code	AECB04				
Program	B.Tech				
Semester	III	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Chief Coordinator	Ms L. Babitha, Assistant Professor				

I COURSE OVERVIEW:

The objective of this laboratory course is to meet the requirements of practical work meant for components basics, analysis and design and provides hands-on experience by examining the characteristics of various semiconductor devices and measuring instruments. This lab covers the analysis of the characteristics of semiconductor devices and functionality of the digital circuits to use as elementary blocks in analog and digital circuit applications. Students will proficiency with the capability to use simulation tools for performing various analysis of semiconductor devices, combinational and sequential circuit applications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
B.Tech	AECB04	III	Analog Electronics	4
B.Tech	AECB04	III	Digital Electronics	4

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Analog and Digital Electronics 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:

20 %	To test the preparedness for the experiment.
20 %	To test the performance in the laboratory.
20 %	To test the calculations and graphs related to the concern experiment.
20 %	To test the results and the error analysis of the experiment.
20 %	To test the subject knowledge through viva – voce.

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

Table 1: Assessment pattern for CIA

Component	Laboratory		
Type of Assessment	**Day to day Performance**	**Final Internal Lab Assessment**	**Total Marks**
CIA Marks	20 Marks	10 Marks	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:

Preparation	Performance	Calculations and Graph	Results and Error Analysis	Viva	Total
2	2	2	2	2	10

B. Programming Based:

Preparation	Performance	Calculations and Graph	Results and Error Analysis	Viva	Total
2	2	2	2	2	10

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		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 Experiments / 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.	3	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
PO 11	Life-long learning: An ability to align with and upgrade to higher learning and research activities along with engaging in life-long learning.	2	Lab Experiments / CIE / SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Build Embedded Software and Digital Circuit Development platform for Robotics, Embedded Systems and Signal Processing Applications.	2	Lab Exercises / CIE / SEE

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

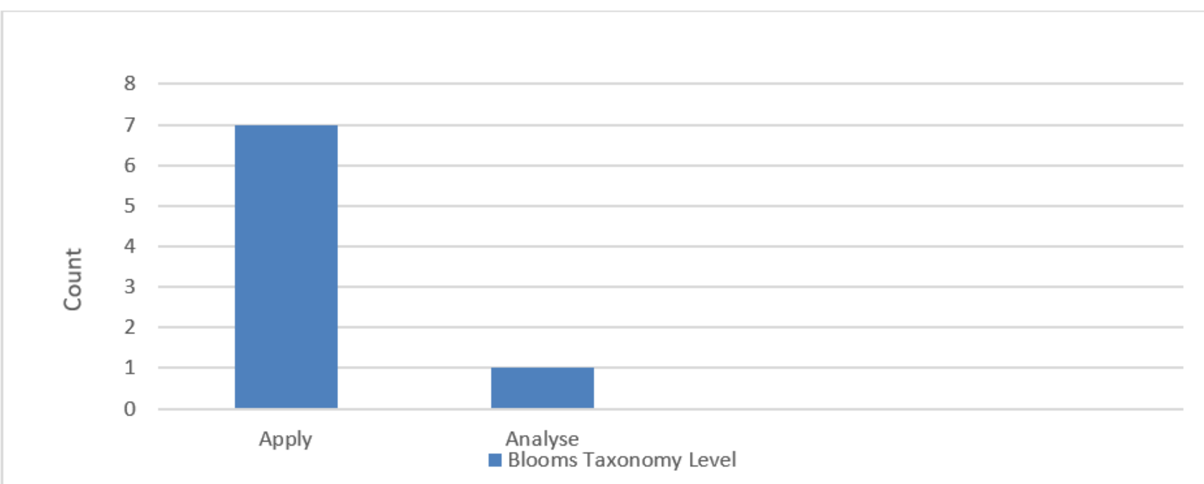
I	The engineering skills using breadboard circuit design with electronic devices and components.
II	The behavior and characteristics of basic electronic devices , semiconductors and digital devices.
III	The basic electronic and digital devices necessary for construct the analog and digital circuits.

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	**Make use of** volt-ampere characteristics of pn junction diode, Zener diode for finding the cut-in voltage, static dynamic resistances and voltage regulation.	Apply
CO 2	**Apply** the pn junction characteristics for the diode applications such as half wave rectifier and full wave rectifier.	Apply
CO 3	**Analyze** the input and output characteristics of transistor configurations for determining the input - output resistances and voltage gain.	Analyze
CO 4	**Identify** the functionality of the Boolean expressions using basic gates such as not, and, or, nand, nor, xor and xnor gates.	Apply
CO 5	**Build** combinational circuits such as adder, subtractor, multiplexers and comparators realization.using low level elementary blocks.	Apply
CO 6	**Experiment** basic gates for data conversion applications like binary to gray conversion.	Apply
CO 7	**Construct** shift registers using the functionality of the flip flops..	Apply
CO 8	**Apply** electronic measuring instruments for measuring voltage, current, frequency and phase of the various signals.	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 2	**Understand** the given problem statement and **formulate** the static and dynamic resistance from the volt-ampere characteristics of the semiconductor devices using **principles of mathematics and engineering science**.	3
	PO 3	**Illustrate(understand)** the volt ampere characteristics**(knowledge)** of P N diode and identify, **formulate(apply)** to derive mathematical model for diode current, static and dynamic resistance and state a (complex) problem to **develop(apply)** solutions to the diode applications such as rectifier ,clipper and clamper for complex engineering problems by **applying** the **principles of mathematics, science** to interpret the result.	6
	P0 9	**Identify, formulate(apply)** to derive mathematical model for diode current, static and dynamic resistance and state a (complex) problem to **develop(apply)** solutions to the diode applications such as rectifier ,clipper and clamper for function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2
CO 2	PO 2	**Understand** the given the diode application problem statement and **finding** the solution implementation of rectifier circuits by analyzing **complex engineering problems.**	3
	PO 9	**Understand** the given the diode application problem statement and finding the solution implementation of rectifier circuits by **analyzing** complex engineering problems function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2
CO 3	PO 2	**Understand** the input and output characteristics of transistor configurations for problem formulation to **determine** the transistor characteristics parameters such as input - output resistances, current gain and voltage gain using mathematics principles.	2

	PO 3	**Design (knowledge)** and **demonstrate(understand)** the various biasing techniques for BJTs amplifier circuits and **identify, formulate(apply)** for stable operation to **develop** solution using appropriate BJT configurations in certain areas of communication(problems) by **applying** mathematics, science and engineering fundamentals for **complex engineering problems.**	6
	PO 9	To **develop** solution using appropriate BJT configurations in certain areas of communication(problems): **function** effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2
CO 4	PO 2	**Identify** the importance of basic gates in the **optimization** of conventional Boolean formulas in general and digital circuits.	2
CO 5	PO 2	**Demonstrate** the design procedures of half and full Adders, subtractors, for fundamental block realization in any processor complex engineering problems by **applying** mathematical principles.	2
	PSO 1	**Develop** the adders and subtractors by applying the fundamental blocks of logic gates.	1
CO 6	PO 2	**Identify** the importance of basic gates in the optimization of conventional Boolean**formulas** in general and digital circuits.	2
CO 7	PO 2	**Implement** the bidirectional and universal shift registers using the **principles** of shift registers for organization of data applications methodology.	2
	PSO 1	**Develop** the synchronous and asynchronous universal shift registers by applying the fundamental blocks of shift registers.	1
CO 8	PO 2	**Design** the different electronic circuits using **mathematical principles** for solving complex engineering problems .	2
	PO 11	**Apply** basic principles create for **apply** appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling the analog and digital circuits lifelong applications such as radio and audio equipment and in many applications where signals are derived from analog sensors and transducers and digital circuits. .	2

XI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 2, PO 3, PSO 1	SEE Exams	PO 2,PO 3, PO 11, PSO 1	Seminars	-
Laboratory Practices	PO 2,PO 3, PO 9, PSO 1	Student Viva	PO 2, PO 3	Certification	-
Assignments	-				

XII ASSESSMENT METHODOLOGY INDIRECT:

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

XIII MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

COURSE OUTCOMES	Program Outcomes / No. of Key Competencies Matched												PROGRAM SPECIFIC OUTCOMES (PSO'S)		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	-	2	6	-	-	-	-	-	2	-	-	-	-	-	-
CO 2	-	3	-	-	-	-	-	-	2	-	-	-	-	-	-
CO 3	-	2	6	-	2	-	-	-	-	-	-	-	-	-	-
CO4	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 6	-	2	-	-	-	-	-	-	-	-	-		-	-	-
CO 7	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 8	-	2	-	-	-	-	-	-	-	-	-	-	2	-	-

3 = High; 2 = Medium; 1 = Low

XIV SYLLABUS:

Week-1	**UNDERSTAND THE PN JUNCTION DIODE CHARACTERISTICS**
	Verify the V-I characteristics of pn junction diode
Week-2	**UNDERSTAND THE ZENER DIODE CHARACTERISTICS AND VOLTAGE REGULATOR.**
	Verify the V-I characteristics of Zener diode and how it works as regulator.
Week-3	**UNDERSTAND HALF WAVE AND FULL WAVE RECTIFIER WITH AND WITHOUT FILTER**
	Verify the operation of half wave and full wave rectifier with and without filter.
Week-4	**ANALYZE INPUT AND OUTPUT CE AND CB CHARACTERISTIC**
	Verify the input and output characteristics of CE and CB configurations.
Week-5	**UNDERSTAND THE FREQUENCY RESPONSE OF CE AMPLIFIER.**
	Plot the frequency response of Common emitter amplifier.
Week-6	**UNDERSTAND BOOLEAN EXPRESSIONS USING GATES**
	Verify the various Boolean expressions using logic gates.
Week-7	**UNDERSTAND UNIVERSAL GATES**
	Verify the operation of NAND and NOR gates.
Week-8	**UNDERSTAND ADDER/ SUBTRACTOR**
	Verify the operation of adders and subtractors using basic gates.
Week-9	**UNDERSTAND BINARY TO GRAY CONVERSION**
	Design binary to gray conversion circuit using gates.
Week-10	**VERIFY TRUTH TABLES AND EXCITATION TABLES**
	Verify the truth tables and excitation tables of all logic gates.
Week-11	**REALIZE SHIFT REGISTER**
	Verify the function of shift register.
Week-12	**REALIZE 8X1 MULTIPLEXER AND 2-BIT COMPARATOR**
	Verify the operations of multiplexer and comparator.

TEXTBOOKS

1. 1. Jacob Millman, Christos C Haikais, “Integrated Electronics”, McGraw Hill Education, 2nd Edition 2010.
2. 2. P Jain, ”Modern Digital Electronics”, McGraw Hill Education, 2009.

REFERENCE BOOKS:

1. Electronic Devices – Conventional current version – Thomas L Floyd, 2015, Pearson.
2. M M Mano, ”Digital logic and Computer design”, Pearson Education India, 2016.
3. A Kumar, ”Fundamentals of Digital Circuits”, Prentice Hall India, 2016.
4. 4. P Jain, ”Modern Digital Electronics”, McGraw Hill Education, 2009.

XV COURSE PLAN:

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

Week No	**Topics to be covered**	**CO's**	**Reference**
1	Understand the pn junction diode characteristics.	CO 1	T1-13.2
2	Understand the Zener diode characteristics and voltage regulator.	CO 2	T1 14.8
3	Program to interface a switch and a buzzer to two different pins of a port such that the buzzer should sound as long as the switch is pressed.	CO 3	T1-8.1 to 8.2
4	Analyze input and output CE characteristics	CO 4	T1 15.5 -15.9
5	Analyze input and output CB characteristics	CO 4	T1 15.17
6	Understand the frequency response of CE amplifier.	CO 5	T1 15.16
7	Understand Boolean expressions using gates.	CO 4	T1 16.1,T1 16.8
8	Understand universal gates.	CO 4	R4 4.1
9	Understand Nand / nor gates.	CO 4	R4 4.2
10	Understand adder/ subtractor.	CO 5	R4 4.3
11	Understand binary to gray conversion.	CO 6	R4 4.6
12	Verify truth tables and excitation tables.	CO 4	R4 4.10
13	Realize shift register.	CO 7	R4 5.6
14	Realize 8x1 multiplexer.	CO 5	R4 5.9
15	Realize 2 bit comparator.	CO 5	R4 5.10

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	**Design Oriented Experiments**
1	Design and verify the functionality of waveform clipper using Zener diode.
2	Design high pass filter using bipolar junction transistor to produce the gain of 150.
3	Design Half and Full adder circuits using NAND gates and NOR gates.
4	Convert J-K flip flop to S-R flip flop using excitation tables.
5	Build the Boolean expression AB+BC+CA using basic gates.

Signature of Course Coordinator **HOD,ECE**

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

ELECTRICAL AND ELECTRON ICS ENGINEERING
COURSE DESCRIPTION

Course Title	**Electrical Machines - I Laboratory**				
Course Code	AEEB13				
Program	B.Tech				
Semester	III	EEE			
Course Type	Core				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. A Sathish kumar, Assistant Professor				

I COURSE OVERVIEW:

This laboratory course is to meet the requirements of practical work meant for basic operation, analysis and design of electrical machines. It provides hands-on experience by examining the electrical and mechanical characteristics of various DC machines. Analyze the characteristics of DC machines and separate the various losses in electrical machines by conducting different tests..

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB02	II	Electrical Circuits Lab

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Machines Laboratory - I	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	-
20 %	Analysis	-
20 %	Design	-
20 %	Conclusion	-
20 %	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 elementary experimental and modelling skills for handling problems with electrical machines in the industries and domestic applications to excel in professional career.
II	The operation of DC Machines and its role in power transmission and distribution.
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.

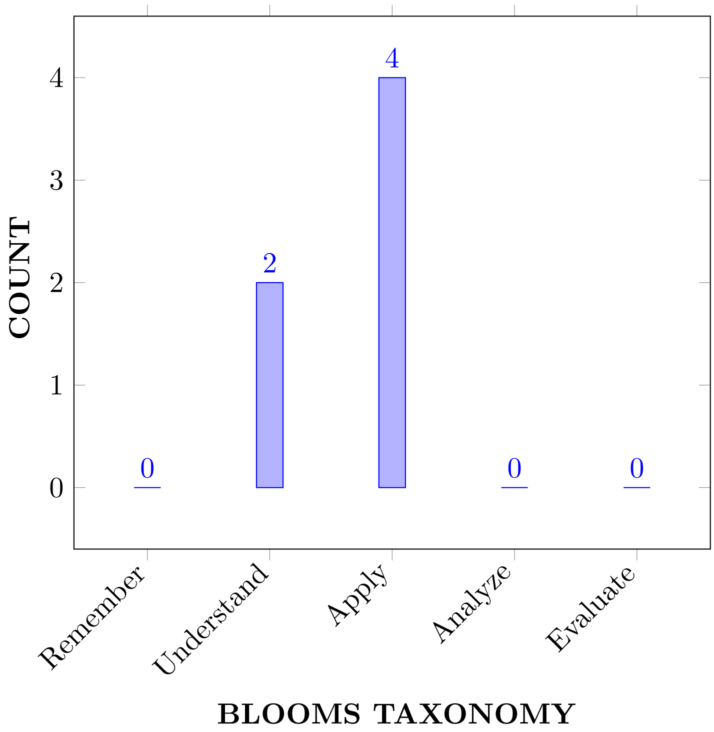
VII COURSE OUTCOMES:

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

CO 1	**Formulate** and then analyze the working of any electrical machine to using mathematical model under loaded and unloaded conditions. .	Understand

CO 2	**Interpret** the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions.	Apply
CO 3	**Apply** magnetization characteristics of dc shunt generator for necessary to do mechanical work in a proper way.	Apply
CO 4	**Demonstrate** the starting and speed control of various DC motors for necessary to do mechanical work in a proper way of DC motors.	Understand
CO 5	**Estimate** the core losses of DC shunt machines for dividing the set losses.	Apply
CO 6	**Apply** digital simulation techniques for speed control methods and load test of DC motors.	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		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 analyze 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	3	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.	3	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	2	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 team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	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.	2	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Lab Exercises
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	2	Lab Exercises
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.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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	Observe the working of electrical machines using mathematical model under loaded and unloaded conditions using **principles of mathematics and engineering science**	2
	PO 2	Understand the working of electrical machines using mathematical model under loaded and unloaded conditons **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the given power electronic components voltage current characteristics **for design solutions of complex engineering problems**	6
	PO 4	Understand the working of electrical machines using mathematical model under loaded and unloaded conditions **with analysis and interpretation of data**	6
	PO 6	Illustrate the working of electrical machines using mathematical model under loaded and unloaded conditions **for safety issues in professional engineering practice**	4
	PO 8	Understand the working of electrical machines using mathematical model under loaded and unloaded conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte working of electrical machines using mathematical model under loaded and unloaded conditions **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret working of electrical machines using mathematical model under loaded and unloaded conditions **with communication of complex engineering practices**	3
	PO 12	Understand the working of electrical machines using mathematical model under loaded and unloaded conditions **in life long learning in technological change**	6
	PSO 1	Demonstrate the working of electrical machines using mathematical model under loaded and unloaded conditions **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the working of electrical machines using mathematical model under loaded and unloaded conditions **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the given working of electrical machines using mathematical model under loaded and unloaded conditions **in automation process using PLC and process controllers**	4

CO 2	PO 1	Observe the the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions using **principles of mathematics and engineering sciences**	2
	PO 2	Understand the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions with**problem statement by analyzing complex engineering problems.**	6
	PO 3	Develop the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **for design solutions of complex engineering problems**	6
	PO 4	Understand thethe load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **with analysis and interpretation of data**	6
	PO 6	Illustrate the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **for safety issues in professional engineering practice**	4
	PO 8	Understand the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **with communication of complex engineering practices**	3
	PO 12	Understand the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **in life long learning in technological change**	6
	PSO 1	Demonstrate the the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the load sharing capabilities and reliability of DC generators using parallel operation under various loading conditions **in automation process using PLC and process controllers**	4

CO 3	PO 1	Observe magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed using **principles of mathematics and engineering science**	2
	PO 2	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **for design solutions of complex engineering problems**	6
	PO 4	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **with analysis and interpretation of data**	6
	PO 5	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **for safety issues in professional engineering practice**	4
	PO 8	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **with communication of complex engineering practices**	3
	PO 12	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **in life long learning in technological change**	6
	PSO 1	Demonstrate magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed**in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate magnetization characteristics of dc shunt generator for calculating the critical resistance and critical speed **in automation process using PLC and process controllers**	4

CO 4	PO 1	Observe the starting and speed control of various DC motors for necessary to do mechanical work in a proper way using **principles of mathematics and engineering science**	2
	PO 2	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper way **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **for design solutions of complex engineering problems**	6
	PO 4	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **with analysis and interpretation of data**	6
	PO 5	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **for safety issues in professional engineering practice**	4
	PO 8	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **with communication of complex engineering practices**	3
	PO 12	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper waysn **in life long learning in technological change**	6
	PSO 1	Demonstrate the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the starting and speed control of various DC motors for necessary to do mechanical work in a proper ways **in automation process using PLC and process controllers**	4

CO 5	PO 1	Observe the core losses of DC shunt machines for dividing the set losses using **principles of mathematics and engineering science**	2
	PO 2	Understand the core losses of DC shunt machines for dividing the set losses **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the core losses of DC shunt machines for dividing the set losses **for design solutions of complex engineering problems**	6
	PO 4	Understand the core losses of DC shunt machines for dividing the set losses **with analysis and interpretation of data**	6
	PO 6	Illustrate the core losses of DC shunt machines for dividing the set losses**for safety issues in professional engineering practice**	4
	PO 8	Understand the core losses of DC shunt machines for dividing the set losses **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the core losses of DC shunt machines for dividing the set losses **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the core losses of DC shunt machines for dividing the set losses **with communication of complex engineering practices**	3
	PO 12	Understand the core losses of DC shunt machines for dividing the set losses **in life long learning in technological change**	6
	PSO 1	Demonstrate the core losses of DC shunt machines for dividing the set losses **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the core losses of DC shunt machines for dividing the set losses **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the core losses of DC shunt machines for dividing the set losses **in automation process using PLC and process controllers**	4
CO 6	PO 1	Observe digital simulation techniques for speed control methods and load test of DC motors using **principles of mathematics and engineering science**	2
	PO 2	Understand digital simulation techniques for speed control methods and load test of DC motors **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate digital simulation techniques for speed control methods and load test of DC motors **for design solutions of complex engineering problems**	6

	PO 4	Understand digital simulation techniques for speed control methods and load test of DC motors **with analysis and interpretation of data**	6
	PO 5	Understand digital simulation techniques for speed control methods and load test of DC motors **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate digital simulation techniques for speed control methods and load test of DC motors **for safety issues in professional engineering practice**	4
	PO 8	Understand digital simulation techniques for speed control methods and load test of DC motors **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte digital simulation techniques for speed control methods and load test of DC motors **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret digital simulation techniques for speed control methods and load test of DC motors **with communication of complex engineering practices**	3
	PO 12	Understand digital simulation techniques for speed control methods and load test of DC motors **in life long learning in technological change**	6
	PSO 1	Demonstrate digital simulation techniques for speed control methods and load test of DC motors **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand digital simulation techniques for speed control methods and load test of DC motors **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate digital simulation techniques for speed control methods and load test of DC motors **in automation process using PLC and process controllers**	4

XII 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	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 2	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 3	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3
CO 4	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3
CO 5	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 6	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK I	**OPEN CIRCUIT CHARACTERISTICS OF DC SHUNT GENERATOR**
	Magnetization characteristics of DC shunt generator.
WEEK II	**LOAD TEST ON DC SHUNT GENERATOR**
	Determination of efficiency by load test in DC shunt generator
WEEK III	**LOAD TEST ON DC SERIES GENERATOR**
	Determination of efficiency by load test on DC series generator.
WEEK IV	**LOAD TEST ON DC COMPOUND GENERATOR**
	Determination of efficiency by load test on DC compound generator
WEEK V	**HOPKINSON'S TEST**
	Study the performance characteristics of two identical DC shunts machines.
WEEK VI	**FIELD'S TEST**
	Study the performance characteristics of two identical DC series machines.
WEEK VII	**SWINBURNE'S TEST AND SPEED CONTROL OF DC SHUNT MOTOR**
	Predetermine the efficiency and study the characteristics of DC shunt machine with different speed control techniques..
WEEK VIII	**BRAKE TEST ON DC COMPOUND MOTOR**
	Study the performance characteristics of DC compound motor.
WEEK IX	**BRAKE TEST ON DC SHUNT MOTOR**
	Study the performance characteristics of DC shunt motor by brake test.
WEEK X	**RETARDATION TEST**
	Study the performance characteristics by using retardation test on DC shunt motor
WEEK XI	**SEPARATION OF LOSSES IN DC SHUNT MOTOR**
	Study the method used for separation of losses in DC shunt motor

WEEK XII	**MAGNETIZATION CHARACTERISTICS OF DC SHUNT GENERATOR**
	Study the magnetization characteristics of DC shunt generator using digital simulation
WEEK XIII	**LOAD TEST ON DC SHUNT GENERATOR USING DIGITAL SIMULATION**
	Perform the load test on DC shunt generator using digital simulation
WEEK XIV	**SPEED CONTROL OF DC SHUNT MOTOR USING DIGITAL SIMULATION**
	Verify the speed control techniques of DC motor using digital simulation

TEXTBOOKS

1. J B Guptha “Theory and performance of Electrical machiines”, S.K.Kataria and Sons Publishers 14th Edition, 2009

2. M G Say, E O Taylor, “Direct Current Machines”, Longman Higher Education, 1st Edition,1985

REFERENCE BOOKS:

1. P S Bimbhra, R.P., —Electrical Machinery, Khanna Publishers, New Delhi 2011

2. I J Nagrath and D P Kothari., Electric Machines, McGraw Hill Education Co. Ltd., 2010.

3. A E Fitzgerald and C Kingsley, ”Electric Machinery”, New York, McGraw Hill Education, 1st Edition, 2013.

XVI 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	Magnetization characteristics of DC shunt generator.	CO 3	R1: 1.2
2	Determination of efficiency by load test in DC shunt generator.	CO 1	R2: 3.5
3	Determination of efficiency by load test on DC series generator	CO 1	R1: 3.4
4	Determination of efficiency by load test on DC compound generator	CO 1	R1: 2.2
5	Study the performance characteristics of two identical DC shunts machines.	CO 1	R1: 2.4
6	Study the performance characteristics of two identical DC series machines.	CO 1	R3: 4.5
7	Predetermine the efficiency and study the characteristics of DC shunt machine with different speed control techniques.	CO 4	R3: 4.6
8	Study the performance characteristics of DC compound motor	CO 1	R2: 5.1
9	Study the performance characteristics of DC shunt motor by brake test.	CO 1	R2: 5.2
10	Study the performance characteristics by using retardation test on DC shunt motor.	CO 1	R1: 7.1

11	Study the method used for separation of losses in DC shunt motor.	CO 5	R1:7.2
12	Study the magnetization characteristics of DC shunt generator using digital simulation	CO 6	R1:7.3
13	Perform the load test on DC shunt generator using digital simulation	CO 6	R2: 7.1
13	Verify the speed control techniques of DC motor using digital simulation.	CO 6	R3: 8.1

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Twin vortex formation:** Design of brushless DC motor for Hybrid Electrical Vehicles.
2	**Open channel:** Design of parallel operation of DC generators for load sharing capabilities .
3	**Capillary action:** Modelling of direct drive motors for performance improvement by design and control.
4	**Buoyancy** Design of three point starter using digital simulation.
5	**Flow through pipes:** Design of permanent magnet DC Motor for Hybrid Electrical Vehicles

Signature of Course Coordinator **HOD,EEE**
Mr.A Sathish Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**COMPLEX ANALYSIS AND PROBABILITY DISTRIBUTIONS**				
Course Code	AHSB06				
Program	B. Tech				
Semester	IV				
Course Type	Foundation				
Regulation	IARE-R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms B Praveena, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
10+2	-	-	-

II COURSE OVERVIEW:

The course focuses on more Advanced Engineering Mathematics which provide with the relevant mathematical tools required in the analysis of engineering problems and scientific professions. The course includes complex functions and differentiation, complex integration, power series expansion of complex function and Probability of single random variables with its distributions. 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
Complex Analysis and probability distributions	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). 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
0%	Remember
36 %	Understand
64 %	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	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 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:

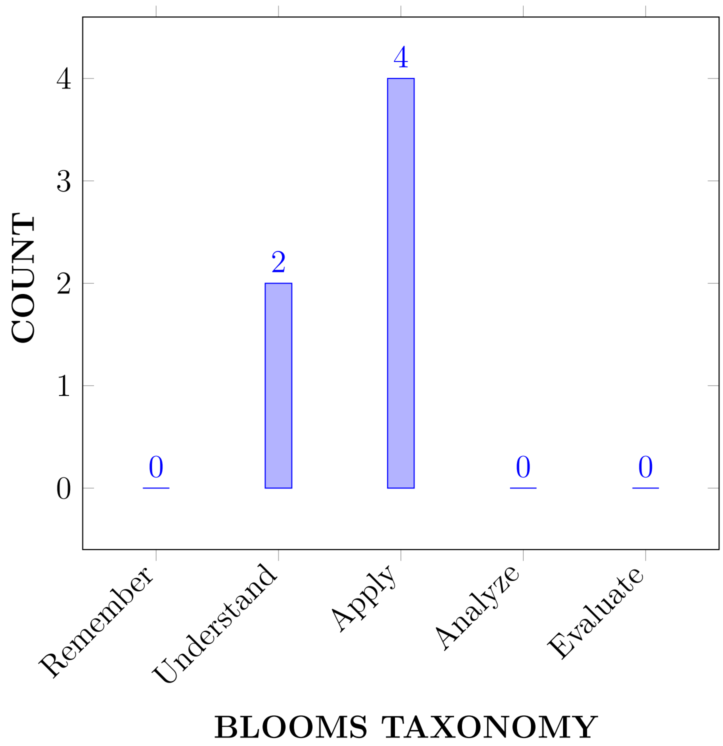
I	The applications of complex variable and conformal mapping in two dimensional complex potential theories.
II	The fundamental calculus theorems and criteria for the independent path on contour integral used in problems of engineering
III	Enrich the knowledge of probability on single random variables and probability distributions

VII COURSE OUTCOMES:

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

CO 1	**Identify** the fundamental concepts of analyticity and differentiability for finding complex conjugates , conformal mapping of complex transformations.	Apply
CO 2	**Apply** integral theorems of complex analysis and its consequences for the analytic function with derivatives of all orders in simple connected region.	Apply
CO 3	**Extend** the Taylor and Laurent series for expressing the function in terms of complex power series.	Apply
CO 4	**Apply** Residue theorem for computing definite integrals by using the singularities and polesof real and complex analytic functions over closed curves.	Apply
CO 5	**Explain** the concept of random variables and types of random variables by using suitable real time examples.	Understand
CO 6	**Interpret** the parameters of random variate Probability distributions by using their probability functions, expectation and variance.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	-	-
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development	-	-
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.	-	-

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 OUT COMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	**PO 1**	Identify the basic properties of analytic functions which are closed with respect to the fundamental operations of arithmetic (knowledge), algebra and applicability in solving majority of functions in various engineering problems by applying Mathematical principles.	2
CO 2	**PO 1**	Apply the integral theorem of complex analysis (knowledge) and its consequences to the analytic function for solving complex problems by applying the principal problems of mathematics.	2
	PO 2	Identify the problem statement to build extensions of Cauchy's theorem and application of necessary condition to vanish a contour integral around the simple connected regions from the provided information and data in reaching substantiated conclusions by using principles of mathematics.	4
	PO 4	Apply quantitative methods to simplify the calculation of certain contour integrals (knowledge) on simply connected regions in order to solve engineering problems.	2
CO 3	**PO 1**	Apply the knowledge of geometric series that enable us to use Cauchy's integral formula for understanding power series representations of analytic functions by applying the principles of mathematics.	2
	PO 2	IdeIdentify the problem formulation and abstraction of rational complex functions for expressing in negative or positive terms of power series (knowledge) using Laurent's series and Taylor's series by applying the principles of mathematics.	4

CO 4	**PO 1**	Apply the method of finding residues of given real or complex integrand (knowledge) the singular points and poles of complex functions and applicability of Residue theorem to solve definite and indefinite complex integrals by applying the principles of mathematics.	2
	PO 4	Make use of the quantitative methods of finding residues for evaluating line integrals (length of curve) of analytic functions over closed curves and applicability of Residue theorem by applying the principles of mathematics.	2
CO 5	**PO 1**	Explain(understanding) the concept of random variables and Calculate the expected values, variances (Application) of the discrete and continuous random variables (knowledge) for making decisions in complex engineering problems under randomized probabilistic conditions by using principles of mathematics.	3
	PO 2	Apply the concepts of discrete and continuous probability distributions which involves the role of Arithmetic mean, median, mode and variance, mathematical functions (principles of mathematics)for solving complex engineering problems under probabilistic conditions	1
CO 6	**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.	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	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	2		-	-	-	-	-	-		-	-	-
CO 5	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.7	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.7	40.0	-	20	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	40.0	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	-	-	20		-	-	-	-	-	-		-	-	-
CO 5	100	-	-	10	-	-	-	-	-	-	-	-	-	-	-
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	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	4	-	3	-	-	-	-	-	-	-	-	-	-	-
AVER-AGE	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓PO4	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	Tech-talk	✓	Concept video	✓
Assignments	-				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**COMPLEX FUNCTIONS AND DIFFERENTIATIONS**
	Complex functions and its representation on argand plane, concepts of limit, continuity, differentiability, analyticity, Cauchy-Riemann conditions and harmonic functions; Milne-Thomson method, Bilinear Transformation
MODULE II	**COMPLEX INTEGRATION**
	Line integral: Evaluation along a path and by indefinite integration; Cauchy's integral theorem; Cauchy's integral formula; Generalized integral formula; Power series expansions of complex functions And contour Integration: Radius of convergence.
MODULE III	**POWER SERIES EXPANSION OF COMPLEX FUNCTION**
	Expansion in Taylor's series, Maclaurin's series and Laurent series. Singular point; Isolated singular point; Pole of order m; Essential singularity; Residue: Cauchy Residue Theorem. Evaluation of Residue by Laurent Series and Residue Theorem. Evaluation of integrals of the type $\int_0^{2\pi} f(\cos\theta, \sin\theta)d\theta$ and $\int_0^{\infty} f(x)dx$
MODULE IV	**SINGLE RANDOM VARIABLES**
	Random variables: Discrete and continuous, probability distributions, mass function-density function of a probability distribution. Mathematical expectation. Moment about origin, central moments, moment generating function of probability distribution.
MODULE V	**PROBABILITY DISTRIBUTIONS**
	Binomial, Poisson and normal distributions and their properties.

TEXTBOOKS

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and Sons Publishers, 10th Edition,2010

2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 43rd Edition, 2015.

REFERENCE BOOKS:

1. T.K.V Iyengar, B. Krishna Gandhi, "Engineering Mathematics - III", S. Chand and Co., 12th Edition, 2015.

2. Churchill, R.V. and Brown, J.W, "Complex Variables and Applications", Tata Mc Graw-Hill, 8th Edition, 2012.

WEB REFERENCES:

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

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 T1: 4.1
OBE DISCUSSION			
1	Course Objectives, Course Outcomes, Program Outcomes, Co-PO Mapping		
CONTENT DELIVERY (THEORY)			
2	Understanding the complex function in Argand plane	CO 1	T1:12.4, R1:4.13
3	Apply the limit of a complex function	CO 1	T1:12.4, R1:4.13
4	Apply the continuity of a complex function	CO 1	T1:12.4, R1:4.13
5	Apply the differentiability and analyticity of a complex function	CO 1	T1:12.4, R1:4.13
6	Identify and Apply the of Cauchy-Riemann conditions in Cartesian and Polar forms	CO 1	T1:12.4, R1:4.13
7	Evaluate the Harmonic Conjugates	CO 1	T1:12.4, R1:4.13
8	Apply the Milne-Thomson method to find the Analytic function	CO 1	T1:12.4, R1:4.13
9	Apply the properties of Bilinear transformation for complex functions.	CO 1	T1:12.5, R1:8.8
10	Evaluate the Line Integral for a given path	CO 2	T1:13.1, R1:5.3
11	Apply the Cauchy's integral theorem in a given plane	CO 3	T1:13.1, R1:5.3
12	Apply the Cauchy's integral formula for evaluating contour integration	CO 3	T1:13.1, R1:5.3
. 13	Apply the Cauchy's general integral formula for evaluating contour integration.	CO 3	T1:13.1, R1:5.3
14	Define the Power series expansions of complex functions and contour Integration	CO 4	T1:14.1, R1:6.1
15	Evaluate the Radius of convergence of power series complex function	CO 4	T1:14.1, R1:6.1
16	Identify the types of power series expansions	CO 4	T1:14.1, R1:6.1
17	Define the types of Singularities and its nature	CO 4	T1:15.2 , R1:6.6
18	Define the concept of Residues	CO 4	T1:15.2 , R1:6.6

19	Evaluate the Residues of complex functions.	CO4	T1:15.2 , R1:6.6
20	Evaluate of contour integrals by Residue theorem.	CO4	T1:15.2 , R1:6.6
21	Establish the basic concepts of Random variables	CO 5	T2: 7.14, R1:1.6
22	Analyze the types of Probability distributions	CO5	T2: 7.14, R1:1.6
23	Discuss the Mass function, Density function	CO5	T2: 7.14, R1:1.6
24	Asses the Expectations of Probability Distribution	CO5	T2: 7.14, R1:1.6
25	Discuss and Estimate the Moment and Central moments	CO 5	T2: 16.6, R1:7.36
26	Discuss and Estimate the Moment Generating functions	CO 5	T2: 16.8, R1:7.41
27	Analyze and Apply the parameters	CO 5	T2: 16.9, R1:7.42
28	Analyze and Apply the Poisson Distribution parameters	CO 6	T2: 16.9, R1:7.42
29	Analyze and Apply the Normal Distribution parameters	CO 6	T2: 16.9, R1:7.42
30	Complex functions differentiation and integration: Complex functions and its representation on argand plane	CO 2	T2: 16.9, R1:7.42
31	Concepts of limit, continuity	CO 1	T1:12.4, R1:4.13
32	Establish the basic concepts of Random variables	CO5	T2: 7.14 R1:1.6
33	Analyze the types of Probability distributions	CO5	T2: 7.15 R1:16.5
34	Discuss the Mass function, Density function	CO8, CO9	T2:11.3 R1:16.5
35	Asses the Expectations of Probability Distribution	CO5	T2: 16.5 R1:7.32
36	Discuss and Estimate the Moment and Central moments	CO 5	T2: 16.6 R1:16.9
37	Discuss and Estimate the Moment Generating functions	CO 5	T2: 11.4 R1:16.18
38	Analyze and Apply the Binomial Distribution parameters	CO6	T2: 16.8 R1:7.41

39	Analyze and Apply the Poisson Distribution parameters	CO 6	T1:17.5-17.6, R1:16.3.1
40	Analyze and Apply the Normal Distribution parameters	CO 6	T2: 16.9, R1:7.422 ,
41	Problems on integral formula	CO 4	T1:13.4, R1:5.10
PROBLEM SOLVING/ CASE STUDIES			
42	Problems on generalized integral formula	CO 2	T1:14.1, R1:6.1
43	Problems on generalized integral formula	CO 2	T1:14.1, R1:6.1
44	Problems on power series expansions of complex functions Expansion in Taylor's series	CO 3	T1:14.1, R1:6.1
45	Problems on Maclaurin's series	CO 3	T1:15.2 , R1:6.6
46	Problems on Laurent series	CO 3	T1:15.3, R1:7.9
47	Problems on types of singularities , pole of order m	CO 4	T1:15.3, R1:7.9
48	Problems on evaluation of residue by Laurent Series	CO 3	T1:15.3, R1:7.9
49	Problems on Residue Theorem.	CO 4	T1:14.1, R1:6.1
50	Problems on definite integrals of the type -I	CO 3	T1:15.3, R1:7.9
51	Problems on indefinite integrals of type-II	CO 4	T1:15.3, R1:7.9
52	Problems on Binomial Distribution	CO 6	T2: 16.9, R1:7.42
53	Problems on Poisson Distribution	CO 6	T2: 16.9, R1:7.42
54	Problems on Normal Distribution	CO 6	T2: 16.9, R1:7.42
55	Problems on Moment Generating functions	CO 5	T2: 16.7, R1:7.36
56	Definitions and terminology Cauchy-Riemann conditions in Cartesian and Polar forms	CO 1,CO2	T1:12.4, R1:4.13
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Definitions and terminology the differentiability and analyticity of a complex function	CO 1,CO2	T1:12.4, R1:4.13
58	Definitions and terminology Milne-Thomson method to find the Analytic function	CO 1,CO2	T1:12.4, R1:4.13
59	Definitions and terminology on Cauchy's general integral formula for evaluating contour integration, on types of singularities , pole of order m	CO 4	T1:13.4, R1:5.10

60	Definitions and terminology on probabilities.	CO 5	T1:15.2 , R1:6.6
61	Definitions and terminology on distributions	CO 6	T1:12.4, R1:4.13
DISCUSSION OF QUESTION BANK			
62	Discussion of Question Bank of Module II Complex functions and differentiation	CO 1	T1:12.3, R1:4.4
63	Discussion of Question Bank of Module II complex integration	CO 2	T1:12.5, R1:8.8
64	Discussion of Question Bank of Module III power series expansion of complex function	CO3,CO 4	T1:15.1, R1:7.4
65	Discussion of Question Bank of Module IV Random variables	CO 5	T2: 7.15, R1:1.65
66	Discussion of Question Bank of Module V Probability distributions	CO 6	T2: 16.9, R1:7.42

Course Coordinator: **HOD, EEE**

Ms B Praveena , Assistant Professor

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

COURSE DESCRIPTION

Department	**ELECTRICAL POWER GENERATION SYSTEMS**				
Course Title	**AEEC10**				
Course Code	B.Tech				
Program	IV				
Semester	EEE				
Course Type	Core				
Regulation	UG-20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr V. Chandra Jagan Mohan, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC03	I	Engineering Physics

II COURSE OVERVIEW:

This course provides ability to recognize, analyze and troubleshoot different elements in electricpower generation systems. It deals with conventional energy systems like thermal and nuclear power stations. This course also introduces non-conventional energy systems like solar energy (radiation, collection, storage, and application), Hydro and Wind energy. This course will also discuss some environmental impacts of power generation and also look at alternative and sustainable energy resources.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical power Generation systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). 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).

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

Percentage of Cognitive Level	Blooms Taxonomy Level
%	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) 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:

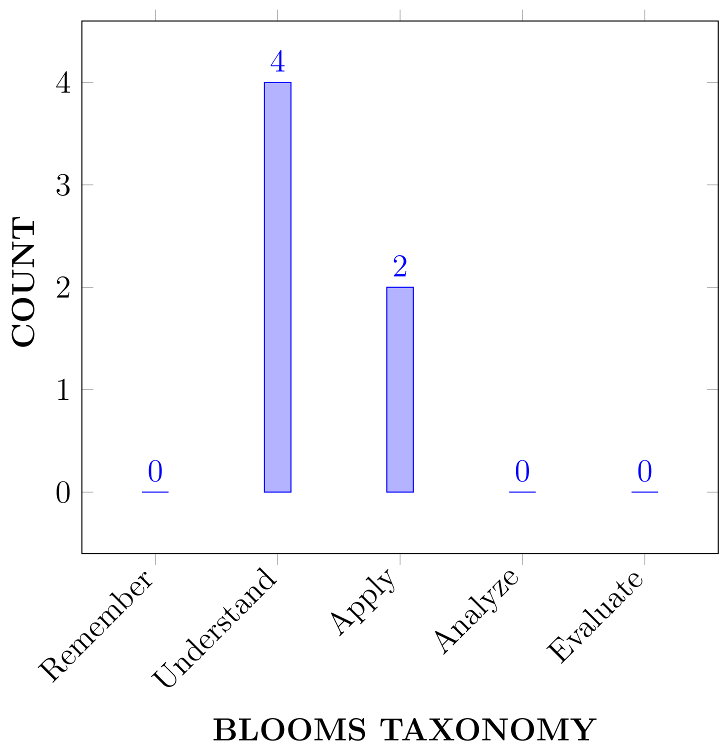
I	The fundamental concepts of power generation and gain knowledge about the different renewable and non-renewable energy sources.
II	Thorough theory on the construction and working principle of thermal, hydro-electric, nuclear and gas power plants.
III	The key aspects in solar and wind power energy systems and analyze their environmental aspects in the present-day scenario to obtain clean energy.
IV	The various factors affecting cost of generations and the different Tariff methods for electrical energy consumption to attain optimum utilization of generated electrical energy.
V	The ability to incorporate the knowledge of electrical power generation in working with minor and major projects and to take up research work in future.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the operating principle of thermal and nuclear power stations to evaluate the significance.	Understand
CO 2	**Elucidate** the working principle and layout of hydroelectric power station (HPS) along with its multi-purpose utility.	Understand
CO 3	**Paraphrase** the solar power generation using photovoltaic effect and its applications.	Understand
CO 4	**Explain** the working principle of wind energy system (WES), types of turbines and the importance of WES.	Understand
CO 5	**Maintain** the optimised working of wind power plants.	Apply
CO 6	**Interpret** the effect of role of tariff on the cost of power generation.	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	
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 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	
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	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Quiz
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Understand the working principle of thermal power station with the knowledge of mathematics and science.	2
	PO 2	Identify the merits and demerits for the validation of thermal power station.	6
	PSO 1	Understand the operating principle of thermal power station in the field of electrical power generation.	5
CO 2	PO 1	Understand the layout and working principle of hydroelectric power station with basic fundamentals of mathematics and science.	2
	PO 2	Identify the multi-use of hydroelectric power stationusing basics of mathematics and engineering sciences.	6
	PSO 1	Understand the operation of hydroelectric power station in the field of electrical power generation.	5
CO 3	PO 1	Understand the concept of power generation using solar energy by photovoltaic effect with the help ofmathematics and sciences.	2
	PO 2	Recognize the various applications of solar energy using basics of mathematics and engineering sciences.	6
	PSO 1	Analyze the solar power generation system using photovoltaic effect in the field of power generation.	5
CO 4	PO 1	Understand the operation of wind energy systems and different water turbines with the principles of mathematics and sciences.	2
	PO 2	Analyze the merits and demerits of wind energy systems for validation.	6
	PSO 1	Understand the basic concepts of wind energy systems in the field of power generation.	5
CO 5	PO 1	Understand the operation of wind poer plants mathematics and sciences	.2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Analyze the merits and demerits of wind power plants for validation.	6
	PSO 1	Understand the basic concepts of wind power plants.	5
CO6	PO 1	Understand various tariff methods used in electrical power economics with the use of mathematics and sciences.	2
	PO 2	Identify the role of tariff on the cost of power generation for validation.	6
	PSO 1	Analyze the tariff methods under economics of power generation in the field of power generation.	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	2	4	-	-	-	-	-	-	-	-	-		4	1	-
CO 2	2	4	-	-	-	-	-	-	-	-	-	-	4	-	-
CO 3	2	4	-	-	-	-	-	-	-	-	-	-	4	-	-
CO 4	2	4	-	-	1	-	-	-	-	-	-		4	-	-
CO 5	2	5	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	2	5	-	-	-	-	-	-	-	-	-		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	66.7	40	-	-	-	-	-	-	-	-	-		80	-	-
CO 2	66.7	40	-	-	-	-	-	-	-	-	-	-	80	-	-
CO 3	66.7	40	-	-	-	-	-	-	-	-	-	-	80	-	-
CO 4	66.7	40	-	-		-	-	-	-	-	-		80	-	-
CO 5	66.7	50	-	-	-	-	-	-	-	-	-	-	60	-	-
CO 6	66.7	50	-	-		-	-	-	-	-	-		60	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 2	2	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	1	-	-	3	-	-	-	-	-	-	-	3	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
TOTAL	28	16	2	4	3	-	-	-	-	-	-	-	18	-	-
AVERAGE	3	1.3	-	-	.5	-	-	-	-	-	-	-	3	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO1.PO2, PO3,PO4	SEE Exams	PO1.PO2, PO3,PO4	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 4	Open Ended Experiments	-
Assignments	PO1.PO2, PO3,PO4				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	CONVENTIONAL POWER GENERATION SYSTEMS
	Thermal Power Stations: Evaluation of power systems, present day scenario, Line diagram of thermal power station (TPS) showing paths of coal, steam, water, air, ash and flue gasses; Brief description of TPS components: Economizers, boilers, super heaters, turbines, condensers, chimney and cooling towers. Nuclear power stations: Nuclear fission and chain reaction, nuclear fuels, principle of operation of nuclear reactor, reactor components, moderators, control rods, reflectors and coolants, radiation hazards, shielding and safety precautions, types of nuclear reactors and brief description of PWR, BWR and FBR; Gas power stations: Principle of operation and components (Block diagram approach only).
MODULE II	HYDROELECTRIC POWER STAIONS
	Hydroelectric Power Stations: Elements of hydro electric power station, types, concept of pumped storage plants, storage requirements, mass curve (explanation only), estimation of power developed from a given catchment area, heads and efficiencies; Hydraulic turbines: Classification of turbines, impulse and reaction turbines, Pelton wheel, Francis turbine and Kaplan turbine, working proportions, work done, efficiencies, hydraulic design, draft tube theory, functions and efficiency.

MODULE III	SOLAR ENERGY
	Solar radiation: Environmental impact of solar power, physics of the sun, solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on tilted surface, instruments for measuring solar radiation, solar radiation data, solar concentrators, collectors, thermal applications, design of standalone solar systems, simple problems. Photovoltaic systems: Photovoltaic effect, semiconducting materials, band gap theory, photo emission of electrons, cell configuration, types of solar cells, cell properties, device physics, electrostatic field across the depletion layer, voltage developed, I-V characteristics, module structure and fabrication, output power and efficiency, fill factor, maximum power point tracking (MPPT), solar grid connected inverters, simple problems.
MODULE IV	WIND ENERGY
	Wind energy: Sources and potential, power from wind, Betz criterion, components of wind energy conversion system, types of turbines, horizontal and vertical axis wind turbines, aerodynamics, operational characteristics, blade element theory, types of generating systems for wind energy, permanent magnet generators, DC generators, induction generators, doubly fed induction generators, applications of wind energy, safety and environmental aspects, simple problems.
MODULE V	ECONOMIC ASPECTS OF POWER STATIONS
	Terms commonly used in system operation, various factors affecting cost of generations; load curves, connected load, maximum demand, peak load, base load and peak load power plants, load factors, plant capacity factor, plant use factor, demand factors, diversity factor, cost of power plant, tariffs.

TEXTBOOKS

1. C L Wadhawa, “Generation, Distribution and Utilization of Electrical Energy”, New Age International Limited, New Delhi, 3rd Edition,2005
2. G D Rai, “Non-Conventional Energy Sources”, Khanna Publishers, 1st Edition, 2011
3. G N Tiwari, M K Ghosal, “Fundamentals of Renewable Energy Sources”, Narosa Publications, New Delhi, 1st Edition, 2007
4. Chetan Singh Solanki, “Solar Photovoltaics”, PHI Publications, 2nd Edition, 2011
5. M L Soni, P V Gupta, U S Bhatnagar and A Chakraborti, “A text book on Power system engineering”, Dhanpat Rai and Co. Pvt. Ltd, 1999

REFERENCE BOOKS:

1. C L Wadhawa, “Generation, Distribution and Utilization of Electrical Energy”, New Age International Limited, New Delhi, 3rd Edition,2005
2. J B Gupta, “A Course in Electrical Power”, S K Kataria and Sons, New Delhi, 15th Edition,2013.
3. M V Deshpande, “Elements of Power Station Design”, Prentice Hall Learning Private Limited New Delhi, 1st Edition, 1992.
4. Mukund R Patel, “Wind and Solar Power Systems”, CRC Press, 1st Edition, 1999.
5. V K Mehta and Rohit Mehta, “Principle of Power Systems”, S Chand and Company, Ltd, New Delhi, 3rd Edition,2005.
6.

WEB REFERENCES:

1. https://www.electrical4u.com
2. https://www.freevideolectures.com
3. 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	Introduction		
CONTENT DELIVERY (THEORY)			
2	Evaluation of power systems, present day scenario	CO 2	T2: 1.2-1.8 R2:1.1
2-3	Line diagram of thermal power station (TPS) showing paths of coal, steam, water, air, ash and flue gasses	CO 1	T2:1.9 R2:1.5 R1: 3.1
4-5	Brief description of TPS components: Economizers, boilers, super heaters, turbines, condensers, chimney and cooling towers	CO 1	T2:1.10 R2:1.2,1.4
6	Thermal efficiency and efficiency of TPS	CO 1	T2: 2.3-2.5 R2:1.6
7	Nuclear fission and chain reaction, nuclear fuels, principle of operation of nuclear reactor	CO 1	T2:1.12 R2:1.14
8	Reactor components, moderators, control rods, reflectors and coolants, radiation hazards, shielding and safety precautions	CO 1	T2: 2.6 R2:1.7,1.8
9-10	Types of nuclear reactors and brief description of PWR, BWR and FBR	CO 1	T2: 2.7 R2:1.12
11	Gas power stations: Principle of operation and components (Block diagram approach only)	CO 1	T2: 2.6 R2:1.7,1.8
12	Elements of hydro electric power stationl CO 2 T2: 1.11 R2:6.2 13 Types, concept of pumped storage plants)	CO 2	T2: 10.4 R2:4.0
14	Storage requirements, mass curve (explanation only)	CO 2	T2: 10.5.1.3 R2:4.0
15-16	Estimation of power developed from a given catchment area, heads and efficiencies	CO 2	T2: 10.5.1.3 R2:4.0
17	Hydraulic turbines: Classification of turbines, impulse and reaction turbinesl	CO 2	T2:7.1 R2:5.2
18	Pelton wheel, Francis turbine and Kaplan turbine	CO 2	T2:7.6 R2:5.3

19-20	Working proportions, work done, efficiencies	CO 2	T2:7.2 R2:5.4
21	Hydraulic design, draft tube theory, functions and efficiency	CO 2	T2: 7.6.1 R2:5.7
22	Environmental impact of solar power, physics of the sun, solar constant, extraterrestrial and terrestrial solar radiation	CO 3	T2: 7.6.3 R2:5.10,5.11
23-24	Solar radiation on tilted surface, instruments for measuring solar radiationv.	CO 3	T2: 7.7 R2:5.16
25-26	Solar concentrators, collectors, thermal applications	CO 3	T2: 7.7.6 R2:5.21,5.22
27	Design of standalone solar systems	CO 3	T2:7.7.5 R2:5.20
28-29	Simple problems	CO 3	T2:4.1 R2:2.1
30	Photovoltaic effect, semiconducting materials, band gap theory	CO 3	T:4.5-4.6 R2:2.2
31-32	Photo emission of electrons, cell configuration, types of solar cells	CO 3	T2: 5.2.4.1 R2:3.2
33	Cell properties, device physics, electrostatic field across the depletion layer	CO 3	T2:6.5 R2:602
34	Voltage developed, I-V characteristics, module structure and fabrication	CO 3	T2: 6.6.1 R2:6.6
35	Output power and efficiency	CO 3	T2: 6.9-6.10 R2:6.13,6.15
36	Fill factor, maximum power point tracking (MPPT), solar grid connected inverters	CO 3	T2:9.3 R2:7.2
37	Simple problems	CO 3	T2: 9.3.1 R2:7.8
38	Sources and potential, power from wind, Betz criterion	CO 4	T2: 8.4 R2:7.11
39	Components of wind energy conversion system, types of turbines	CO 4	T2: 8.4 R2:7.13
40	Horizontal and vertical axis wind turbines, aerodynamics, operational characteristics	CO 4	T2: 8.8 R2:7.16
PROBLEM SOLVING/ CASE STUDIES			
1-2	Blade element theory, types of generating systems for wind energy	CO 4	T2: 8.8 R2
3-4	Permanent magnet generators, DC generator	CO 4	T4: 4.11 R2:8.1
5-6	Induction generators, doubly fed induction generators	CO 5	T4: 4.23 R2:8.8,8.17
7-8	Applications of wind energy, safety and environmental aspects	CO 5	T4: 4.19,5.2 R2:8.22.5
9-10	Simple Problems	CO 5	T4:4.23 R2:8.23

11-12	Terms commonly used in system operation, various factors affecting cost of generations	CO 6	T4: 6.4-6.5 R2:9.1
13-14	Load curves, connected load, maximum demand, peak load	CO 6	T4: 6.6 R2:9.21,9.22
15-16	Base load and peak load power plants, load factors	CO 6	T4:6.3 R2:9.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57-58	Plant capacity factor, plant use factor, demand factors, diversity factor, cost of power plant	CO 6	T4:6.7 R2:9.5
59-60	Tariffs	CO 6	T4:6.6 R2:9.7
DISCUSSION OF QUESTION BANK			
1	CONVENTIONAL POWER GENERATION	CO 1,2, 3	R4:2.1
2	HYDRO ELECTRIC POWER STATIONS	CO 4,11	T4:7.3
3	WIND ENERGY	CO 6,7	R4:5.1
4	SOLAR ENERGY	CO 8,11	T1:7.5
5	ECONOMIC ASPECTS OF POWER STATIONS	CO 9,10, 11	T1: 4.1

Signature of Course Coordinator

HOD,EEE

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**ELECTRICAL MACHINES LABORATORY-II**				
Course Code	AEEB17				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. K Devender Reddy, Assistant Professor				

I COURSE PRE-REQUISITES AND CO-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB11	III	ELECTRICAL MACHINES-I
B.Tech	AEEB15	IV	ELECTRICAL MACHINES-II

II COURSE OVERVIEW:

This course is intended to train the students on alternating current machines. It provides hands-on experience by conducting various direct and indirect tests on transformers, synchronous and asynchronous machines to analyse the characteristics of AC machines and separate various losses. This course also enables to develop skills to select, install, operate, and maintain various types of AC machines and transformers

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Machines Laboratory-II	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:

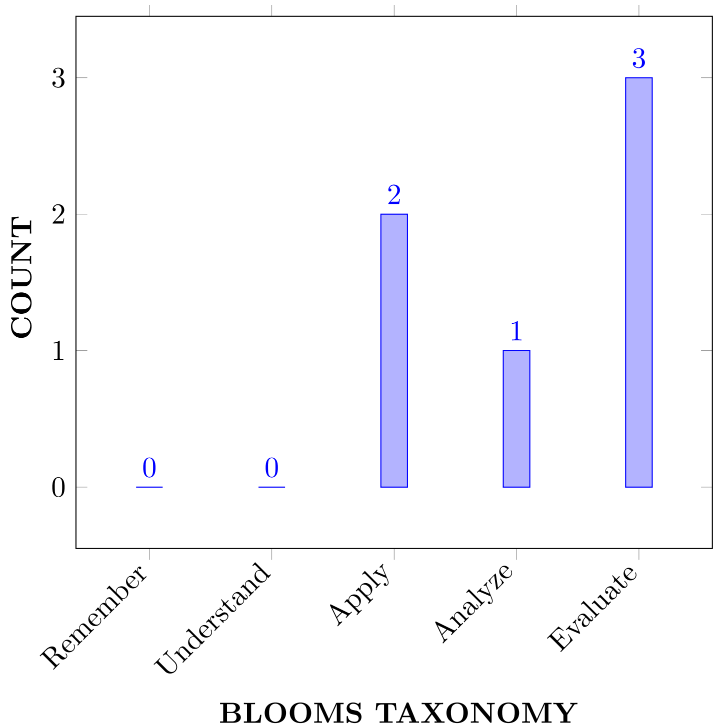
I	The elementary experimental and modelling skills for handling problems with electrical machines in industries and domestic applications.
II	The operation of AC machines and its role in power transmission and generating stations.
III	The automation concepts through programmable logic controllers to control the speed and starting current.

VII COURSE OUTCOMES:

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

CO 1	**Select** suitable testing strategies for evaluating the performance characteristics of transformers.	Apply
CO 2	**Determine** the performance parameters of induction motor by conducting direct and indirect tests.	Evaluate
CO 3	**Explain** the parallel operation of alternators for load sharing under various loading conditions.	Evaluate
CO 4	**Distinguish** the synchronous impedance and ampere turns methods for the computation of voltage regulation of an alternator.	Analyze
CO 5	**Estimate** the voltage and current swings in salient pole alternator for determination of direct and quadrature axis reactance.	Evaluate
CO 6	**Apply** programmable logic controllers for limiting the starting current of poly phase induction motors.	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		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 analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	3	Lab Exercise
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	Lab Exercise
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 Exercise
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
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.	2	Lab Exercises
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 Exercise
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

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 Exercise

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	3	Lab Exercises
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.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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	Understand the performance characteristics of transformer using **principles of Mathematics and Engineering**	2
	PO 2	Solve the complex problems related to efficiency and characteristics of transformers and validate their specifications with **basics principles of mathematics and engineering sciences**.	7
	PO 3	Demonstrate the single phase transformer characteristics **for design solutions of complex engineering problems**	7
	PO 4	Understand the working of transformers using mathematical model under loaded and unloaded conditions **with analysis and interpretation of data**	9
	PO 6	Illustrate the working of transformers using mathematical model under loaded and unloaded conditions **for safety issues in professional engineering practice**	3
	PO 8	Understand the working of transformers using mathematical model under loaded and unloaded conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte working of transformers using mathematical model under loaded and unloaded conditions **to function effectively as an individual and as a member in team**	6

	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 presentation and give and receive clear instructions.	3
	PO 12	Understand the working of transformer using mathematical model under loaded and unloaded conditions **in life long learning in technological change**	4
	PSO 1	Understand different transformer connections in **Power transmission**	2
	PSO 3	Illustrate the working of transformers using mathematical model under loaded and unloaded conditions **in automation process using PLC and process controllers**	5
CO 2	PO 1	Understand the performance characteristics of poly phase induction motors and determine equivalent circuit parameters by applying the principles of **mathematics, science to the solutions of complex engineering problems**.	2
	PO 2	Solve the **complex engineering problems** related to efficiency and characteristics of induction motors and **validate** their specifications with **basics principles of mathematics and engineering sciences**.	4
	PO 3	Demonstrate the poly phase induction motor characteristics **for design solutions of complex engineering problems**	7
	PO 4	Understand the working of three phase induction motor using mathematical model under loaded and unloaded conditions **with analysis and interpretation of data**	9
	PO 6	Illustrate the working of three phase induction motor using mathematical model under loaded and unloaded conditions **for safety issues in professional engineering practice**	3
	PO 8	Understand the working of three phase induction motor using mathematical model under loaded and unloaded conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance winding factors.	3
	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 presentation and give and receive clear instructions .	3
	PO 12	Understand the working of induction machines using mathematical model under loaded and unloaded conditions **in life long learning in technological change**	4

	PSO 1	Understand different function of different types of induction motors in **Power utilization**	2
	PSO 3	Illustrate the working of induction machines using mathematical model under loaded and unloaded conditions **in automation process using PLC and process controllers**	7
CO 3	PO 1	Apply the **(knowledge)** of load characteristics for the parallel operation of alternator by analyzing **complex engineering problems** using the principles of **mathematics, engineering science.**	2
	PO 2	Understand the load sharing capabilities and reliability of alternators using parallel operation under various loading conditions with**problem statement by analyzing complex engineering problems.**	7
	PO 3	Develop the load sharing capabilities and reliability of synchronous generators using parallel operation under various loading conditions **for design solutions of complex engineering problems**	7
	PO 4	Understand thethe load sharing capabilities and reliability of alternators using parallel operation under various loading conditions **with analysis and interpretation of data**	9
	PO 6	Illustrate the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **for safety issues in professional engineering practice**	3
	PO 8	Understand the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the the load sharing capabilities and reliability of synchronous generators using parallel operation under various loading conditions **to function effectively as an individual and as a member in team**	6
	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 presentation and give and receive clear instructions .	3
	PO 12	Understand the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **in life long learning in technological change**	4
	PSO 1	Demonstrate the the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **in power genration**	4

	PSO 3	Illustrate the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **in automation process using PLC and process controllers**	7
CO 4	PO 1	Apply the **(knowledge)** of no load and load characteristics for computing voltage regulation by analyzing **complex engineering problems** using the principles of **mathematics, engineering science.**	2
	PO 2	Demonstrate synchronous impedance and ampere turns methods and apply these methods for **problem formulation** to determine the voltage regulation using **basic principles of mathematics.**	7
	PO 3	Demonstrate the synchronous impedance and ampere turns methods **for design solutions of complex engineering problems**	7
	PO 4	Understand the voltage regulation calculations by graphical methods **with analysis and interpretation of data**	9
	PO 6	Illustrate the synchronous impedance and ampere turns methods **for safety issues in professional engineering practice**	3
	PO 8	Understand the voltage regulation calculation methods **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the voltage regulation calculation methods **to function effectively as an individual and as a member in team**	6
	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 presentation and give and receive clear instructions .	3
	PO 12	Understand the synchronous impedence and ampere turns methods for **in life long learning in technological change**	4
	PSO 1	Demonstrate the voltage regulation calculations **in power genration**	4
	PSO 3	Illustrate the synchronous impedence and ampere turns methods of AC generators **in automation process using PLC and process controllers**	5
CO 5	PO 1	Understand the voltage and current swings in salient pole alternator using **principles of Mathematics and Engineering**	2
	PO 2	Analyze the phasor diagram of salient pole synchronous machine to understand mathematical equations of direct and quadrature axis components and validate their specifications with basic principles of mathematics and engineering science	7

	PO 3	Demonstrate the slip test **for design solutions of complex engineering problems**	7
	PO 4	Understand the direct axis and quadrature axis reactance calculations **with analysis and interpretation of data**	9
	PO 6	Illustrate the voltage and current swings in salient pole alternators **for safety issues in professional engineering practice**	3
	PO 8	Understand the direct and quadrature axis reactance calculations **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of voltage and current swings in synchronous motor	3
	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 presentation and give and receive clear instructions.	3
	PSO 1	Illustrate the effect of voltage and current swings on power generation and its effect on inter connected devices in **power system.**	2
	PSO 3	Illustrate the voltage and current swings of synchronous motors **in automation process using PLC and process controllers**	5
CO 6	PO 1	Understand the starting methods of poly phase induction motor using **principles of Mathematics and Engineering**	2
	PO 2	Analyze the starting methods of poly phase induction motor using programmable logic controllers and validate their specifications with basic principles of mathematics and engineering science	7
	PO 3	Demonstrate programmable logic controllers for limiting the starting current **for design solutions of complex engineering problems**	7
	PO 4	Understand the programmable logic controllers application for limiting starting current **with analysis and interpretation of data**	9
	PO 5	Create, select, and apply appropriate techniques, resources, and **modern Engineering tools** for starting and speed control of poly phase induction motors using programmable logic controllers to complex Engineering activities with an understanding of the limitations.	1
	PO 6	Illustrate the function of PLCs for limiting starting current of three phase induction motors**for safety issues in professional engineering practice**	3

	PO 8	Understand the function of PLCs for limiting starting current of three phase induction motors **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance PLCs in limiting the starting current in three phase induction motor	6
	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 presentation and give and receive clear instructions .	3
	PSO 1	Illustrate the function of PLCs for limiting the starting current in three phase induction motor **power system.**	4
	PSO 3	Design the different control circuits using programmable logic controller and different tools necessary for entry level position to meet the Requirements of the Employer	7

XII 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	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	3	-	2	-	3	3	3	-	2	3	0	2
CO 2	3	3	3	3	-	2	-	3	3	3	-	2	3	0	3
CO 3	3	3	3	3	-	2	-	3	3	3	-	2	3	0	3
CO 4	3	3	3	3	-	2	-	3	3	3	-	2	3	0	2
CO 5	3	3	3	3	-	2	-	3	3	3	-	2	3	0	2
CO 6	3	3	3	3	3	2	-	3	3	3	-	2	3	0	3

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK I	**OC AND SC TEST ON SINGLE PHASE TRANSFORMER**
	Determine the equivalent circuit parameters; predetermine the efficiency and regulation by open circuit and short circuit test on a single phase transformer.
WEEK II	**SUMPNER'S TEST**
	Predetermine the efficiency and regulation of two identical single phase transformers
WEEK III	**LOAD TEST ON SINGLE PHASE TRANSFORMERS**
	Determination of efficiency by load test on a single phase transformer.
WEEK IV	**SCOTT CONNECTION OF TRANSFORMERS**
	Conversion of three phase to two phase using single phase transformers
WEEK V	**SEPARATION OF CORE LOSSES IN SINGLE PHASE TRANSFORMER**
	Find out the eddy current and hysteresis losses in single phase transformer
WEEK VI	**HEAT RUN TEST ON SINGLE PHASE TRANSFORMERS**
	Determine the temperature rise in three single phase transformers set.
WEEK VII	**BRAKE TEST ON THREE PHASE SQUIRREL CAGE INDUCTION MOTOR**
	Plot the performance characteristics of three phase induction motor.
WEEK VIII	**CIRCLE DIAGRAM OF THREE PHASE SQUIRREL CAGE INDUCTION MOTOR**
	Plot the circle diagram and predetermine the efficiency and losses of three phase squirrel cage induction motor.
WEEK IX	**REGULATION OF ALTERNATOR BY EMF METHOD**
	Determine the regulation of alternator using synchronous impedance method.
WEEK X	**REGULATION OF ALTERNATOR BY MMF METHOD**
	Determine the regulation of alternator using ampere turns method.
WEEK XI	**SLIP TEST ON THREE PHASE SALIENT POLE SYNCHRONOUS MOTOR**
	Determination of Xd and Xq in a three phase salient pole synchronous motor
WEEK XII	**V AND INVERTED V CURVES OF SYNCHRONOUS MOTOR**
	Plot V and inverted V curves to study the effect of power factor in synchronous motor.
WEEK XIII	**EQUIVALENT CIRCUIT PARAMETERS OF SINGLE PHASE INDUCTION MOTOR**
	Determine the equivalent circuit parameters of a single phase induction motor.
WEEK XIV	**STAR – DELTA STARTER OF INDUCTION MOTOR USING PLC**
	Implementation of star-delta starter using PLC; Speed control of three phase slip ring induction motor with rotor resistance cutting using PLC.

TEXTBOOKS

1. P S Bimbhra, "Electrical Machinery", Khanna Publishers, 1^{st} Edition, 2011.
2. J B Guptha "Theory and performance of Electrical machines", S.K.Kataria and Sons Publishers 14^{th} Edition, 2009.
3. I J Nagrath and D P Kothari, "Electric Machines", McGraw Hill Education, 1^{st} Edition, 2010.

REFERENCE BOOKS:

1. M G Say, E O Taylor, "Direct Current Machines", Longman Higher Education, 1^{st} Edition, 2002.
2. A E Fitzgerald and C Kingsley, "Electric Machinery", New York, McGraw Hill Education, 1^{st} Edition, 2013

XVI 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	OC and SC test on single phase transformer.	CO 1	T2:1.21
2	Sumpner's test.	CO 1	T2:2.10
3	Load test on single phase transformers	CO 1	T2:1.19
4	Scott connection of transformers	CO 1	T2:2.5
5	Separation of core losses in single phase transformer.	CO 1	T2.1.19
6	Heat run test on single phase transformers.	CO 1	T2:2.3
7	Brake test on three phase squirrel cage induction motor.	CO 2	T2:7.29
8	Circle diagram of three phase squirrel cage induction motor	CO 2	T2:7.31
9	Regulation of alternator by EMF method.	CO 4	T2:3.17
10	Regulation of alternator by MMF method.	CO 4	T2:3.17
11	Slip test on three phase salient pole synchronous motor.	CO 5	T2:5.11
12	V and inverted v curves of synchronous motor.	CO 3	T2:5.13
13	Equivalent circuit parameters of single phase induction motor.	CO 3	T2:10.7
14	Implementation of star-delta starter using PLC.	CO 6	T2:8.2

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design two phase to three phase conversion system using single phase transformers.
2	Design parallel operation of alternators with synchro scope.
3	Design speed control of induction motor using digital simulation.
4	Design back-to-back connection of identical single phase transformers using digital simulation.
5	Design zero power factor method for calculating voltage regulation.

Signature of Course Coordinator **HOD, EEE**
Mr. K Devender Reddy, Assistant Professor

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**CONTROL SYSTEMS**				
Course Code	AEEB16				
Program	B.Tech				
Semester	IV				
Course Type	CORE				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	3	1.5
Course Coordinator	Ms.K Harshini, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB11	II	Mathematical Transform Techniques
B.Tech	AEEB11	III	Electrical Machines – I

II COURSE OVERVIEW:

This course deals with the basic concepts of block diagram reduction technique, time response analysis of first order and second order systems. It deals with various time and frequency domain analysis. It elaborates the concept of stability and its assessment for linear time invariant systems. This course address the various real time issues and how the control strategies are used in automation areas associates with variety of engineering streams.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Control Systems	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
0%	Remember
66.7 %	Understand
33.3%	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:

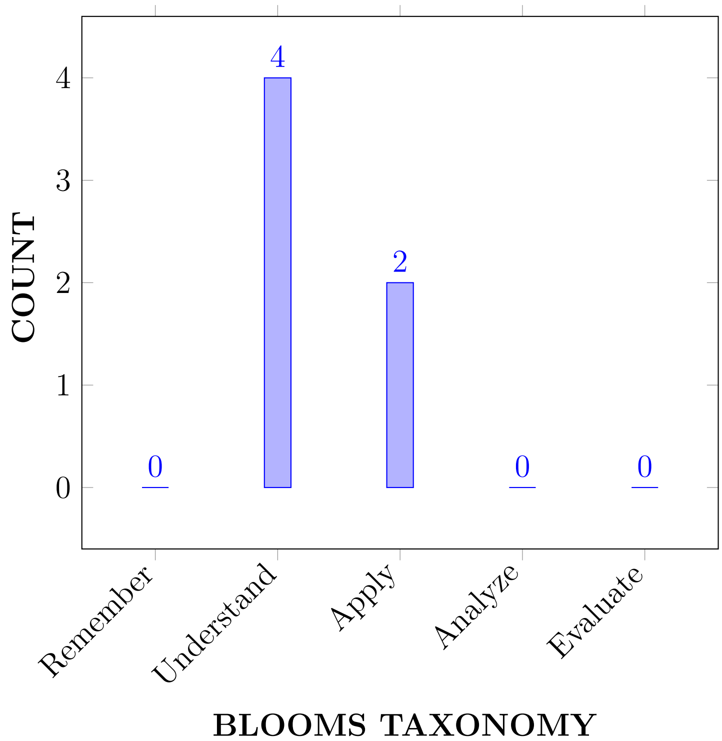
I	The mathematical models of dynamic systems using the concepts of basic sciences.
II	The system performance using time domain and frequency domain analysis for standard inputs.
III	Classification of controllers and compensators as per the desired dynamic response of the system.
IV	The different ways of system representation such as transfer function and state space.

VII COURSE OUTCOMES:

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

CO 1	**Relate** the different physical and mechanical systems into equivalent electrical analogies using the mathematical form of complex physical systems.	Understand
CO 2	**Utilize** various reduction techniques for developing the transfer function and steady state error with the standard input signals.	Apply
CO 3	**Make use of** the time domain analysis to predict transient response specifications for analysing system's stability	Apply
CO 4	**Infer** the stability of a first and second order systems using frequency domain specifications.	Understand
CO 5	**Classify** the types of compensators in time domain and frequency domains specifications for increasing the steady state accuracy of the system.	Understand
CO 6	**Interpret** linear system equations in state-variable form for the analysis of system's dynamic behavior.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
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 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 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.	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 SPECIFIC OUTCOMES		**Strength**	**Proficiency Assessed by**
PSO 1	Design, develop fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	1	Research Paper / Quiz / AAT
PSO 2	Focus on the components of electrical drives with its converter topologies, for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	1	Research Paper / Quiz / AAT
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	Research Paper / Quiz / 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**	Understands the concept of control systems and its types with the knowledge of mathematics, science and engineering fundamentals.	3
	PO 2	Determine the mathematical model of complex systems by analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 3	Design the equivalent electrical models using force-voltage and force-current analogy by analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 4	Analyze the characteristics of Motors of Field and Armature control by conducting some investigations using technical literature and research based knowledge	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 6	Understands the concept of open loop and closed loop with examples informed by the contextual knowledge to assess societal engineering practice.	3
	PO 10	Understands the basics of control systems and should be able to communicate effectively on engineering activities	2
	PO 12	Recognize the types of control systems is what we use in daily life through the preparation and ability in personal development.	2
	PSO 3	Understands the operation of open and closed loop control systems to meet the requirements of the employer.	1
CO 2	**PO 1**	Explain the different complex physical systems with the knowledge of mathematics, science, and engineering fundamentals.	3
	PO 2	Determine the mathematical model of complex systems by analyze complex engineering problems using principles of mathematics and engineering sciences.	6
	PO 3	Design the solution for analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 4	Analyze the behavior of first and second order system with different standard inputs by conducting some investigations using technical literature and research based knowledge	5
	PO 6	Understands the concept of various controllers and how they are applicable to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of various controllers ability to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of controllers and various types of system should be able to communicate effectively on engineering activities	2
	PO 12	Recognize the types of controllers is what we use in daily life through the preparation and ability in personal development.	3
	PSO 1	Design and operate controllers in electrical systems in order to protect the system.	1
CO 3	**PO 1**	Understand the concept of stability of the system from the characteristic equation using principles of mathematics, science, and engineering fundamentals.	3
	PO 2	Formulate the mathematical equations for a system's stability framed using basics of mathematics and engineering sciences	5
	PO 3	Design the solution for a system of unity feedback by analyze complex engineering problems using principles of mathematics and engineering sciences.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	Analyze the nature of stability of the type of system by conducting some investigations using technical literature and research based knowledge	5
	PO 6	Understands the concept of stability of open and closed loop system and type of feedback from the contextual knowledge to assess societal engineering practice.	3
	PSO 1	Design and operate controllers in electrical systems in order to protect the system.	1
CO 4	**PO 1**	Understand the concept of frequency response of a system using principles of mathematics, science, and engineering fundamentals.	3
	PO 2	Derive frequency domain specifications and correlation between time and frequency domain framed using basics of mathematics and engineering sciences.	4
	PO 3	Determine the frequency response of a system by analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 4	Analyze the magnitude and phase plot by conducting some investigations using technical literature and research based knowledge	7
	PO 6	Understands the concept of frequency response of a system from the contextual knowledge to assess societal engineering practice.	3
	PSO 2	Understands frequency response of a system involving transmission and distribution of Electrical Energy	1
CO 5	**PO 1**	Understands the concept of compensators and its types using the fundamentals of mathematics, science, and engineering fundamentals.	3
	PO 2	Derive the equation for lead, lag, lead-lag compensators to meet the specifications framed using basics of mathematics and engineering sciences.	5
	PO 3	Determine the frequency response of a system by analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 4	Analyze the behavior of types of compensators by conducting some investigations using technical literature and research based knowledge	7
	PO 6	Understands the concept of various compensators and how they are applicable to the contextual knowledge to assess societal engineering practice.	2
	PO 8	Knowledge of various compensators ability to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of compensators and various types of system should be able to communicate effectively on engineering activities	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 12	Recognize the types of compensators is what we use in daily life through the preparation and ability in personal development.	2
	PSO 1	Design and operate compensators in electrical systems in order to protect the system.	2
	PSO 2	Control the system's power utilization in electrical systems in specific applications of industry and sustainable rural development.	2
CO 6	**PO 1**	Understands state model of control system using its block diagram using basic knowledge of science and engineering fundamentals.	3
	PO 2	Formulate the state transmission matrix for controllability and observability to evaluate stability of the system framed using basics of mathematics and engineering sciences.	4
	PO 3	Determine the state of stability of a system or a differential linear equation analyze complex engineering problems using principles of mathematics and engineering sciences.	7
	PO 6	Understands the concept of state of stability of a system they are application to the contextual knowledge to assess societal engineering practice.	2

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	7	7	5	-	3	-	-	-	2	-	2	-	-	1
CO 2	3	3	7	5	-	3	-	3	-	2	-	3	2	-	-
CO 3	3	5	5	5	-	3	-	-	-	-	-	-	1	-	-
CO 4	3	4	7	7	-	3	-	-	-	-	-	-	-	1	-
CO 5	3	5	7	7	-	2	-	3	-	2	-	2	2	2	-
CO 6	3	4	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	100	66	9	-	60	-	-	-	20	-	8.3	-	-	14.2
CO 2	100	100	66.7	9	-	60	-	100	-	20.0	-	8.3	40.0	-	-
CO 3	100	100	50	9	-	60	-	-	-	-	-	-	20.0	-	-
CO 4	100	66.7	66.7	100	-	60	-	-	-	-	-	-	-	9.09	-
CO 5	100	66.7	66.7	100	-	40	-	100	-	20.0	-	8.3	40.0	18.2	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 6	100	66.7	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	3	2	1	-	2	-	-	-	1	-	1	-	-	1
CO 2	3	3	2	1	-	2	-	1	-	1	-	1	2	-	-
CO 3	3	3	3	1	-	3	-	-	-	-	-	-	1	-	-
CO 4	3	2	2	3	-	3	-	-	-	-	-	-	-	1	-
CO 5	3	2	2	3	-	1	-	1	-	1	-	1	2	2	-
CO 6	3	2	2	-	-	1	-	-	-	-	-	-	-	-	-
TOTAL	18	15	13	9	-	12	-	2	-	3	-	3	5	3	1
AVERAGE	3	2.5	2.0	1.8	-	2	-	1	-	1	-	1	1.5	1.5	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	INTRODUCTION AND MODELING OF PHYSICAL SYSTEMS
	Control systems: Introduction, open loop and closed loop systems, examples, comparison, mathematical modelling and differential equations of physical systems, concept of transfer function, translational and rotational mechanical systems, electrical systems, force, voltage and force, current analogy.

MODULE II	**BLOCK DIAGRAM REDUCTION AND TIME RESPONSE ANALYSIS**
	Block Diagrams: Block diagram representation of various systems, block diagram algebra, characteristics of feedback systems, AC servomotor, signal flow graph, Mason's gain formula; Time response analysis: Standard test signals, shifted unit step, impulse response,unit step response of first and second order systems, time response specifications, steady state errors and error constants, dynamic error coefficients method, effects of proportional, derivative and proportional derivative, proportional integral and PID controllers.
MODULE III	**CONCEPT OF STABILITY AND ROOT LOCUS TECHNIQUE**
	Concept of stability: Necessary and sufficient conditions for stability, Routh's and Routh Hurwitz stability criterions and limitations. Root locus technique: Introduction, root locus concept, construction of root loci, graphical determination of 'k' for specified damping ratio, relative stability, effect of adding zeros and poles on stability.
MODULE IV	**FREQUENCY DOMAIN ANALYSIS**
	Frequency domain analysis: Introduction, frequency domain specifications, stability analysis from Bode plot, Nyquist plot, calculation of gain margin and phase margin, determination of transfer function, correlation between time and frequency responses.
MODULE V	**STATE SPACE ANALYSIS AND COMPENSATORS**
	State Space Analysis: Concept of state, state variables and state model, derivation of state models from block diagrams, diagonalization, solving the time invariant state equations, state transition matrix and properties, concept of controllability and observability; Compensators: Lag, lead, lead - lag networks.

TEXTBOOKS

1. I J Nagrath, M Gopal, "Control Systems Engineering", New Age International Publications, 3rd Edition, 2007.
2. K Ogata, "Modern Control Engineering", Prentice Hall, 4th Edition, 2003
3. N C Jagan, "Control Systems", BS Publications, 1st Edition, 2007.

REFERENCE BOOKS:

1. Anand Kumar, "Control Systems", PHI Learning, 1st Edition, 2007.
2. S Palani, "Control Systems Engineering", Tata McGraw-Hill Publications, 1st Edition, 2001.
3. N K Sinha, "Control Systems", New Age International Publishers, 1st Edition, 2002.

WEB REFERENCES:

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

COURSE WEB PAGE:

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
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 to Control systems	CO 1	T1:1.1
2	Types of Control systems Open loop and Closed loop systems	CO 1	T1:1.1
3	Examples of closed control system and open loop system	CO 1	T1:1.4-1.6
4	Concept of transfer function	CO 1	T1: 2.4
5	Mechanical translational system, Force balance equations.	CO 1	T1:2.2
6	Mechanical rotational system, Torque balance equations.	CO 1	T1:2.2
7	Transfer function of Armature controlled and Field controlled of DC Motor.	CO 1	T1:2.4
8	Force -Voltage and Force-Current Analogy	CO 1	T1:2.2
9	Block Diagrams: Block diagram representation of various control systems	CO 2	T1:2.5
10	Block diagram reduction and Rules of block diagram	CO 2	T1:2.5
11	Characteristics of feedback systems	CO 2	T1: 3.1-3.2
12	AC Servomotor working and characteristics	CO 2	T1: 1..2
13	Signal Flow Graph, properties and rules of signal flow graph	CO 2	T1 :2.6
14	Step by step procedure of transfer function from signal flow graph using Mason's Gain Formula	CO 2	T1 :2.6
15	Time response analysis, Standard test signals	CO 2	T1 :5.1-5.2
16	Impulse response	CO 2	T1 :5.1-5.2
17	Response of first order system for step input	CO 2	T1: 5.3
18	Response of Un damped second order system for step input	CO 2	T1: 5.3
19	Response of Under damped and Over damped second order system for step input	CO 2	T1: 5.3
20	Time Domain specifications of second order system	CO 2	T1: 5.4
21	Steady state errors and error constants	CO 2	T1: 5.5
22	Error constants for various inputs and for different Types of system	CO 2	T1: 5.5
23	PID Controllers	CO 2	T1:5.8
24	Concept of stability Necessary and sufficient conditions for stability	CO 3	T1: 6.1 -6.2

25	Conditions and special cases for stability using Routh's Hurwitz method.	CO 3	T1: 6.3 -6.5
26	Introduction to Root locus concept.	CO 3	T1: 7.1 -7.2
27	Step by step procedure for construction of root locus	CO 3	T1: 7.3
28	Effect of adding zeros and poles on stability.	CO 3	T1: 5.6
29	Frequency domain analysis Introduction	CO 4	T1: 8.1 -8.2
30	Frequency domain specifications, stability analysis	CO 4	T1: 8.2
31	Procedure of Bode Plot for magnitude and phase plot.	CO 4	T1: 8.4
32	Procedure for gain margin and phase margin	CO 4	T1: 8.4
33	Procedure of Nyquist plot for magnitude and phase plot.	CO 4	T1: 9.1-9.4
34	Determination of transfer function, correlation between time and frequency responses	CO 4	T1: 8.1 -8.2
35	State Space Analysis: Concept of state, state variables and state model	CO 6	T1: 12.1-12.2
36	Derivation of state models from block diagrams	CO 6	T1: 12.3-12.4
37	State transition matrix and properties,	CO 6	T1: 12.4
38	Canonical Form of state variables	CO 6	T1: 12.6
39	Concept of controllability and observability	CO 6	T1:12.7
40	Compensators: Lag, lead, lead - lag networks.	CO 5	T1:10.3
PROBLEM SOLVING/ CASE STUDIES			
41	Determine transfer function from mechanical systems	CO 1	R1: 2.6
42	Determine transfer function from electrical systems	CO 1	R1: 2.6
43	Transfer function from Block diagram using reduction technique	CO 2	R1: 3.2
44	Transfer function from Signal Flow Graph using masons gain formula	CO 2	R1: 3.2
45	Problems on Error constants	CO 2	R1: 4.4 Pg No 195-198
46	Problems on time domain specifications	CO 2	R1: 4.4 Pg No 198-209
47	Stability using Routh's Hurwitz method	CO 3	R1:5.3 Pg No 285-292
48	Problems on Root Locus for a given transfer function	CO 3	R1:6.4 Pg No 339-347
47	Problems on Routh's Hurwitz method to find K	CO 3	R1:5.6 Pg No 298-307

48	Problems on Frequency domain specifications	CO 4	R1:7.2 Pg No 413-416
49	Sketch Bode Plot for stability	CO 4	R1:7.3 Pg No 417-427
50	Sketch Bode Plot for gain and phase margin	CO 4	R1:7.4 Pg No 452-465
51	Sketch Polar Plot for gain and phase margin	CO 4	R1:7.3 Pg No 417-427
52	Problems on state model to the canonical form	CO 6	R1:10.3 Pg No 594-597
53	State controllability and observability of a system	CO 6	R1: 10.4 Pg No 661-671
54	Problems on Compensators	CO 5	R1: 9.2
55	Problems on State Transition Matrix	CO 6	R1: 10.7 Pg No 630-639
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Transfer function, components of feedback control system, Automatic Controllers.	CO 1	T1: 2.4
57	Basic elements in Block Diagram, signal flow graph, transient response, transmittance, Masons Gain formula	CO 2	T1: 3.1-3.2
58	Stability, Routh stability criterion, Auxiliary polynomial, Relative stability	CO 3	T1: 6.3 -6.5
59	Frequency response, Resonant frequency, Corner frequency, Polar plot.	CO 4	T1: 8.1 -8.2
60	State variable, Controllability, Compensator, sampling theorem	CO 5, CO 6	T1: 12.3-12.4
DISCUSSION OF QUESTION BANK			
61	Mechanical Rotational System	CO 1	T1: 2.4
62	Block Diagram, Signal flow graph	CO 2	T1: 3.1-3.2
63	Root Locus and Routh's Hurwitz method	CO 3	T1: 6.3 -6.5
64	Bode plots, polar plot and Nyquist plot	CO 4	T1: 8.1 -8.2
65	State Transmission matrix and compensators	CO 5, CO 6	T1: 12.3-12.4

Signature of Course Coordinator **HOD,EEE**

Mrs K Harshini, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**COMPUTER SCIENCE AND 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:

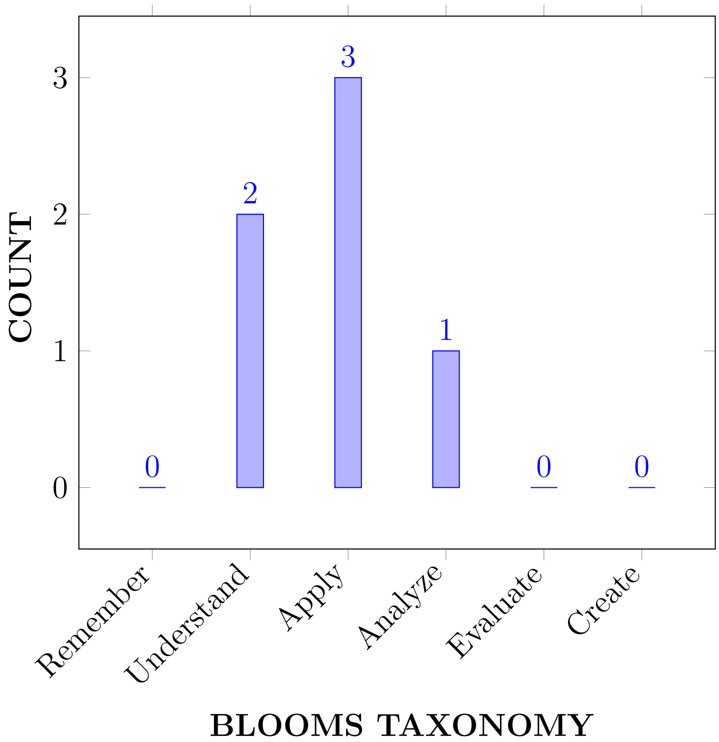
I	The skills needed to understand and analyze performance trade-offs of different algorithms implementations and asymptotic analysis of their running time and memory usage.
II	The knowledge of basic abstract data types (ADT) and associated algorithms: stacks, queues, lists, tree, graphs, hashing and 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	**Understand** design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	3	CIA/ SEE/ Tech Talk/ Concept Videos
PSO 2	**Focus on** improving software reliability, network security information retrieval systems.	2	CIA/ SEE/ Tech Talk/ Concept Videos
PSO 3	**Make use of** modern computer tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	CIA/ SEE/ Tech Talk/ Concept Videos

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
	PSO1	**Design and analyze** complex algorithms and specify its space and time complexities and representing it by asymptotic notations for faster processing of data.	3
	PSO3	**Make use of modern** computer tools for finding space and time complexities of a complex algorithm	1
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
	PSO1	**Understand**complex problems and analyzing it and apply appropriate sorting and searching techniques for data processing.	4
	PSO2	**Applying**various selecting and sorting techniques while designing and developing information retrieval systems and its applications	2
	PSO3	**Make use of** various selecting and sorting techniques and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
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
	PSO1	**Understand** complex problems and analyzing it and apply appropriate operations on linear or nonlinear data structures for Developing the solution.	5
	PSO2	**Applying** various linear or nonlinear data structures while designing and developing information retrieval systems and its applications	2
	PSO3	**Make use of** various linear or nonlinear data structures and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
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
	PSO1	**Understand** complex problems and analyzing it and apply appropriate operations on linear or nonlinear data structures for solving real time applications.	5
	PSO2	**Applying** various linear or nonlinear data structures while designing and developing information retrieval systems and its applications	1

	PSO3	**Make use of** various linear or nonlinear data structures and extend the knowledge for advance frame works and platforms which are necessary for engineering practices and higher studies or become an entrepreneur.	1
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
	PSO1	**Understand** complex problems and analyzing it and apply appropriate hashing techniques and collision resolution methods for efficiently accessing data with respect to performance.	4
	PSO2	**Applying** various hashing techniques and collision resolution methods while designing and developing information retrieval systems and its applications	1
	PSO3	**Build** sufficient knowledge hashing techniques and collision resolution methods so that new product can be developed, which leads to become successful entrepreneur in the present market.	1
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
	PSO 1	**Understand** complex problems and analyzing it and apply Implementation of various types of data structures.	5
	PSO 2	**Applying** Implementation of various types of data structures while designing and developing information retrieval systems and its applications	1
	PSO 3	**Build** sufficient knowledge Implementation of various types of data structures so that new product can be developed, which leads to become successful entrepreneur in the present market.	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
	3	10	10	11	1	5	3	3	12	5	12	12	6	2	2
CO 1	1	4	2	-	-	-	-	-	-	2	-	-	3	-	1
CO 2	1	5	2	-	1	-	-	-	-	2	-	3	4	2	1
CO 3	2	7	5	4	1	-	-	-	-	2	-	3	5	2	1
CO 4	3	7	2	4	1	-	-	-	-	2	-	3	5	1	1
CO 5	1	-	2	-	1	-	-	-	-	2	-	-	4	1	1
CO 6	3	7	5	4	1	-	-	-	-	2	-	3	5	1	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
	3	10	10	11	1	5	3	3	12	5	12	12	2	2	2
CO 1	33.3	40	20	-	-	-	-	-	-	40	-	-	50	-	50
CO 2	33.3	50	20	-	100	-	-	-	-	40	-	25	66.6	100	50
CO 3	66.6	70	50	36.3	100	-	-	-	-	40	-	25	83.3	100	50
CO 4	100	70	20	36.3	100	-	-	-	-	40	-	-	66.6	50	50
CO 5	33.3	-	20	-	100	-	-	-	-	40	-	-	66.6	50	50
CO 6	100	70	50	36.3	100	-	-	-	-	40	-	25	83.3	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	1	1	1	-	-	-	-	-	-	1	-	-	2	-	2
CO 2	1	2	1	-	3	-	-	-	-	1	-	1	3	3	2
CO 3	3	3	2	1	3	-	-	-	-	1	-	1	3	3	2
CO 4	3	3	1	1	3	-	-	-	-	1	-	1	3	2	2
CO 5	1	-	1	-	3	-	-	-	-	1	-	-	3	2	2
CO 6	3	3	2	1	3	-	-	-	-	1	-	1	3	2	2
TOTAL	**12**	**12**	**8**	**3**	**15**	**-**	**-**	**-**	**-**	**6**	**-**	**4**	**17**	**12**	**12**
AVERAGE	**2.0**	**2.4**	**1.3**	**1.0**	**3.0**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2.8**	**2.4**	**2.0**

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,CSE**
Dr V Sitharamulu, Associate Professor

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**ELECTRICAL MACHINES LABORATORY-II**				
Course Code	AEEB17				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. K Devender Reddy, Assistant Professor				

I COURSE PRE-REQUISITES AND CO-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB11	III	ELECTRICAL MACHINES-I
B.Tech	AEEB15	IV	ELECTRICAL MACHINES-II

II COURSE OVERVIEW:

This course is intended to train the students on alternating current machines. It provides hands-on experience by conducting various direct and indirect tests on transformers, synchronous and asynchronous machines to analyse the characteristics of AC machines and separate various losses. This course also enables to develop skills to select, install, operate, and maintain various types of AC machines and transformers

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Machines Laboratory-II	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:

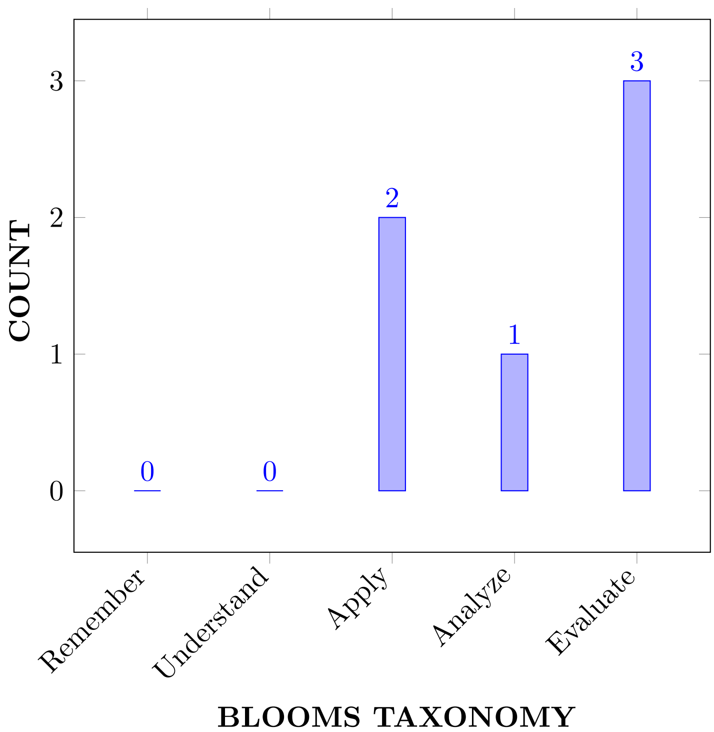
I	The elementary experimental and modelling skills for handling problems with electrical machines in industries and domestic applications.
II	The operation of AC machines and its role in power transmission and generating stations.
III	The automation concepts through programmable logic controllers to control the speed and starting current.

VII COURSE OUTCOMES:

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

CO 1	**Select** suitable testing strategies for evaluating the performance characteristics of transformers.	Apply
CO 2	**Determine** the performance parameters of induction motor by conducting direct and indirect tests.	Evaluate
CO 3	**Explain** the parallel operation of alternators for load sharing under various loading conditions.	Evaluate
CO 4	**Distinguish** the synchronous impedance and ampere turns methods for the computation of voltage regulation of an alternator.	Analyze
CO 5	**Estimate** the voltage and current swings in salient pole alternator for determination of direct and quadrature axis reactance.	Evaluate
CO 6	**Apply** programmable logic controllers for limiting the starting current of poly phase induction motors.	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		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 analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	3	Lab Exercise
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	3	Lab Exercise
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 Exercise
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
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.	2	Lab Exercises
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 Exercise
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

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 Exercise

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	3	Lab Exercises
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.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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	Understand the performance characteristics of transformer using **principles of Mathematics and Engineering**	2
	PO 2	Solve the complex problems related to efficiency and characteristics of transformers and validate their specifications with **basics principles of mathematics and engineering sciences**.	7
	PO 3	Demonstrate the single phase transformer characteristics **for design solutions of complex engineering problems**	7
	PO 4	Understand the working of transformers using mathematical model under loaded and unloaded conditions **with analysis and interpretation of data**	9
	PO 6	Illustrate the working of transformers using mathematical model under loaded and unloaded conditions **for safety issues in professional engineering practice**	3
	PO 8	Understand the working of transformers using mathematical model under loaded and unloaded conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte working of transformers using mathematical model under loaded and unloaded conditions **to function effectively as an individual and as a member in team**	6

	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 presentation and give and receive clear instructions.	3
	PO 12	Understand the working of transformer using mathematical model under loaded and unloaded conditions **in life long learning in technological change**	4
	PSO 1	Understand different transformer connections in **Power transmission**	2
	PSO 3	Illustrate the working of transformers using mathematical model under loaded and unloaded conditions **in automation process using PLC and process controllers**	5
CO 2	PO 1	Understand the performance characteristics of poly phase induction motors and determine equivalent circuit parameters by applying the principles of **mathematics, science to the solutions of complex engineering problems**.	2
	PO 2	Solve the **complex engineering problems** related to efficiency and characteristics of induction motors and **validate** their specifications with **basics principles of mathematics and engineering sciences**.	4
	PO 3	Demonstrate the poly phase induction motor characteristics **for design solutions of complex engineering problems**	7
	PO 4	Understand the working of three phase induction motor using mathematical model under loaded and unloaded conditions **with analysis and interpretation of data**	9
	PO 6	Illustrate the working of three phase induction motor using mathematical model under loaded and unloaded conditions **for safety issues in professional engineering practice**	3
	PO 8	Understand the working of three phase induction motor using mathematical model under loaded and unloaded conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance winding factors.	3
	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 presentation and give and receive clear instructions .	3
	PO 12	Understand the working of induction machines using mathematical model under loaded and unloaded conditions **in life long learning in technological change**	4

	PSO 1	Understand different function of different types of induction motors in **Power utilization**	2
	PSO 3	Illustrate the working of induction machines using mathematical model under loaded and unloaded conditions **in automation process using PLC and process controllers**	7
CO 3	PO 1	Apply the **(knowledge)** of load characteristics for the parallel operation of alternator by analyzing **complex engineering problems** using the principles of **mathematics, engineering science.**	2
	PO 2	Understand the load sharing capabilities and reliability of alternators using parallel operation under various loading conditions with**problem statement by analyzing complex engineering problems.**	7
	PO 3	Develop the load sharing capabilities and reliability of synchronous generators using parallel operation under various loading conditions **for design solutions of complex engineering problems**	7
	PO 4	Understand thethe load sharing capabilities and reliability of alternators using parallel operation under various loading conditions **with analysis and interpretation of data**	9
	PO 6	Illustrate the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **for safety issues in professional engineering practice**	3
	PO 8	Understand the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the the load sharing capabilities and reliability of synchronous generators using parallel operation under various loading conditions **to function effectively as an individual and as a member in team**	6
	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 presentation and give and receive clear instructions .	3
	PO 12	Understand the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **in life long learning in technological change**	4
	PSO 1	Demonstrate the the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **in power genration**	4

	PSO 3	Illustrate the load sharing capabilities and reliability of AC generators using parallel operation under various loading conditions **in automation process using PLC and process controllers**	7
CO 4	PO 1	Apply the **(knowledge)** of no load and load characteristics for computing voltage regulation by analyzing **complex engineering problems** using the principles of **mathematics, engineering science.**	2
	PO 2	Demonstrate synchronous impedance and ampere turns methods and apply these methods for **problem formulation** to determine the voltage regulation using **basic principles of mathematics.**	7
	PO 3	Demonstrate the synchronous impedance and ampere turns methods **for design solutions of complex engineering problems**	7
	PO 4	Understand the voltage regulation calculations by graphical methods **with analysis and interpretation of data**	9
	PO 6	Illustrate the synchronous impedance and ampere turns methods **for safety issues in professional engineering practice**	3
	PO 8	Understand the voltage regulation calculation methods **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the voltage regulation calculation methods **to function effectively as an individual and as a member in team**	6
	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 presentation and give and receive clear instructions .	3
	PO 12	Understand the synchronous impedence and ampere turns methods for **in life long learning in technological change**	4
	PSO 1	Demonstrate the voltage regulation calculations **in power genration**	4
	PSO 3	Illustrate the synchronous impedence and ampere turns methods of AC generators **in automation process using PLC and process controllers**	5
CO 5	PO 1	Understand the voltage and current swings in salient pole alternator using **principles of Mathematics and Engineering**	2
	PO 2	Analyze the phasor diagram of salient pole synchronous machine to understand mathematical equations of direct and quadrature axis components and validate their specifications with basic principles of mathematics and engineering science	7

	PO 3	Demonstrate the slip test **for design solutions of complex engineering problems**	7
	PO 4	Understand the direct axis and quadrature axis reactance calculations **with analysis and interpretation of data**	9
	PO 6	Illustrate the voltage and current swings in salient pole alternators **for safety issues in professional engineering practice**	3
	PO 8	Understand the direct and quadrature axis reactance calculations **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of voltage and current swings in synchronous motor	3
	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 presentation and give and receive clear instructions.	3
	PSO 1	Illustrate the effect of voltage and current swings on power generation and its effect on inter connected devices in **power system.**	2
	PSO 3	Illustrate the voltage and current swings of synchronous motors **in automation process using PLC and process controllers**	5
CO 6	PO 1	Understand the starting methods of poly phase induction motor using **principles of Mathematics and Engineering**	2
	PO 2	Analyze the starting methods of poly phase induction motor using programmable logic controllers and validate their specifications with basic principles of mathematics and engineering science	7
	PO 3	Demonstrate programmable logic controllers for limiting the starting current **for design solutions of complex engineering problems**	7
	PO 4	Understand the programmable logic controllers application for limiting starting current **with analysis and interpretation of data**	9
	PO 5	Create, select, and apply appropriate techniques, resources, and **modern Engineering tools** for starting and speed control of poly phase induction motors using programmable logic controllers to complex Engineering activities with an understanding of the limitations.	1
	PO 6	Illustrate the function of PLCs for limiting starting current of three phase induction motors**for safety issues in professional engineering practice**	3

	PO 8	Understand the function of PLCs for limiting starting current of three phase induction motors **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance PLCs in limiting the starting current in three phase induction motor	6
	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 presentation and give and receive clear instructions .	3
	PSO 1	Illustrate the function of PLCs for limiting the starting current in three phase induction motor **power system.**	4
	PSO 3	Design the different control circuits using programmable logic controller and different tools necessary for entry level position to meet the Requirements of the Employer	7

XII 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	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	3	-	2	-	3	3	3	-	2	3	0	2
CO 2	3	3	3	3	-	2	-	3	3	3	-	2	3	0	3
CO 3	3	3	3	3	-	2	-	3	3	3	-	2	3	0	3
CO 4	3	3	3	3	-	2	-	3	3	3	-	2	3	0	2
CO 5	3	3	3	3	-	2	-	3	3	3	-	2	3	0	2
CO 6	3	3	3	3	3	2	-	3	3	3	-	2	3	0	3

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK I	**OC AND SC TEST ON SINGLE PHASE TRANSFORMER**
	Determine the equivalent circuit parameters; predetermine the efficiency and regulation by open circuit and short circuit test on a single phase transformer.
WEEK II	**SUMPNER'S TEST**
	Predetermine the efficiency and regulation of two identical single phase transformers
WEEK III	**LOAD TEST ON SINGLE PHASE TRANSFORMERS**
	Determination of efficiency by load test on a single phase transformer.
WEEK IV	**SCOTT CONNECTION OF TRANSFORMERS**
	Conversion of three phase to two phase using single phase transformers
WEEK V	**SEPARATION OF CORE LOSSES IN SINGLE PHASE TRANSFORMER**
	Find out the eddy current and hysteresis losses in single phase transformer
WEEK VI	**HEAT RUN TEST ON SINGLE PHASE TRANSFORMERS**
	Determine the temperature rise in three single phase transformers set.
WEEK VII	**BRAKE TEST ON THREE PHASE SQUIRREL CAGE INDUCTION MOTOR**
	Plot the performance characteristics of three phase induction motor.
WEEK VIII	**CIRCLE DIAGRAM OF THREE PHASE SQUIRREL CAGE INDUCTION MOTOR**
	Plot the circle diagram and predetermine the efficiency and losses of three phase squirrel cage induction motor.
WEEK IX	**REGULATION OF ALTERNATOR BY EMF METHOD**
	Determine the regulation of alternator using synchronous impedance method.
WEEK X	**REGULATION OF ALTERNATOR BY MMF METHOD**
	Determine the regulation of alternator using ampere turns method.
WEEK XI	**SLIP TEST ON THREE PHASE SALIENT POLE SYNCHRONOUS MOTOR**
	Determination of Xd and Xq in a three phase salient pole synchronous motor
WEEK XII	**V AND INVERTED V CURVES OF SYNCHRONOUS MOTOR**
	Plot V and inverted V curves to study the effect of power factor in synchronous motor.
WEEK XIII	**EQUIVALENT CIRCUIT PARAMETERS OF SINGLE PHASE INDUCTION MOTOR**
	Determine the equivalent circuit parameters of a single phase induction motor.
WEEK XIV	**STAR – DELTA STARTER OF INDUCTION MOTOR USING PLC**
	Implementation of star-delta starter using PLC; Speed control of three phase slip ring induction motor with rotor resistance cutting using PLC.

TEXTBOOKS

1. P S Bimbhra, "Electrical Machinery", Khanna Publishers, 1^{st} Edition, 2011.
2. J B Guptha "Theory and performance of Electrical machines", S.K.Kataria and Sons Publishers 14^{th} Edition, 2009.
3. I J Nagrath and D P Kothari, "Electric Machines", McGraw Hill Education, 1^{st} Edition, 2010.

REFERENCE BOOKS:

1. M G Say, E O Taylor, "Direct Current Machines", Longman Higher Education, 1^{st} Edition, 2002.
2. A E Fitzgerald and C Kingsley, "Electric Machinery", New York, McGraw Hill Education, 1^{st} Edition, 2013

XVI 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	OC and SC test on single phase transformer.	CO 1	T2:1.21
2	Sumpner's test.	CO 1	T2:2.10
3	Load test on single phase transformers	CO 1	T2:1.19
4	Scott connection of transformers	CO 1	T2:2.5
5	Separation of core losses in single phase transformer.	CO 1	T2.1.19
6	Heat run test on single phase transformers.	CO 1	T2:2.3
7	Brake test on three phase squirrel cage induction motor.	CO 2	T2:7.29
8	Circle diagram of three phase squirrel cage induction motor	CO 2	T2:7.31
9	Regulation of alternator by EMF method.	CO 4	T2:3.17
10	Regulation of alternator by MMF method.	CO 4	T2:3.17
11	Slip test on three phase salient pole synchronous motor.	CO 5	T2:5.11
12	V and inverted v curves of synchronous motor.	CO 3	T2:5.13
13	Equivalent circuit parameters of single phase induction motor.	CO 3	T2:10.7
14	Implementation of star-delta starter using PLC.	CO 6	T2:8.2

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design two phase to three phase conversion system using single phase transformers.
2	Design parallel operation of alternators with synchro scope.
3	Design speed control of induction motor using digital simulation.
4	Design back-to-back connection of identical single phase transformers using digital simulation.
5	Design zero power factor method for calculating voltage regulation.

Signature of Course Coordinator **HOD, EEE**
Mr. K Devender Reddy, Assistant Professor

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

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">CONTROL SYSTEMS LABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">AEEB18</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>IV</td><td colspan="4">EEE</td></tr>
<tr><td>Course Type</td><td>Core</td><td colspan="4"></td></tr>
<tr><td>Regulation</td><td>IARE - R-18</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>3</td><td>1.5</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">K Harshini, Assistant Professor</td></tr>
</table>

I COURSE OVERVIEW:

The Control Systems laboratory course is indeed to train the students practically on the modelling, analysis and design of linear feedback control systems. This course deals with modelling of dynamical systems, and the control components and designing the compensator. The hands on training in the laboratory enable students to apply and modelling control principles in various areas of industrial applications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSC07	II	Mathematical Transform Techniques
B.Tech	AEEC05	III	Network Analysis
B.Tech	AEEC07	III	DC Machines and Transformers
B.Tech	AEEC12	IV	Control Systems

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Control Systems 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:

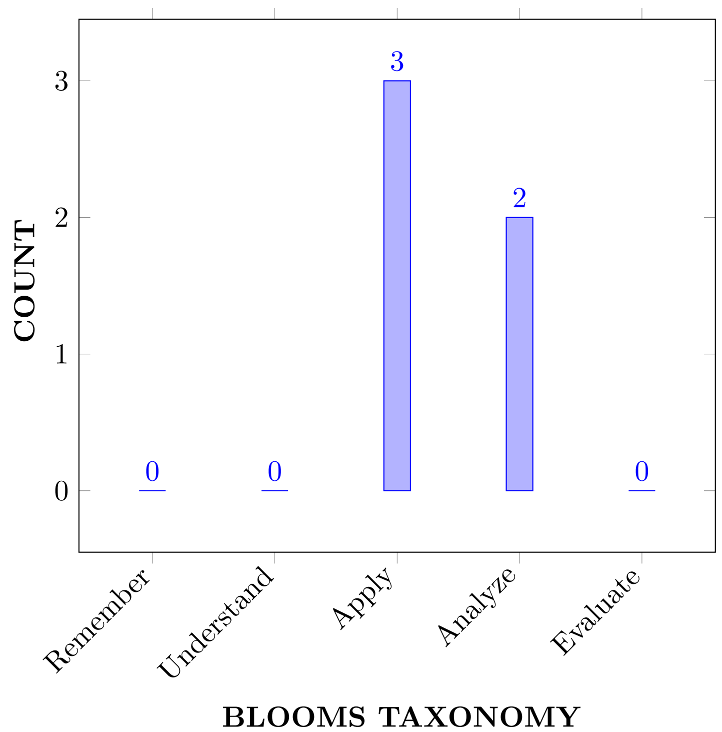
I	The estimation of stability of dynamical systems using Digital simulation.
II	The various techniques of modeling and analysing system's performance.
III	Design the time and frequency response of system by both classical and modern techniques.

VII COURSE OUTCOMES:

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

CO 1	**Make use of** the knowledge of digital simulation tool for system analysis with different standard inputs .	Apply
CO 2	**Model** the dynamic systems in transfer function using digital simulation tool and validate the performance characteristics of motors.	Apply
CO 3	**Analyse** and select various electronics devices for improving system performance along with tuning mechanism in virtual environment.	Analyse
CO 4	**Experiment** the types of compensation techniques for improving the system's accuracy	Apply
CO 5	**Analyse** the system's stability in time and frequency domain by computing gain and phase margin.	Analyse

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 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

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
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
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.	2	Lab Exercises
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
PO 10	textbfCommunication: 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	Lab Exercises
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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	2	Lab Exercises
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	1	Lab Exercises
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.	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	Understands the standard test signals using the**fundamentals of mathematics, science, and engineering fundamentals**	3
	PO 2	Formulate the standard test signals using the**using first principles of mathematics and engineering sciences**	3
	PO 3	Understand the (**Problem Solving**) for step input at various gain levels and, analysis the data, and using the (complex Engineering problems)	3
	PO 4	Understand the (**research-based knowledge**) step response for second order at various gain levels and, analysis and interpretation of data (provided **synthesis of the information to provide valid conclusions**)	3
	PO 5	Analyse (**computational and experimental tools**) of various dynamic systems into transfer function **for analysing systems performance using digital simulation**	1
	PO 6	Apply the (**knowledge**) to assess societal issues and the consequent responsibilities relevant to the professional engineering practice. **the professional engineering practice.**	2
	PO 8	Apply the (**ethical principles**) to assess second order responses for step input as per the **norms of the engineering practice**	2

	PO 9	Understands the (**Individual and team work**) to assess second order responses for step input as per the **multidisciplinary**and as a member or leader in diverse teams	2
	PO 10	Understands the (**Communication**) effectively on complex engineering activities with the engineering community and with society and design documentation **multidisciplinary**and as a member or leader in diverse teams	2
	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 Apply (**Life-Long Learning**) recognize the need of it and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	2
	PSO 1	Understands (**knowledge**) the basics of various test signals and apply to the RLC network which involves in **transmission and distribution of Electrical Energy**	2
	PSO 2	Understands (**knowledge**) the basics of various test signals and apply to the RLC network which involves in **transmission and distribution of Electrical Energy**	2
CO 2	PO 1	Explain (understand) the characteristics of electrical and mechanical physical systems **using principles of mathematics, science, and engineering fundamentals.**	2
	PO 2	Formulate the (given **problem statement**) the mathematical equations for a governing system (from the provided **framed using basics of mathematics and engineering sciences**) in solving analysis problems.	4
	PO 5	Analyse (**computational and experimental tools**) of various plots in time and frequency domain **for improving the system performance using virtual tools**	1
	PSO 2	Understands (**knowledge**) the working of components in servomotors which **specify the applications of industry and sustainable rural development.**	2
CO 3	PO 1	Summarize (**knowledge**) the characteristics of types of controllers **using principles of mathematics, science, and engineering fundamentals.**	1
	PO 2	Formulate the (given **problem statement**) the mathematical equations for a electronic devices (from the provided **framed using basics of mathematics and engineering sciences**) in solving analysis problems.	4
	PO 5	Analyse (**computational and experimental tools**) of the electronic devices **for improving the system performance using virtual tools**	1

	PSO 2	Understands (knowledge) the characteristics of P, I, D, PID controllers which in solving aircraft analysis problems by applying the **specify the applications of industry and sustainable rural development.**	3
CO 4	PO 1	Understand (knowledge) the characteristics of(apply) types of compensators **using principles of mathematics, science, and engineering fundamentals.**	3
	PO 3	Understand the (**Problem Solving**) for types of compensator s and, analysis the data, and (provided **synthesis of the information to provide valid conclusions**)	3
	PO 5	Analyse (**computational and experimental tools**) of various compensators schemes **for improving the system performance using virtual tools**	1
	PSO 2	Understands (knowledge) the characteristics of compensators which**specify the applications of industry and sustainable rural development.**	3
CO 5	PO 1	Understand the concept of Root Locus, Bode Plots and Nyquist Plot to determine stability using **mathematical principles** basic fundamentals of mathematics science and engineering fundamentals. **engineering fundamentals** of control systems.	2
	PO 2	Determine the **problem statement** stability performance in time and frequency domain transfer function of control system for **interpretation** using basics of mathematics and engineering sciences.	2
	PO 5	Analyse (**computational and experimental tools**) of various plots in time and frequency domain **for improving the system performance using virtual tools**	1

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

COURSE OUTCOMES	PROGRAM 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
CO 1	3	2	2	1	3	2	-	1	2	3	-	1
CO 2	3	2	2	2	2	2	-	1	3	3	-	1
CO 3	3	1	2	2	2	2	-	2	3	3	-	2
CO 4	3	1	2	2	3	2	-	1	2	3	-	1
CO 5	3	1	2	2	3	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	**TIME RESPONSE OF SECOND ORDER SYSTEM**
	To obtain the time response of a given second order system with time domain specifications.
WEEK II	**TRANSFER FUNCTION OF DC MOTOR**
	Determine the transfer function, time response of DC motor and verification with digital simulation.
WEEK III	**AC SERVO MOTOR**
	Study of AC servomotor and plot its torque speed characteristics.
WEEK IV	**EFFECT OF VARIOUS CONTROLLERS ON SECOND ORDER SYSTEM**
	Study the effect of P, PD, PI and PID controller on closed loop second order systems.
WEEK V	**COMPENSATOR**
	Study lead-lag compensator and obtain its magnitude, phase plots.
WEEK VI	**TEMPERATURE CONTROLLER**
	Study the performance of PID controller used to control the temperature of an oven.
WEEK VII	**DESIGN AND VERIFICATION OF OP-AMP BASED PID CONTROLLER**
	Implementation of op-amp based PID Controller and verification using MATLAB.
WEEK VIII	**STABILITY ANALYSIS USING DIGITAL SIMULATION**
	Stability analysis using root locus, Bode plot, Polar, Nyquist criterions of linear time invariant system by digital simulation.
WEEK IX	**STATE SPACE MODEL USING DIGITAL SIMULATION**
	Verification of state space model from transfer function and transfer function from state space model using digital simulation.
WEEK X	**LADDER DIAGRAMS USING PLC**
	Input output connection, simple programming, ladder diagrams, uploading, running the program and debugging in programmable logic controller.

WEEK XI	**TRUTH TABLES USING PLC**
	Study and verification of truth tables of logic gates, simple boolean expressions and application to speed control of DC motor using programmable logic controller.
WEEK XII	**IMPLEMENTATION OF COUNTER**
	Implementation of counting number of objects and taking action using PLC.
WEEK XIII	**BLINKING LIGHTS USING PLC**
	Implementation of blinking lights with programmable logic controller.
WEEK XIV	**WATER LEVEL CONTROL**
	Control of maximum and minimum level of water in a tank using PLC.

TEXTBOOKS

1. Norman S. Nise, "Control Systems Engineering", John Wiley Sons, Inc., 6th Edition, 2004.
2. J Nagrath, M Gopal, "Control Systems Engineering", New Age International, 3rd Edition,2007.
3. John W. webb, Ronald A.Reis, "Programmable Logic Controllers, Principles and Applications",5th Edition, 2002.
4. A Nagoor Kani, "Control Systems", RBA Publications,1st Edition, 2009.

REFERENCE BOOKS:

1. 1. Benjamin Kuo, "Automatic Control Systems", PHI, 7th Edition, 1987.
2. 2. K Ogata, "Modern Control Engineering", Prentice Hall, 4th Edition, 2003.

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	Time response of Second Order system.	CO 1	T1:2.1
2	Transfer function of DC motor.	CO 2	T1:3.1
3	Characteristics of Ac Servo Motor	CO 3	T1:3.11
4	Effect of various Controllers on second order systems	CO 4	T1:4.8
5	Compensator.	CO 4	T1:4.8
6	Temperature Controller.	CO 4	T1.5.5
7	Design and verification of Op-Amp Based PID Controller.	CO 4	T1:5.6
8	Stability Analysis Using Digital Simulation.	CO 5	T1:8.3
9	State Space Model Using Digital Simulation.	CO 6	T1:8.3
10	Ladder Diagrams Using PLC.	CO 1	T1:2.1
11	Truth Tables Using PLC	CO 6	T1:8.3
12	Implementation Of Counter Using PLC	CO 2	T1:3.1
13	Blinking Lights Using PLC	CO 2	T1:3.1
14	Water Level Control Using PLC.	CO 5	T1:8.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Design the lead compensator using MATLAB:** Modelling of lead compensator using Matlab to study its characteristics .
2	**Controllers using LABVIEW:** Develop the circuits of Controllers for analysing the performance using LABVIEW .
3	**Step Response of system using LABVIEW:** Design various control system circuits using LABVIEW .
4	**Stability Analysis:** Study the stability of a given system by root locus, Bode plot, Nyquist plot using LABVIEW .
5	**Inverted Pendulum:** Study the Inverted Pendulum of DC Motor using LABVIEW on the Quanser Controls Board

Signature of Course Coordinator **HOD,EEE**
K Harshini, Assistant Professor

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

Course Title	**DATA STRUCTURES LABORATORY**				
Course Code	ACSB05				
Program	B.Tech				
Semester	IV	AE			
Course Type	CORE				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr. P Ravinder, Assistant Professor, CSE				

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
UG	ACSB01	I	Programming for problem solving

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	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 domains.
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.

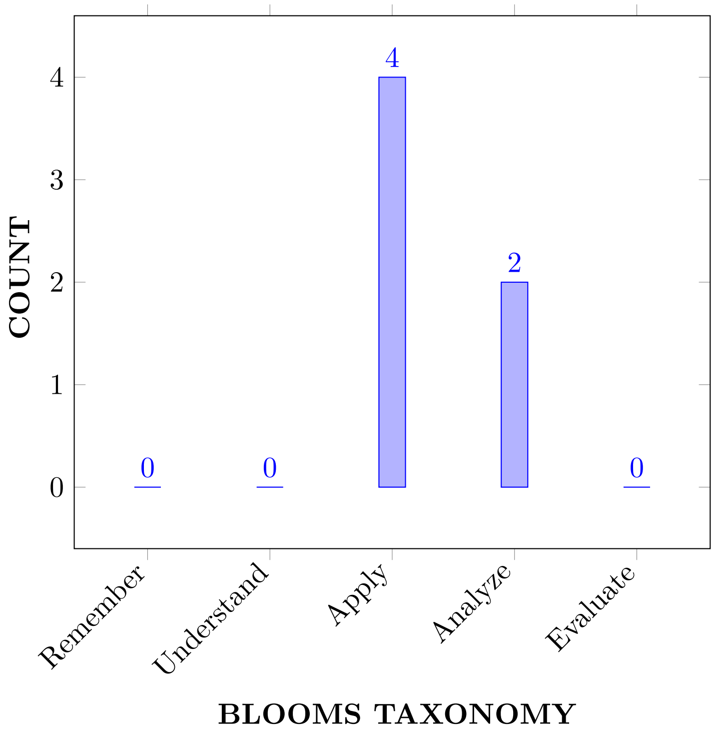
VII COURSE OUTCOMES:

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

CO 1	Carryout the analysis of a range of algorithms in terms of algorithm analysis and express algorithm complexity using the O notation.	Apply
CO 2	Implement techniques like searching, to find the most efficient solutions for underlying problems in different domains.	Apply
CO 3	Gain the 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.	Understand
CO 4	Interpret the recursive and non-recursive techniques to solve problems in DFS of Graph, Towers of Hanoi, Different Types of Tree Traversals, and others (Graphs and Tree traversals)	Apply
CO 5	Implement the sorting algorithm to order the elements of the array according to zip code before printing a set of mailing labels.	Analyze
CO 6	Apply appropriate data structures for solving computing problems with respect to performance.	Analyze
CO 7	Interpret Dynamic data structures like linked list considered efficient with respect to memory complexity of the code.	Analyze
CO 6	Apply appropriate data structures for solving computing problems with respect to performance.	Analyze
CO 8	Extend their knowledge of data structures to more sophisticated data structures to solve problems involving balanced binary search trees, AVL Trees, B-trees and B+ trees, hashing, and basic graphs.	Analyze
CO 9	Interpret the use of basic data structures such as arrays, stacks, queues and linked lists in program design.	Analyze
CO 10	Interpret the benefits of dynamic and static data structures with respect to memory complexity of the code.	Analyze
CO 11	Apply appropriate data structures for solving computing problems with respect to performance.	Analyze

CO 12	Implement the hashing technique to triad's primary principles of assuring the integrity of data	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.	1	LAB PROGRAMS / / 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.	3	LAB PROGRAMS / / 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 PROGRAMS / / CIA/SEE

PO 5	**Conduct investigations of complex problems:** 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 PROGRAMS / / 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.	3	LAB PROGRAMS / / CIA/SEE
PO 12	**Life-long learning:** 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 PROGRAMS / / CIA/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**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.	2	LAB PROGRAMS / CIA/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	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 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.	3
CO 3	PO 1	(**Design**) a Test Plan which helps us to validate the quality of the application for finding the solution of **complex engineering**	1
	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
	PO 10	Recognize the importance of efficient sorting techniques for optimizing the efficiency of other algorithms that require input data to be in sorted by communicating effectively with engineering community.	3
CO 5	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 10	Recognize the importance of efficient sorting techniques for optimizing the efficiency of other algorithms that require input data to be in sorted by communicating effectively with engineering community.	3

CO 6	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 10	Recognize the importance of efficient sorting techniques for optimizing the efficiency of other algorithms that require input data to be in sorted by communicating effectively with engineering community.	3
CO 7	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 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.	3
	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.	2
	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	(**Design**) a Test Plan which helps us to validate the quality of the application for finding the solution of **complex 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.	7
	PO 3	Understand the applications of basic data structures such as stacks, queues, linked lists in designing and developing solutions of complex engineering applications.	6
	PSO 1	Make use of modern computer tools for applying the basic data structure concepts in building real-time applications for a successful career.	2
CO 9	PO 1	(**Design**) a Test Plan which helps us to validate the quality of the application for finding the solution of **complex engineering**	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.	6

	PO 3	Extend the concept of tree data structures to design and develop solutions for complex engineering problems.	6
	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.	2
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.	6
	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.	6
	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.	2
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.	4
	PO 3	Describe (knowledge) the usage of static and dynamic data structures in designing solutions for complex Engineering problems.	6
	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.	2
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.	4
	PO 3	Make use of broad usage of data structures in designing and developing of complex engineering applications.	6

	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.	2

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

Course Outcomes	Program Outcomes					Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO12	PSO1	PSO2	PSO3
CO1	3							
CO2	3							
CO3	1							
CO4	1		3			3		
CO5						3		
CO6	3		2					

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO1, PO2,PO4	SEE Exams	PO1, PO2,PO4	Seminars	-
Laboratory Practices	PO1, PO2,PO4	Student Viva	PO1, PO2,PO4	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**
	a. 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**
	a. 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 STACKL**
	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	**IMPLEMENTATION 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. 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 & Sons, INC., 2011.
5. Benjamin Baka, David Julian, “Python Data Structures and Algorithms”, Packt Publishing Ltd., 2017.

WEB REFERENCE:

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	Searching Techniques	CO 1	T1
2	Sorting Techniques	CO 2	T1
3	Sorting Techniques	CO 3	T1, T2
4	Implementation of Stack and Queue	CO 3, CO 4	T1, T2
5	Applications of Stack	CO 5, CO4	T1, W1
6	Implementation of Single Linked List	CO1, CO3	T1, W2
7	Implementation of Circular Single Linked List	CO 5	T1, W3
8	Implementation of Double Linked List	CO 5	T2, W3
9	Implementation of Stack Using Linked List	CO 4	T2, W2

10	Implementation of Queue Using Linked List	CO5	T2, W5
11	Graph Traversal Techniques	CO4, CO5	T2, W2
12	Implementation of Binary Search Tree	CO1	T1, W5

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	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	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	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	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	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	How many non-null links are there in a binary tree with N nodes?
7	How can we remove loops in a linked list? What are the functions of fast and slow pointers?
8	Which data structures are applied when dealing with a recursive function?

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

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Electrical Power Transmission systems**				
Course Code	AEEB19				
Program	B. Tech				
Semester	V				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	1	3	-	-
Course Coordinator	Mr. P Mabuhussain, Assistant Professor, EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB09	III	Network Analysis
B.Tech	AEEB14	IV	Electrical Power Generating Systems

II COURSE OVERVIEW:

Electrical Power Transmission Systems deals with the modeling, analysis and design of electrical power transmission lines. It gives an emphasis on overhead line insulators, underground cables, transient behavior of the lines, corona phenomena, Extra High Voltage Alternating Current (EHVAC) and High Voltage Direct Current (HVDC) transmission system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Power Transmission systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE 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
5%	Remember
50 %	Understand
40%	Apply
5 %	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
50%	50%	-

VI COURSE OBJECTIVES:

The students will try to learn:

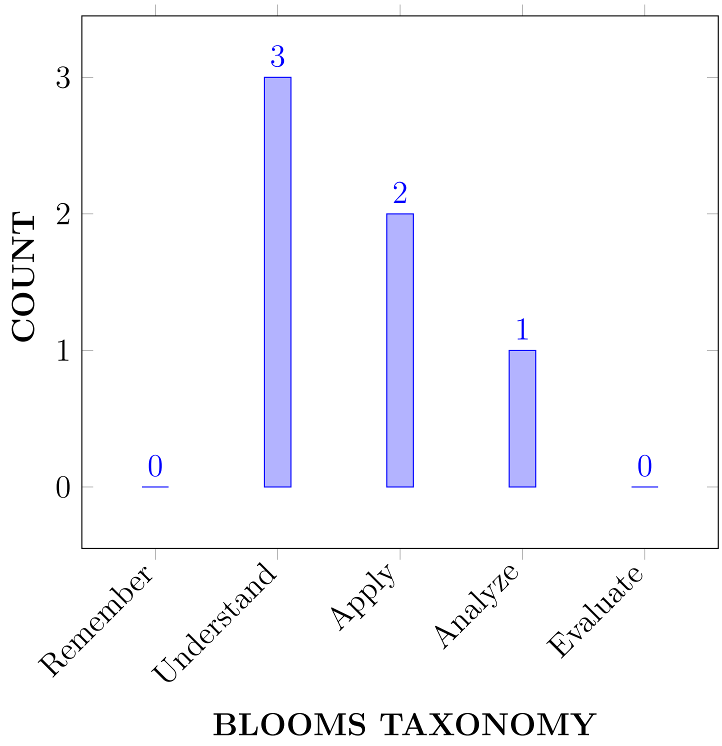
I	The mathematical solutions for transmission line parameters of a single phase and three phase system.
II	The mechanical design of overhead transmission lines, the use of insulators and underground cables in electrical power transmission system.
III	The mathematical modeling of short, medium and long transmission linesalong with the transient behavior.
IV	The Extra High Voltage Alternating Current (EHVAC) and High Voltage Direct Current (HVDC) transmission systems used for transmitting electrical power to consumers.

VII COURSE OUTCOMES:

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

CO 1	**Compute** the line parameters of a single phase and three phase transmission lines using the concepts of Geometric Mean Radius (GMR) and Geometric Mean Distance (GMD).	Apply
CO 2	**Discuss** about ovehead line insulators, string efficiency, sag and tesion parameters which are used in the mechanical design of transmission lines.	Understand
CO 3	**Classify** the transmission lines and model them using ABCD constants to evalutate the performance of tranmission system.	Apply
CO 4	**Discuss** the concepts of skin effect, proximity effect, Ferranti effect, surge impedance and corona effect in electrical power transmission inorder to improve the performance of lines.	Understand
CO 5	**Analyze** the power system transients under different loding conditions of tranmission line using circuit concepts and Bewley's lattice diagram method.	Analyze
CO 6	**Describe** the EHV, HVDC and Underground transmission systems along with its parameters which affects the efficiency and quality operation of power system.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/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.	3	CIE/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	2	CIE/AAT/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.	3	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	CIE/AAT/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	**Recall** the knowledge of **mathematics,science and electrical engineering fundamentals** and apply them to calculate the resistance, inductance and capacitance of transmission lines.	3
	PO 2	**Identify** the type of tranmsiision line, Formulate the equations to calculate the transmission line parameters using the **first principles of mathematics, science and engineering.**	6
	PO 3	**Develop** the solutions for complex netwroks involving double ciruit lines, neighbouring communicaton system by effectively **designing** the tranmission system.	5
	PO 10	**Demonstrate** the process of developing the equations of calculation of inductance and capacitance using the conscept of GMR and GMD using the PPT presentation and wtriting the technical paper.	3
	PSO 1	**Analyze** the types of overhead transmission line systems and **develop** the equations for transmission line inductance and capacitance using the concepts of GMR and GMD.	3
CO 2	PO 1	**Classify** the types of overhead insulators and calcualte the string efficiency, sag and tension by applying the e **knowledge of science, engineering fundamentals.**	3
	PO 2	**Develop** the equations for determining the string efficiency and sag of ovehead lines using the **principles of mathematics, science and engineering fundamentals.**	5
	PO 10	**Explain** the importance of string efficiency and methods of improving it by using the PPT presentation and wtriting the technical paper.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	**Investigate** the methods available to increase the string efficiency or voltage distribution across a string of insulators and to increse the flexibility of tranmission system.	23
CO 3	PO 1	**Classify** the types of transmission lines based on the distance and define the performance parameters of lines using the **knowledge of science, engineering fundamentals.**	3
	PO 2	**Analyze** the performance parameters (efficiency and regulation) of lines using the ABCD constants using the first **principles of mathematics, and engineering sciences.**	6
	PO 3	**Develop** the mathematical **solutions** by mathematical **modeling** of transmission lines and solve **the complex engineering problems** related to these lines.	5
	PO 10	**Demonstrate** the classification of tranmission lines and the performance calculations using the PPT presentation and wtriting the technical paper.	3
	PSO 1	**Analyze** the performance of short, medium and long transmission lines using the ABCD constants and observe the Ferranti effect in transmission line system.	3
CO 4	PO 1	**Define** the skin effect, proximity effect, Ferranti effect and corona effect from the **knowledge of science, engineering fundamentals.**	3
	PO 2	**Analyze** the surge impedance and surge impedance loading of lines and also **identify the solutions** to minimize the skin effect, proximity effect, Ferranti effect and corona effect using the **principles of mathematics, natural sciences, and engineering sciences.**	4
	PO 10	**Describe** the different types of effects like proximity effet, skin effect, corona effect in transmission system using the PPT presentation and wtriting the technical paper.	3
CO 5	PO 1	**Understand** the incident, reflected and refracted waves and specifications of travelling waves from the **basic knowledge of science and engineering fundamentals.**	3
	PO 2	**Analyze** the travelling wave under different loading conditions using the **principles of mathematics, natural sciences, and engineering sciences.**	5
	PO 3	**Solve** the **complex engineering problems** related to travelling waves using Bewley's lattice diagram.	4
	PO 10	**Explain** the transients in power systems and effects of trasnsients under different loading conditions using the PPT presentation and wtriting the technical paper.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	**Investigate** the causes for surges in electrical power system and **analyze** the surges which are propagating in the form of a travelling wave and suggest the methods to minimize the effect of surges.	2
CO 6	PO 1	Know the insulation resistance, capacitance and dielectric stress of cables and **Compare** the EHVAC and HVDC transmission systems from the basic **knowledge of science and engineering fundamentals.**	3
	PO 2	**Analyze** the dielectric stress in cables and HVDC links using the **principles of mathematics and engineering sciences.**	5
	PO 10	**Discuss** the importance of HVDC and EHV transmission in power trasmission system using the PPT presentation and wtriting the technical paper.	3
	PSO 1	**Analyze** the underground cable operating parameters such as insulation resistance, capacitance and dielectric stress and know the Indian electricity rules and HVDC tranmission systems in India **suggest** the methods to get uniform dielectric stress in cable and to improve the power tranmission system.	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	6	5	-	-	-	-	-	-	3	-	-	3	-	-
CO 2	3	5	-	-	-	-	-	-	-	3	-	-	3	-	-
CO 3	3	6	5	-	-	-	-	-	-	3	-	-	3	-	-
CO 4	3	4	-	-	-	-	-	-	-	3	-		-	-	-
CO 5	3	5	4	-	-	-	-	-	-	3	-	-	2	-	-
CO 6	3	5	-	-	-	-	-	-	-	3	-	-	2	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	60	50	-	-	-	-	-	-	60	-	-	60	-	-
CO 2	100	50	-	-	-	-	-	-	-	60	-	-	60	-	-
CO 3	100	60	50	-	-	-	-	-	-	60	-	-	60	-	-
CO 4	100	40	-	-		-	-	-	-	60	-	-	-	-	-
CO 5	100	50	40	-	-	-	-	-	-	60	-	-	40	-	-
CO 6	100	50	-	-	-	-	-	-	-	60	-	-	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	2	-	-	-	-	-	-	3	-		3	-	-
CO 2	3	2	-	-	-	-	-	-	-	3	-	-	3	-	-
CO 3	3	3	2	-	-	-	-	-	-	3	-	-	3	-	-
CO 4	3	1	-	-	-	-	-	-	-	3	-		-	-	-
CO 5	3	2	1	-	-	-	-	-	-	3	-	-	1	-	-
CO 6	3	2	-	-	-	-	-	-	-	3	-		1	-	-
TOTAL	18	13	5	-	-	-	-	-	-	18	-	-	- 11	-	-
AVERAGE	3.0	2.16	1.67	-	-	-	-	-	-	3.0	-	-	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	TRANSMISSION LINE PARAMETERS
	Transmission line parameters: Types of conductors, calculation of resistance for solid conductors, description and effect of resistance on solid conductors, calculation of inductance for single phase and three phase, single and double circuit lines, concept of GMR, GMD, symmetrical and asymmetrical conductor configuration with and without transposition, Skin and Proximity effect ; Numerical Problems: Calculation of capacitance for 2 wire and 3 wire systems, effect of ground on capacitance, capacitance calculations for symmetrical and asymmetrical single and three phase, single and double circuit lines, numerical problems.

MODULE II	**MECHANICAL DESIGN OF TRANSMISSION LINES**
	Overhead line insulators: Types of insulators, string efficiency and methods for improvement, numerical problems, voltage distribution, calculation of string efficiency, capacitance grading and static shielding, testing of insulators; Sag and tension calculations: Sag and tension calculations with equal and unequal heights of towers, effect of wind and ICE on weight of conductor, numerical problems, stringing chart and sag template and its applications; mechanical design of typical towers and conductors for 400KV, 220KV and 132KV operations
MODULE III	**PERFORMANCE OF TRANSMISSION LINES**
	Performance of short and medium length transmission lines: Classification of transmission lines, short, medium and long line and their model representations, nominal-T, nominal-Pie and A, B, C, D constants for symmetrical and asymmetrical networks, numerical problems, mathematical solutions to estimate regulation and efficiency of all types of lines, numerical problems.
	Performance of long transmission lines: Long transmission line, rigorous solution, evaluation of A, B, C, D constants, representation of long lines, equivalent-T and equivalent Pie network models (numerical problems); Ferranti effect, charging current, effect on regulation of the transmission line, surge impedance and SIL of long lines, wave length and velocity of propagation of waves.
MODULE IV	**POWER SYSTEM TRANSIENTS AND FACTORS GOVERNING PERFORMANCE OF TRANSMISSION LINES**
	Power systems transients: Incident reflected and refracted waves, Types of system transients, travelling or propagation of surges, attenuation, distortion, reflection and refraction coefficients, termination of lines with different types of conditions, open circuited line, short circuited line, T-junction, lumped reactive junctions (numerical problems), Bewley's lattice diagrams (for all the cases mentioned with numerical examples); Corona, description of the phenomenon, factors affecting corona, critical voltages and power loss, radio interference, Electrostatic and electromagnetic interference with communication lines.
MODULE V	**UNDERGROUND CABLES, EHV TRANSMISSION AND HVDC TRANSMISSION**
	Underground cables: Types of cables, construction, types of insulating materials, calculation of insulation resistance and stress in insulation, numerical problems, capacitance of single and 3core belted cables, numerical problems, grading of cables, capacitance grading, numerical problems, description of inter-sheath grading, HV cables. Need of EHV transmission systems, types of DC links, comparison of AC and DC transmission, advantage of DC transmission, HVDC systems in India.

TEXTBOOKS

1. D P Kothari and I J Nagrath, "Power System Engineering", McGraw-Hill Education, 2nd Edition, 2007.

2. V K Mehta and Rohit Mehta, "Principles of Power System", S Chand, 3rd revised Edition, 2015.

3. D Das, "Electrical Power systems", New age international publishers, 2nd edition, 2006.

4. K R Padiyar, "HVDC transmission Systems", New age international publishers, 2nd

edition, 2005.

5. B R Guptha, "Power system analysis and Design" S. Chand Publishing, 2nd edition, 1998.

REFERENCE BOOKS:

1. C L Wadhwa, "Electric Power Systems", New age publications, New Delhi, 9th Edition, 2007.
2. Turan Gonen, "Electrical Power Distribution System Engineering", CRC Press, 3rd Edition, 2014.
3. V Kamaraju, "Electrical Power Distribution Systems", TMH, Publication, Edition 2009.
4. Singh S N, "Electric Power Generation, Transmission and Distribution", Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Edition, 2002.

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, Types of conductors	CO 1	T1: 2.1-2.5, R1:2.2- 2.8
3	Calculation of resistance for solid conductors, description and effect of resistance on solid conductors, skin effect and proximity effect	CO 1	T1: 2.11, R1:2.13
4	Calculation of inductance for single phase line	CO 1	T1: 2.3, R1:2.1-2.3
5	Calculation of inductance for three phase line	CO 1	T1: 2.4, R1:2.4
6	Single and double circuit lines, concept of GMR, GMD	CO 1	T1: 2.6, R1:2.5
7	Inductance of bundled conductors and double circuit transmission line	CO 1	T1: 2.7, R1: 2.11
8	Capacitance for 3 wire line symmetrical and asymmetrical line	CO 1	T1: 2.8, R1: 2.6-2.7
9	Capacitance for bundled conductor line and double circuit line.	CO 1	T1: 2.8, R1: 2.6-2.7
10	Effect of ground on capacitance	CO 1	T1: 2.9, R1: 2.10
11	Overhead line insulators: properties, materials used and types of insulators	CO 2	T2: 8.4-8.5, R1: 81
12	String efficiency and methods for improvement	CO 3	T2: 8.6, R1: 8.2

13	Testing of insulators	CO 2	T2: 8.4-8.5, R1: 81
14	Sag and tension calculations with equal and unequal heights of towers, Effect of wind and ICE on weight of conductor	CO 4	T2: 8.15& 8.16
15	Stringing chart, sag template and its applications, Mechanical design of typical towers and conductors for 400KV, 220KV and 132KV operations	CO 4	T2: 8.16, R1: 7.4&7.5
16	Classification of transmission lines, modeling, equivalent representation and performance of short lines	CO 5	T1: 5.1-5.2, R1: 4.1-4.2
17	Modeling of nominal –T and Nominal –Pie representation of medium lines.	CO 5	T1:5.3, R1: 4.3
18	Modeling and performance of long transmission line using rigorous solution	CO 5	T1:5.4, R1:4.4
19	Evaluation of ABCD constants of long lines, Equivalent-T and equivalent-Pie representation of long lines	CO 5	T1: 5.4, R1:4.5
20	Ferranti effect, charging current, effect on regulation of the transmission line	CO 6	T1:5.6, R1: 4.6
21	Surge impedance and SIL of long lines, wave length and velocity of propagation of waves.	CO 6	T1:5.5, R1:4.4
22	Introduction to power system transients: types, causes and effects of transients	CO 7	T5:12.1, R1: 12.1
23	Travelling or propagation of surges/waves and their specifications	CO 7	T5:12.5-12.8, R1: 12.4
24	Reflection and refraction coefficients of a line in open circuit and short circuit conditions	CO 7	T5:12.9-12.10, R1: 12.4
25	Reflection and refraction coefficients of a line terminated by passive elements and with T-junction (Forked line)	CO 7	T5:12.12, R1: 12.4
26	Attenuation and distortion of travelling waves	CO 7	T5:12.15, R1: 12.5
27	Reflection and refraction coefficients of a line terminated by lumped passive elements	CO 7	T5:12.13, R1: 12.4
28-29	Bewley's lattice diagrams for all types of lines	CO 7	T5:12.14, R1: 12.4
30	Corona, description of the phenomenon, factors affecting corona, critical voltages and power loss	CO 8	T2:14.1-14.9, R1: 6.1 & 6.2
31	Radio interference, Electrostatic and electromagnetic interference with communication lines	CO 8	T3: 14.10, R1: 6.5 & 6.6
32	Underground cables: Construction, types of insulating materials	CO 2	T2: 11.1 -11.5, R1: 9.1&9.9
33	Types of cables	CO 2	T2: 11.1 -11.5, R1: 9.1&9.9

34	Calculation of insulation resistance and capacitance in insulation of a single core cable	CO 9	T2:11.7-11.10, R1: 9.4 & 9.5
35	Calculation of Dielectric stress on single core cables	CO 9	T2:11.7-11.10, R1: 9.4 & 9.5
36	Capacitance of 3-core belted cables	CO 9	T2:11.7-11.10, R1: 9.4 & 9.5
37	Grading of cables: description of capacitance grading and inter-sheath grading	CO 9	T2:11.11-11.13
38	Need of EHV transmission systems, comparison of AC and DC transmission with advantages and disadvantages	CO 10	T4:1.4, R1:5.4
39	Comparision of AC and DC tranmission systems	CO 10	T4:1.2, R1: 5.16
40	HVDC transmission and HVDC links	CO 10	T4:1.2, R1: 5.16
41	HVDC systems in India	CO 10	T4:1.2, R1: 5.16
PROBLEM SOLVING/ CASE STUDIES			
42	Numerical Problems to calculate inductance of single phase and three phase line	CO 1	T1: 3.4, R1: 3.4
43	Numerical Problems to calculate inductance of bundled conductor line and double circuit line	CO 1	T1: 3.5, R1: 3.5
44	Numerical Problems to calculate capacitance of single phase and three phase line	CO 1	T1: 3.9, R1: 3.6
45	Numerical Problems to calculate capacitance of bundled conductor line	CO 1	T1: 3.7, R1: 3.7
46	Numerical Problems to calculate capacitance of double circuit line	CO 1	T1: 3.1-3.7, R1: 3.1-3.7
47	Numerical problems to calculate string efficiency	CO 3	T2: 8.7, R1: 8.2
48	Numerical problems to calculate sag and tension	CO 3	T2: 8.4-8.7, R1: 8.1-8.2
49	Numerical problems to evaluate performance of short and medium transmission lines	CO 5	T1:5.1-5.3, R1:4.1-4.3
50	Numerical problems to evaluate performance of long lines	CO 5	T1:5.1-5.3, R1:4.1-4.3
51	Problems on Ferranti effect, surge impedance and SIL of long lines	CO 6	T1: 5.4 -5.10, R1:4.4-4.6
52	Numerical problems on power system transients	CO 7	T5:12.1-12.15, R1: 12.1-12.4
53	Numerical Problems on corona	CO 8	T2: 14.1-14.10, R1: 6.1-6.6

54	Numerical problems on resistance, capacitance of cables	CO 9	T2: 11.7-11.10, R1: 9.1-9.5
55	Numerical problems on dielectric stress of cables	CO 9	T2: 11.7-11.10, R1: 9.1-9.5
56	Numerical problems on grading of cables	CO 9	T2:11.11-11.13
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Skin effect, Proximity effect, inductive reactance spacing factor, transposition of lines	CO 6	T1: 2.1-2.10
58	String efficiency, safety factor of insulators, sag and tension on lines, sag template, stringing chart	CO 3	T2: 8.4-8.7
59	Propagation constant, characteristic impedance, surge impedance and surge impedance loading, wave length, velocity of propagation of waves	CO 5	T1: 5.1-5.7
60	Incident and reflected waves, attenuation and distortion, corona, critical disruptive voltage	CO 7	T5:12.1-12.14
61	Insulation resistance, dielectric stress, capacitance grading, inter sheath grading	CO 9	T2:11.1-11.13
DISCUSSION OF QUESTION BANK			
62	Module I: Transmission line parameters	CO 1	T1: 2.1-2.10
63	Module II: Mechanical design of transmission lines	CO 4	T2: 8.4-8.7
64	Module III: Performance of transmission lines	CO 5	T1: 5.1-5.7
65	Module IV: Power system transients	CO 7	T5:12.1-12.14
66	Module V: Underground cables	CO 9	T2:11.1-11.13

Signature of Course Coordinator **HOD,EEE**

Mr. P Mabuhussain, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Power Electronics**				
Course Code	AEEB20				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	3	2
Course Coordinator	Dr. Ranjith kumar Gatla, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB09	III	Network Analysis
B.Tech	AECB02	III	Analog Electronic

II COURSE OVERVIEW:

The course focuses on presenting concepts for conversion, control and monitoring of electrical energy using power semiconductor devices. Methods for analyzing power electronic converters suitable for DC/AC, DC/DC, AC/AC and AC/DC electrical energy conversions including regulators are presented. Additionally, principles for designing power electronic converters, including their power semiconductors and passive elements are established. The applications of power electronics in the fields of sustainable energy technologies, switched mode power supplies and uninterruptible power supplies as well as application of power electronic converters for transmission, distribution and control in the power systems is described.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Power Electronics	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	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
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), 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:

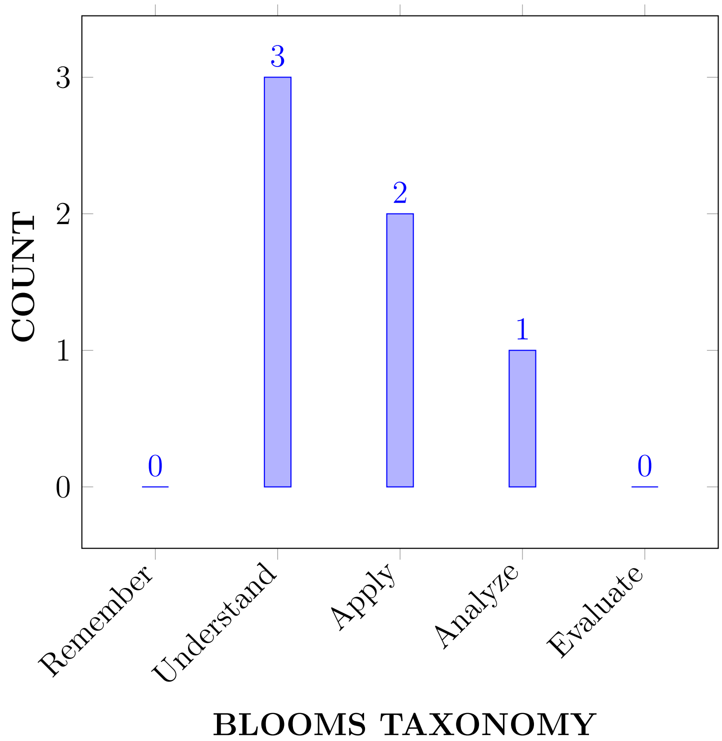
I	The concepts on power semiconductor devices related to its characteristics, ratings, and protection to select these devices for various applications.
II	The fundamental principles and control techniques of power electronic converters for analyzing AC/DC, DC/DC, AC/AC and DC/AC power conversion circuits.
III	The application of power electronic converters in the fields of battery management system, industrial drive applications and enhancement of power quality.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the static and dynamic characteristics of power semiconductor devices used for power conversion in converter circuits.	Understand
CO 2	**Summarize** the various firing circuits and commutation techniques useful for accurate switching function of the SCR.	Understand
CO 3	**Analyze** the performance parameters of ac-dc converters under various loading conditions.	Analyze
CO 4	**Identify** the switching techniques and control strategies in switched mode regulators and perform steady state analysis in the chopper circuit.	Apply
CO 5	**Demonstrate** single phase ac voltage controllers and cyclo converter used for converting fixed ac supply into variable ac output	Understand
CO 6	**Apply** modulation and switching topologies in inverters for output voltage control.	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	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	1	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 SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Seminars
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	1	Seminars

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	Power semi conductor devices are described (Knowledge) through **mathematically** sound and **physics-based models** and circuits made with these devices, capacitor and inductor are analyzed by the **application of first order differential equations**.	3
	PO 2	Understand the given **problem** and **choose** appropriate devices to achieve **desired output** based on performance characteristics of devices.	3
	PO 6	**Understand** the characterstics of power semiconductor devices used in converters for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**	1
	PO 9	Focus on working as a member or leader in understanding the characteristics of power devices **individual and team work**.	3
	PO 10	Recognize the role of power semiconductor switches in converter design by **communicating effectively with engineering community.**	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of optimal selection of power devices.	2
	PSO 1	Make use of semiconductor devices for **fabricating** the power electronic systems used in various stages of utilization of electrical energy.	1
CO 2	PO 1	**Identify** the suitable commutation technique, protection and the isolation techniques of thyristors and understand their operation by applying the **principles of mathematics science and engineering fundamentals**. Principles of **energy efficiency** and **heat transfer** are also addressed.	3
	PO 2	Understand problems associated with SCRs during turn on/off and apply this knowledge in design and analysis of protection circuits and commutation circuits by using **first principles of mathematics and engineering sciences**.	3
	PO 9	Focus on working as a member or leader in designing the cummutation circuit to turn off SCR by **individual and team work**.	3
	PO 10	Recognize the role of commutation circuit by **communicating effectively with engineering community.**	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of energy conversion systems.	2

	PSO 1	Make use of the protection and commutation techniques for the circuits associated with power electronic devices for smooth operation while **energy conversion**.	1
CO 3	PO 1	AC-DC converters comprises of semiconductor devices, resistors, capacitors and inductors. The principle of operation and characteristics of such devices are explained by **applying engineering fundamentals including device physics** and deduce the expressions using **mathematical principles**.	3
	PO 2	Design (formulate) ac-dc converter for power electronics systems to meet given objectives (problem statement & formulation) under realistic constraints. Designs are tested (validation) through numerical simulation or hardware implementation (experimental design), and modifications are implemented as needed (interpretation of results) using **first principles of mathematics and engineering sciences**.	5
	PO 9	Focus on working as a member or leader in designing the rectifier circuits by **individual and team wor**k.	3
	PO 10	Recognize the role of pulse width modulation technique in three phase controlled rectifiers by **communicating effectively with engineering community**.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of optimal selection of power devices to design rectifier.	4
	PSO 1	**Design and simulate** converter circuits to rectify electrical energy in various applications. .	1
	PSO 2	Utilize DC-DC converters to constant and reliable energy for **applications** includes mobile chargers, electric vehicles and **industrial drives**.	1
CO 4	PO 1	Identify (Knowledge) suitable switching techniques and control strategies to operate DC-DC converters with the **Knowledge of mathematics, science and engineering fundamentals related to electrical engineering**.	3
	PO 2	Design (formulate) dc-dc converter for power electronics systems to meet given objectives (problem statement & formulation). Designs are tested (validation) through numerical simulation or hardware implementation (experimental design), and modifications are implemented as needed (interpretation of results) **using first principles of science and mathematics**	6
	PO 4	**Identify the Various switching techniques** to apply the different control stratagies and understand the corresponding **context of engineering knowledge related** to the performance indicators and measures in the switched mode regulators	6

	PO 9	Focus on working as a member or leader in designing the regulated power supplies using chopper circuits by **individual and team work**.	3
	PO 10	Recognize the role of passive components and switches in choppers by **communicating effectively with engineering community.**	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing the regulated power supplies using chopper circuits.	4
	PSO 1	**Design** the converter circuits to perform DC-DC conversion and interpret the results through **simulation** and hardware implementation.	1
	PSO 2	Make use of ac-dc converters for **energy conversion** to operate electrical drives in various **applications**.	1
CO 5	PO 1	Analyze AC voltage controller circuits using **fundamentals of engineering and science** including the application of **first order differential equations** in the roles of capacitance and inductance in power electronics circuits.	3
	PO 2	Identify the problems associated with conversion of fixed AC supply into variable output and apply suitable control to achieve desired output. The developed models and control strategies are validated through numerical simulation or hardware implementation and modifications are implemented as needed (interpretation of results) **using first principles of science and mathematics**	5
	PO 9	Focus on working as a member or leader in designing the AC voltage controllers by **individual and team work**.	3
	PO 10	Recognize the role of semiconductro devices in ac voltage controllers by **communicating effectively with engineering community**.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing the AC voltage cotroller.	4
	PSO 1	**Design** the converter circuits to perform AC-AC conversion to achieve desired voltage output and interpret the results through **simulation** and hardware implementation.	1
	PSO 2	Make use of ac-ac converters for **energy conversion** to control the speed of electrical drives used in **industrial applications**.	1
CO 6	PO 1	Explain the concepts and working principle involved in inverter circuits with **the knowledge of mathematics, science and engineering fundamentals related basic electrical and electronics**.	3

	PO 2	Select a suitable switching technique for inverter to obtain **desired** output voltage. The techniques and corresponding models are **validated** through numerical simulation or hardware implementation and results are **interpreted using first principles of mathematics and engineering fundamentals**.	5
	PO 3	The **design** of inverter systems includes interfacing with alternate energy sources and improvement of **energy efficiency**, both of which are tied into the **global, economic, environmental and societal context**.	4
	PO 9	Focus on working as a member or leader in designing the inverter circuits by **individual and team wor**k.	3
	PO 10	Recognize the role of modulation techniques in output voltage control of inverters by **communicating effectively with engineering community**.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of designing the Inverter circuit.	4
	PSO 1	**Design** the inverter circuit to perform DC-AC conversion and interpret the results through **simulation** and hardware implementation.	1
	PSO 2	Make use of inverters to drive the **appliances** and other **devices** connected to it by energy conversion.	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	3	-	-	-	1	-	-	3	1	-	2	1	-	-
CO 2	3	3	-	-	-	-	-	-	3	1	-	4	1	-	-
CO 3	3	5	-	-	-	-	-	-	3	1	-	4	1	1	-
CO 4	3	6	-	6	-	-	-	-	3	1	-	4	1	1	-
CO 5	3	5	-	-	-	-	-	-	3	1	-	4	1	1	-
CO 6	3	5	4	-	-	-	-	-	3	1	-	4	1	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	30	-	-	-	20	-	-	25	25	-	25	50	-	-
CO 2	100	30	-	-	-	-	-	-	25	25	-	50	50	-	-
CO 3	100	50	-	-	-	-	-	-	25	25	-	50	50	33.3	-
CO 4	100	60	-	54.5	-	-	-	-	25	25	-	50	50	33.3	-
CO 5	100	50	-	-	-	-	-	-	25	25	-	50	50	33.3	-

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 6	100	50	40	-	-	-	-	-	25	25	-	50	50	33.3	-

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	1	-	-	-	1	-	-	1	1	-	1	2	-	-
CO 2	3	1	-	-	-	-	-	-	1	1	-	2	2	-	-
CO 3	3	2	-	-	-	-	-	-	1	1	-	2	2	1	-
CO 4	3	3	-	2	-	-	-	-	1	1	-	2	2	1	-
CO 5	3	2	-	-	-	-	-	-	1	1	-	2	2	1	-
CO 6	3	2	1	-	-	-	-	-	1	1	-	2	2	1	-
TOTAL	18	11	1	2	-	1	-	-	6	6	-	11	12	4	-
AVERAGE	3	2	1	1	-	1	-	-	1	1	-	2	2	1	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVIII SYLLABUS:

MODULE I	**POWER SWITCHING DEVICES AND COMMUTATION CIRCUITS**
	Power semiconductor devices and commutation circuits: Thyristors, principle of operation of silicon controlled rectifiers (SCR), bipolar junction transistor (BJT), power metal oxide semiconductor field effect transistor (MOSFET), power insulated gate bipolar transistor (IGBT), gate turn off thyristor (GTO) and characteristics, turn on and turnoff methods, dynamic characteristics of SCR, two transistor analogy, unijunction transistor firing circuit, series and parallel operation of SCRs, design of snubber circuit; Specifications and ratings: Ratings of SCR, BJT and IGBT, line commutation and forced commutation circuits, numerical problems.
MODULE II	**SINGLE PHASE AND THREE PHASE CONTROLLED RECTIFIERS**
	AC - DC converters: Phase control technique, single phase line commutated converters, midpoint and bridge connections, half controlled converters and semi converters with R, RL and RLE loads, derivation of average load voltage and current, active and reactive power inputs to the converters without and with freewheeling diode, numerical problems; Fully controlled converters: Midpoint and bridge connections with R, RL loads and RLE load, derivation of average load voltage and current, line commutated inverters, active and reactive power inputs to the converters without and with freewheeling diode, derivation of load voltage and current, numerical problems; Three phase converters: Three pulse and six pulse converters, midpoint and bridge connections, average load voltage with R and RL loads, effect of source inductance, operation of single phase and three phase dual converters, numerical problems.
MODULE III	**AC VOLTAGE CONTROLLERS AND CYCLOCONVERTERS**
	AC - AC controllers: Introduction, single phase two SCRs in anti – parallel with R and RL loads, modes of operation of triac, triac with R and RL loads, derivation of RMS load voltage, current and power factor, wave forms, numerical problems. Cycloconverters: Principle of operation of single phase midpoint and bridge type cycloconverters with resistive and inductive loads, continuous and discontinuous mode of operation.
MODULE IV	**DC – DC CONVERTERS**
	DC - DC converters: Principle of operation of choppers, time ratio control and current limit control strategies, types of choppers, derivation of load voltage and currents with R, RL and RLE loads, AC chopper, problems; Switched mode regulators: Study of buck, boost and buck - boost regulators, Cuk regulators.
MODULE V	**INVERTERS**
	DC - AC converters: Single phase inverter, basic series inverter, parallel inverter, operation and waveforms, voltage source inverter (VSI), three phase inverters 180^0 , 120^0 conduction modes of operation, voltage control techniques for inverters, pulse width modulation techniques, reduction of harmonics, current source inverter (CSI) with ideal switches, capacitor commutated type CSI, numerical problems.

TEXTBOOKS

1. M D Singh, K B Kanchandhani, "Power Electronics", Tata McGraw-Hill Publishing Company, 2 nd Edition, 1998.
2. Dr. P S Bimbhra, "Power Electronics", Khanna Publishers, 5th Edition, 2012.
3. Ned Mohan, Tore M Undeland, William P Robbins, "Power Electronics: Converters, Applications, and Design", 3 rd Edition, John Wiley and sons, 2002.
4. M H Rashid, "Power Electronics, Circuits, Devices and Applications", Pearson, 3rd Edition, 2001.

REFERENCE BOOKS:

1. Vedam Subramanyam, "Power Electronics", New Age International Limited, 2nd Edition, 2006.
2. P C Sen, "Power Electronics", Tata McGraw-Hill Publishing, 1st Edition, 1987.
3. G K Dubey, S R Doradra, A Joshi, R M K Sinha, "Thyristorised Power Controllers", New Age International Limited, 2nd Edition, 2008.

WEB REFERENCES:

1. https://www.coursera.org/learn/power-electronics
2. https://nptel.ac.in/courses/108/102/108102145/
3. https://www.electronicsforu.com/videos-slideshows/power-electronic-devices
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-334-power-electronics- spring-2007/lecture-notes/

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)		
CONTENT DELIVERY (THEORY)			
2	Basic elements of power electronics and devices	CO1	T2: 1.1 R2: 1.1
3	Thyristors (SCR's) characteristics	CO1	T2: 1.1 R2: 1.1
4	Two transistor analogy of SCR	CO1	T2: 1.1 R2: 1.1
5	Operation of SCR and Turn on methods	CO2	T2: 1.1 R2: 1.1
6	Turn off method of SCR class A and Class B commutation	CO2	T2: 1.1 R2: 1.1
7	Turn off method of SCR class C, Class D, class E commutation and natural commutation	CO2	T2: 5.5 R2: 1.7

8	Dynamic characteristics of SCR and Operation of UJT firing circuit	CO1	T2: 5.5 R2: 1.7 T2: 5.5 R2: 1.7
9	Series and parallel connections of SCR's	CO2	T2: 5.5 R2: 1.7
10	Snubber circuit for SCR	CO2	T2: 5.5 R2: 1.7
11	Characteristics of BJT and Power MOSFET	CO1	T2: 5.5 R2: 1.7
12	Characteristics of Power IGBT and GTO	CO1	T2: 5.5 R2: 1.7
13	Specifications and ratings: Ratings of SCR, BJT and IGBT	CO1	T2: 5.5 R2: 1.7
14	Phase controlled rectifiers (1ph) and Operation of half converter with R, RL and RLE loads	CO3	T2: 5.5 T2:6.1.1 R2: 1.7
15	Fully controlled converter with R, RL and RLE loads	CO3	T2: 6.3.1 T2: 6.3.2 R2: 5.2 R2: 5.4
16	Effect of source inductance on converter	CO3	T2: 6.3.2 R2:5.5
17	3-ph Half controlled converters with Resistive load and necessary derivations for analysis	CO3	T2: 6.6.2 R2: 6.1
18	3-ph fully controlled converters with R & RL load and necessary derivations	CO3	T2: 6.6.3 R2: 6.4
19	3-ph full controlled converters with RLE load and necessary derivations	CO3	T2: 6.6.3 R2: 6.4
20	Effect of source inductance in three phase rectifiers	CO3	T2: 6.7.2 R2: 4.11
21	Introduction to Dual Converters and operation of Single phase, three phase dual converter operation	CO3	T2: 6.8 T2: 6.9 R2: 6.11 R2: 6.11
22	Principle of operation of single phase AC voltage controller	CO5	T2: 9.1 T2: 9.2 R2: 8.5 R2: 8.1
23	Modes of operation of Triac	CO1	T2: 9.3.2 R2: 8.12
24	Principle of operation and control strategies of Cyclo converters	CO5	T2: 10.1 R2: 9.41
25	Single phase midpoint Cyclo converters with resistive load	CO5	T2: 10.1.1 R2: 9.42

26	Single phase Cyclo converter Bridge configuration Waveforms	CO5	T2: 10.1.2 R2: 9.42.1
27	Principle and control strategies of choppers	CO4	T2: 7.1 R2: 9.40
28	Operation of Step up and step down choppers	CO4	T2: 7. R2: 9.40.1
29	Operation of class A chopper	CO4	T2: 7.4.1, R2: 9.40.3
30	Operation of class B and class C chopper	CO4	T2: 7.4.2 R2: 9.40.4
31	Operation of Class D and class E chopper	CO4	T2: 7.4.4 R2: 9.40.5
32	Operation of Switched mode regulators	CO4	T2: 7. R2: 10.3
33	Single Phase inverter and operation of Single phase half bridge inverter	CO6	T2: 8.1.1, R2: 9.1
34	Single phase full bridge inverter and series inverter	CO6	T2: 8.9 R2: 9.2
35	Parallel Capacitor inverter	CO6	T2: 8.10 R2: 9.6
36	Three phase Voltage source inverter 180 dergee conduction mode	CO6	T2: 8.4.1 R2: 9.32
37	Three phase Voltage source inverter 120 dergee conduction mode	CO6	T2: 8.4.2 R2: 9.33
38	Voltage control and PWM techniques for inverters	CO6	T2: 8.5 R2: 9.36
39	Sinusoidal pulse width modulation	CO6	T2: 8.6.3 R2: 9.37
40	Current source inverter with ideal switches	CO6	T2: 8.8.1 R2: 9.38
41	Operation of commutated type CSI	CO6	T2: 8.8.2 R2: 9.17
PROBLEM SOLVING/ CASE STUDIES			
42	Numerical problems on Series and parallel connections of SCR's	CO2	T2: 4.9 R2: 1.10
43	Numerical problems on half controlled converters	CO3	T2: 6.1.2 R2: 5.1.2
44	Numerical problems on fully controlled converters	CO3	T2: 6.9 R2:5.4
45	Numerical problems on fully controlled converters with RL load	CO3	T2: 6.9 R2:5.4

46	Numerical problems on dual converters	CO3	T2: 6.8 T2: 6.9
47	Problems on three phase half controlled converters	CO3	T2: 6.6.2 R2:6.1
48	Problems on three phase full controlled converters	CO3	T2: 6.6.2 R2:6.1
49	Problems on three phase full controlled converters with RL loads	CO3	T2: 6.6.3 R2:6.2
50	Problems on three phase full controlled converters with RL loads	CO3	T2: 6.6.3 R2:6.2
51	Numerical problems on AC voltage controller	CO5	T2: 9.3.2 R2: 8.4
52	Numerical problems on AC voltage controller with RL loads	CO5	T2: 9.3.2 R2: 8.4
53	Numerical problems on cycloconverters	CO5	T2: 10.1.2 R2: 9.42.2
54	Numerical problems on choppers	CO4	T2: 7.7 R2: 9.40.1
55	Numerical problems on step down and step up choppers	CO4	T2: 7.7 R2: 9.40.1
56	Numerical problems on switched mode regulators	CO4	T2: 7.5 R2: 10.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Power electronic devices, SCR characteristics, turn on and turn off methods for SCRs	CO1, CO2	T2: 1.1 T2: 5.1 R2: 1.7 R2: 1.1
58	Phase controlled rectifiers with different loads and dual converters	CO3	T2: 6.1 R2: 5.1
59	AC voltage regulators and cycloconverters	CO5	T2: 9.1 T2: 10.1 R2: 9.41 R2: 8.1
60	Choppers and switched mode regulators	CO4	T2: 7.1 T2: 7.6 R2: 10.3 R2: 9.40
61	Voltage source inverters and current source inverters	CO6	T2: 8.8.1 T2: 8.1.1 R2: 9.1 R2: 9.38
DISCUSSION OF QUESTION BANK			
1	POWER SWITCHING DEVICES AND COMMUTATION CIRCUITS	CO1,CO2	-

2	SINGLE PHASE AND THREE PHASE CONTROLLED RECTIFIERS	CO3	-
3	AC VOLTAGE CONTROLLERS AND CYCLOCONVERTERS	CO5	-
4	DC – DC CONVERTERS	CO4	-
5	INVERTERS	CO6	-

Signature of Course Coordinator **HOD,EEE**

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF(s)
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

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

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Microprocessors and Microcontrollers**				
Course Code	AECB24				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	1	3	-	-
Course Coordinator	Mr V.R.Seshagiri Rao, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB07	III	Digital System Design
B.Tech	AECB32	V	Computer Architecture

II COURSE OVERVIEW:

Processor and controller cores are the key components in most of the modern embedded and system-on-chip designs. This course outlines the architecture and signal description of Intel microprocessor and microcontrollers. The instruction set and assembly language programming along with I/O and memory interfacing techniques are covered. The knowledge acquired from this course will enable the students in development of embedded hardware projects and models for engineering and scientific applications.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	✓	Tech talk	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
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), 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
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

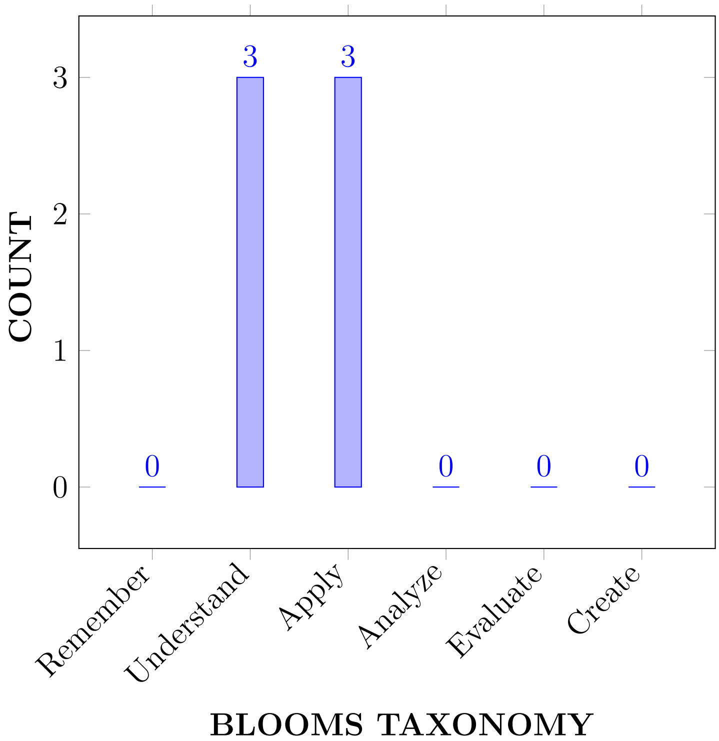
I	The signal descriptions along with functional architecture and hardware interfacing skills using microprocessors and micro controllers.
II	The instruction set and logic to build assembly language programs for arithmetic, logic and automated electronic systems.
III	The essential concepts of development 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	**Describe** the features of intel processors and micro controllers for signal description and architecture.	Understand
CO 2	**Make use of** addressing modes and instruction set of target microprocessors and micro controllers for writing efficient assembly language programs.	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 micro controllers using interrupt controller.	Understand
CO 5	**Choose** an appropriate data transfer scheme and hardware for data transfer between the devices.	Apply
CO 6	**Develop** microprocessor and micro controller based applications using appropriate input and output devices.	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	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	Build embedded software and digital circuit development platform for robotics, embedded systems and signal processing applications.	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 10	Explain the functional components of microprocessors and microcontrollers by **giving effective presentations and 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 micro controllers micro controllers by **with clarity.**	1
	PSO 1	Develop software program skills to write efficient programs by **understanding the performance parameters** of software/ Hardware systems for **robotics, embedded systems and signal processing applications**	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
	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.** for interfacing memory and I/O devices.	1

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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 micro processor and micro controller based applications using necessary input and output devices and **give effective oral presentations and instructions.**	1
	PSO 1	Develop microprocessor and microcontroller based applications in the fields of r**obotics and embedded systems** using **embedded software** and necessary input output devices.	2

Note: For Key Attributes refer **Annexure - I**

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	-	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	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 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	**8086 MICROPROCESSORS**
	Register organization of 8086, Architecture, signal description of 8086, physical memory organization, general bus operation, I/O addressing capability, special purpose activities Minimum mode, maximum mode of 8086 system and timings, machine language instruction formats, addressing mode of 8086, instruction set of 8086, assembler directives and operators.
MODULE II	**PROGRAMMING WITH 8086 MICROPROCESSOR**
	Machine level programs, programming with an assembler, Assembly language programs, introduction to stack, stack structure of 8086/8088, interrupts and interrupt service routines. Interrupt cycle of 8086, non-mask able interrupt and mask able interrupts, interrupt programming.
MODULE III	**INTERFACING WITH 8086/88**
	Semiconductor memory interfacing, dynamic RAM interfacing, interfacing i/o ports, PIO 8255 modes of operation of 8255,interfacing to D/A and A/D converters, stepper motor interfacing, control of high power devices using 8255. Programmable interrupt controller 8259A, the keyboard /display controller8279, programmable communication interface 8251 USART, DMA Controller 8257.
MODULE IV	**8051 MICROCONTROLLER**
	8051 Microcontroller – Internal architecture and pin configuration, 8051 addressing modes, instruction set, Bit addressable features. I/O Port structures, assembly language programming using data transfer, arithmetic, logical and branch instructions.
MODULE V	**SYSTEM DESIGN USING MICROCONTROLLER**
	8051 Timers/Counters, Serial data communication and its programming, 8051 interrupts, Interrupt vector table, Interrupt programming. Real world interfacing of 8051 with external memory, expansion of I/O ports, LCD, ADC, DAC, stepper motor interfacing.

TEXTBOOKS

1. D. V. Hall, "Microprocessors and Interfacing", Tata McGraw-Hill Education, 3rd Edition 2013.
2. A.K Ray, K. M. Bhurchandani, "Advanced Microprocessors and Peripherals" Tata McGraw-Hill Education, 2nd Edition, 2006.
3. Savaliya M. T, "8086 Programming and Advance Processor Architecture", Wiley India Pvt., 1st Edition, 2012.

REFERENCE BOOKS:

1. N. Senthil Kumar, M. Saravanan, S. Jeevanathan, S. K. Shah, "Microprocessors and Interfacing", Oxford University, 1st Edition, 2012.
2. Lyla B. Das, "The x86 Microprocessors", Pearson India, 2nd Edition, 2014.

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			
1	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)			
2	Register organization of 8086 microprocessor	CO 1	T1:1.1 R2:1.3
3	Flag Register of 8086 Microprocessor	CO 1	T1:1.1 R2:1.2.2
4	Architecture and signal description of 8086 microprocessor	CO 1	T1:1.2 R2:1.1,6.1
5	Physical memory organization of 8086 microprocessor	CO 1	T1:1.4 R2:2.3
7	General bus operation, I/O addressing capability and special purpose activities	CO 1	T1:1.5,1.6,1.7
8	Operation of 8086 microprocessor in minimum mode with read nd write timing diagrams	CO 1	T1:1.8 R2:6.3
9	Operation of 8086 microprocessor in maximum mode with read nd write timing diagrams	CO 1	T1:1.9 R2:6.4
10	Machine language instruction formats	CO 2	T1:2.1 R2:3.1
11	Addressing modes of 8086 Microprocessor	CO 2	T1:2.2 R2:1.4
12	Instruction Set Of 8086 Microprocessor: Data transfer instructions	CO 2	T1:2.3 R2:3.2
13	Instruction Set Of 8086 Microprocessor: Arithmetic and Logical instructions	CO 2	T1: 2.3 R2:3.4,3.5
14	Instruction Set Of 8086 Microprocessor: Program control transfer instructions	CO 2	T1: 2.3 R2:3.3
15	Instruction Set Of 8086 Microprocessor: Machine Control Instructions and Flag manipulation instructions	CO 2	T1: 2.3 R2:3.7
16	Instruction Set Of 8086 Microprocessor: Shift and rotate instructions	CO 2	T1: 2.3 R2:3.6

17	Instruction Set Of 8086 Microprocessor: String instructions	CO 2	T1: 2.3 R2:4.1
18	Assembler Directives and operators	CO 2	T1:2.4 R2:2.2
19	Machine level programs, programming with an assembler	CO 2	T1:3.1,3.2,3.3 R2:2.1
24	Introduction to stack and stack structure of 8086/8088 microprocessor	CO 1	T1:4.1,4.2
25	Interrupts and Interrupt service routines	CO 4	T1:4.3 R2:8.1
26	Interrupt cycle of 8086 microprocessor, non- mask able interrupt and mask able interrupts	CO 4	T1:4.4,4.5,4.6 R2:8.2
27	Interrupt programming	CO 4	T1:4.7
28	Interfacing I/O ports	CO 3	T1:5.3
29	Pin diagram and Architecture 8255 PPI	CO 3	T1:5.4 R2:9.2
30	Operating modes of 8255 PPI	CO 3	T1:5.5 R2:9.3
31	A/D and D/A converters	CO 6	T1:5.6,5.7 R2:9.8,9.9
33	Stepper motor interfacing	CO 6	T1:5.8 R2:9.11
34	Control of high power devices using 8255 PPI	CO 6	T1:5.9
35	Pin configuration of 8259 PIC	CO 4	T1:6.2 R2:10.3
36	Architecture of 8259 PIC	CO 4	T1:6.2 R2:10.3
38	Keyboard /display controller 8279	CO 6	T1:6.3 R2:10.2
40	Programmable communication interface 8251 USART	CO 5	T1:6.4 R2:11.3
42	DMA Controller 8257	CO 3	T1:7.1 R2:11.6
43	Internal architecture and pin configuration of 8051 microcontroller	CO 1	T1:17.2 R2:20.1
44	Addressing modes of 8051 microcontroller	CO 2	T1:17.3
45	Instruction set of 8051 microcontroller	CO 2	T1:17.8 R2:19.9
46	Bit addressable features and I/O Port structures	CO 1	T1:17.4 R2:19.10
48	8051 Timers/Counters	CO 1	T1:17.5 R2:20.3,20.4
49	Serial data communication and its programming	CO 5	T1:17.6 R2:20.6
50	8051 interrupts, Interrupt vector table	CO 4	T1:17.7 R2:20.5

PROBLEM SOLVING/ CASE STUDIES			
6	Physical address calculation	CO 1	T1:1.1 R2:1.1
20	Assembly language programs For Sorting of numbers using 8086 microprocessor	CO 2	T1:3.4 R2:4.7
21	Assembly language programs for multibyte addition and subtraction, sum of squares using 8086 microprocessor	CO 2	T1:3.4 R2:4.7
22	Assembly language programs for String manipulations using 8086 microprocessor	CO 2	T1:3.4 R2:4.1
23	Assembly language programs for Code conversions using 8086 microprocessor	CO 2	T1:3.4 R2:4.4,4.5
28	Memory interfacing to 8086 microprocessor (Static RAM)	CO 3	T1:5.1 R2:12.2,12.3
29	Memory interfacing to 8086 microprocessor (EPROM)	CO 3	T1:5.2 R2:12.4
32	Interfacing A/D and D/A converters with 8086 microprocessor	CO 6	T1:5.6,5.7 R2:9.8,9.9
34	Assembly language programs to rotate stepper motor in clockwise and anticlock wise direction	CO 2	T1:5.8 R2:9.11
37	Cascading of Interrupt Controller and its importance, interfacing 8259 PIC with 8086 microprocessor	CO 4	T1:6.2 R2:10.3,10.4
39	Interfacing keyboard /display controller 8279 to 8086 microprocessor	CO 6	T1:6.3 R2:10.2
41	Interfacing programmable communication interface 8251 USART to 8086 microprocessor	CO 5	T1:6.4 R2:11.3
47	Assembly language programming using data transfer, arithmetic, logical and branch instructions	CO 2	T1:17.8 R2:19.3
51	Real world interfacing of 8051 microcontroller with external memory	CO 6	T1:17.6 R2:20.2
52	Interfacing 8051 microcontroller with LCD	CO 6	T1:17.9 R2:21.3
53	Interfacing 8051 microcontroller with ADC and DAC	CO 6	T1:17.9 R2:21.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
54	8086 Microprocessor	CO 1, CO 2	T1, R2
55	Programming with 8086 microprocessor	CO 1, CO 2, CO 4	T1, R2
56	Interfacing with 8086/88	CO 2, CO 3, CO 4, CO 5, CO 6	T1, R2
57	8051 microcontroller	CO 1, CO 2,	T1, R2

58	System design using microcontroller	CO 3, CO 4, CO 5, CO 6	T1, R2
DISCUSSION OF QUESTION BANK			
59	8086 Microprocessor	CO 1, CO 2	T1, R2
60	Programming with 8086 microprocessor	CO 1, CO 2, CO 4	T1, R2
61	Interfacing with 8086/88 microprocessor	CO 2, CO 3, CO 4, CO 5	T1, R2
62	8051 microcontroller	CO 1, CO 2	T1, R2
63	System design using microcontroller	CO 3, CO 4, CO 5	T1, R2

Signature of Course Coordinator
Mr. V.R.Seshagiri Rao, Associate Professor **HOD, ECE**

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

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).** "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**
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 **(Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change **(Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

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

COURSE DESCRIPTION

<table>
<tr><td>Department</td><td colspan="5">ELECTRICAL AND ELECTRONICS ENGINEERING</td></tr>
<tr><td>Course Title</td><td colspan="5">WIND AND SOLAR ENERGY SYSTEMS</td></tr>
<tr><td>Course Code</td><td colspan="5">AEEB46</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td colspan="5">FIVE</td></tr>
<tr><td>Course Type</td><td colspan="5">Professional Elective</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 Naresh Kumar, Assistant Professor</td></tr>
</table>

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB14	IV	Electrical Power Generating Systems

II COURSE OVERVIEW:

This course is intended to generate electrical power using renewable energy sources like wind and solar. It describes power conditioning schemes for solar energy system, maximum power point tracking algorithms, wind energy conversion systems and power quality issues in the integration of renewable energy resources to grid. It concludes the knowledge of solar, wind energy for thermal and electrical applications

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Wind and Solar Energy Systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two 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
16.6%	Remember
50 %	Understand
33.3 %	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
50%	50%	-

VI COURSE OBJECTIVES:

The students will try to learn:

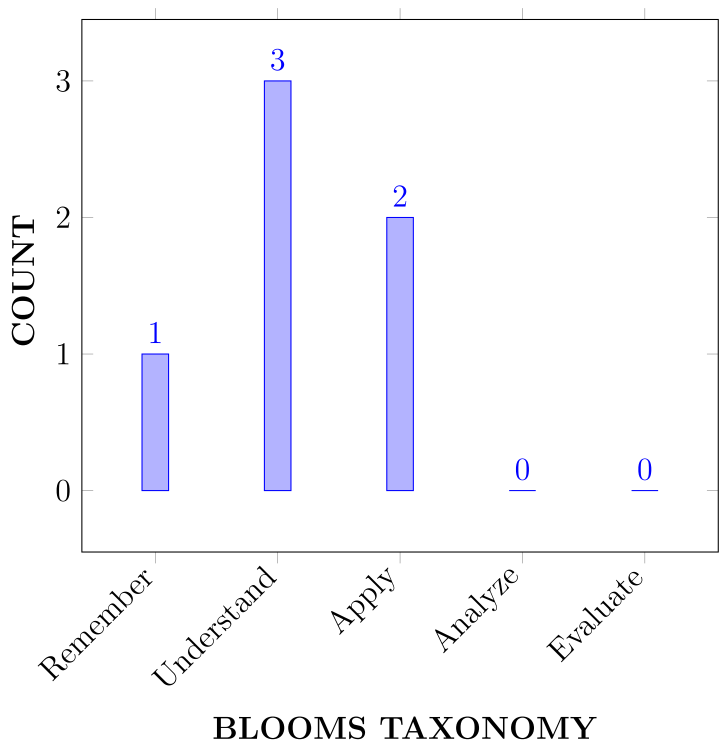
I	Analyze the environmental aspects of renewable energy sources
II	Familiarize on the availability of renewable energy sources for sustainable conversion of energy
III	Energy conversion systems in solar, wind and facilitate developing systems for different applications
IV	The present energy scenario and need for energy conversion
V	The power quality issues in integration of renewable energy resources

VII COURSE OUTCOMES:

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

CO 1	**Recall** the power conversions involved in windmills, photovoltaic systems for production of electricity	Remember
CO 2	**Summarize** the control schemes, environmental aspects and classify the wind energy conversion systems for reliable operation	Understand
CO 3	**Demonstrate** the functioning of various components involved in solar thermal systems for designing commercial solar power plants	Understand
CO 4	**Develop** the suitable scheme for extracting maximum power from solar photovoltaic module using maximum power point tracking algorithms	Apply
CO 5	**Make use of** AC voltage controllers for power factor improvement and harmonic reduction in isolated induction generators of wind energy conversion systems	Understand
CO 6	**Identify** the power quality issues and mitigation techniques used in standalone and grid connected systems for ensuring the quality of power	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	AAT/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	AAT/CIE/SEE

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	AAT/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	1	AAT/CIE/SEE

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Quiz
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	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 about the power conversions involved in wind mills for producing electricity knowledge of mathematics, science and engineering fundamentals.	2
	PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization	2
CO 2	PO 1	Provide knowledge about control schemes and classification of wind energy conversion systems with basic fundamentals of science, and engineering fundamentals.	3
	PO 2	Get knowledge on operations of modern energy sources to analyze wind energy conversion systems using principles of mathematics and engineering sciences.	6
	PO 7	Provide knowledge about environmental aspects of wind and solar energy using environmental contexts and demonstrate the knowledge of and need for sustainable development	2
	PSO 2	Make use of wind energy conversion system as another source of aid to power system	1
CO 3	PO 1	Summarize various operating modes of solar thermal systems with the knowledge of mathematics, science and engineering fundamentals.	3
	PO 2	Derive the solution for generating electrical power commercially using basic mathematics and engineering principles.	7
	PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization	2
	PSO 2	Recognize the importance of various operating modes of solar thermal systems in generation, transmission and distribution of power.	1
CO 4	PO 1	Use the basics of mathematics, science and engineering fundamentals for obtaining maximum power tracking algorithms.	3
	PO 2	Develop the solutions for power conditioner and inverters using which complex engineering problems can be solved with help of basic mathematics and engineering sciences.	7
	PSO 2	Understand the maximum power point tracking algorithms used in generation of electrical power with PV system	1
CO 5	PO 1	Distinguish different AC voltage controllers for power factor improvement by applying basic knowledge of science and engineering fundamentals.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	Understanding the harmonic reduction in induction generators according to the necessities.	5
	PSO 2	Understand the solar energy collection and generation of electrical power with PV system	1
CO 6	PO 1	Summarize power quality issues, mitigation techniques used in standalone and grid connected system swith the help of basic fundamentals of mathematics science and engineering fundamentals.	3
	PO 2	Determine power quality issues of grid connected system for analyzing the behavior of complex electrical components.	6
	PSO 2	Summarize the power quality features of standalone and grid connected systems with the required electrical machines in power system.	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	-	-	-	-	-	-	-	-	-	-		2	-	-
CO 2	3	6	-	-	-	-	2	-	-	-	-	-	-	1	-
CO 3	3	7	-	-	-	-	-	-	-	-	-	-	2	1	-
CO 4	3	7	-	-	-	-	-	-	-	-	-		-	1	-
CO 5	2	-	5	-	-	-	-	-	-	-	-	-	-	1	-
CO 6	3	6	-	-	-	-	-	-	-	-	-	-	-	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	66.6	-	-	-	-	-	-	-	-	-	-		100	-	-
CO 2	100	60	-	-	-	-	66.6	-	-	-	-	-	-	50	-
CO 3	100	70	-	-	-	-	-	-	-	-	-	-	100	50	-
CO 4	100	70	-	-		-	-	-	-	-	-		-	50	-
CO 5	66.6	-	50	-	-	-	-	-	-	-	-	-	-	50	-
CO 6	100	60	-	-	-	-	-	-	-	-	-	-	-	50	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 $< C \leq 40\%$ – Low/ Slight

2 - 40 % $< C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	-	-		3	-	-
CO 2	3	3	-	-	-	-	3	-	-	-	-	-	-	2	-
CO 3	3	3	-	-	-	-	-	-	-	-	-	-	3	2	-
CO 4	3	3	-	-	-	-	-	-	-	-	-		-	2	-
CO 5	3	-	2	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	3	3	-	-	-	-	-	-	-	-	-	-	-	2	-
TOTAL	18	12	2	-	-	-	3	-	-	-	-	-	6	10	
AVERAGE	3.0	3.0	2.0	-	-	-	3.0	-	-	-	-	-	3	2.0	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

-	Assessment of mini projects by experts	✓	End Semester OBE Feedback
-	Assessment of activities/Modelling and Experimental Tools in Engineering by Experts		

XVIII SYLLABUS:

MODULE I	**DESIGN AND OPERATION OF WIND POWER SYSTEM**
	Wind Power System: Components, turbine rating, electrical load matching, variable-speed operation, system design features, maximum power operation, system control requirements, speed control, rate control and environmental aspects, wind energy conversion systems and their classification
MODULE II	**DESIGN AND OPERATION OF PV SYSTEM**
	Solar Photovoltaic Power System: The PV Cell, module and array, equivalent electrical circuit, open circuit voltage and short circuit current, I-V and P-V curves, array design, peak power point operation, PV system components; Solar Thermal System: Energy collection, synchronous generator, equivalent electrical circuit, excitation methods, electrical power output, transient stability limit, commercial power plants.
MODULE III	**POWER CONDITIONING SCHEMES FOR SOLAR ENERGY SYSTEMS**
	Switching devices for solar energy conversion: DC power conditioning converters, maximum power point tracking algorithms. AC Power conditioners, Line commutated inverters, synchronized operation with grid supply, Harmonic reduction.

MODULE IV	**WIND ENERGY CONVERSION SYSTEMS**
	Wind energy Conversion system (WECS): Performance of Induction generators for WECS, Selfexcited induction generator (SEIG) for isolated power generators. Controllable DC power from SEIGs, system performance, Grid related problems, generator control, AC voltage controllers, Harmonic reduction and Power factor improvement
MODULE V	**POWER QUALITY ISSUES IN INTEGRATION OF RENEWABLE ENERGY RESOURCES**
	Stand alone and Grid connected systems, Power Quality issues, Impact of power quality problems on DG, Mitigation of power quality problems, and Role of custom power devices in Distributed Generation.

TEXTBOOKS

1. Mukund R Patel, “Wind and Solar Power Systems”, CRC Press, 1stEdition, 1999.
2. G D Rai, “Non- Conventional Energy Resources”, Khanna Publishers, 1stEdition, 2002.

REFERENCE BOOKS:

1. Daniel, Hunt. V Wind Power, A Hand Book of WECS, Van Nostrend Co., Newyork, 2ndEdition, 1998.
2. ArindamGhosh, Gerard Ledwich, “Power Quality Enhancement Using Custom Power Devices”, Springer, 1stEdition, 2002.
3. Roger C Dugan, Mark E Mc. Granaghan, Surya Santosh and H. Wayne Beaty, “Electrical Power Systems Quality”, TATA McGraw Hill, 2ndEdition, 2010.

WEB REFERENCES:

1. https://www.NPTEL video lectures.
2. https://www.books.askvenkat.com/engineering-textbooks
3. https://www.electrical4u.com.

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courses/elective/wind-and-solar-energy-systems

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	OBE DISCUSSION		
CONTENT DELIVERY (THEORY)			
1	Wind Power System Components	CO 2	T1: 5.1-1.5,R2:1-7.5 T1: 4.1

2	Wind Turbine rating, electrical load matching	CO 2	T1: 5.2 R1:1.1-1.8
3	Wind turbine Variable-speed operation, system design features	CO 2	T1: 5.4 R1:1.1-1.8
4	Maximum power operation in wind turbines	CO 1	T1: 5.6 R2:2.3
5	Wind power system control requirements	CO 1	T1: 5.7 R2:2.3
6	Speed control, rate control of wind turbines	CO 2	T1: 5.7.1 R2:3.2
7	Environmental aspects of wind power stations	CO 2	T1:5.8 R2:3.2
8	Wind energy conversion systems and their classification.	CO 1	T2:6.6 R2:2.9
9	Review of wind energy systems	CO 1	T2:6.6 R2:2.9
10	PV Cell, module and array ,equivalent electrical circuit	CO 3	T1: 8.1 R2:2.9-2.10
11	Open circuit voltage and short circuit current in solar system	CO 3	T1: 8.4 R2:2.11
12	Solar plate I-V and P-V curves, array design	CO 3	T1:8.5 R2:2.11
13	PV system components of solar power plant	CO 3	T1:8.8 R2:3.5
14	Solar Thermal System, energy collection of solar plates	CO 3	T1:9.1 R2:3.5
15	Synchronous generator used in solar power stations	CO 3	T1:6.1.2 R2:3.7
16	Equivalent electrical circuit of synchronous generator	CO 3	T1:6.1.2 R2:3.7
17	Excitation methods, electrical power output of synchronous generator	CO 5	T1:6.1.3 R2:3.7
18	Transient stability limit in synchronous generator	CO 3	T1:6.1.4 R2:3.7
19	Commercial solar power plants	CO 3	T1:8.6 R2:3.7
20	Overview of solar thermal power plants	CO 4	T1:8.5 R2:2.11
21	Switching devices for solar energy conversion	CO 4	T1:8.2 R2:4.1
22	DC power conditioning converters used in solar power plant	CO 4	T1:8.3 R2:5.1
23	Maximum power point tracking algorithms in solar power system	CO 4	T1:8.7 R2:5.2

24	AC Power conditioners used in solar power plants	CO 4	T1:8.8 R2:5.4
25	Line commutated inverters used in solar power generation	CO 4	T1:8.9 R2:4.3-4.4
26	Synchronized operation of solar plant with grid supply	CO 4	T1:8.6.2 R2:4.3-4.4
27	Harmonic reduction in solar power stations	CO 4	T1:8.6.3 R2:4.5
28	Overview of power switching devices used in solar thermal plant	CO 4	T1:8.7 R2:5.2
29	Introduction wind energy Conversion system	CO 5	T2:6.1 R2:6.1
30	Performance of Induction generators used for WECS	CO 5	T2:6.1 R2:6.2
31	Self-excited induction generator (SEIG) for isolated power generators	CO 5	T2:6.5 R2:7.1-7.2
32	Controllable DC power from SEIGs	CO 5	T2:6.11 R2:7.4
33	Wind energy conversion system performance	CO 5	T2:6.10 R2:7.4
34	Grid related problems with wind power plants	CO 5	T2:6.12 R2:7.4
35	Induction Generator control in wind power stations	CO 5	T2:6.11 R2:7.4
36	AC voltage controllers used in wind power stations	CO 5	T2:6.13 R2:7.3
37	Harmonic reduction in AC voltage controllers used in wind farms	CO 5	T2:6.14 R2:7.3
38	Overview AC power conditioners used in wind power plants	CO 5	T2:6.11 R2:7.4
39	Power factor improvement in wind power plants	CO 5	T2:6.16
40	Stand alone and Grid connected systems of wind power stations	CO 6	T2:6.3-6.4
41	Power Quality issues in integration of renewable energy systems	CO 6	T2:6.3-6.4 R2:7.4
42	Impact of power quality problems on Distributed Generation	CO 6	T2:6.2 R2:6.3
43	Mitigation of power quality problems	CO 6	T2:6.3-6.4 R2:7.8
44	Role of custom power devices in Distributed Generation	CO 6	T1:6.3-6.4 R2:7.8

45	Review of power quality issues in wind and solar power plants	CO 6	T2:6.2 R2:6.3
PROBLEM SOLVING/ CASE STUDIES			
46	Wind power system control requirements	CO 1	T1: 5.7 R2:2.3
47	Wind Turbine rating, electrical load matching	CO 2	T1: 5.2 R4:1.1-1.8
48	Wind turbine Variable-speed operation, system design features	CO 2	T1: 5.4 R1:1.1-1.8
49	Maximum power operation in wind turbines	CO 1	T1: 5.6 R2:2.3
50	PV Cell, module and array ,equivalent electrical circuit	CO 3	T1: 8.1 R2:2.9-2.10
51	Solar Thermal System, energy collection of solar plates	CO 3	T1:9.1 R2:3.5
52	Open circuit voltage and short circuit current in solar system	CO 3	T1: 8.4 R2:2.11
53	Line commutated inverters used in solar power generation	CO 4	T1:8.9 R2:4.3-4.4
54	Synchronized operation of solar plant with grid supply	CO 4	T1:8.6.2 R2:4.3-4.4
55	Harmonic reduction in solar power stations	CO 4	T1:8.6.3 R2:4.5
56	Performance of Induction generators used for WECS	CO 5	T2:6.1 R2:6.2
57	Stand alone and Grid connected systems,	CO 5	T1:8.5 R2:2.11
58	Power Quality issues,	CO 6	T1:8.8 R2:3.5
59	Impact of power quality problems on DG,	CO 6	T1:9.1 R2:3.5
60	Mitigation of power quality problems, and Role of custom power devices in Distributed Generation.	CO6	T1:6.1.2 R2:3.7
DISCUSSION OF DEFINITION AND TERMINOLOGY			
61	Electrical load matching	CO 2	T1:6.1.2 R2:3.7
62	I-V and P-V curves, array design, peak power point operation	CO 3	T1:6.1.3 R2:3.7
63	Line commutated inverters	CO 4	T1:6.1.4 R2:3.7
64	Selfexcited induction generator (SEIG) for isolated power generators	CO 5	T1:8.6 R2:3.7

65	Impact of power quality problems on DG	CO 6	T1:8.5 R2:2.11
DISCUSSION OF QUESTION BANK			
66	Design and Operation of Wind Power System	CO 1, 2	R2:2.1
67	Design and Operation of PV System	CO 3	T2:7.3
68	Power Conditioning Schemes for Solar Energy Systems	CO4	R2:5.1
69	Wind Energy Conversion Systems	CO 5	T1:7.5
70	Power Quality Issues in Integration of Renewable Energy Resources	CO 6	T1: 4.1

Signature of Course Coordinator **HOD,EEE**

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

COURSE DESCRIPTION

Department	**AERONAUTICAL ENGINEERING**				
Course Title	**RELATIONAL DATA BASE MANAGEMENT SYSTEM**				
Course Code	ACSB34				
Program	B.Tech				
Semester	VI				
Course Type	ELECTIVE				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	1	3	-	-
Course Coordinator	Ms. K RASHMI,Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS003	I	Computational Mathematics and Integral Calculus

II COURSE OVERVIEW:

The purpose of this course is to provide a clear understanding of fundamentals with emphasis on their applications to create and manage large data sets. It highlights on technical overview of database software to retrieve data from n database. The course includes database design principles, normalization, concurrent transaction processing,, security, recovery and file organization techniques

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Discrete Mathematical Structures	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
40 %	Understand
50 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

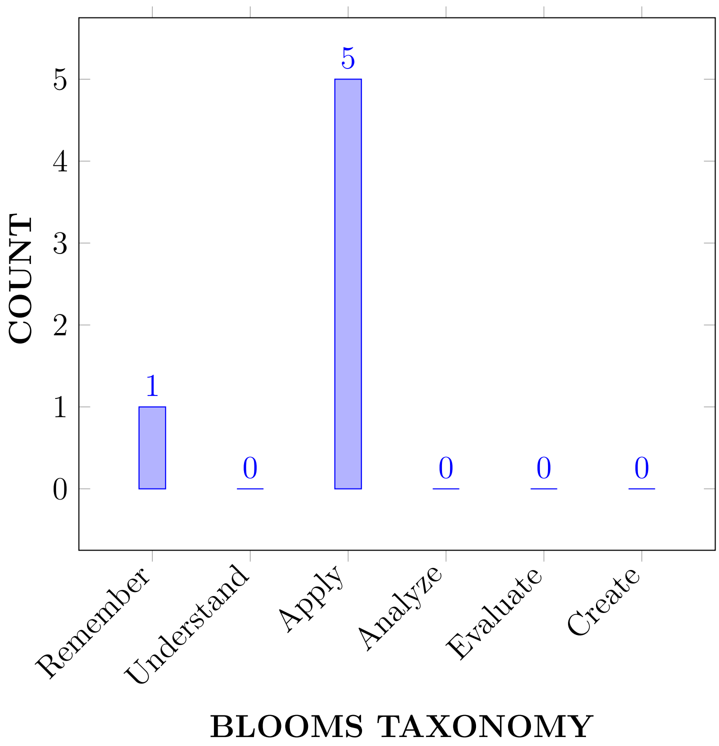
I	Acquire analytical thinking and identify efficient ways of designing database by encapsulating data requirements for business and organizational scenarios.
II	Develop expertise in database language SQL to develop sophisticated queries to extract information from large datasets.
III	Enhance skills to develop and manage data in solving related engineering problems.

VII COURSE OUTCOMES:

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

CO 1	**Outline** the importance of database system and its functionalities using entity relationship model for data storage and management.	Remember
CO 2	**Illustrate** basic and relational operations to access data from the database.	Apply
CO 3	**Build** SQL queries for database creation, manipulation and data retrieval.	Apply
CO 4	**Identify** the appropriate normalization technique for controlling the redundancy of database.	Apply
CO 5	**Demonstrate** the ACID properties of transaction processing to preserve the database in a consistent state.	Apply
CO 6	**Make use of** concurrency control protocols to provide the congestion free transactions of data.	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	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.	3	SEE / CIE / 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	SEE / 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.	3	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
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	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	**Understand, design and analyze** computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking.	3	SEE/AAT

PROGRAM SPECIFIC OUTCOMES		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.	2	SEE/AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Define database, characteristics, functions of database management system and types of users to describe large sets of data with knowledge of mathematics, and Engineering Fundamentals..	2
CO 2	PO 1	Compare traditional File Processing System and a Database System for constructing a database using the knowledge of mathematics, science, and engineering fundamentals.	3
	PO 2	Compare traditional File Processing System and a Database System for constructing a database With Problem statement and system definition , Problem formulation and abstraction .	7
CO 3	PO 1	Describe data models, schemas, instances, view levels and database architecture for voluminous data storage using principles of mathematics, science, and engineering fundamentals.	3
	PO 2	Describe data models, schemas, instances, view levels and database architecture for voluminous data storage with Problem statement and system definition , Problem formulation and abstraction	2
CO 4	PO 2	Model the real world database systems using Entity Relationship Diagrams from the requirement specification with the Problem statement and system definition, Problem formulation and abstraction , Information and data collection, Model translation.	4

	PO 3	Model the real world database systems using Entity Relationship Diagrams from the requirement specification through Investigate and define a problem and identify constraints ,Understand customer and user needs, Manage the design process and evaluate outcomes.	4
	PO 4	Model the real world database systems using Entity Relationship Diagrams from the requirement specification by Understanding of contexts in which engineering knowledge can be applied, Understanding use of technical literature, Understanding of appropriate codes of practice and industry standards.	3
	PSO 1	Model the real world database systems using Entity Relationship Diagrams from the requirement specification by using sequence of steps.	1
CO 5	PO 1	Define the relational data model, its constraints and keys to maintain integrity of data using the knowledge of mathematics, science, and engineering fundamentals.	3
	PO 2	Define the relational data model, its constraints and keys to maintain integrity of data with the Problem statement and system definition, Problem formulation and abstraction , Information and data collection, Model translation.	4
CO 6	PO 1	Define the concept of Relational Algebra and Relational Calculus from set theory to represent queries with knowledge of mathematics, science and engineering fundamentals for capacitance calculation.	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	1	-	-	-	-	-	-	1	-	-	-	-	1
CO 2	3	2	1	1	3	-	-	-	-	1	-	-	-	-	-
CO 3	3	2	1	2	3	-	-	-	-	1	-	1	-	-	1
CO 4	3	2	1	2	-	-	-	-	-	1	-	1	-	-	-
CO 5	3	2	1	1	3	-	-	-	-	1	-	1	-	-	1
CO 6	3	2	1	-	-	-	-	-	-	1	-	3	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	100.0	60.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 2	100.0	70.0	60.0	72.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 3	100.0	80.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 4	100.0	60.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 5	100.0	80.0	80.0	72.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0
CO 6	100.0	80.0	80.0	72.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	37.5	66.66	0.0	50.0

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	3	3	-	-	-	-	-	-	1	-	1	3	-	2
CO 2	3	3	3	3	-	-	-	-	-	1	-	1	3	-	2
CO 3	3	3	3	-	-	-	-	-	-	1	-	1	3	-	2
CO 4	3	3	3	-	-	-	-	-	-	1	-	1	3	-	2
CO 5	3	3	3	3	-	-	-	-	-	1	-	1	3	-	2
CO 6	3	3	3	3	-	-	-	-	-	1	-	1	3	-	2
TOTAL	18	18	18	9	-	-	-	-	-	6	-	6	18	-	12
AVERAGE	3.0	3.0	3.0	3.0	-	-	-	-	-	1	-	1	3.0	-	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
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**CONCEPTUAL MODELING INTRODUCTION**
	Introduction to Databases and Database Management System - Database system Applications Advantages of DBMS over File System - Data Models – Instances and schema - View of Data - Database Languages - DDL-DML - Database Users and Administrator - Database System Structure.
MODULE II	**RELATIONAL APPROACH**
	Database Design and ER diagrams – Attributes and Entity Sets – Relationships and Relationship Sets – Constraints - Keys - Design Issues - Entity-Relationship Diagram- Weak Entity Sets - Extended E-R Features-Database Design with ER model - Database Design for Banking Enterprise.
MODULE III	**SQL QUERY - BASICS, RDBMS - NORMALIZATION**
	SIntroduction to the Relational Model – Structure of RDBMS - Integrity Constraints over Relations – Enforcing Integrity Constraints – Querying Relational Data - Relational Algebra and Calculus. Introduction to SQL-Data Definition commands, Data Manipulation Commands, Basic Structure, Set operations Aggregate Operations - Join operations - Sub queries and correlated queries, SQL functions, views, Triggers, Embedded SQL.
MODULE IV	**TRANSACTION MANAGEMENT**
	Functional Dependencies– Introduction , Basic Definitions, Trivial and Non trivial dependencies, closure of a set of dependencies, closure of attributes, irreducible set of dependencies- Schema Refinement in Database Design-Problems Caused by Redundancy Decompositions – Problem Related to Decomposition — Lossless Join Decomposition – Dependency Preserving Decomposition - FIRST, SECOND, THIRD Normal Forms – BCNF –Multi valued Dependencies – Fourth Normal Form.
MODULE V	**DATA STORAGE AND QUERY PROCESSING**
	Transaction concept- Transaction state- Implementation of atomicity and Durability- Concurrent executions – Serializability, Recoverability; File Organization – Organization of records in file - Data Dictionary Storage – Indexing and Hashing – Basic Concepts , Ordered Indices,B+Tree Index files, B- tree index files.

TEXTBOOKS

1. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, "Database System Concepts", McGraw-Hill 6th Edition, 2017.

REFERENCE BOOKS:

1. Ramez Elmasri, Shamkant B. Navathe, "Fundamental Database Systems", Pearson Education, 6th Edition, 2014. 2. Raghu Ramakrishnan, "Database Management System", Tata McGraw
2. Hector Garcia Molina, Jeffrey D. Ullman, Jennifer Widom, "Database System Implementation", Pearson Education, United States, 1st Edition, 2000.
3. Peter Rob, Corlos Coronel, "Database System, Design, Implementation and Management", Thompson Learning Course Technology, 5th Edition, 2003.

WEB REFERENCES:

1. http://www.web.stanford.edu/class/cs103x
2. http://www.saylor.org/course/cs202/.
3. http://www.cse.iitd.ernet.in/ bagchi/courses/discrete-book

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index ?route=course/details& course id=84

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://lms.iare.ac.in/index ?route=course/details& course id=84
CONTENT DELIVERY (THEORY)			
2-3	Introduction, Data base System Applications, Purpose of data base Systems, View of Data – Data Abstraction, Instances and Schemas Data Models,, Database Languages, Data base access for applications Programs	CO 1, ,CO 2	T2: 1.1- 1.5
4-6	Transaction Management component of DB architecture, Data base users, History of database systems, Database design, ER Diagrams.	CO 3, CO 4	T2: 1. 6 - 1.8,, 1.10,T1: 2.1
7	Entities, Attributes and entity sets, Relationships and relationship sets, Additional features of ER model, Conceptual design with ER model, Conceptual design for large enterprises	CO 1	T2: 1. 6 - 1.8,, 1.10,T1: 2.1

8– 14	Relational Model: Introduction to the Relational Model – Integrity Constraint Over relations, Enforcing Integrity constraints – Querying relational data	CO 5	T1:1.5, 1.4.2,1.4.3
15-20	Relational Algebra and Calculus: Relational Algebra – Selection and projection –set operations – renaming, Joins – Division	CO 2,CO 6	T1:1.4.3, 1.4.4,2.3.1, 2.3.2,2.3.6,2.3.7,2.3.8
21-25	Relational calculus – Tuple relational Calculus – Domain relational calculus – Expressive Power of Algebra and calculus.	CO 2	R2:4.3 T1:2.4.1, 2.4.2,2.4.3, 4.1
26-29	Form of Basic SQL Query – Examples of Basic SQL Queries Comparison Operators – Aggregative Operators, NULL values , Logical connectivity's – AND, OR and NOT, complex Integrity Constraints in SQL	CO 2,CO 3,CO 6	T1:3.1,3.2 R1:6.2-6.8
30-35	Introduction to Nested Queries – Correlated Nested Queries Set Comparison Operators – Aggregative Operators, Triggers and Active Data bases.	CO 3 ,CO 6	R1: 7.1-7.6
36-38	Introduction to Schema refinement – Problems Caused by redundancy ,Decompositions – Problem related to decomposition	CO 3,CO 6	R2:8.1
39-44	Functional dependencies, reasoning about FDS ,Lossless join Decomposition , Dependency preserving Decomposition	CO 3	R2:8.2, 8.3
45-48	Schema refinement in Data base Design, Normal Forms, MVDs, JDs	CO 4,CO 6	R2: 9.1-9.3
49-54	Transaction Management: Transaction Concept-Transaction State- Implementation of atomicity and Durability, Concurrent Executions, Serializability , Recoverability, Implementation of Isolation, Testing for Serializability.	CO 4	R2: 9.8, 9.9, 10.1, 10.2
55-59	Concurrency Control: Lock-Based Protocols –time Stamp Based protocols-,Validation Based Protocols-Multiple Granularity	CO 5,CO 6	T2:5.5, 5.9, 5.10
60	Recovery System-Failure Classification-storage Structure recovery and Atomicity-Log Based Recovery.Tree Structured Indexing: B+ Trees, Hashing	CO 5,CO 6	R2:10.4, 10.6,10.7
PROBLEM SOLVING/ CASE STUDIES			
1	Entity Sets and Attributes	CO1,CO 6	T2:2.1
2	Degree and Cardinality constraints of relationship	CO1	T2:2.3
3	Distributed Query Processing – Case Studies	CO1,CO 6	T2:2.3.1
4	Aggregation – Role in ER Model	CO 2	T2:7.2,7.3
5	Syntax and Semantics of Data log Languages	CO 2,CO 6	T2:10.3.1
6	Rules to convert ER model into relational models (Entity sets)	CO 2,CO 6	T2:13.3.2, 13.4.1
7	Triggers – Introduction	CO 2	T2:17.1.1, 17.1.3
8	Closure of Set of FDs	CO 2,CO 6	T2:18.3.4, 18.3.4.1

9	Update, insert and Delete Anomalies	CO 3	T2:22.12, 19.1.2
10	Join Dependencies and 5NF .	CO 3,CO 6	T2:18.4, 18.4.3
11	Cloud Storage Architectures-Cloud Data Models	CO 5,CO 6	T2:19.2, 18.4.4
12	SAP as an Applications of databases	CO 5,CO 6	T2:23.1.1, 23.1.3
DISCUSSION ON DEFINITION AND TERMINOLOGY			
1	Define Database Management System?	CO 1,CO 6	T2:18.3.4, 18.3.4.1
2	What is Hierarchical model?	CO 2,CO 6	T2:22.12, 19.1.2
3	Compare Logical data independence and physical data independence?	CO 3,CO 6	T2:18.4, 18.4.3
4	What are natural join operations?	CO 4,CO 6	T2:19.2, 18.4.4
5	Define Functional Dependency?	CO 5, CO6	T2:23.1.1, 23.1.3
DISCUSSION ON QUESTION BANK			
1	Why relational model became more popular comparing with other record based models?	CO 1, CO 2	T2:18.3.4, 18.3.4.1
2	Illustrate different set operations in Relational algebra with an example.	CO 2, CO 6	T2:22.12, 19.1.2
3	Define a View in SQL. Write about updates on views.	CO 3, CO6,	T2:18.4, 18.4.3
4	Explain ACID properties and Illustrate them through examples?	CO4, CO 6	T2:19.2, 18.4.4
5	Why do you need concurrency in Transactions?	CO 5, CO 6	T2:23.1.1, 23.1.3

Course Coordinator **HOD,AE**
Mrs K Rashmi,Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
ELECTRICAL AND ELECTRON ICS ENGINEERING
COURSE DESCRIPTION

Course Title	**POWER ELECTRONICS LABORATORY**				
Course Code	AEEB21				
Program	B.Tech				
Semester	V	EEE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. S. Srikanth, Assistant Professor				

I COURSE OVERVIEW:

This course is intended for practical experience by conducting experiments on rectifiers, inverters, choppers, AC voltage controllers and cycloconverters. It provides hands-on experience by examining the electrical characteristics of various power converters. The power electronic converter applications have been analyzed with simulation tools.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB04	III	Analog and Digital Electronics Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power Electronics 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	-
20 %	Analysis	-
20 %	Design	-
20 %	Conclusion	-
20 %	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:

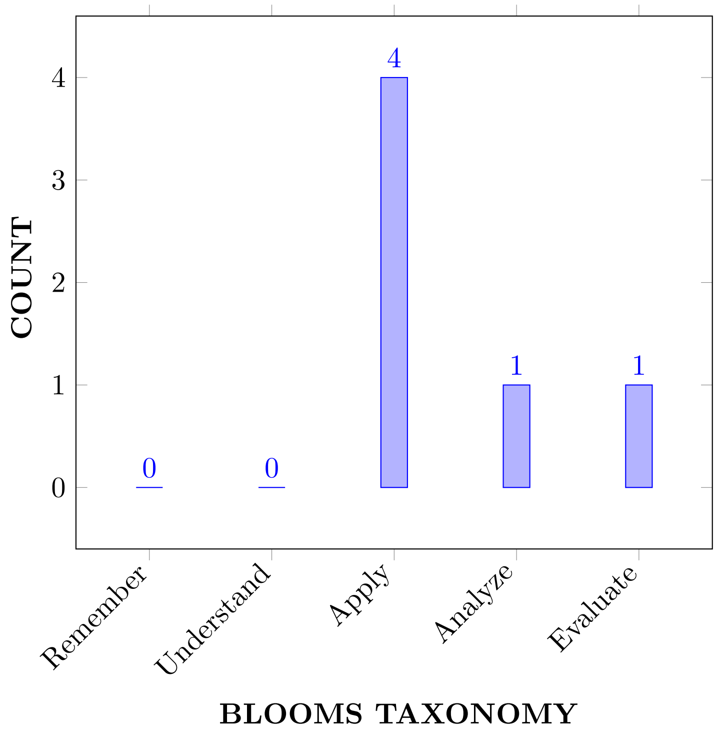
I	The engineering skills by way of electrical circuit design with power electronic devices and components.
II	Simulation and testing the different power converter circuits using simulation tools.
III	The demonstration of basic power electronic circuits for developing complex power converter modules.

VII COURSE OUTCOMES:

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

CO 1	**Experiment** the operation of SCR, MOSFET and IGBT for obtaining static voltage - current characteristics. .	Apply
CO 2	**Utilize** the forced commutation circuits and gate firing circuits for turning off and on of the SCR.	Apply
CO 3	**Analyze** the input and output waveforms of controlled rectifier circuits for determining the output voltages.	Analyze
CO 4	**Construct** the various inverter circuits for direct current to Alternating current conversion.	Apply
CO 5	**Determine** the performance characteristics of ac to ac converters for getting variable output voltage using hard ware and modern tools.	Evaluate
CO 6	**Develop** the chopper circuits for measuring output voltage and current .	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		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 analyze 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	3	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.	3	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	2	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 team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	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.	2	Lab Exercises
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Lab Exercises

PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	2	Lab Exercises
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.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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	Observe the functionality of power electronic components for static voltage current characteristics using **principles of mathematics and engineering science**	2
	PO 2	Understand the given power electronic components application **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the given power electronic components voltage current characteristics **for design solutions of complex engineering problems**	6
	PO 4	Understand the given power electronic components characteristics **with analysis and interpretation of data**	6
	PO 6	Illustrate the given power electronic component operation **for safety issues in professional engineering practice**	4
	PO 8	Understand the given power electronic components characteristics **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the given power electronic components operation **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the power electronic components operation **with communication of complex engineering practices**	3
	PO 12	Understand the given power electronic components application **in life long learning in technological change**	6
	PSO 1	Demonstrate the given power electronic components application **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the given power electronic components application **in electrical drives with converter topologies for energy conversion and management**	7

	PSO 3	Illustrate the given power electronic components application **in automation process using PLC and process controllers**	4
CO 2	PO 1	Observe the functionality of forced commutation circuits and gate firing circuits using **principles of mathematics and engineering sciences**	2
	PO 2	Understand the forced commutation circuits and gate firing circuits with**problem statement by analyzing complex engineering problems.**	6
	PO 3	Develop the forced commutation circuits and gate firing circuits **for design solutions of complex engineering problems**	6
	PO 4	Understand the forced commutation circuits and gate firing circuits operation **with analysis and interpretation of data**	6
	PO 6	Illustrate the forced commutation circuits and gate firing circuits **for safety issues in professional engineering practice**	4
	PO 8	Understand the forced commutation circuits and gate firing circuits **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the forced commutation circuits and gate firing circuits **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the turn on and turn off methods of SCR **with communication of complex engineering practices**	3
	PO 12	Understand the forced commutation circuits and gate firing circuits **in life long learning in technological change**	6
	PSO 1	Demonstrate the forced commutation circuits and gate firing circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the forced commutation circuits and gate firing circuits **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the forced commutation circuits and gate firing circuits **in automation process using PLC and process controllers**	4
CO 3	PO 1	Observe the input and output waveforms of controlled rectifier circuits using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of controlled rectifier circuits **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the controlled rectifier circuits **for design solutions of complex engineering problems**	6
	PO 4	Understand the input and output waveforms of controlled rectifier circuits **with analysis and interpretation of data**	6

	PO 5	Understand the controlled rectifier circuits **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate the input and output waveforms of controlled rectifier circuits **for safety issues in professional engineering practice**	4
	PO 8	Understand the input and output waveforms of controlled rectifier circuits **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the controlled rectifier circuits operation **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the input and output waveforms of controlled rectifier circuits **with communication of complex engineering practices**	3
	PO 12	Understand the controlled rectifier circuits operation **in life long learning in technological change**	6
	PSO 1	Demonstrate the input and output waveforms of controlled rectifier circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the controlled rectifier circuits applications **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the operation of controlled rectifier circuits **in automation process using PLC and process controllers**	4
CO 4	PO 1	Observe the various inverter circuits for direct current to Alternating current conversion using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of various inverter circuits **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the inverter circuits **for design solutions of complex engineering problems**	6
	PO 4	Understand the various inverter circuits for direct current to Alternating current conversion **with analysis and interpretation of data**	6
	PO 5	Understand the inverter circuits **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate the various inverter circuits for direct current to Alternating current conversion **for safety issues in professional engineering practice**	4
	PO 8	Understand the various inverter circuits for direct current to Alternating current conversion **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the inverter circuits operation **to function effectively as an individual and as a member in team**	8

	PO 10	Interpret the various inverter circuits for direct current to Alternating current conversion **with communication of complex engineering practices**	3
	PO 12	Understand the inverter circuits operation **in life long learning in technological change**	6
	PSO 1	Demonstrate the operation of inverter circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the inverter circuits applications **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the operation of inverter circuits **in automation process using PLC and process controllers**	4
CO 5	PO 1	Observe the performance characteristics of ac to ac converters using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of AC voltage controllers and cycloconverters **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the operation of AC voltage controllers and cycloconverters **for design solutions of complex engineering problems**	6
	PO 4	Understand the operation of AC voltage controllers and cycloconverters **with analysis and interpretation of data**	6
	PO 6	Illustrate the performance characteristics of ac to ac converters **for safety issues in professional engineering practice**	4
	PO 8	Understand the performance characteristics of ac to ac converters **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the operation of AC voltage controllers and cycloconverters **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the operation of AC voltage controllers and cycloconverters **with communication of complex engineering practices**	3
	PO 12	Understand the AC voltage controllers and cycloconverters applications **in life long learning in technological change**	6
	PSO 1	Demonstrate the AC voltage controllers and cycloconverters applications **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the AC voltage controllers and cycloconverters applications **in electrical drives with converter topologies for energy conversion and management**	7

	PSO 3	Illustrate the operation AC voltage controllers and cycloconverters applications **in automation process using PLC and process controllers**	4
CO 6	PO 1	Observe the chopper circuits operation using **principles of mathematics and engineering science**	2
	PO 2	Understand the operation of chopper circuits **with problem statement by analyzing complex engineering problems.**	6
	PO 3	Demonstrate the chopper circuits **for design solutions of complex engineering problems**	6
	PO 4	Understand the various chopper circuits for dc to variable dc conversion **with analysis and interpretation of data**	6
	PO 5	Understand the chopper circuits **modelling using IT tools such as MATLAB**	6
	PO 6	Illustrate the chopper circuits for dc to varible dc conversion **for safety issues in professional engineering practice**	4
	PO 8	Understand the chopper circuits for dc to varible dc conversion **with ethical principles, professional ethics and responsibilities**	2
	PO 9	Demonstarte the chopper circuits operation **to function effectively as an individual and as a member in team**	8
	PO 10	Interpret the the chopper circuits for dc to varible dc conversion **with communication of complex engineering practices**	3
	PO 12	Understand thechopper circuits operation **in life long learning in technological change**	6
	PSO 1	Demonstrate the operation of chopper circuits **in the electrical systems involved in power genration, transmikssion and distribution**	3
	PSO 2	Understand the chopper applications **in electrical drives with converter topologies for energy conversion and management**	7
	PSO 3	Illustrate the operation of chopper circuits **in automation process using PLC and process controllers**	4

XII 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	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 2	3	3	3	3	-	2	-	3	2	2	-	2	2	3	3
CO 3	3	3	3	3	3	2	-	3	2	2	-	2	2	3	3

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

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK I	**SCR, MOSFET AND IGBT**
	Study the characteristics of SCR, MOSFET and IGBT.
WEEK II	**GATE FIRING CIRCUITS**
	Study the operation of gate firing circuits of SCR.
WEEK III	**HALF CONTROLLED CONVERTER**
	Study the performance characteristics of single phase half controlled converter with R and RL loads.
WEEK IV	**FORCED COMMUTATION CIRCUITS**
	Plot the characteristics of forced commutation circuits (Class A, Class B, Class C, Class D and Class E).
WEEK V	**FULLY CONTROLLED BRIDGE CONVERTER**
	Study the characteristics of single phase fully controlled bridge converter with R and RL loads.
WEEK VI	**SERIES INVERTER**
	Study the characteristics of single phase series inverter with different loads.
WEEK VII	**PARALLEL INVERTER**
	Study the characteristics of single phase parallel inverter with different loads.
WEEK VIII	**VOLTAGE CONTROLLER**
	Plot the characteristics of Single phase AC voltage controller with R and RL loads.
WEEK IX	**DUAL CONVERTER**
	Study the characteristics of single phase dual converter with R and RL loads.

WEEK X	**CYCLOCONVERTER**
	Study the characteristics of single phase cycloconverter with R and RL loads.
WEEK XI	**THREE PHASE CONVERTERS**
	Plot the characteristics of three phase half converter with R and RL loads.
WEEK XII	**MOSFET BASED CHOPPERS**
	Study the principle of operation of step down chopper using MOSFET.
WEEK XIII	**SIMULATION OF THREE PHASE FULL CONVERTER AND PWM INVERTER**
	Simulation of three phase full converter and PWM inverter with R and RL loads by using MATLAB.
WEEK XIV	**SIMULATION OF BUCK – BOOST CHOPPER**
	Simulation of boost, buck, buck boost converter with R and RL loads by using MATLAB.

TEXTBOOKS

1. M D Singh, K B Kanchandhani, "Power Electronics", Tata Mc Graw Hill Publishing Company, 2nd Edition, 1998.
2. Dr. P S Bimbhra, "Power Electronics", Khanna Publishers, 5th Edition, 2012.

REFERENCE BOOKS:

1. Vedam Subramanyam, "Power Electronics", New Age International Limited, 2nd Edition, 2006.
2. G K Dubey, S R Doradra, A Joshi, R M K Sinha, "Thyristorised Power Controllers", New Age International Limited, 2nd Edition, 2008.
3. V R Moorthi, "Power Electronics Devices", Oxford University Press, 4th Edition, 2005.

XVI 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	Study the characteristics of SCR, MOSFET and IGBT..	CO 1	T1:3.1
2	Study the operation of gate firing circuits of SCR..	CO 2	T1:3.11
3	Study the performance characteristics of single phase half controlled converter with R and RL loads.	CO 3	T1:4.8
4	Plot the characteristics of forced commutation circuits (Class A, Class B, Class C, Class D and Class E).	CO 2	T1:4.8
5	Study the characteristics of single phase fully controlled bridge converter with R and RL loads. .	CO 3	T1.5.5
6	Study the characteristics of single phase series inverter with different loads.	CO 4	T1:5.6
7	Study the characteristics of single phase parallel inverter with different loads..	CO 4	T1:8.3
8	Plot the characteristics of Single phase AC voltage controller with R and RL loads..	CO 5	T1:8.3

9	Study the characteristics of single phase dual converter with R and RL loads..	CO 3	T1:9.2
10	Study the characteristics of single phase cycloconverter with R and RL loads. .	CO 5	T1:9.3
11	Plot the characteristics of three phase half converter with R and RL loads..	CO 3	T1:10.6
12	Study the principle of operation of step down chopper using MOSFET.	CO 6	T1:10.7
13	Simulation of three phase full converter and PWM inverter with R and RL loads by using MATLAB.	CO 3	T1:10.7
14	Simulation of boost, buck, buck boost converter with R and RL loads by using MATLAB.	CO 6	T1:10.8

Signature of Course Coordinator **HOD, EEE**
Mr. S. Srikanth, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**

PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**

PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**

PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**
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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

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

ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE DESCRIPTION

Course Title	MICROPROCESSORS AND MICROCONTROLLERS LABORATORY				
Course Code	AECB26				
Program	B.Tech				
Semester	VI	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1
Course Coordinator	Ms. B Lakshmi Prasanna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB07	III	Digital System Design

II COURSE OVERVIEW:

This laboratory course will facilitates the students to program 8086 microprocessor and 8051 microcontroller. Win862 software will be used for writing and debugging assembly language programs. The course includes performing arithmetic and logical operations, string manipulations, code conversions and interfacing of I/O devices to processor/controller. The hands-on experience acquired by the student's during the course makes them to carry out processor/controller based projects and extend their knowledge on the latest trends and technologies in the field of embedded system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Microprocessors and Microcontrollers 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
1	1	1	1	1	05

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
1	1	1	1	1	05

VI COURSE OBJECTIVES:

The students will try to learn:

I	Assembly language programming skills ranging from simple arithmetic operations to interfacing real time systems.
II	The usage of software tools to design, debug and test microprocessor/microcontroller based projects using assembly language programming.
III	The design of microcomputer and microcontroller based real-time applications in the fields of communication systems, home based automation systems, automobiles and unmanned applications.

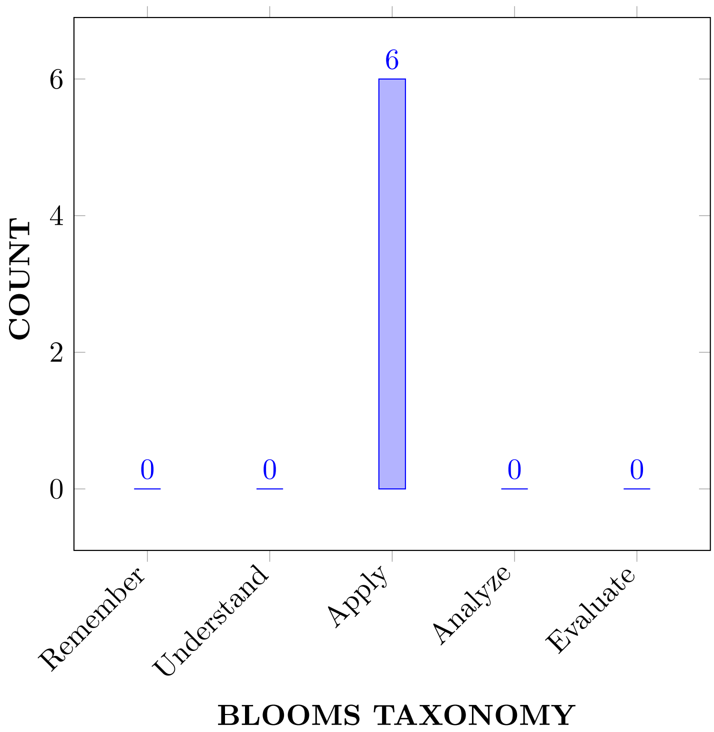
VII COURSE OUTCOMES:

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

CO 1	**Make use of** emulators and assemblers for writing, compiling and running an assembly language programs on training boards.	Apply
CO 2	**Develop** Assembly language programs for accomplishing code conversions, string manipulations and sorting of numbers.	Apply
CO 3	**Choose** serial or parallel communication for transmitting the data between microprocessor or microcontroller and peripherals.	Apply

CO 4	**Utilize** Analog to Digital and Digital to Analog converters with processor or controller for data conversion.	Apply
CO 5	**Select** suitable registers of microcontroller and write assembly language program to verify timer or counter operations.	Apply
CO 6	**Build** an interface between processor or controller and peripherals to provide solutions to the real world problems.	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	Day to Day Evaluation/ 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	Day to Day Evaluation/ 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	Day to Day Evaluation/ 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	Day to Day Evaluation/ CIE/SEE
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	2	Day to Day Evaluation/ 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.	1	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	Build embedded software and digital circuit development platform for robotics, embedded systems and signal processing applications.	3	Day to Day Evaluation/ 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	Make use of emulators and assemblers for writing, compiling and running an assembly language programs with the **knowledge of science, Engineering fundamentals, and an Engineering specialization** on training boards to the solution of complex Engineering problems.	3
	PO 2	Make use of emulators and assemblers for writing, compiling and running an assembly language programs with **information and data collection** for **developing solutions** on training boards and **interpret the results**.	3
	PO 3	**Understand customer needs** and make use of emulators and assemblers for **managing design process** and **use creativity to establish innovative solutions** by writing, compiling and running an assembly language programs on training boards	3
	PO 5	Make use of emulators and assemblers for writing, compiling and running an assembly language program on training boards using **Computer software**.	1

	PO 9	Make use of emulators and assemblers for writing, compiling and running an assembly language programs by **referring textbooks** on training boards in **hands-on labs** and **build an ability to work with all levels of people in an organization**	3
	PO 10	Make use of emulators and assemblers for writing, compiling and running an assembly language programs on training boards and **write effective reports** .	1
	PSO 1	Make use of emulators and assemblers**(embedded software)** for writing, compiling and running an assembly language programs on training boards to **build embedded system applications.**	2
CO 2	PO 1	write Assembly language programs for accomplishing code conversions, string manipulations and sorting of numbers by **applying the knowledge of mathematics, Engineering fundamentals, and an Engineering specialization** to the solution of complex Engineering problems	3
	PO 2	Understand the given **problem statement** and develop assembly language program for accomplishing sorting of numbers, code conversions and string manipulation to provide processor/controller based **solution** and **validate** the obtained **results.**	4
	PO 3	Develop **design process** for accomplishing code conversions, string manipulations and sorting of numbers and establish **innovative solutions** to meet the **requirements of user**.	3
	PO 5	Use **computer software** and write Assembly language programs for accomplishing code conversions, string manipulations and sorting of numbers to provide solutions for complex Engineering activities with an understanding of the limitations.	1
	PO 9	**Take a defined problem** and **refer appropriate textbook, use hands-on labs** and develop **the solutions** for code conversions, string manipulations and sorting of numbers.	4
	PO 10	Develop Assembly language program for accomplishing code conversions, string manipulations and sorting of numbers **and write effective reports and design documentation.**	1
	PSO	Utilize **embedded software and digital circuit platforms** perform code conversions which are commonly used in various **embedded applications**.	2
CO 3	PO 1	Perform serial or parallel communication by applying the **knowledge of mathematics, Engineering fundamentals, and an Engineering specialization** for transmitting the data between microprocessor or microcontroller and peripherals.	3

	PO 2	Understand the given data transfer schemes **(problem statement)**and interface microprocessor with serial I/O ports and develop**experimental design** to establish data transfer **(solution)** and**validate** the obtained **results.**	5
	PO 3	Develop processor or controller based systems by **managing the designing process** to establish serial/ parallel communication based on **customer needs** with appropriate consideration for **the public health and safety,**and Environmental considerations and provide the **innovative solutions**	4
	PO 5	Make use of **software and hardware tools** to perform data transfer between processor and I/O devices.	1
	PO 9	Focus on working as a **member or leader** in designing the processor based data transfer schemes in **hands-on labs** by **referring appropriate textbooks** and **evaluate their performance.**	4
	PO 10	Recognize the role of microprocessors and controllers in performing the data transfer by **communicating effectively and write effective reports.**	1
	PSO 1	Utilize **embedded software and digital circuit platforms** to perform data transfer in various **Embedded applications.**	2
CO 4	PO 1	Utilize Analog to Digital and Digital to Analog converters by the **knowledge of mathematics,Engineering fundamentals, and an Engineering specialization** with processor or controller for data conversion.	3
	PO 2	**Identify the problem** and **conduct experimental design** using Analog to Digital and Digital to Analog converters with processor or controller with **Information and data collection** for data conversion**(Solution development)** and **Interpretation of results**.	5
	PO 3	Design processor or controller based systems to perform analog to digital conversion or digital to analog conversion based on **customer needs** and use **creativity** in designing solution with appropriate consideration for the**public health and safety, and Environmental considerations.**	4
	PO 5	Utilize **software and hardware tools** to perform data conversion between processor and ADC/DAC.	1
	PO 9	Focus on working as a **member or leader** in designing the processor based data conversion techniques in **hands-on labs** by **referring appropriate textbooks** and**evaluate their performance**	4
	PO 10	Identify the role of microprocessors, ADC and DAC devices in performing the data conversion and **write effective reports.**	1
	PSO 1	Make use of **embedded software** to perform data conversion in various **embedded applications.**	2

CO 5	PO 1	Make use of suitable registers of microcontroller and write assembly language program to verify timer or counter operations **by applying the knowledge of mathematics,Engineering fundamentals, and an Engineering specialization**.	3
	PO 2	Understand the requirements **(opportunity)** of timer/counters in industrial applications**(problem statement)** and design controller based solution**(solution)** to perform given job and **validate** the obtained **results** in real time environment.	5
	PO 3	Design microcontroller based systems to perform timer/counter operations which is necessary in automated industries based on **customer needs** and use**creativity** in designing solution with appropriate consideration for the**public health and safety, and Environmental considerations**	4
	PO 5	Make use of **software and hardware tools** for effective implementation of timer/counter applications.	1
	PO 9	Work effectively as a **member or leader** in designing the controller based timer/ counter operations in **hands-on labs** by**referring appropriate textbooks** and**evaluate their performance**	4
	PO 10	Identify the role of microcontrollers in performing the timer/ counter operations by **writing effective reports.**	1
	PSO 1	Utilize **embedded software and digital circuit platforms** to build **robotic applications** where timer/counter operations are required.	2
CO 6	PO 1	Develop an interface between processor or controller and peripherals by applying **the knowledge of mathematics,Engineering fundamentals, and an Engineering specialization** to provide solutions to the real world problems.	3
	PO 2	Understand the requirements **(opportunity)** of industrial applications **(problem statement)** and design processor or controller based solution **(solution)** to perform given job and **validate** the obtained**results** in real time environment.	5
	PO 3	Develop processor or controller based systems by **managing the designing process** to establish **innovative solutions** based on**customer needs** with appropriate consideration for **the public health and safety,** and Environmental considerations.	4
	PO 5	Make use of **software and hardware tools** for effective design of processor or controller based applications.	1
	PO 9	Focus on working as a **member or leader** in designing the processor and controller based solutions in**hands-on labs** by **referring appropriate textbooks** and**evaluate their performance**	4

	PO 10	Recognize the role microprocessors and controllers in providing the solutions to real-time systems by **writing effective reports.**	1
	PSO 1	Utilize **embedded software and digital circuit platforms** to create processor or controller based solutions in **Embedded applications**.	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	PO 5	PO 9	PO 10	PSO 1
CO 1	3	3	3	1	3	1	2
CO 2	3	4	3	1	4	1	2
CO 3	3	5	4	1	4	1	2
CO 4	3	5	4	1	4	1	2
CO 5	3	5	4	1	4	1	2
CO 6	3	5	4	1	4	1	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	**DESIGN A PROGRAM USING WIN862**
	Design and develop an Assembly language program using 8086 microprocessor and to show the following aspects. (a)Programming (b)Execution (c)Debugging To Demonstrate the win 862 software and Trainer kit for 8086 Microprocessor
WEEK II	**16 BIT ARITHMETIC AND LOGICAL OPERATIONS**
	Write an ALP program to perform 16 Bit arithmetic and logical operations using WIN862 software
WEEK III	**MULTIBYTE ADDITION AND SUBTRACTION**
	(a) Write an ALP program to perform multi byte addition and subtraction (b) Write an ALP program to perform 3*3 matrix multiplication and addition

WEEK IV	**PROGRAMS TO SORT NUMBERS**
	(a)Write an ALP program to perform ascending order using 8086 (b)Write an ALP program to perform descending order using 8086
WEEK V	**PROGRAMS FOR STRING MANIPULATIONS OPERATIONS**
	(a)Write an ALP program to insert or delete a byte in the given string (b)Write an ALP program to search a number/character in a given string (c)Write an ALP program to move a block of data from one memory location to the other (d)Write an ALP program for reverse of a given string.
WEEK VI	**CODE CONVERSIONS**
	(a) Write an ALP program to convert packed BCD to Unpacked BCD (b) Write an ALP program to convert packed BCD to ASCII (c) Write an ALP program to convert hexadecimal to ASCII
WEEK VII	**INTERFACING STEPPER MOTOR**
	(a) Write an ALP program to rotate stepper motor in clockwise direction (b) Write an ALP program to rotate stepper motor in anti clockwise directio
WEEK VIII	**INTERFACING ADC and DAC DEVICES**
	(a) Write an ALP program to convert analog to digital using 8086 (b) Write an ALP program to convert digital to analog using 8086
WEEK IX	**INTERFACING KEYBOARD TO 8086**
	Write an ALP program to interface keyboard to 8086
WEEK X	**SERIAL AND PARALLEL COMMUNICATION**
	(a) Parallel communication between two microprocessors using 8255 (b) Serial communication between two microprocessor kits using 8251
WEEK XI	**INTERFACING TRAFFIC LIGHT CONTROLLER AND TONE GENERATOR**
	(a) Write a program to interface traffic light controller (b) Write an ALP program to interface tone generator
WEEK XII	**ARITHMETIC AND LOGICAL OPERATIONS USING 8051**
	Write an ALP program to perform 16 Bit arithmetic and logical operations using 8051 microcontroller
WEEK XIII	**TIMER/COUNTER**
	Write an ALP Program and verify Timer/Counter using 8051
WEEK XIV	**INTERFACING KEYBOARD TO 8051**
	Write an ALP program to interface keyboard to 8051

TEXTBOOKS

1. Ray A.K, Bhurchandi K.M, “Advanced Microprocessor and Peripherals”, TMH, 2nd Edition, 2012

2. Muhammad Ali Mazidi, J.G. Mazidi, R.D McKinlay,” The 8051 Microcontroller and Embedded systems using Assembly and C”, Pearson education, 2nd Edition, 2009.

3. Douglas V. Hall, “Microprocessors and Interfacing Programming and Hardware”, TMGH, 2nd Edition, 1994.

REFERENCE BOOKS:

1. Kenneth J. Ayala, “The 8051 Microcontroller”, Thomson Learning, 3rd edition, 2005.

2. Manish K. Patel, “The 8051 Microcontroller Based Embedded Systems”, McGraw Hill, 1st Edition, 2014.

3. Ajay V Deshmukh, ”Microcontrollers”, TATA McGraw Hill publications, 2nd Edition, 2012.

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	Design a program using WIN862	CO 1/ CO 2	T1: 3.3
2	16 bit arithmetic and logical operations	CO1/ CO2	T1: 3.4
3	Multibyte addition and subraction	CO1/ CO2	T1: 3.4
4	Programs to sort numbers	CO1/ CO2	T1: 3.4
5	Programs for string manipulations operations	CO1/ CO2/ CO3	T1: 3.4
6	Code conversions.	CO1/ CO2	T1: 3.4
7	Interfacing stepper motor to 8086 microprocessor	CO1/ CO6	T1: 5.8
8	Interfacing ADC and DAC devices	CO1/ CO4/ CO6	T1: 5.6, 5.7
9	Interfacing keyboard to 8086 microprocessor	CO1/ CO6	T1: 6.3
10	Serial and Parallel communication	CO1/ CO3/ CO6	T1: 6.4
11	Interfacing traffic light controller and tone Generator to 8086 microprocessor	CO1/ CO6	T1: 6.5, 6.6
12	Arithmetic and logical operations using 8051 microcontroller	CO1/ CO2	R1: 4,5
13	Timer/Counter operations	CO1/ CO5/ CO6	R1: 2
14	Interfacing keyboard to 8051 microcontroller	CO1/ CO6	R1: 8

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Write an Assembly Language Program to rotate a 200 teeth, 4 phase stepper motor with 5 rotations clockwise and then 5 rotations anticlockwise, Rotate through angle 135o in 2 sec, rotate the shaft at a speed of 10 rotations per minute.
2	Develop an Assembly Language program to interface 8251 with 8086 at an address 80H, initialize it in asynchronous transmit mode, with 7 bits character size, baud factor 16, one start bit and 1 stop bit, even parity enabled and then transmit a message "HAPPY NEW YEAR" in ASCII form to a modem.
3	Interface ADC 0808 with 8086 using 8255 ports. Use Port A of 8255 for transferring digital data output of ADC to the CPU and Port C for control signals. Assume that an analog input is present at I/P2 of the ADC and a clock input of suitable frequency is available for ADC. Draw the schematic and timing diagram of different signals of ADC0808.
4	Interface 12-bit DAC with 8086 and develop the Assembly Language program to generate the step waveform of duration 1sec, maximum voltage 3 volts and determine the duration of each step.
5	Write a program to initialize 8251 in synchronous mode with even parity, single SYNCH character, 7-bit data character. Then receive FFH bytes of data from a remote terminal and store it in the memory at address 5000H: 2000H.
6	A switch is connected to pin P1.2. Write an 8051 Assembly Language program to monitor SW and create the following frequencies on pin P1.7. SW=0: 500Hz, SW=1: 750Hz, use Timer 0, mode 1 for both of them.
7	Write an Assembly Language program for 8051 Microcontroller to count number of interrupts arriving on external interrupt pin INT1. Stop when counter overflows and disable the interrupt. Give the indication on pin P0.0

Signature of Course Coordinator **HOD,ECE**
Ms. B Lakshmi Prasanna, Assistant Professor

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**POWER SYSTEM ANALYSIS**				
Course Code	AEEB22				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	1	3	-	-
Course Coordinator	Dr. P. Rajendhar, Associate Professor, EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB09	III	Network Analysis
B.Tech	AEEB19	V	Electrical Power Transmission Systems

II COURSE OVERVIEW:

Power System Analysis course enables students to study the performance of interconnected power system under steady state and transient stability conditions. The course deals with formation of impedance and admittance matrices for various configurations, finding unknown electrical quantities at various buses, symmetrical and unsymmetrical fault analysis, power system using per unit representation. The course helps in selecting the protective devices to gain back normal operation of power system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power System Analysis	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
40%	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), 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:

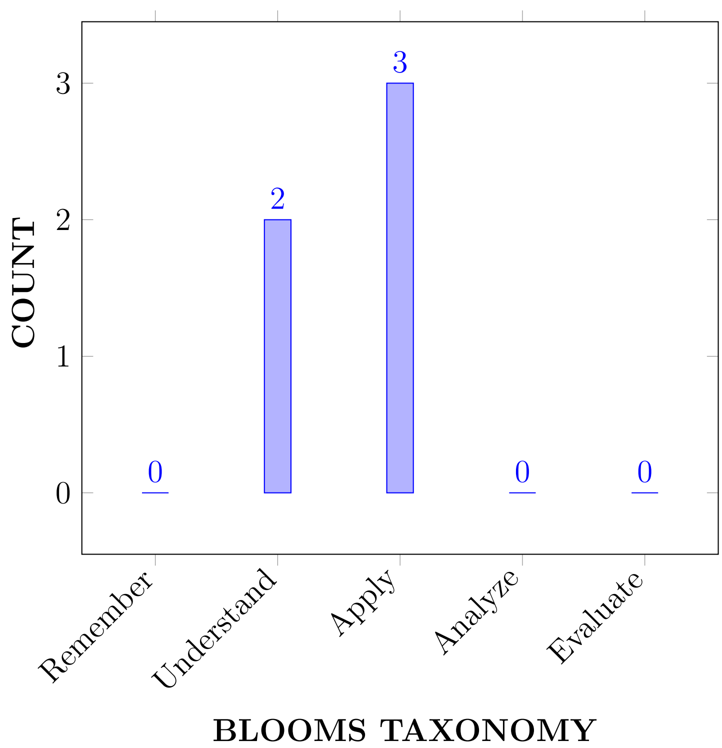
I	The methods to build the bus impedance and bus admittance matrices for primitive and non-primitive networks.
II	The numerical methods for load flow analysis of n bus interconnected power system.
III	The theorems and techniques involved in the fault level calculations during balanced and unbalanced faults.
IV	The performance of power system under steady and transient state stability conditions.

VII COURSE OUTCOMES:

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

CO 1	**Build** the mathematical models and matrices of interconnected power system network for analyzing power flows and fault conditions	Apply
CO 2	**Develop** a network's power flow problem and solve it using multiple iterative strategies in obtaining optimal solution	Apply
CO 3	**Experiment** with power system fault analysis for balanced and unbalanced faults in order to determine fault levels and protective device ratings, as well as to grasp the ideas of per-unit system.	Apply
CO 4	**Classify** the different types of stability, including the elements that influence the steady state stability limitations and how to improve it	Understand
CO 5	**Demonstrate** the different numerical integration and graphical approaches to understand the transient stability and the factors affecting as well as the methods of enhancing it	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.	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	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	Analyse Design, investigate, simulate and/or fabricate/commission the electrical system involving generation, transmission, distribution and utilization of electrical energy.	3	Research Paper / Quiz / 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	✓	✓	✓	-	✓	-	-	-	-	-	-	-	✓	-	-

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 the nomenclature of graph theory,procedure to form incidence matrices with knowledge of **mathematics, science and engineering fundamentals.** which are useful for load flow and fault analysis	3
	PO 3	Form the bus impedance and admittance matrices **to understand required specifications for load flow analysis of power system.** and to understand the formation of modified bus impedance matrix for various changes in the existing network.	5
	PSO 1	Understand the concepts of graph and matrix theory which helps in **load flow analysis of power system.** and to design the solution a solution with inclusion of line charging capacitance to the power transmission network	2
CO 2	PO 1	Recollect the numerical methods for solving linear and nonlinear algebraic equations those are encountered in power flow studies with knowledge from mathematics and engineering fundamentals **basic fundamentals of science, and engineering fundamentals.**	3
	PO3	**Designing a load flow problem and to develop solutions for the same** using different numerical methods for different conditions of the bus systems	6
	PO 5	Draw the flow chart of numerical methods used to find solution of power flow problem **helps in simulation interconnected system for all requited specifications.**	1
	PSO 1	**Simulate the power system to obtain complete data of the buses** under various set of conditions in analysing power flows of a network	3
CO 3	PO 1	Recollect the definitions of electrical quantities to introduce per unit system and symmetrical component theory using **fundamentals of mathematics, science, and engineering fundamentals.**	3
	PO 2	Understand the different types of faults on any power system and its effects **using basic mathematics and engineering principles.**	7
	PO 3	**Design the ratings for protective devices under complex power system fault conditions and to incorporate fault limiting devices**	5
	PSO 1	**Usage of per unit method and symmetrical components** to understand the symmetrical and unsymmetrical faults which helps in **designing a switch gear equipment of power system.**	3
CO 4	PO 1	Recollect the dynamics of electrical components to analyze and classify the stability of power system with basic **fundamentals of mathematics science and engineering fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Determine the conditions and limits for power system using various methods **to meet the stability requirement specifications.**	6
	PO3	Determine solutions to avoid power system stability issues and to give suggestions for enhancing the steady state stability	6
	PSO 1	Understand the **necessity of stability study in power system for economic and reliable operation.**	3
CO 5	PO 1	Recollect the dynamics of electrical components to find the solution for swing equation and understand equal area criterion and point by point method with **basic fundamentals of mathematics science and engineering fundamentals.**	3
	PO2	Understand the concepts of equal area criterion and point by method in analyzing transient stability **of complex power system with basic mathematics and engineering sciences.**	7
	PO 3	**Calculate the critical clearing angle to determine the condition** to underlie in the limits of transient state stability.	6
	PO 5	**Usage of software tools and flow charts** to understand the complex power system problems such as load flows, fault studies and stability in an simulation environment	1
	PSO1	Understand the importance of load flow studies, fault analysis and stability **in planning, operation and requirements of power system**	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	-	6	-	1	-	-	-	-	-	-		3	-	-
CO 3	3	7	5	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	6	6	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	3	7	6	-	1	-	-	-	-	-	-	-	4	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 2	100	-	60	-	100	-	-	-	-	-	-		60	-	-
CO 3	100	70	50	-	-	-	-	-	-	-	-	-	60	-	-
CO 4	100	60	60	-	-	-	-	-	-	-	-	-	60	-	-
CO 5	100	70	60	-	100	-	-	-	-	-	-	-	80	-	-

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	-	3	-	3	-	-	-	-	-	-	-	3	-	-
CO 3	3	3	2	-	-	-	-	-	-	-	-	-	3	-	-
CO 4	3	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO 5	3	3	3	-	3	-	-	-	-	-	-	-	3	-	-
TOTAL	30	18	23	-	6	-	-	-	-	-	-	-	29	-	-
AVERAGE	3.0	3.0	3.0	-	3.0	-	-	-	-	-	-	-	3.0	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	PO 1,PO 2, PO 3, PO 5	SEE Exams	PO 1,PO 2, PO 3, PO 5	Seminars	PO 1,PO 2, PO 3, PO 5
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 1,PO 2, PO 3, PO 5	Open Ended Experiments	-
Assignments	PO 1,PO 2, PO 3, PO5				

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**POWER SYSTEM NETWORK MATRICES**
	Graph Theory: Definitions, bus incidence matrix, Y bus formation by direct and singular transformation methods, numerical problems; Formation of Z Bus: Partial network, algorithm for the modification of Z bus matrix for addition of element from a new bus to reference bus, addition of element from a new bus to an old bus, addition of element between an old bus to reference bus and addition of element between two old busses (Derivations and Numerical Problems), modification of Z bus for the changes in network (Numerical Problems).
MODULE II	**POWER FLOW STUDIES AND LOAD FLOWS**
	Load flows studies: Necessity of power flow studies, data for power flow studies, derivation of static load flow equations; Load flow solutions using Gauss Seidel method: Acceleration factor, load flow solution with and without PV buses, algorithm and flowchart; Numerical load flow solution for simple power systems (Max. 3 buses): Determination of bus voltages, injected active and reactive powers (Sample one iteration only) and finding line flows / losses for the given bus voltages; Newton Raphson method in rectangular and polar coordinates form: Load flow solution with or without PV busses derivation of Jacobian elements, algorithm and flowchart, decoupled and fast decoupled methods, comparison of different methods, DC load flow study.
MODULE III	**SHORT CIRCUIT ANALYSIS PER UNIT SYSTEM OF REPRESENTATION**
	Per unit system: Equivalent reactance network of a three phase power system, numerical problems; Symmetrical fault analysis: Short circuit current and MVA calculations, fault levels, application of series reactors, numerical problems; Symmetrical component theory: Symmetrical component transformation, positive, negative and zero sequence components, voltages, currents and impedances. Sequence networks: Positive, negative and zero sequence networks, numerical problems; Unsymmetrical fault analysis: LG, LL, LLG faults with and without fault impedance, numerical problems.
MODULE IV	**STEADY STATE STABILITY ANALYSIS**
	Steady state stability: Elementary concepts of steady state, dynamic and transient stabilities, description of steady state stability power limit, transfer reactance, synchronizing power coefficient, power angle curve and determination of steady state stability and methods to improve steady state stability.
MODULE V	**TRANSIENT STATE STABILITY ANALYSIS**
	Swing equation: Derivation of swing equation, determination of transient stability by equal area criterion, application of equal area criterion, critical clearing angle calculation, solution of swing equation, point by point method, methods to improve stability, application of auto reclosing and fast operating circuit breakers.

TEXTBOOKS

1. D P Kothari and I J Nagrath, "Power System Engineering", McGraw-Hill Education, 2nd Edition, 2007.
2. M A Pai, "Computer Techniques in Power System Analysis", TMH Publications, 2nd edition, 2005.
3. B R Guptha, "Power system analysis and Design" S. Chand Publishing, 2nd edition,

1998.

4. K Umarao, “Computer techniques and models in power systems”, I K International Pvt. Ltd., 2nd edition, 2006.

REFERENCE BOOKS:

1. Stagg , El Abiad, “ Computer Methods In Power System”. Tata McGraw-Hill.1968.
2. Grainger and Stevenson, “Power System Analysis”, Tata McGraw-Hill, 3rd Edition, 2011.
3. J Duncan Glover and M S Sarma., THOMPSON, “Power System Analysis and Design”, 3rd Edition 2006.
4. Abhijit Chakrabarthi and Sunita Haldar, “Power system Analysis Operation and control”, 3rd Edition, PHI, 2010.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108/105/108105067/

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			
CONTENT DELIVERY (THEORY)			
1	Introduction to graph theory.	CO 1	T4:9.41, R1:3.1-3.2
2	Solve numerical problems on graph theory.	CO 1	T4:9.4.1, R1:3.1-3.2
3	Building bus incidence matrix.	CO 1	T4:9.4.3, R1:3.3-3.5
4	Forming Y bus formation by direct method.	CO 1	T4:9.2, R1:3.3-3.5
5,6	Forming Y bus formation by singular transformation. methods,	CO 1	T4:9.2, R1:3.3-3.5
7	Solve numerical problems on bus matrices.	CO 1	T4:9.2, R1:3.3-3.5
8	Formation of ZBUS: Partial network.	CO 1	T4:9.4, R1:4.1

9	Algorithm for the Modification of Z Bus Matrix for addition element from a new bus to reference.	CO 1	T4:9.3-9.5, R1:4.2
10	Algorithm for the Modification of Z Bus Matrix for addition element from a new bus to an old bus.	CO 1	T4: 9.3-9.5, R1:4.3-4.4
11,12	Algorithm for the Modification of Z Bus Matrix for addition element between an old bus to reference Addition of element between two old busses (Derivations and Numerical Problems without mutual coupling).	CO 1	T4: 9.3-9.5, R1:4.3-4.4
13	Study of necessity of power flow studies – Data for power flow studies – derivation of static load flow equations.	CO 2	T4:9.1, R1:8.1
14	Solution of load flow solutions using Gauss Seidel Method: Acceleration Factor.	CO 2	T4:9.8, R1:8.2
15	Load flow solution with and without P- V buses, Algorithm and Flowchart.	CO 2	T4:9.9.1, R1:9.2
16,17	Find numerical load flow solution for simple power systems (Max. 3- Buses): Determination of bus voltages, injected active and reactive powers (Sample One Iteration only).	CO 2	T4:9.8, R1:9.2
18,19	Discuss on newton raphson method in rectangular form: load flow, solution with or without PV busses- Derivation of jacobian elements.	CO 2	T4:9.10, R1:9.2
20	Discussion newton raphson method in polar co- ordinates form: load flow solution with or without pv busses-Derivation of jacobian elements.	CO 2	T4:9.11.2, R1:9.2
21,22	Study on decoupled and fast decoupled methods for load flow solution.	CO 2	T4:9.12, R1:9.2
23	Comparison of Different Methods – DC load Flow.	CO 2	T4:9.4.12, R1:9.2
24,25	Short Circuit Analysis: Short Circuit Current and MVA Calculations.	CO 3	T4:10.3, R1:6.1-6.3
26	Understand fault levels.	CO 3	T4:10.4, R1:6.1-6.3
27	Application of series reactors.	CO 3	T4:10.4, R1:6.1-6.3
28	Solving numerical problems (Symmetrical fault Analysis).	CO 3	T4:10.4, R1:6.4
29	Understand symmetrical component transformation, positive, negative and zero sequence components.	CO 3	T4:10.5, R1:6.4
30	Draw sequence networks.	CO 3	T4:10.6, R1:6.3
31	Derive sequence voltages, currents and impedances.	CO 3	T4:10.7, R1:6.3
32	Solving numerical problems on symmetrical components.	CO 3	T4:10.5, R1:6.3

33,34	Understand LG fault with and without fault impedance and numerical problems.	CO 3	T4:10.13, R1:6.3
35,36	Study fault with and without fault impedance and numerical problems.	CO 3	T4:10.13, R1:6.1-6.3
37,38	Determine LLG fault with and without fault impedance and numerical problems.	CO 3	T4:10.16, R1:6.1-6.3
39	Compare LG, LL, LLG faults with and without fault impedance and numerical problems.	CO 3	T4:10.17, R1:6.1-6.3
40,41	Introduction to steady state, dynamic and transient stabilities.	CO 4	T4:13.1, R1:10.1
42,44	Description of steady state stability power limit, transfer reactance, synchronizing power coefficient.	CO 4	T4:13.2, R1:10.3
45,46	Plot Power Angle Curve and determination of steady state,. stability.	CO 4	T4:13.2, R1:6.4
47,48	Explain methods to improve steady state stability.	CO 4	T4:13.2, R1:10.3
49	Derivation of swing equation.	CO 4	T4:13.3, R1:10.2
50,51	Determination of transient stability by equal area criterion.	CO4	T4:13.6, R1:10.5
52	Application of equal area criterion to different cases.	CO 4	T4:13.7, R1:10.5
53	Discuss importance of critical clearing angle calculation.	CO 4	T4:13.6, R1:10.5
54,55	Solving numerical problems on equal area criteria.	CO 4	T4:13.7, R1:10.5
56	Solution of swing equation: point-by- point method.	CO 4	T4:13.8, R1:10.5
57	Explain methods to improve stability.	CO 5	T4:13.11, R1:10.6
58	Application of auto reclosing and fast operating circuit breakers.	CO 5	T4:13.11, R1:10.7
PROBLEM SOLVING/ CASE STUDIES			
1	15 problem solving classes	CO 1	R2:7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	5 classes	CO 1	R4:2.1
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	R4:5.1
4	Module IV	CO 4	T1:7.5
5	Module V	CO 5	T1: 4.1

Signature of Course Coordinator **HOD,EEE**

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Electrical Drives and Static Control**				
Course Code	AEEB23				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	P SHIVAKUMAR Asistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB15	IV	Electrical Machines - II
B.Tech	AEEB20	V	Power Electronics

II COURSE OVERVIEW:

This course deals with the basic theory, construction, operation, performance characteristics and application of electromechanical energy conversion devices such as synchronous and asynchronous machines. It also facilitates the study of the alternating machines which are the major part of industrial drives and agricultural pump sets

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical drives and static 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	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
83.33 %	Understand
16.66%	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 steady state behavior and transient dynamics of the converter/chopper fed DC drive.
II	The steady state behavior and transient dynamics of the converter/chopper fed DC drive
III	The performance of different industrial drives considering issues such as energy efficiency, power quality, economic justification, environmental issues and practical liabilities.

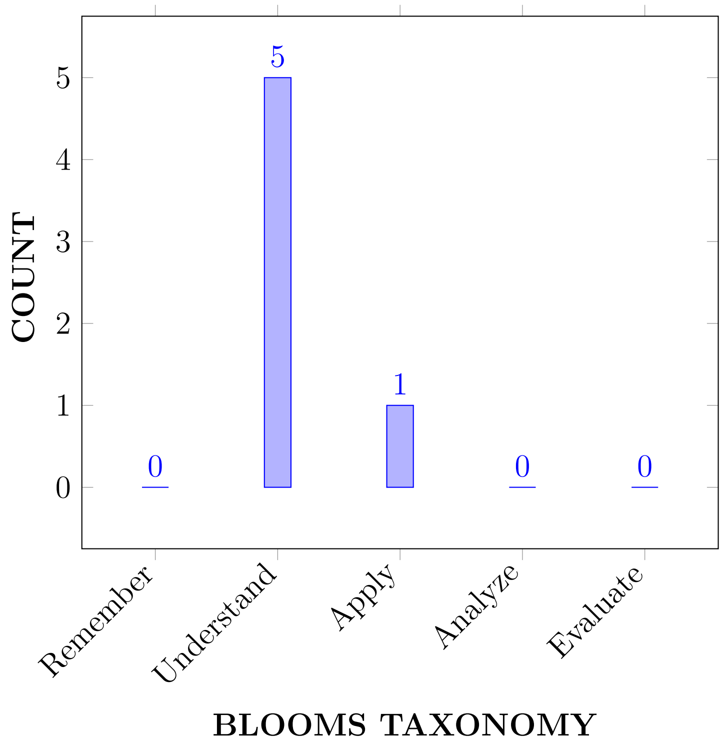
IV	Starting, braking, and speed control arrangements for electric motors and their applications.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the speed control of DC motors with single phase and three phase-controlled rectifiers for verification of speed torque characteristics	Understand
CO 2	**Explain** the four-quadrant chopper fed dc motor drives for verification of speed torque characteristics	Understand
CO 3	**Describe** the working of stator voltage control of induction motor for speed control of the drive.	Understand
CO 4	**Identify** the variable frequency control methods for induction motor drive applications.	Apply
CO 5	**Summarize** the slip power recovery schemes, direct and indirect vector control methods for speed control of induction motors.	Understand
CO 6	**Demonstrate** the working of voltage source and current source inverter fed synchronous motor dive for speed control 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	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.	3	SEE/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.	2	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development	2	-

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 speed control of DC motors with single phase and three phase-controlled rectifiers using science and engineering fundamentals.	3
	PO 2	Understand speed torque characteristics of dc motor using first principles of mathematics and engineering sciences	6
	PSO 2	Demonstrate the speed control of dc drives using rectifiers topologies for energy conversion and specific applications of industry	7
CO 2	PO 1	Demonstrate the fourquadrant chopper fed dc motor using science and engineering fundamentals	2
	PO 2	Illustrate thechopper controlled drives using first principles of mathematics and engineering sciences.	6
	PO 4	Demonstrate the speed torque characteristics of chopper fed drives	6
	PSO 2	Demonstrate the speed control of dc drives using rectifiers topologies for energy conversion and specific applications of industry	6
CO 3	PO 1	Understand stator voltage control of induction motor using engineering fundamentals	3
	PO 2	Illustrate speed control of induction motor drives using first principles of mathematics and engineering sciences	6
	PSO 2	Demonstrate stator voltage control of induction motor drive using AC voltage controller for energy conversion and specific controller applctions of industry needs	7
CO 4	PO 1	Understand v/f control of induction motor drive using engineering funda	3
	PO 2	Demonstrate v/f control of ac using first principles of mathematics and engineering sciences	7
	PSO 2	Illustrate operation of AC drives with v and f using different control topologies for energy conversion andspecific applications of induction motor	6
CO 5	PO 1	Understand slip power recovery schemes and vectror controlled drives using knowledge of science and engineering fundamentals	3
	PO 2	Understand understand slip power recovery schemes and vectror controlled of induction motor with knowledge of science and engineering fundamentals	7
	PSO 2	Demonstrate speed control of induction motor with static rotor resistance controlling different control topologies for energy conversion andspecific applications of induction motol	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	Voltage source inverter and current source inverter fed drives with knowledge of science and engineering fundamentals	3
	PO 2	Describe the control of synchronous motor drive using science and engineering fundamentals	6
	PO 4	Develop self and separately control of ac drives with analysis and innterpretition of data	6
	PSO 2	Illustrate synchronous motor drives with converter topologies voltage and current source inverter	7

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	-	-	-	-	-	-	-	-	-		-	7	-
CO 2	2	6	-	6	-	-	-	-	-	-	-	-	-	6	-
CO 3	3	6	-	-	-	-	-	-	-	-	-	-	-	7	-
CO 4	3	7	-	-		-	-	-	-	-	-		-	6	-
CO 5	3	6	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	5	-	6	-	-	-	-	-	-	-		-	7	-

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	-	-	-	-	-	-	-	-	-		-	63.6	-
CO 2	66	60	-	60	-	-	-	-	-	-	-	-	-	54.5	-
CO 3	100	70	-	-	-	-	-	-	-	-	-	-	-	63.6	-
CO 4	100	70	-	-		-	-	-	-	-	-		-	63.6	-
CO 5	100	70	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	60	-	60		-	-	-	-	-	-		-	63.6	-

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	2	-	-	-	-	-	-	-	-	-	-	-	3	
CO 2	2	2	-	2	-	-	-	-	-	-	-	-	-	2	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 4	3	3	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 5	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	2	-	2	-	-	-	-	-	-	-	-	-	3	-
TOTAL	17	14	2	-	4	-	-	-	-	-	-	-	3	11	6
AVERAGE	2.8	2.33	-	2	-	-	-	-	-	-	-	-	3	2.2	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	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**CONTROL OF DC MOTORS THROUGH PHASE CONTROLLED RECTIFIERS**
	Introduction to thyristor controlled drives: Single phase semi and fully controlled converters connected to DC separately excited and dc series motors, continuous current operation, output voltage and current waveforms, speed and torque expressions, speed torque characteristics, problems on converter fed DC motors; Three phase semi and fully controlled converters connected to DC separately excited and DC series motors, output voltage and current waveforms, speed and torque expressions, speed torque characteristics and problems.

MODULE II	**SPEED CONTROL OF DC MOTORS**
	Introduction to four quadrant operation: Motoring operations, electric braking, plugging, dynamic and regenerative braking operations; Four quadrant operation of DC motors by dual converters, closed loop operation of DC motor; Chopper fed DC drives: Single quadrant, two quadrant and four quadrant chopper fed DC separately excited and series excited motors, continuous current operation output voltage and current wave forms, speed torque expressions, speed torque characteristics, problems on chopper fed DC motors and closed loop operation.
MODULE III	**SPEED CONTROL OF INDUCTION MOTORS THROUGH VARIABLE VOLTAGE AND FREQUENCY**
	Variable voltage characteristics: Control of induction motor by AC voltage controllers, waveforms, speed torque characteristics. Variable frequency characteristics: Variable frequency characteristics, variable frequency control of induction motor by voltage source and current source inverter and cycloconverters, pulse with modulation control, comparison of voltage source inverter and current source inverter operations, speed torque characteristics, numerical problems on induction motor drives, closed loop operation of induction motor drives.
MODULE IV	**SPEED CONTROL OF INDUCTION MOTORS THROUGH ROTOR RESISTANCE AND VECTOR CONTROL**
	Static rotor Resistance control: Slip power recovery schemes, static Scherbius drive, static Kramer drive, their performance and speed torque characteristics, advantages and applications, vector control of induction motor drives: Principles of vector control, vector control methods, direct methods of vector control, indirect methods of vector control and problems.
MODULE V	**SPEED CONTROL OF SYNCHRONOUS MOTORS**
	Separate control and self-control of synchronous motors, operation of self-controlled synchronous motors by voltage source inverter and current source inverter cyclo converters. Load commutated CSI fed synchronous motor, operation, waveforms, speed torque characteristics, applications, advantages and numerical problems, closed loop control operation of synchronous motor drives (block diagram only), variable frequency control, cycloconverter, PWM, variable frequency inverter and current source inverter.

TEXTBOOKS

1. PV Rao, "Power Semiconductor Drives", BS Publications, 1st Edition, 2014.

2. G K Dubey, "Fundamentals of Electric Drives", Narosa Publications, 2nd Edition, 2001.

REFERENCE BOOKS:

1. Vedam Subramanyam, "Thyristor Control of Electric Drives", Tata McGraw Hill Publication, 5th Edition, 2008.

2. John Hindmarsh, Alasdair Renfew", Electrical machines and drive systems", Oxford Butterworth Heinemann, 3rd Edition.

3. Austin Hughes, "Electrical motors and drives Fundamentals Types and Applications", Elsevier, 3rd Edition, 2006.

WEB REFERENCES:

1. https://www.electrical4u.com

2. https://www.freevideolectures.com

COURSE WEB PAGE:

1. https://lms.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	Presentation on Outcome based education		
CONTENT DELIVERY (THEORY)			
2	Understand the principle of thyristor controlled drives	CO1	T2:2.3,
3	Describe the operation of Single phase semi controlled converters connected to DC separately excited motors	CO1	T1: 5.2
4	Understand the operation Single phase semi controlled converters connected to DC series motors	CO1	T2:2.2 R2:1.1-1.8
5	Analyze the problems on Single phase semi controlled converters fed DC motors	CO1	T1: 5.6 R2:2.3
6	Discuss the operation of Single phase fully controlled converters connected to DC separately excited motors	CO1	T1: 5.7 R2:2.3
7	Describe the operation of Single phase fully controlled converters connected to DC series motors	CO1	T1: 5.7.1 R2:3.2
8	Analyze the problems on Single phase fully controlled converters fed DC motors	CO1	T1:5.8 R2:3.2
9	Demonstrate the operation of Three phase semi controlled converters connected to DC separately excited motors	CO1	T2:6.6 R2:2.9
10	Understand the operation of Three phase semi controlled converters connected to DC series motors	CO1	T2:5.7 R2:2.9
11	Analyze the problems on three phase semi controlled converters fed DC motors	CO1	T1:6.1 R2:2.9-2.10
12	Describe the operation of Three phase fully controlled converters connected to DC separately excited motors	CO1	T1:6.2 R2:2.11
13	Discuss the operation of Three phase fully controlled converters connected to DC series motors	CO1	T1:6.2 R2:2.11
14	Analyze the problems on three phase fully controlled converters fed DC motorsn	CO1	T1:6.3 R2:3.5
15	Understand the four quadrant operation of DC motors	CO2	T1:6.1.2 R2:3.5
16	Describe the electric braking operations	CO2	T1:6.1.2 R2:3.7
17	Demonstrate the Regenerative braking operations of DC Motors	CO2	T1:13.1 R2:3.7
18	Discuss the Four quadrant operation of DC motors by dual Converters	CO2	T1:13.2 R2:3.7
19	Describe the closed loop operation of DC motor with four quadrant operations	CO2	T1:13.2 R2:3.7

20	Understand the operation of Single quadrant chopper fed DC separately excited and series motors	CO2	T1:8.2 R2:3.7
21	Describe the operation of Two quadrant chopper fed DC separately excited and series motors	CO2	T1:11.3 R2:2.11
22	Analyze the problems on Chopper fed DC motors	CO2	T2:4.5 R2:4.1
23	Discuss the operation of Four quadrant chopper fed DC separately excited and series motors	CO2	T2:4.6 R2:5.1
24	Analyze the problems on Chopper fed DC motors.	CO2	T2:4.7 R2:5.2
25	Demonstrate the Closed loop operation of chopper fed DC motors	CO2	T1:11.2 R2:5.4
26	Understand the variable voltage characteristics of induction Motor	CO5	T2:4.6 R2:4.3-4.4
27	Discuss the speed control of induction motor by AC voltage Controllers	CO3	T2:4.6.2 R2:4.3-4.4
28	Describe the Speed torque characteristics of induction motor with variable voltage	CO3	T2:4.6.3 R2:4.5
29	Demonstrate the variable frequency characteristics of induction motor	CO4	T1:12.3 R2:5.2
30	Understand the operation of voltage source inverter fed induction motor	CO4	T1:12.3 R2:6.1
31	Discuss the operation of current source inverter fed induction Motor	CO3	T1:12.1 R2:6.2
32	Describe the operation of cycloconverter fed induction motor	CO4	T111.4: R2:7.1-7.2
33	Apply the pulse width modulation control for variable frequency control of induction motor	CO4	T2:3.3 R2:7.4
34	Distinguish voltage source inverter and current source inverter	CO4	T2:3.1 R2:7.4
35	Analyze the numerical problems on induction motor drives	CO4	T1:13.2 R2:7.4
36	Demonstrate the Closed loop operation of induction motor drives	CO3	T1:13.3 R2:7.4
37	Analyze the numerical problems on induction motor drives	CO4	T1:12.1, R2:7.3
38	Understand the operation of rotor resistance control of induction motors	CO5	T1:12.4 R2:7.3
39	Discuss the Static rotor Resistance control of induction motors	CO5	T1:12.4 R2:7.4
40	Demonstrate the Slip power recovery schemes of induction motor	CO5	T2:7.1
41	Describe the operation of static Scherbius drive	CO5	T1:12.4.1
42	Understand the operation of static Kramer drive	CO5	T2:12.4.2 R2:7.4

43	List the advantages and applications of slip power recovery Schemes	CO5	T2:7.2 R2:6.3
44	Understand the principles of vector control of induction motor	CO5	T1:12.4.3 R2:7.8
45	Describe the vector control methods of induction motor	CO5	T1:12.4.4 R2:7.8
46	Demonstrate the direct methods of vector control	CO5	T2:7.1 R2:6.3
47	Understand the Separate control of synchronous motors	CO6	T2:7.1 R2:6.3
48	Describe the Self control of synchronous motors	CO6	T2:7.1 R2:6.3
49	Describe the operation of Load commutated CSI fed synchronous motor	CO6	T2:7.1 R2:6.3
50	Describe the operation of Load commutated CSI fed synchronous motor	CO6	T2:7.1 R2:6.3
51	Demonstrate the closed loop control operation of synchronous motor drives with block diagram	CO6	T2:7.1 R2:6.3
52	Describe the Variable frequency inverter and current source inverter fed synchronous motor	CO6	T2:7.1 R2:6.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Electric drive,Power Modulator and critical speed	CO1	T1: 5.2 -5.9
2	Dynamic braking,plugging in DC motor and Define chopper	CO2	T1:6.1-6.6
3	soft start, slip, base speed	CO3	T1:8.1-8.6
4	VSI and CSI plugging in induction motor drives	CO4,CO5	T1:12.1-12.8
5	self control,separate control and power factor control	CO6	T1:13.1-13.9
DISCUSSION OF QUESTION BANK			
1	Control of dc motors through phase controlled rectifiers	CO1	T2: 3.2-3.3
2	Speed control of dc motors	CO2	T3: 6.9-6.14
3	Speed control of induction motors through variable voltage and frequency	CO3,4	T2: 5.1-5.20
4	Speed control of induction motors through rotor resistance and vector control	CO5	T2: 7.1-7.20
5	Speed control of synchronous motors	CO6	T3:36.8

Course Coordinator **HOD,EEE**
Mr P.Shivakumar , Assistant Professor

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**ELECTRICAL MEASUREMENTS AND INSTRUMENTATION**				
Course Code	AEEB24				
Program	B.Tech				
Semester	VI				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. M Laxmidevi Ramanaiah, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB09	III	Network Analysis
B.Tech	AEEB10	III	Electromagnetic Field

II COURSE OVERVIEW:

This course introduces and develops the basic understanding of measurement principles and measuring instruments used in numerous electrical applications. The course provides the concept of measurement, analysis of errors and various specification parameters used to judge and compare measuring instruments. It provides an insight to develop advanced instruments in industries.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Measurements and Instrumentation	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	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
30%	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	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.

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
50%	50%	-

VI COURSE OBJECTIVES:

The students will try to learn:

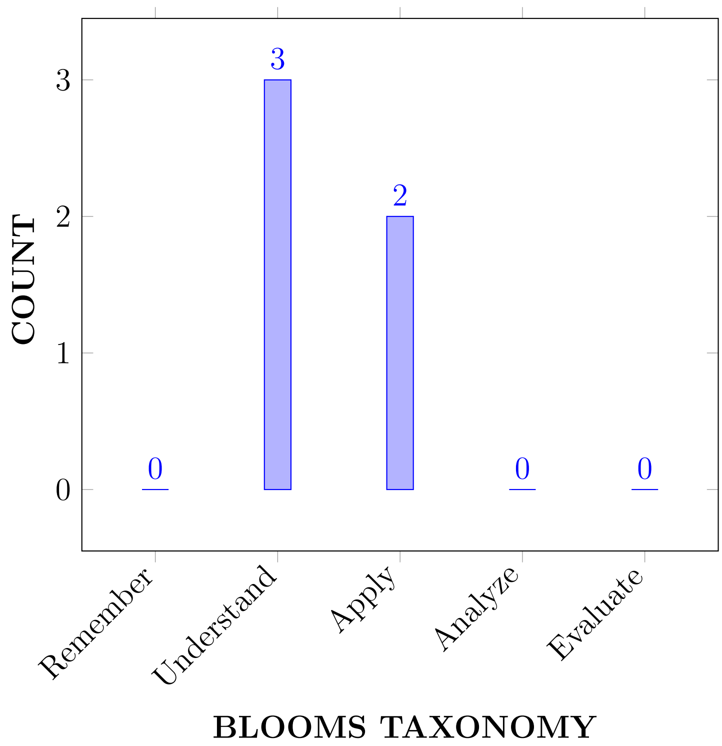
I	The types and characteristics of instruments employed for measuring electrical quantities.
II	The construction, operation and maintenance of different types of instruments.
III	The concepts of Cathode Ray Oscilloscope and transducers to measure the physical quantities in the field of science, engineering and technology.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the working of PMMC, MI and electrostatic voltmeter in view of principle of operation, construction, extension of range and various errors.	Understand
CO 2	**Make use of** potentiometer and instrument transformers in view of construction, extension of range and various errors.	Understand
CO 3	**Demonstrate** the construction and operation of wattmeter and energy meter for obtaining power and energy in single phase and three phase networks.	Understand
CO 4	**Select** the DC and AC bridges suitable for the measurement of passive parameters.	Apply
CO 5	**Summarize** various working models, features and applications of transducers and oscilloscopes.	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	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 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.	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	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	-

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Recall the instruments used for measuring electrical quantities,Faraday's laws of electromagnetic induction, the concept of torque and error,phenomenon of electrostatic effect using the principles of mathematics, science and engineering fundamentals.	3
	PO 2	Determine the expressions for torque in PMMC, MI and electrostatic instruments to solve complex engineering problems problems using principles of mathematics and engineering sciences. .	5
	PO 3	Design the solution for problems to minimize errors in PMMC, MI and electrostatic instruments.	5
	PO 10	Demonstrate the ability to communicate effectively in writing /orally to obtain the solutions for problems to minimize errors in PMMC, MI and electrostatic instruments.	2
	PSO 1	Understand the characteristics of different measuring instruments for the operation and control of electrical power system.	1
CO 2	PO 1	Recall the working of potentiometer the principle of electromagnetic induction which helps in structuring the principles of instrument transformer with the fundamentals of mathematics, science, and engineering fundamentals. .	3
	PO 2	Derive the expression for the different types of errors encountered in instrument transformers to analyze complex engineering problems using principles of mathematics and engineering sciences.	4
	PO 3	Illustrate the expression for phase angle error and ratio error to operate at desired specifications of electrical components in power systems.	3
	PO 10	Demonstrate the ability to communicate effectively in writing /orally for minimizing phase angle error and ratio error to operate at desired specifications of electrical components in power systems.	2
	PSO 1	Understand the importance of current transformer and potential transformer for protection in power system.	3
CO 3	PO 1	Understand the behavior of current carrying conductor placed in magnetic field and the principle of induction effect with the help of basic fundamentals of mathematics science and engineering fundamentals.	3
	PO 2	Derive the expression for torque in wattmeter to solve complex engineering problems using basic mathematics and engineering principles.	6
	PO 3	Determine power losses in power system to reduce these losses in power system.	2
	PO 10	Demonstrate the ability to communicate effectively in writing /orally to find solutions to power system problems.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 1	Understand the principle of power balance to ensure efficient operation of electrical system.	3
CO 4	PO 1	Explain the concept of null deflection with the help of fundamentals of mathematics, science, and engineering fundamentals.	3
	PO 2	Derive the expression for balanced bridge with the help of fundamentals of mathematics, science, and engineering fundamentals.	5
	PO 3	Determine the resistance, inductance and capacitance of different electrical components to design electrical components.	2
	PO 10	Demonstrate the ability to communicate effectively in writing /orally to understand the problems based on passive parameters.	2
CO 5	PO 1	Identify the different non-electrical parameters and recall the working of cathode ray oscilloscope applying basic knowledge of science and engineering fundamentals.	3
	PO 2	Illustrate the different methods for the measurement of non-electrical parameters which helps to solve complex engineering problems	5
	PO 10	Demonstrate the ability to communicate effectively in writing /orally to understand non-electrical parameter measurement.	2

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	5	5	-	-	-	-	-	-	2	-	-	1	-	-
CO 2	3	4	3	-	-	-	-	-	-	2	-	-	3	-	-
CO 3	3	6	2	-	-	-	-	-	-	2	-	-	3	-	-
CO 4	3	5	2	-	-	-	-	-	-	2	-	-	-	-	-
CO 5	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	50	50	-	-	-	-	-	-	40	-	-	20	-	-
CO 2	100	40	30	-	-	-	-	-	-	40	-	-	60	-	-
CO 3	100	60	20	-	-	-	-	-	-	40	-	-	60	-	-
CO 4	100	50	20	-	-	-	-	-	-	40	-	-	-	-	-

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

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	2	-	-	-	-	-	-	1	-	-	1	-	-
CO 2	3	1	1	-	-	-	-	-	-	1	-	-	3	-	-
CO 3	3	3	1	-	-	-	-	-	-	1	-	-	3	-	-
CO 4	3	2		-	-	-	-	-	-	1	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	1	-	-	-	-	-
TOTAL	15	10	4	-	-	-	-	-	-	5	-	-	7	-	-
AVERAGE	3	2	1.25	-	-	-	-	-	-	1	-	-	2.3	-	-

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	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	INTRODUCTION TO MEASURING INSTRUMENTS
	Introduction: Classification of measuring instruments, deflecting, damping and control torques, types of errors, ammeter and voltmeter: PMMC, MI instruments, expression for deflection and control torque, errors and compensation, extension of range using shunts and series resistances; Electro static voltmeter: attracted type, disc type, extension of range of voltmeters, electro dynamic type voltmeters

MODULE II	**POTENTIOMETERS AND INSTRUMENT TRANSFORMERS**
	DC Potentiometers: Principle and operation of Crompton potentiometer, standardization, measurement of unknown resistance, current, voltage; AC potentiometers: polar and coordinate type, standardization, applications; Instrument transformers: CT and PT, ratio and phase angle error.
MODULE III	**MEASUREMENT OF POWER AND ENERGY**
	Measurement of Power: Single phase dynamometer type wattmeter, LPF and UPF, double elements and three elements dynamometer wattmeter; Expression for deflection and control torque, extension of range of wattmeter by using instrument transformers, measurement of active and reactive power for balanced and unbalanced Systems. Measurement of Energy: Single phase induction type energy meter, driving and braking torques, errors and compensations, testing by phantom loading using RSS meter, three phase energy meter, introduction to net energy metering (web ref: 4 and 5), maximum demand meters.
MODULE IV	**DC AND AC BRIDGES**
	Measurement of Resistance: Methods of measuring low, medium, high resistance, Wheatstone bridge, carry foster, Kelvin's double bridge, loss of charge method; Measurement of Inductance: Maxwell's bridge, Hay's bridge, Anderson's bridge, Owen's bridge; Measurement of Capacitance: Desauty's bridge, Wein's bridge, Schering bridge.
MODULE V	**TRANSDUCERS AND OSCILLOSCOPES**
	Transducers: Definition of transducers, classification of transducers, advantages of electrical transducers, characteristics and choice of transducers, principle of operation of LVDT and capacitor transducers, LVDT applications, strain gauge and its principle of operation, gauge factor, thermistors, thermocouples, synchros, piezo-electric transducers, photovoltaic, photo conductive cells, photo diodes; Cathode ray oscilloscope: Cathode ray tube, time base generator, horizontal and vertical amplifiers, CRO probes, applications of CRO, measurement of phase and frequency, Lissajous patterns, sampling oscilloscope, analog oscilloscope, tubeless oscilloscopes, digital storage oscilloscope (web ref: 6).

TEXTBOOKS

1. A K Sawhney, —Electrical and Electronic measurement and instruments, Dhanpat Rai and Sons Publications, 2002

2. E W Golding and F C Widdis , Electrical measurements and measuring instruments,Wheeler publishing, 2006

REFERENCE BOOKS:

1. Buckingham and Price, —Electrical measurements, Prentice Hall

2. D V S Murthy, Transducers and Instrumentation, Prentice Hall of India, London, 2009.

3. A S Morris, Principles of measurement of instrumentation, Pearson/Prentice Hall of India, 1994.

4. H S Kalsi,Electronic Instrumentation, Tata McGraw-Hill Publications, 1995.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108/105/108105153/

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Presentation on Outcome based education		
CONTENT DELIVERY (THEORY)			
2	Classification of measuring instruments	CO 1	T1: 6.1
3	Types of torques	CO 1	T1: 6.4
4	PMMC instruments	CO 1	T1: 8.5
5	MI instruments	CO 1	T1: 8.1
6-7	Extension of range using shunt and series resistances	CO 1	T1: 8.8
8	Electro static voltmeter	CO 1	T1: 8.67
9-10	Crompton potentiometer	CO 2	T1: 14.1
11-12	Applications of DC potentiometers	CO 2	T1: 14.12
13-14	Applications of AC potentiometersor	CO 2	T1: 14.21
15	Current transformer	CO 2	T1: 9.5
16	Potential transformer	CO 2	T1: 9.17
17	Errors in Instrument transformers	CO 2	T1:9.7
18	Single phase dynamometer type wattmeter	CO 3	T1: 10.3
19-20	Measurement of active power for balanced and unbalanced systems.	CO 3	T1: 10.19
21	Measurement of reactive power for balanced and unbalanced systems.	C0 3	T1: 10.21
22	Single phase induction type energy meter	CO 3	T1: 11.6
23	Three phase energy meter	CO 3	T1: 11.15
24	Measurement of low resistance	CO 4	T1: 13.12
25	Measurement of medium resistance	CO 4	T1: 13.2
26	Measurement of high resistance	CO 4	T1: 13.19
27-28	Measurement of Inductance	CO 4	T1: 16.5
29-30	Measurement of Capacitance	CO 4	T1: 16.11
31	Classification of transducers	CO 5	T1: 25.11
32	Principle of operation of LVDT	CO 5	T1: 25.1
33	Thermistors, Thermocouples	CO 5	T1: 25.22
34	Photovoltaic,Photoconductive cells and Photo Diodes	CO 5	T1: 25.1
35	Measurement of Strain, Gauge Sensitivity	CO 5	T1: 25.18
36	Piezo-electric transducers	CO 5	T1: 25.31
37	Cathode ray oscilloscope	CO 5	T1: 21.11
38	Sampling oscilloscopes	CO 5	T1: 21.17
39	Analog oscilloscopes	CO 5	T1: 21.1
40	Digital storage oscilloscopes	CO 5	T1: 21.21
41	Lissajous pattern	CO 5	T1: 21.14

PROBLEM SOLVING/ CASE STUDIES			
42	A moving-coil instrument gives a full scale deflection. When the current is 40 mA and its resistance is 25Ohms. Calculate the value of the shunt to be connected in parallel with the meter to enable it to be used as an ammeter for measuring currents up to 50 A.	CO 1	T1:8.1
43	A meter of resistance 50 ohm has a full scale deflection of 4 mA. Determine the value of shunt resistance required in order that full scale deflection should be i) 15 mA ii) 20 A iii) 100 A	CO 1	T1:8.1
44	The capacity of an electrostatic voltmeter ranging from 0 to 2000 V increases from 80 to 90pF as the pointer moves from zero to full scale deflection. Calculate the value of external capacitor used to increase its range to 20 kV. If the capacitor is adjusted to make the full scale reading correct, what will be the error at half scale reading	CO 1	T1:8.1
45	A potential transformer ratio 2000/100 V has the following constants: Primary resistance = 105 ohms, secondary resistance = 0.7Ω, primary reactance = 75.2Ω, total equivalent reactance = 0.087Ω, no-load current at 0.03 A at 0.36 power factor lagging. Solve for phase angle error on no load , phase angle error on a load of 5 A at 0.92 lagging power factor and burden in VA at unity power factor at which the phase angle will be zero.	CO 2	T1:9.1
46	Develop a volt- ratio box with a resistance of 20 ohms/V and ranges 3 V, 10V, 30 V, 100 V. the volt-ratio box is to be used with a potentiometer having a measuring range of 1.5 V	CO 2	T1:9.1
47	A current transformer with bar primary has 300 turns in its secondary winding. The resistance and reactance of the secondary circuit are 1.5ohm and 1.0ohm respectively, including the transformer winding. With 5A flowing in the secondary winding, the magnetizing mmf is 100AT and the core loss is 1.2 W. Identify the ratio and phase angle errors	CO 2	T1:9.1
48	A wattmeter has a current coil of 0.1 ohms resistance and a pressure coil of 6500Ω resistance. Calculatethepercentageer-rors,duetoresistanceonlywitheachofthetwomethodsofconnection of wattmeter when reading the input to an apparatus which takes i) 12 A at 250 V with unity power factor and ii) 12 A at 250 V and 0.4 power factor.	CO 2	T1:10.1
49	A 500V,20A dynamometer instrument is used as a wattmeter. Its current coil has 0.1ohm resistance and pressure coil has 25kohm resistance with 0.1 H inductance. The meter was calibrated on DC supply. Solve for the error in the instrument if it is used to measure the power in a circuit with supply voltage of 500 V, load current of 24 A at 0.2 P.f. assume that pressure coil is connected across load?	CO 3	T1:10.1
50	An energy meter is designed to make 100 revolutions of the disc for one unit of energy. Solve for the number of revolutions made by it when connected to a load carrying 20 A at 230 V at 0.8 p.f. for an hour. If it actually makes 360 revolutions, find the percentage error?	CO 3	T1:11.1

51	The four arms of the Hay's bridge at balances are: Arm AB: Coil of unknown impedance. Arm BC : A non-reactive resistance of 100 ohms,Arm CD : A non-reactive resistance of 833 ohms in series with 0.38 uF capacitor. Arm DA : A non-reactive resistance of 16800 ohms. If the supply frequency is 50 Hz, Solve for the inductance and resistance at the balance condition	CO 4	T1:16.1
52	A Kelvin's double bridge is balanced with the following constants. Outer ratio = 100 ohms and 1000 ohms, Inner ratio arms = 99.92 ohms and 1000.6 ohms, resistance of link = 0.1 ohms, Standard resistance = 0.00377 ohms, calculate the value of unknown resistance.	CO 4	T1:16.1
53	The four arm bridge ABCD, supplied with a sinusoid voltage, have the following values: AB = 330 ohms resistance in parallel with 0.2 uF capacitor.BC = 400 ohms resistance, CD = 800 ohms resistance: DA R in series with a 1.5 uF capacitor. Identify the value of R and supply frequency at which bridge will be balanced.	CO 4	T1:16.1
13	A CRT has anode voltage of 2000V and parallel deflecting plates 1.5 cm long and 5 mm apart. The screen is 50 cm from the center of the plates. Solve for i) beam speed (ii) deflection sensitivity (iii) deflection factor of the tube	CO 5	T1:21.1
54	A parallel plate capacitive transducer has a plates of 600 mm2 area which are separated by air by a distance of 0.2mm. The resistance of the transducer is 20x106ohm.Calculate the time constant of the transducer and fined the attenuation of the output at 1000Hz. The resistivity of air is 8.85x10^{-12} F/m.	CO 5	T1:21.1
55	A Lissajous pattern on the CRT screen is stationary and has 2 vertical tangencies and 5 horizontal tangencies. If the frequency of horizontal input is1000 Hz. Calculate the frequency of the vertical input.	CO 5	T1:21.1
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Measurement, Instrument,Measurand, Absolute instrument, Secondary instrument, Indicating instrument, Recording instrument,Static srror, Range	CO 1	T1:1.1,6.1, 8.1
57	Potentiometer, Volt ratio box, Standardization,burden, ratio correction factor, nominal ratio, transformation ratio	CO 2	T1:14.1, 19.1
58	Two-element wattmeter,Pressure coil, Creeping error , net energy metering,maximum demand, Phantom Loading	CO 3	T1:10.1, 11.1
59	DC bridge, AC bridge, Loss of Charge Method	CO 4	T1:13.1, 16.1
60	Transducer, Pressure transducer,Thermocouple, piezoelectric sensor,Photodiode, Photocell,sampling oscilloscope,Sweep time, Lissajous pattern	CO 5	T1:25.1, 21.1
DISCUSSION OF QUESTION BANK			
61	Module I : PMMC, MI instruments, extension of range using series and shunt resistances.	CO 1	T1:1.1,6.1, 8.1
62	Module II : Potentiometer, Instrument transformers	CO 2	T1:14.1, 19.1

63	Module III : Active and Reactive power, Energy	CO 3	T1:10.1, 11.1
64	Module IV : Measurement of resistance, inductance and capacitance	CO 4	T1:13.1, 16.1
65	Module V : Transducers and types of Transducers	CO 5	T1:25.1, 21.1

Signature of Course Coordinator **HOD,EEE**
Dr. M Laxmidevi Ramanaiah

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Power Electronics in Renewable Energy Systems**				
Course Code	AEEB45				
Program	B.Tech				
Semester	VI				
Course Type	Professional Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. S. Srikanth, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB14	IV	Electrical Power Generating Systems
B.Tech	AEEB15	IV	Electrical Machines-II
B.Tech	AEEB20	V	Power Electronics

II COURSE OVERVIEW:

This course highlights the applications of power electronics in renewable energy power conversion systems. It describes the basic principles and characteristics of renewable energy sources, conversion systems and hybrid renewable energy resources in order to control and regulate the electrical power. The conversion and monitoring of electric energy with the use of semiconductors has been analyzed in this course elaborately.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power Electronics in Renewable Energy Sources	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	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
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), 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:

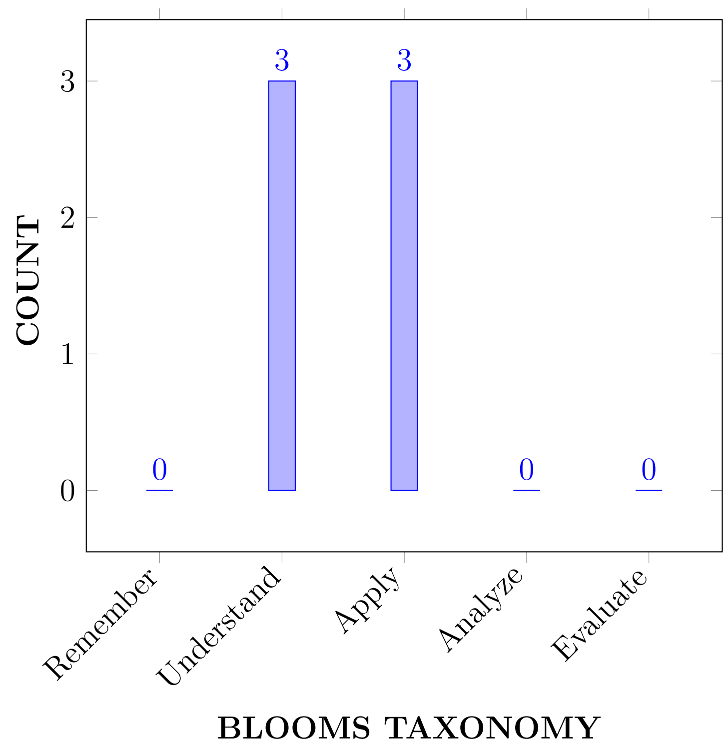
I	The importance of energy conversion in the present energy scenario and the availability of renewable energy sources for sustainable energy conversion.
II	The basic concepts of power semiconductor devices to perform switching action in order to achieve a desired conversion strategy.
III	The hybrid renewable energy resources for grid integration and facilitate developing renewable systems for domestic and industrial applications.

VII COURSE OUTCOMES:

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

CO 1	**Outline** the environmental aspects, operating principles and characteristics of renewable sources for sustainable energy conversion.	Understand
CO 2	**Demonstrate** the principle of operation of various generators for conversion of renewable energy into electricity	Understand
CO 3	**Identify** the power quality issues and mitigation techniques used in grid connected systems for ensuring the quality of power.	Apply
CO 4	**Choose** the appropriate power converters and inverters or harmonic reduction in solar photovoltaic systems.	Apply
CO 5	**Demonstrate** the stand alone and grid connected renewable energy resources for generating power.	Understand
CO 6	**Utilize** the control and protection techniques in hybrid renewable energy systems for stable operation of power 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 analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIE/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	SEE/CIE/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	SEE/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	2	SEE/CIE/AAT
PO 7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development	1	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	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	-
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development	2	-

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	**Understandl** the operation renewable energy systems using **science and engineering fundamentals**.	2
	PO 7	**Demonstrate** the environmental aspects of renewable energy systems with **engineering solutions in societal and environmental contexts**.	1
	PSO 1	**List** the renewable energy systems for **electrical power generation**	3
CO 2	PO 1	**Explain** the operating principles of renewable energy sources using **science and engineering fundamentals**	2
	PSO 1	**Demonstrate** the characteristics of renewable energy sources for **electrical power generation**	3
CO 3	PO 1	**Demonstrate** the grid connected renewable energy systems using **science and engineering fundamentals**.	2
	PO 2	**Illustrate** the power quality issues in grid connected renewable energy systems using **first principles of mathematics and engineering sciences**.	4
	PO 3	**Demonstrate** the power quality issues and mitigation techniques used in grid connected systems using **system components that meet the specified needs with appropriate consideration**	6
	PSO 2	**Explain** power quality issues used in integration of renewable energy systems with **converter topologies for energy conversion**.	4
CO 4	PO 1	**Choose** the power converters used in solar photovoltaic systems with **science and engineering fundamentals**.	2
	PO 2	**Understand** the various inverters used in solar power plants using **first principles of mathematics and engineering sciences**.	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	**Describe** the converters and inverters used in solar photovoltaic systems using **system components that meet the specified needs with appropriate consideration**	6
	PSO 2	**Utilize** the knowledge of power converters and inverters for harmonic reduction with **control and operation of electrical system**.	4
CO 5	PO 1	**Recall** the parameters of power quality with knowledge of **science and engineering fundamentals**.	2
	PO 2	**Understand** stand alone and grid connected renewable energy sources using **science and engineering fundamentals**.	4
	PO 3	**Demonstrate** the stand alone and grid connected renewable energy sources using **system components that meet the specified needs with appropriate consideration**	6
	PSO 1	**Illustrate** the operation of standalone and grid connected renewable energy systems involving **power generation**.	3
CO 6	PO 1	**Utilize** the control and protection techniques used in hybrid renewable energy systems with **knowledge of science and engineering fundamentals**.	2
	PO 2	**Describe** the control of hybrid renewable energy systems using **science and engineering fundamentals**	4
	PO 4	**Demonstrate** the control and protection of hybrid renewable energy systems with **analysis and interpretation of data**.	4
	PSO 1	**Provide** the operation of hybrid renewable energy systems for **electrical power generation**	3
	PSO 2	**Utilize** the knowledge of stable operation of power systems with **converter topologies for energy conversion**.	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	-	-	-	-	-	1	-	-	-	-		3	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	2	4	6	-		-	-	-	-	-	-		-	4	-
CO 4	2	4	6	-		-	-	-	-	-	-		-	4	-
CO 5	2	4	6	-		-	-	-	-	-	-		3	-	-
CO 6	2	4	-	4		-	-	-	-	-	-		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	66.6	-	-	-	-	-	33.4	-	-	-	-		60.0	-	-
CO 2	66.6	-	-	-	-	-	-	-	-	-	-	-	60.0	-	-
CO 3	66.6	40.0	60.0	-		-	-	-	-	-	-		-	36.4	-
CO 4	66.6	40.0	60.0	-		-	-	-	-	-	-		-	36.4	-
CO 5	66.6	40.0	60.0	-		-	-	-	-	-	-		60.0	-	-
CO 6	66.6	40.0	-	36.4		-	-	-	-	-	-		60.0	36.4	-

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	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	3	2	3	-		-	-	-	-	-	-		-	1	-
CO 4	3	2	3	-		-	-	-	-	-	-		-	1	-
CO 5	3	2	3	-		-	-	-	-	-	-		-	1	-
CO 6	3	2	-	1		-	-	-	-	-	-		3	1	-
TOTAL	18	8	9	1	-	-	1	-	-	-	-	-	9	4	-
AVERAGE	3	2	3	1	-	-	1	-	-	-	-	-	3	1	-

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	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO RENEWABLE ENERGY SYSTEMS**
	Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission), qualitative study of different renewable energy resources ocean, biomass; Hydrogen energy systems: operating principles and characteristics of: Solar PV, fuel cells, wind electrical systems control strategy, operating area.
MODULE II	**ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION**
	Renewable energy conversion systems: fundamental principle of operation of self excited induction generator, squirrel cage induction generator, doubly fed induction generator, synchronous generator, permanent magnet synchronous generator; Grid related problems: harmonic reduction and power factor improvement
MODULE III	**POWER CONVERTERS**
	Solar: Block diagram of solar photo voltaic system, Line commutated converters (inversion mode), boost and buck-boost converters, selection of inverter, battery sizing, array sizing. Wind: three phase AC voltage controllers used in wind energy conversion. Switching devices: AC – DC converters, PWM Inverters, Grid Interactive Inverters-matrix converters.
MODULE IV	**ANALYSIS OF WIND AND PV SYSTEMS**
	Stand alone operation of fixed and variable speed wind energy conversion systems and solar system, grid connection issues, grid integrated PMSG and SCIG Based WECS-Grid integrated solar system.
MODULE V	**HYBRID RENEWABLE ENERGY SYSTEMS**
	Need for Hybrid Systems: Range and type of hybrid systems, case studies of wind-PV maximum power point tracking (MPPT), biomass-fuel cell hybrid systems, fuel cell-PV hybrid system and wind-fuel cell hybrid systems

TEXTBOOKS

1. Mukund R Patel, “Wind and Solar Power Systems”, CRC Press, 1stEdition, 1999.
2. SN Bhadra, D. Kastha, S. Banerjee, “wind electrical systems”, OXFORD higher education, 2018

REFERENCE BOOKS:

1. Daniel, Hunt. V Wind Power, A Hand Book of WECS, Van Nostrend Co., Newyork, 2nd Edition, 1998. Publications, 2nd Edition, 2001.
2. G D Rai, “Non- Conventional Energy Resources”, Khanna Publishers, 1st Edition, 2002.
3. Arindam Ghosh, Gerard Ledwich, “Power Quality Enhancement Using Custom Power Devices”, Springer, 1stEdition, 2002.

WEB REFERENCES:

1. https://pdfroom.com
2. https://www.technicalbookspdf.com

COURSE WEB PAGE:

1. https://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 T1: 4.1
OBE DISCUSSION			
1	Discussion on outcome based education		
CONTENT DELIVERY (THEORY)			
2	Environmental aspects of electrical energy conversion	CO1	T2:2.3
3	Impacts of renewable energy generation on environment	CO1	T1: 5.2
4	Cost-greenhouse gas emission in power generation	CO1	T2:2.2 R2:1.1-1.8
5	Study of ocean energy and biomass energy	CO2	T1: 5.6 R2:2.3
6	Operation of hydrogen energy systems	CO2	T1: 5.7 R2:2.3
7	Operating principles and characteristics of Solar PV	CO2	T1: 5.7.1 R2:3.2
8	Operating principles and characteristics of fuel cells	CO2	T1:5.8 R2:3.2
9	Operation of wind electrical systems control strategy	CO2	T2:6.6 R2:2.9
10	Operating area of wind power plant	CO2	T2:5.7 R2:2.9
11	Introduction to Renewable energy conversion systems	CO2	T1:6.1 R2:2.9-2.10
12	Fundamental principle of operation of self-excited induction generator	CO2	T1:6.2 R2:2.11
13	Operation of squirrel cage induction generator and its application to renewable energy conversion	CO2	T1:6.2 R2:2.11
14	Operation of doubly fed induction generator and its application to renewable energy conversion	CO2	T1:6.3 R2:3.5
15	Operation of synchronous generator and its applications	CO2	T1:6.1.2 R2:3.5
16	Operation of permanent magnet synchronous generator and its applications	CO2	T1:6.1.2 R2:3.7
17	Introduction to grid related problems in renewable energy sources integration	CO3	T1:13.1 R2:3.7
18	Harmonic reduction techniques used in power system	CO3	T1:13.2 R2:3.7
19	Power factor improvement techniques used in power system	CO3	T1:13.2 R2:3.7
20	Block diagram of solar photo voltaic system	CO3	T1:8.2 R2:3.7
21	Operation of line commutated inverters	CO4	T1:11.3 R2:2.11

22	Operation of boost and buck-boost converters	CO4	T2:4.5 R2:4.1
23	Selection of inverter, battery sizing and array sizing in solar photovoltaic system	CO4	T2:4.6 R2:5.1
24	Operation of three phase AC voltage controllers used in wind energy conversion.	CO4	T2:4.7 R2:5.2
25	Operation of AC – DC converters	CO4	T1:11.2 R2:5.4
26	Operation of PWM Inverters	CO4	T2:4.6 R2:4.3-4.4
27	Grid Interactive Inverters operating principles	CO4	T2:4.6.2 R2:4.3-4.4
28	Operation of matrix converters used in renewable energy systems	CO4	T2:4.6.3 R2:4.5
29	Stand alone operation of fixed speed wind energy conversion systems	CO4	T1:12.3 R2:5.2
30	Stand alone operation of variable speed wind energy conversion systems	CO4	T1:12.3 R2:6.1
31	Stand alone operation of solar system	CO5	T1:12.1 R2:6.2
32	Grid connection issues of wind and solar integration	CO5	T111.4: R2:7.1-7.2
33	Operation of grid integrated permanent magnet synchronous generator	CO5	T2:3.3 R2:7.4
34	Squirrel cage induction generator based wind energy conversion systems	CO5	T2:3.1 R2:7.4
35	Grid integrated solar system	CO5	T1:13.2 R2:7.4
36	Grid integrated wind power plant	CO5	T1:13.3 R2:7.4
37	Review of standalone and grid connected photovoltaic systems	CO8	T1:12.1, R2:7.3
38	Introduction to Hybrid Systems	CO5	T1:12.4 R2:7.3
39	Importance of Hybrid Systems	CO5	T1:12.4 R2:7.4
40	Range of hybrid systems	CO5	T2:7.1
41	Types of hybrid systems	CO6	T1:12.4.1
42	Case study of wind-PV maximum power point tracking	CO6	T2:12.4.2 R2:7.4
43	Operation of biomass-fuel cell hybrid systems	CO6	T2:7.2 R2:6.3
44	Operation of fuel cell-PV hybrid system	CO6	T1:12.4.3 R2:7.8

45	Operation of wind-fuel cell hybrid system	CO6	T1:12.4.4 R2:7.8
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Environmental aspects of electric energy conversion and qualitative study of different renewable energy resources	CO1,2	T1: 5.2 -5.9
2	Renewable energy conversion systems and grid related problems	CO3	T1:6.1-6.6
3	Power converters used in renewable energy conversion systems	CO4	T1:8.1-8.6
4	Stand alone operation of fixed and variable speed wind energy conversion systems and solar system	CO5	T1:12.1-12.8
5	Hybrid renewable energy systems	CO6	T1:13.1-13.9
DISCUSSION OF QUESTION BANK			
1	Environmental aspects of electric energy conversion and qualitative study of different renewable energy resources	CO 1,2	R4:2.1
2	Renewable energy conversion systems and grid related problems	CO 3	T4:7.3
3	Power converters used in renewable energy conversion systems	CO 4	R4:5.1
4	Stand alone operation of fixed and variable speed wind energy conversion systems and solar system	CO 5	T1:7.5
5	Hybrid renewable energy systems	CO 6	T1: 4.1

Course Coordinator **HOD,EEE**
Mr S. Srikanth, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**UTILIZATION OF ELECTRICAL POWER**				
Course Code	AEEB51				
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. T Mahesh, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB11	III	Electrical Machines-I
B.Tech	AEEB15	IV	Electrical Machines-II

II COURSE OVERVIEW:

This course deals with effective utilization of electrical power. It describes the basic principles and performance characteristics of drives, electric traction and illumination, it also facilitates the use of electrical power for domestic and industrial consumers

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
UTILIZATION OF ELECTRICAL POWER	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	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
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), 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:

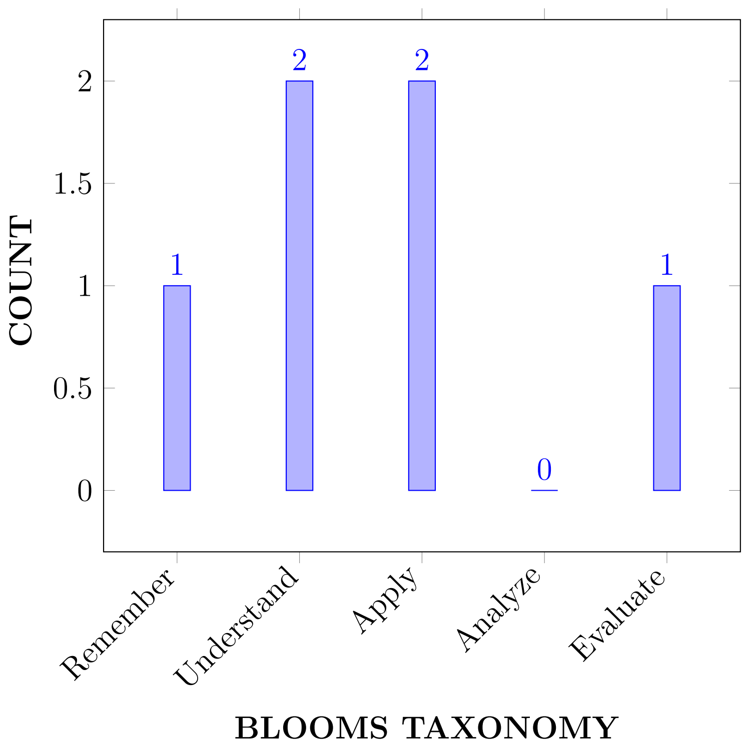
I	The performance characteristics of electrical drives and their deployment with different loading environment.
II	The importance of Electrical power in various utilities with illumination, heating and welding.
III	The impact of acceleration, braking retardation and adhesive weight in electric traction system.

VII COURSE OUTCOMES:

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

CO 1	**Choose** appropriate electric drive and electric system for different types of loads.	Remember
CO 2	**Summarize** the advantages of electric heating techniques for commercial consumers.	Understand
CO 3	**Describe** types of AC and DC Welding methods for domestic applications.	Understand
CO 4	**Make use of** the principle of Illumination for designing of Electrical appliances.	Apply
CO 5	**Interpret** speed-time curves for various services for economical Operation of electric traction.	Apply
CO 6	**Determine** the tractive effort, coefficient of adhesion and braking retardation for reliable traction run	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/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.	3	SEE/CIE/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	SEE/CIE/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	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development	2	-
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.t	2	-

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 5	-	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 2	**Choose** appropriate eclectic drive for different loads with **Basics fundamentals of mathematics and engineering sciences.**.	3
	PO 5	**Use modern tools** to know the limitations of various electrical drives according **to various industrial applications.**.	2
	PSO 2	**Demonstrate** the sodium, mercury vapor, incandescent and fluorescent lamps **with basics of engineering sciences and mathematics.**	1
CO 2	PO 1	**Explain** the operating principles of renewable energy sources using **science and engineering fundamentals**	2
	PSO 2	**Demonstrate** the sodium, mercury vapor, incandescent and fluorescent lamps **with basics of engineering sciences and mathematics.**	1
CO 3	PO 1	**Demonstrate** the grid connected renewable energy systems using **science and engineering fundamentals**.	2
	PO 2	**Illustrate** the power quality issues in grid connected renewable energy systems using **first principles of mathematics and engineering sciences**.	4
	PO 3	**Demonstrate** the power quality issues and mitigation techniques used in grid connected systems using **system components that meet the specified needs with appropriate consideration**	6
	PSO 2	**Explain** power quality issues used in integration of renewable energy systems with **converter topologies for energy conversion**.	4
CO 4	PO 1	**Apply** the knowledge of different for techniques (scientific Principles and mathematical principles) **for Hessian Matrix, Generalization, Cross Validation and describe different performance parameters.**.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 11	**Determine** the parameters and Network Pruning Techniques **using first principles and Mathematics and Engineering sciences.**.	2
	PSO 1	**Utilize** the knowledge of power converters and inverters for harmonic reduction with **control and operation of electrical system**.	4
CO 5	PO 2	**Inspect**mathematical and graphical analysis considering different practical issues to ensure effective traction system **With the knowledge of mathematics and engineering sciences.**.	3
	PO 4	**Analyze** tractive effort, coefficient of adhesion **with principles of mathematics, natural sciences, and engineering for reliable traction run.**	6
	PSO 2	**Utilize** the knowledge of power converters and inverters for harmonic reduction with **control and operation of electrical system**.	4
CO 6	PO 1	**Inspect**mathematical and graphical analysis considering different practical issues to ensure effective traction system **With the knowledge of mathematics and engineering sciences.**.	3
	PO 2	**Solve** the complex problems related to traction system with **basics principles of mathematics and engineering sciences**	6

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	-	-	-	-		3	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	2	4	6	-		-	-	-	-	-	-		-	4	-
CO 4	2	4	6	-		-	-	-	-	-	-		-	4	-
CO 5	2	4	6	-		-	-	-	-	-	-		3	-	-
CO 6	2	4	-	4		-	-	-	-	-	-		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	66.6	-	-	-	-	-	33.4	-	-	-	-		60.0	-	-
CO 2	66.6	-	-	-	-	-	-	-	-	-	-	-	60.0	-	-
CO 3	66.6	40.0	60.0	-		-	-	-	-	-	-		-	36.4	-
CO 4	66.6	40.0	60.0	-		-	-	-	-	-	-		-	36.4	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	66.6	40.0	60.0	-		-	-	-	-	-	-		60.0	-	-
CO 6	66.6	40.0	-	36.4		-	-	-	-	-	-		60.0	36.4	-

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	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO 3	3	2	3	-		-	-	-	-	-	-		-	1	-
CO 4	3	2	3	-		-	-	-	-	-	-		-	1	-
CO 5	3	2	3	-		-	-	-	-	-	-		-	1	-
CO 6	3	2	-	1		-	-	-	-	-	-		3	1	-
TOTAL	18	8	9	1	-	-	1	-	-	-	-	-	9	4	-
AVERAGE	3	2	3	1	-	-	1	-	-	-	-	-	3	1	-

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	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	ELECTRIC DRIVES
	Electric Drives: Type of electric drives, choice of motor, starting and running characteristics, speed control, temperature rise, particular applications of electric drives, types of industrial loads, continuous, intermittent and variable loads, load equalization
MODULE II	ELECTRIC HEATING AND WELDING
	Electric heating: Advantages and methods of electric heating, resistance heating induction heating and dielectric heating: Electric welding: resistance and arc welding, electric welding equipment, comparison between AC and Welding.
MODULE III	ILLUMINATION
	Illumination: Introduction, terms used in illumination, laws of illumination, polar curves, photometry, integrating sphere. Sources of light: Discharge lamps, MV and SV lamps, comparison between tungsten filament lamps and fluorescent tubes, basic principles of light control, types and design of lighting and flood lighting.
MODULE IV	TRAIN MECHANICS
	System of electric traction and track electrification, review of existing electric traction systems in India, special features of traction motor, methods of electric braking-plugging, rheostat braking and regenerative braking, mechanics of train movement, speed-time curves for different service: Trapezoidal and quadrilateral speed time curves.
MODULE V	ELECTRIC TRACTION
	Calculations of tractive effort, power, specific energy consumption for given run, effect of varying acceleration and braking retardation, adhesive weight and braking retardation adhesive weight and coefficient of adhesion

TEXTBOOKS

1. 1. S Sivarnagaraju, D Srilatha, M Balasubbareddy, "Generation and Utilization of Electrical Energy", Pearson Education India, 1st Edition, 2010.
2. 2. E Openshaw Taylor, Orient Longman, "Utilizations of Electric Energy", 1st Edition, 2003.

REFERENCE BOOKS:

1. 1. N V Suryanarayana, "Utilization of Electrical Power including Electric drives and Electric traction New Age International (P) Limited, Publishers, 1st Edition, 1996.
2. C L Wadhwa, "Generation, Distribution and Utilization of electrical Energy", New Age International (P) Limited, 1st Edition, 1997.
3. Partab, "Art and Science of Utilization of electrical Energy", Dhanpat Rai and Sons 2nd Edition, 2000.

XIX COURSE PLAN:

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

XX COURSE PLAN:

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

S.No	**Topics to be covered**	**CO's**	**Reference T1: 4.1**
1-2	Demonstrate importance of ac and dc electric drives	CO 1,	T2: T2: 1.1 R2: 1.1
3-4	Describe principle operation of dc series and dc shunt electric drives	CO 2	T2: 4.1 R2: 1.6
5-6	Demonstrate principle operation of three phase and single phase ac electric drives	CO 2	T2: 4.2 R2: 1.6
7-8	Understand choice of electric dives for different loads	CO 2	T2: 5.1 R2: 1.7
9-10	Discuss starting and running characteristics of ac and dc electric drives	CO 2	T2: 5.3 R2: 1.7 3
11-12	Explain speed control techniques of ac and dc electric drives .	CO 3	T2: 5.5 R2: 1.7
13-14	Discuss various applications of electrical drives .	CO 3	T2: 4.5 R2: 1.7.1
15-16	Understand the principle of operation and constructional features of three phase induction motor	CO 3	T2: 4.12 R2: 1.15
17-18	Demonstrate importance of conventional and electric heating	CO 2	T2: 4.9 R2: 1.8
19-20	Demonstrate selection and properties of heating elements	CO 4	T2: 4.9 R2: 1.10
21-22	Demonstrate the types and principle operation of dielectric heating and applications of dielectric heating	CO 3	R2: 2.7
23-24	Explain principle operation of electric welding	CO 1	T2: 2.3 R2: 1.4
25-26	Explain principle operation of Discharge lampsy	CO 1	T2: 4.6 R2: 1.4
27-28	Understand the concept of definite minimum time relays	CO 4	T2: 6.1 R2: 5.1
29-30	Describe tractive effort for given run	CO 4	T2:6.1.1
31-32	Analyze power, specific energy consumption for given run	CO 4	T2: 6.1.2 R2: 5.1.2
33-34	Discuss effect of varying acceleration and braking retardation	CO 4	T2: 6.1.2 R2: 5.1.2
35-36	Numerical problems on mechanics of train movement	CO 4	T2: 6.3.1 R2: 5.2
37-40	Explain adhesive weight and braking retardation.	CO 5	T2: 6.3.2 R2: 5.4

41-42	Explain adhesive weight and coefficient of adhesion.	CO 5	T2: 6.3.2 R2: 5.4
43-46	Demonstrate principle operation of three phase and single phase ac electric drives Numerical problems on adhesive weight and coefficient of adhesion	CO 4	T2: 6.7.1 R2:5.5

Course Coordinator **HOD,EEE**
Mr T Mahesh, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Industrial Automation and Control**				
Course Code	AEEB58				
Program	B.Tech				
Semester	VI				
Course Type	Open Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3		3	-	-
Course Coordinator	Dr. M Pala Prasad Reddy, Associate Professor				

I COURSE OVERVIEW:

This course provides an exposure to technology of industrial automation and control as widely seen in across a range of industries. It contains a wide range of topics from the advantages and architecture of automation systems, measurement systems including sensors and signal conditioning, discrete and continuous variable control systems, programmable logic controllers, CNC machines and actuators.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE008	IV	Electrical Measurements and Instrumentation
B.Tech	AEE009	IV	Control Systems

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Industrial Automation and Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	✓	Tech talk	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
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), 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
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

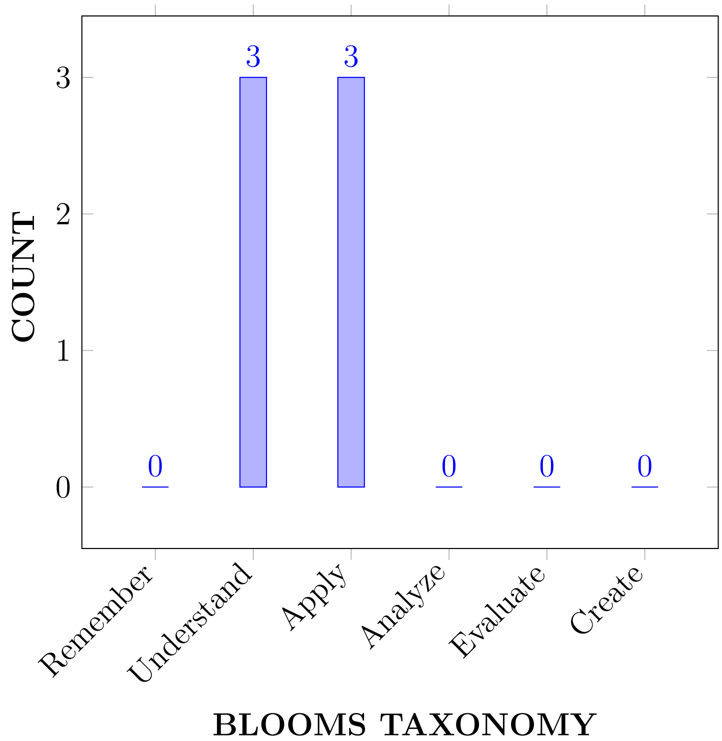
I	The functionality of the basic elements of industrial automation systems and the fundamental principles of operation of numerous instruments and machines.
II	The various control techniques employed in process automation including programmable logic controllers.
III	The substantial applications of automation systems and analyze real-life problems from an automation perspective based on engineering and cost-oriented thinking.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the architecture of automation system and its hierarchical levels for supervisory control of an industrial process.	Understand
CO 2	**Demonstrate** the operating principles of various instruments instruments for measuring variables in a controlled process.	Understand
CO 3	**Identify** the suitable control technique to control a given process for achieving desired response.	Apply
CO 4	**Makeuse of** PLC's in hardware and software environment and ladder logic for Automatic control of an industrial application.	Apply
CO 5	**Demonstrate** the principle of operation of CNC machines, control valves and actuators to perform various operations in an industrial application.	Understand
CO 6	**Choose** an appropriate electric driver for an industrial application based on drive characteristics.	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 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	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
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	AAT
PO 7	**Environment and Sustainability:** Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	1	AAT
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	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	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	AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

	PROGRAM SPECIFIC OUTCOMES	Strength	Proficiency Assessed by
PSO 1	Build embedded software and digital circuit development platform for robotics, embedded systems and signal processing applications.	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	Identify **(knowledge)** the various components of automation systems and understand their role in automating the complex industrial processes by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Understand the **problems** associated with manual control and build automated systems by selecting appropriate devices to achieve **automatic control** and interpret the results for increased productivity.	5
	PO 3	Understand the requirements of supervisory control in industrial applications and **Identify the limitations** in existing systems, **use creativity** in applying the automation techniques to provide **innovative solutions**. **Evaluate the outcomes** of the automated process **and understand the economic context.**	3
	PO 4	Recognize (knowledge) the characteristics of various industrial processes without automation (context) ; understand the principles of industrial automation system and apply it to control a complex process.	3
	PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health and safety issues and the consequent responsibilities relevant to the automation of processes with professional engineering practice	3
	PO 9	Function effectively in automating an industry or process as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	5
	PO 10	Communicate effectively with the Engineering community while configuring the industry in automation perspective and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 12	Recognize the need of automation in daily activities and enhance the functionality with new and cutting edge technologies to engage in independent job role and as a life-long learning.	6
	PSO 3	Understand the various modules of automation systems used for measuring, modifying and transforming the information with the help of necessary software/hardware tools.	4
CO 2	PO 1	Identify **(knowledge)** the need of measuring instruments at various levels in performing the automation and understand their role in measuring complex quantities of industrial processes by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Understand the requirements of measuring instruments for supervisory control in industrial applications and **Identify the limitations** of manual measurement, **use creativity** in selecting instruments to provide **innovative solutions**. **Evaluate the outcomes** of the automated process and **understand the economic context.**	5
	PO 3	Understand the requirements of measuring instruments for supervisory control in industrial applications and **Identify the limitations** of manual measurement, **use creativity** in selecting instruments to provide **innovative solutions**. **Evaluate the outcomes** of the automated process and **understand the economic context.**	5
	PO 10	Communicate effectively with the Engineering community while installing the various instruments in automation perspective and write effective reports and design documentation for further inspections and communication	3
	PSO 3	Make use of measuring instruments with appropriate **software integration** for transforming and measurement of data in an industrial application.	4
CO 3	PO 1	Identify **(knowledge)** the need of controllers at various levels in performing the automation and understand their role in controlling complex industrial processes by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Understand the **problems** associated in achieving desired response of a process and use advanced control techniques and tuning methods to achieve precise **control** and interpret the results for accuracy.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	Investigate the problems in achieving precise control of an automated process and **Identify the limitations on controllers** and **use creativity** in selecting controllers to provide **solutions**. **Evaluate the performance** of a process using various controllers to understand the accuracy in precise control.	4
	PO 4	Recognize (knowledge) the characteristics of controllers (context) ; understand the principles of industrial automation system and apply the control techniques to control a complex process	4
	PO 9	Function effectively in automating an industry or process as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	5
	PO 10	Communicate effectively with the Engineering community while configuring the industry in automation perspective and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3
	PSO 3	Develop programming skills in tuning and designing controllers using various tools at various levels of automation and analyze the performance.	4
CO 4	PO 1	Identify **(knowledge)** the different ways of programming PLC's in automation applications and understand their role in controlling complex industrial processes by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Identify the **problems** of using manual control in industrial process and use different techniques of programming programmable logic controllers to achieve precise control, increased productivity and other benefits in any automation applications.	4
	PO 3	Investigate the problems in achieving precise control of an automated process and **use creativity** in programming the PLC's. **Evaluate the performance** of an automated process for increased flexibility in control and economic growth.	4
	PO 4	**Recognize (knowledge) the characteristics** of various industrial processes with logic controllers; understand the corresponding **context of the engineering knowledge related** to the performance indicators and measures, **technical uncertainty** of the process and specific quantities causing the variations in the performance of automated applications.	4
	PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health and safety issues and the consequent responsibilities relevant to the automation of processes using programmable logic controllers with professional engineering practice	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 10	Communicate effectively with the Engineering community while configuring the industry using programmable logic controllers and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3
	PO 12	Recognize the need of programmable logic controllers in daily activities and enhance the functionality with new and cutting edge technologies to engage in independent job role and as a life-long learning.	5
	PSO 3	Develop the ability to program logic controllers and work in an automated industrial environment	3
CO 5	PO 1	Identify **(knowledge)** the necessity of computer numerical control machines, actuators and control valves in automation applications and understand their role in complex industrial processes for machining operations by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Identify **(knowledge)** the necessity of computer numerical control machines, actuators and control valves in automation applications and understand their role in complex industrial processes for machining operations by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 3	Investigate the problems in making fine products with conventional machinery and use creativity in providing solutions with the usage of CNC machines for increasing the accuracy and productivity. Evaluate the accuracy of end products in an automated process with CNC operations	3
	PO 4	Recognize (knowledge) the characteristics of various machinery used in industrial processes (context) ; understand the principles and program them using available tools to perform complex tasks.	3
	PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health and safety issues and the consequent responsibilities relevant to the automation of processes using CNC machines with professional engineering practice	3
	PO 9	Function effectively in automating an industry or process using CNC machines as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	5
	PO 10	Communicate effectively with the Engineering community while configuring the industry using programmable logic controllers and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 3	Gain the hands-on skills to work with CNC machines, actuators and control valves and program them using appropriate tools to perform various machining operations in an industrial process.	4
CO 6	PO 1	Identify **(knowledge)** the necessity of electric drives in automation applications and understand their role in complex industrial processes to perform various operations by **applying the knowledge of mathematics and science and engineering fundamentals.**	3
	PO 2	Identify the **problems** of using electric drives in industrial process for various operations and select suitable drive for an industrial application.	4
	PO 3	Investigate the problems in achieving efficiency while operating various units with drives in automated process and **use creativity** in selecting suitable drives with appropriate control strategy.	4
	PO 4	Recognize (knowledge) the characteristics of electrical drives used in industrial processes (context) ; understand the principles and configure them to perform complex tasks. .	4
	PSO 2	Examine the necessity of various electric drives in energy conversion and management while automating a process for economic growth and sustainable rural development.	5
	PSO 3	Apply the knowledge to integrating electric drives in software environments with PLC's and HMI for industrial applications.	4

Note: For Key Attributes refer **Annexure - I**

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	5	3	3	-	3	-	-	5	3	-	6	-		4
CO 2	3	5	5	-	-	-	-	-	-	3	-	-	-	-	4
CO 3	3	5	4	4	-	-	-	-	5	3-	-	-	-	-	4
CO 4	3	4	4	4	-	2	-	-	-	3	-	5	-		4
CO 5	3	3	3	3-	-	3	-	-	5	3	-	-	-	-	4
CO 6	3	4	4	4	-	-	-	-	-	-	-		-	5	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
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	100	50	30	28	-	60	-	-	42	60	-	50	-	-	57
CO 2	100	50	50	-	-	-	-	-	-	30	-	-	-	-	57
CO 3	100	50	30	-	-	-	-	-	-	-	-	-	-	-	57
CO 4	100	40	40	37	-	40	-	-	-	30	-	50	-	-	57
CO 5	100	40	30	28	-	60	-	-	42	30	-	-	-	-	57
CO 6	100	40	40	37	-	-	-	-	-	-	-		-	45	57

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

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

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 INDUSTRIAL AUTOMATION AND CONTROL**
	Introduction to Industrial Automation and Control: Introduction to industrial automation and control architecture of industrial automation system, measurement systems specifications, temperature measurement, pressure and force measurement, displacement and speed measurement, signal conditioning circuits, errors and calibration.
MODULE II	**PROCESS CONTROL**
	Process control: Introduction to process control, PID control, controller tuning, implementation of PID controllers, special control structures, feed forward and ratio control special control structures: predictive control, control of systems with inverse response.
MODULE III	**PROGRAMMABLE LOGIC CONTROL SYSTEMS**
	Programmable logic control systems: introduction to sequence or logic control and programmable logic controllers, the software environment and programming of PLCs, formal modeling of sequence control specifications. Programming , programming of PLCs: sequential function charts, the PLC hardware environment
MODULE IV	**CNC MACHINES AND ACTUATORS**
	CNC machines and actuators: Introduction to computer numerically controlled machines, control valves, hydraulic actuation systems, principle and components, directional control valves, switches and gauges, industrial hydraulic circuits.

MODULE V	**ELECTRICAL MACHINE DRIVES**
	Electrical machine drives: Energy savings with variable speed drives, step motors: principles, construction and drives, electrical actuators, DC motor drives, electrical actuators: induction motor drives, electrical actuators, BLDC motor drives.

TEXTBOOKS

1. Madhu Chanda Mitra, Samarjit Sen Gupta, "Programmable Logic Controllers and Industrial Automation: An Introduction", Penram International Publishing (India) Pvt. Ltd., 1 st Edition, 2008.
2. K Krishnaswamy, S Vijayachitra, "Industrial Instrumentation", New Age Publications, 1 st Edition, 2010.
3. Rajesh Mehra, Vikrant Vij, PLCs & SCADA: Theory and Practice, Laxmi publications, 2nd Edition, 2016

REFERENCE BOOKS:

1. AK Gupta, S K Arora, "Industrial Automation and Robotics", Laxmi Publications, 2nd Edition, 2013.
2. Jon Stenerson, "Industrial Automation and Process Control", Prentice Hall, 1st Edition, 2002.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108105088
2. https://www.iare.ac.in/?q=pages/btech-course-descriptions-iare-r18-1

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			
1	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)			
2	Role of automation in industries	CO 1	T1: 1.1 – 1.5
3	Architecture of Industrial Automation Systems	CO 1	T1: 1.1 – 1.5
4	Measurement system characteristics	CO 2	T3: 1.1.1 – 1.1.2
5	Measurement Systems Specifications	CO 2	T3: 1.3.1
6	Temperature measurement	CO 2	T3: 1.3.3
7	Pressure Measurement	CO 2	T3: 1.3.2 - 1.3.4
8	Force measurement	CO 2	T3: 1.3.8
9	speed and displacement measurement	CO 2	T3: 2.1 – 2.4
10	Signal conditioning circuits	CO 2	T3: 5.2
11	Data acquisition systems	CO 2	T3: 5.7
12	Errors in instruments	CO 2	T3: 5.7
13	Calibration of instruments	CO 2	T3: 5.7
14	Introduction to Automatic Control	CO 3	T3: 5.7
15	PID controller	CO 3	T1: 9.1 -9.4
16	Controller tuning methods	CO 3	T1: 9.1 -9.4
17	Implementation of controllers	CO 3	T1: 9.1 -9.4
18	Special control structures	CO 3	T1: 9.1 -9.4
19	Feed forward and ratio control	CO 3	T1: 9.1 -9.4
20	Predicative control	CO 3	T1: 9.1 -9.4
21	Systems with inverse response	CO 3	T1: 6.2 – 6.3
22	Applications of industrial automation in process industries	CO 3	T1: 3.1 – 3.8
23	Case studies	CO 3	T1: 3.1 – 3.8
26	Introduction to Sequence Control	CO 4	T1: 7.1 – 7.5
27	Programmable logic control	CO 4	T1: 7.1 – 7.5
28	Programming techniques for PLC	CO 4	T1: 7.1 – 7.5
29	Sequence Control. Scan Cycle, Simple RLL Programs	CO 4	T1: 7.2 -7.4
30	Sequence Control. More RLL Elements, RLL Syntax	CO 4	T1: 7.2 -7.4
31	Structured Design Approach to Sequence Control	CO 4	T1: 7.2 -7.4
32	Sequential flow charts	CO 4	T1: 6.1 – 6.10

33	State machine models	CO 4	T1: 6.1 – 6.10
34	Design of relay ladder logic for various problems	CO 4	T1: 5.7
35	PLC Hardware Environment	CO 4	T1: 5.7
44	Introduction to computer numerically controlled machines	CO 5	T1: 5.7
45	Contour generation and motion control	CO 5	T1: 2.2
46	CNC machining operations	CO 5	T1: 2.3
47	Basics of part programming	CO 5	T1: 5.7
48	Flow control valves	CO 5	T2: 2.1 - 2.4
49	Hydraulic control systems	CO 5	T2: 2.1-2.4
50	Industrial hydraulic circuit	CO 5	T2: 3.2
51	Pneumatic control system	CO 5	T2: 3.2.3
54	Energy savings with variable speed drives	CO 6	T2: 3.2.1
55	DC motor drives	CO 6	T2: 3.2.1
56	DC and BLDC servo drive	CO 6	T2: 3.2.2
57	Induction motor drives	CO 6	T2: 3.2.3
58	Step motor drives	CO 6	T2: 3.2.2
PROBLEM SOLVING/ CASE STUDIES			
14	Automation in cement industry	CO 1	T1:1.1 R2:1.1
15	Automated Welding Robots for Cars	CO 1	T1:3.4 R2:4.7
16	Industrial stamping process	CO 1	T1:3.4 R2:4.7
24	Effect of P, PI controllers	CO 3	T1:3.4 R2:4.1
25	Effect of PD and PID controllers	CO 3	T1:3.4 R2:4.4,4.5
36	RLL for 24 hours clock	CO 4	T1:5.1 R2:12.2,12.3
37	RLL for star-delta operation of dc motor drive	CO 4	T1:5.2 R2:12.4
38	Timer RLL diagrams	CO 4	T1:5.6,5.7 R2:9.8,9.9
39	RLL for DOL starter	CO 4	T1:5.8 R2:9.11
40	RLL for counter operationr	CO 4	T1:6.2 R2:10.3,10.4
41	Sequence control program for the industrial stamping process	CO 4	T1:6.3 R2:10.2
42	Design of RLL for industrial stamping process	CO 4	T1:6.4 R2:11.3
43	Industrial Logic Control using SFC	CO 4	T1:17.8 R2:19.3
52	Metal cutting through CNC machine	CO 5	T1:17.6 R2:20.2

53	The Fluid Delivery Subsystem	CO 5	T1:17.9 R2:21.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
59	Introduction to industrial automation and control	CO 1, CO 2	T1, R2
60	Process control	CO 3	T1, R2
61	Programmable logic controllers	CO 4	T1, R2
62	CNC machines and actuators	CO 5	T1, R2
63	Electric machine drives	CO 6	T1, R2
DISCUSSION OF QUESTION BANK			
64	Introduction to industrial automation and control	CO 1, CO 2	T1, R2
65	Process control	CO 3	T1, R2
66	Programmable logic controllers	CO 4	T1, R2
67	CNC machines and actuators	CO 5	T1, R2
68	Electric machine drivesr	CO 6	T1, R2

Signature of Course Coordinator
Dr. M Pala Prasad Reddy **HOD, EEE**

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**

PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**

PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**

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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**
PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

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

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">Electrical Measurements and Instrumentation Laboratory</td></tr>
<tr><td>Course Code</td><td colspan="5">AEEB25</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>VI</td><td colspan="4">EEE</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">Dr. M Laxmidevi Ramamaniah, Associate Professor</td></tr>
</table>

I COURSE OVERVIEW:

The objective of this laboratory course is to learn about the electrical measurement methods, operational principles with suitable software and hardware. It provides an opportunity for the students to identify and calibrate the various electrical instruments for obtaining errors. The lab emphasizes on the practical skills to design and realize the use of instruments for different electrical applications..

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB11	III	Electrical Machines Laboratory - I
B.Tech	AEEB12	III	Network Analysis Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Measurements and Instrumentation 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:

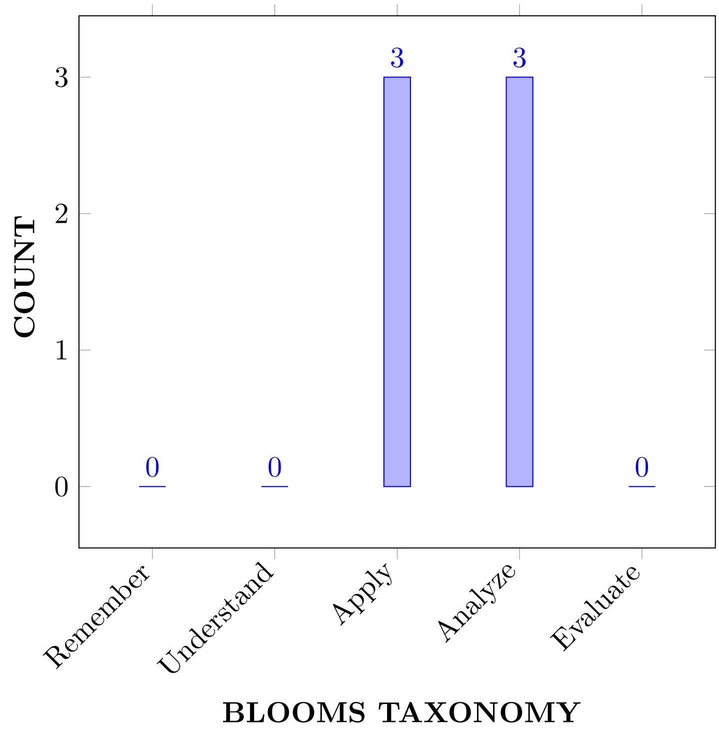
I	The calibration and testing methods of different electrical measuring instruments used for the measurement of voltage, current, power, energy.
II	The different transducers for measurement of physical quantities like pressure, temperature, level.
III	The simulation models in Labview to measure passive electrical parameters.

VII COURSE OUTCOMES:

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

CO 1	**Make use of** transducers like thermocouple, thermistorand resistance temperature detector for measuring temperature.	Apply
CO 2	**Choose** appropriate transducers for the measurement of strain, pressure, position and level.	Apply
CO 3	**Examine** the errors in measuring instrument by calibrating voltmeter, ammeter, LPF wattmeter, single phase energy meter,dynamometer power factor meter.	Analyze
CO 4	**Develop** Labview programs for displaying electrical waveforms and Lissajous patterns .	Analyze
CO 5	**Build** simulation models in digital environment forthe measurement of passive parameters like inductance, capacitance and resistance.	Apply
CO 6	**Analyze** the quantities like turns ratio, reactive power, errors associated with current transformer for reducing the errors in measuring instruments.	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		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 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
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	3	Lab Exercises
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	2	Lab Exercises
PO 9	**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
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
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	Lab Exercises

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	1	Lab Exercises
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.	3	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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 the instruments used for measuring physical parameters using the **knowledge of mathematics, science, and engineering fundamentals.**	3
	PO 8	Understand the performance characteristics of PMMC, MI instruments **with ethical principles, professional ethics and responsibilities**	2
	PO 9	**Develop** the attitude to get along with each other to function effectively.	2
	PO 10	**Make use of** oral, written and visual means to critique, negotiate, create and communicate understanding	2
	PO 12	**Recognize the need for** the importance of temperature in measuring devices to calibrate at specific temperature.	1
	PSO 3	Illustrate the operation of transducer applications **in automation process**	3
CO 2	PO 1	**Recall** the working of transducers with the help of **fundamentals of science and engineering fundamentals.**	2
	PO 2	**Understand** the operation of various instruments **with problem statement by analyzing complex engineering problems.**	2
	PO 3	**Design** solutions for measurement of physical parameters with economic perspective.	2
	PO 4	**Make use of** engineering knowledge of different transducers to solve engineering problems.	2
	PO 8	**Make use of** engineering knowledge of different transducers to solve engineering problems.	2

	PO 9	**Identify** and define an appropriate team negotiates solutions, ideas, roles and responsibilities.	2
	PO 10	**Use** communication as a tool for clarity	1
	PO 12	**Develop** significant skills and find learning resources to develop a Lab VIEW application.	1
	PSO 3	Illustrate the operation of transducer applications **in automation process**	3
CO 3	PO 1	Recall the basic electrical parameters with the help of **fundamentals of mathematics, science, and engineering fundamentals.**	1
	PO 2	Recall the basic electrical parameters with the help of **fundamentals of mathematics, science, and engineering fundamentals.**	2
	PO 3	**Understand customer and user needs of** power and energy requirements and understand economic context of engineering processes.	3
	PO 4	**Recognize (Knowledge) the characteristics of** wattmeter, ammeter, power factor meter with appropriate codes of practice and apply to analyse key engineering processes in laboratory	3
	PO 8	**Recognize (Knowledge) the characteristics of** wattmeter, ammeter, power factor meter with appropriate codes of practice and apply to analyse key engineering processes in laboratory	2
	PO 9	**Develop** ability to Work well with a team and get along with others.	3
	PO 10	**Make use of** communication as a tool helps in negotiating and creating new understanding, interacting with others, and furthering their own learning	3
	PO 12	**Identify** new technology in measuring electrical parameters	1
	PSO 1	Quantify the errors in power systems to ensure **efficient operation of electrical system.**	1
	PSO 3	Illustrate the operation of voltmeter, ammeter applications **in automation process**	3
CO 4	PO 1	Recall the electrical parameters using the **engineering scientific principles and methodology.**	2
	PO 2	**Identify** the phase and frequency of waveforms using Lissajous patterns.	2
	PO 3	**Use** LabVIEW for engineering activities to establish innovative solutions	2
	PO 4	**Develop** laboratory skills of simulation models and computer software relevant to engineering disciplines	2

	PO 5	**Develop** simulation program in **Labview software** to analyse voltage and current waveforms, Lissajous patterns	3
	PO 8	**Use** LabVIEW for engineering activities to establish innovative solutions	2
	PO 9	**Use** LabVIEW for engineering activities to establish innovative solutions	3
	PO 10	**Share** knowledge and skills with colleagues using oral, written, and visual communication to further their own learning	3
	PO 12	**Identify** significant skills for advanced engineering concepts.	2
	PSO 3	Illustrate the operation of LabVIEW applications **in automation process**	3
CO 5	PO 1	**Recall** the electrical parameters using the **engineering scientific principles and methodology.**	2
	PO 2	**Understand** the purpose of using bridges and **identify and apply the information** to measure inductance and capacitance.	3
	PO 3	**Use** LabVIEW for engineering activities to establish innovative solutions	2
	PO 4	**Develop** laboratory skills of simulation models and computer software relevant to engineering disciplines.	2
	PO 5	**Develop** Labview program **in Labview software** to measure passive parameters	3
	PO 8	**Develop** Labview program **in Labview software** to measure passive parameters	2
	PO 9	**Develop** ability to Work well with a team and get along with others.	3
	PO 10	Share knowledge and skills with colleagues using oral, written, and visual communication to further their own learning.	3
	PO 12	**Identify** significant skills for advanced engineering concepts	2
	PSO 3	Illustrate the operation of ac and dc bridge applications **in automation process**	3

CO 6	PO 1	**Remember** the measuring principles of reactive power, turns ratio etc., using the **principles of mathematics and engineering science.**	3
	PO 2	**Identify** the problem of power system and analyze it to select a particular method **using the principles of engineering.**	1
	PO 3	**Develop** solutions to reduce errors in instrument transformers	1
	PO 4	**Develop** laboratory skills to work with technical uncertainty to solve engineering problems.	1
	PO 8	**Develop** laboratory skills to work with technical uncertainty to solve engineering problems.	2
	PO 9	**Experiment with** hands-on labs enable the students to complete the assignments	3
	PO 10	**Demonstrate** the ability to communicate effectively in writing and orally	3
	PO 12	**Identify** industry trends/ new technology relevant to instrument transformers.	1
	PSO 1	**Interface** current transformer **for protection in power system.**	3
	PSO 3	Illustrate the operation of wattmeter applications **in automation process**	3

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

XIII ASSESSMENT METHODOLOGY DIRECT:

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

XIV ASSESSMENT METHODOLOGY INDIRECT:

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

XV SYLLABUS:

WEEK I	**SENSING OF TEMPERATURE AND SPEED**
	Measurement of temperature using transducers like thermocouple, thermistors and resistance temperature detector with signal conditioning; speed measurement using proximity sensor.
WEEK II	**CALCULATION OF DISTANCE AND LEVEL**
	Distance measurement using ultrasonic transducer, measurement of level using capacitive transduce.
WEEK III	**MEASUREMENT OF STRAIN AND PRESSURE**
	Strain measurement using strain gauge; measurement of pressure using differential pressure transducer.
WEEK IV	**MEASUREMENT OF POSITION AND LINEAR DISPLACEMENT**
	Measurement of position using encoders and measurement of linear displacement using Linear Voltage Differential Transformer (LVDT).
WEEK V	**PHANTOM LOADING ON LPF WATTMETER**
	Calibration of electrodynamometer type LPF wattmeter using phantom loading.
WEEK VI	**CALIBRATION OF SINGLE PHASE ENERGY METER AND POWER FACTOR METER**
	Calibration of single phase energy meter using resistive load and dynamometer power factor meter.
WEEK VII	**MEASUREMENT OF TURNS RATIO AND APPLICATIONS OF CTs**
	Measurement of turns ratio using AC bridge; the extension of range of wattmeter to measure three phase power using two CTs and one single phase wattmeter.
WEEK VIII	**MEASUREMENT OF REACTIVE POWER**
	Measurement of reactive power using one single phase wattmeter
WEEK IX	**NET METERING**
	Study of bidirectional energy measurement using net metering.
WEEK X	**MEASUREMENT OF FREQUENCY AND THD USING DIGITAL SIMULATION**
	Determination of frequency and Total Harmonic Distortion THD using LabVIEW.
WEEK XI	**ANALYSIS OF WAVE FORMS DIGITAL SIMULATION**
	Measurement and display of voltage, current wave forms and analysis using LabVIEW.

WEEK XII	**TWO WATTMETER METHOD USING DIGITAL SIMULATION**
	Measurement of real reactive power using two wattmeter method and verification with LabVIEW.
WEEK XIII	**WORKING OF STATIC ENERGY METER USING DIGITAL SIMULATION**
	Measurement of energy using static energy meter and verification with LabVIEW.
WEEK XIV	**MEASUREMENT OF PASSIVE PARAMETERS USING DIGITAL SIMULATION**
	Resistance measurement using Kelvin's bridge, inductance measurement using Anderson bridge and capacitance measurement using Schering bridge and verification with LabVIEW.

REFERENCE BOOKS:

1. A K Sawhney, —Electrical and Electronic measurement and instruments, Dhanpat Rai and Sons Publications, 2002

2. E W Golding and F C Widdis , Electrical measurements and measuring instruments,Wheeler publishing, 2006

3. D V S Murthy, Transducers and Instrumentation, Prentice Hall of India, London, 2009.

Web references :

1. https://www.gnindia.dronacharya.info/EEEDept/Downloads/Labmanuals/EMI-Lab.pdf

2. https://www.scribd.com/doc/25086994/electrical-measurements-lab

XVI 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	Measurement of temperature using transducers like thermocouple, thermistors and resistance temperature detector with signal conditioning; speed measurement using proximity sensor.	CO 1	R3:7.1
2	Measurement of low resistance using Kelvins double bridge.	CO 5	R3:6.1
3	Measurement of strain using strain gauge and measurement of pressure using differential pressure transducer.	CO 2	R3:6.1
4	Measurement of position using encoders and measurement of level using capacitive transducer.	CO 2	R3:6.3
5	Calibration of electrodynamometer type LPF wattmeter using phantom loading.	CO 3	R1:11.6
6	Calibration of single phase energy meter using resistive load and dynamometer power factor meter.	CO 3	R1:11.6

7	Measurement of turns ratio using AC bridge; the extension of range of wattmeter to measure three phase power using two CTs and one single phase wattmeter.	CO 5	R1:9.7
8	Measurement of reactive power using one single phase wattmeter.	CO 6	R1:10.21
9	Measurement of percentage ratio error and phase angle of given ct by null method.	CO 6	R1:9.7
10	Calibration of PMMC ammeter and PMMC voltmeter.	CO 3	R1:8.5
11	Measurement and display of voltage, current wave forms, frequency Lissajeous patterns and THD using LabVIEW.	CO 4	R1:21.14
12	Measurement of three phase power with single wattmeter and two numbers of current transformer.	CO 63	R1:10.9
13	Measurement of energy using static energy meter and verification with LabVIEW.	CO 5	R1:11.15
14	Inductance measurement using Anderson bridge and capacitance measurement using Schering bridge and verification with LabVIEW.	CO 5	R1:16.5

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Tri-vector meter** Use Tri-vector meter for measuring kW, kVar and kVA of a power line.
2	**MEASUREMENT OF PASSIVE PARAMETERS USING DIGITAL SIMULATION** Measurement of self-inductance by Maxwell's inductance bridge using digital simulation.
3	**MEASUREMENT OF PASSIVE PARAMETERS USING DIGITAL SIMULATION** Measurement of self-inductance by Hay's bridge using digital simulation.
4	**MEASUREMENT OF PASSIVE PARAMETERS USING DIGITAL SIMULATION** Measurement of capacitance by Wein's bridge using digital simulation.
5	**MEASUREMENT OF PASSIVE PARAMETERS USING DIGITAL SIMULATION** Measurement of capacitance by Wein's bridge using digital simulation.

Signature of Course Coordinator **HOD,EEE**
Dr. M Laxmidevi Ramanaiah, Associate Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**

PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**

PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**

PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**
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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

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

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION

Course Title	**PLC AND INDUSTRIAL AUTOMATION LABORATORY**				
Course Code	AEEB26				
Program	B.Tech				
Semester	VI	EEE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. P Mabuhussain, Assistant Professor, EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE007	IV	AC Machines
B.Tech	AEE008	IV	Electrical Measurements and Instrumentation

II COURSE OVERVIEW:

The objective of this laboratory course is to measure, analyze and control the physical input and outputs like temperature, speed, voltage, current, etc., in an industrial automation process using programmable logic controllers (PLCs). The lab emphasizes on the software and hardware skills to design and realize an automation process. The lab is mainly intended to give hands-on skills on PLCs to implement software timers, counters and their usage in traffic signal control, lift control, sequential control, solar tracking, starting and braking of electrical machines.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
PLC and Aautomation 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:

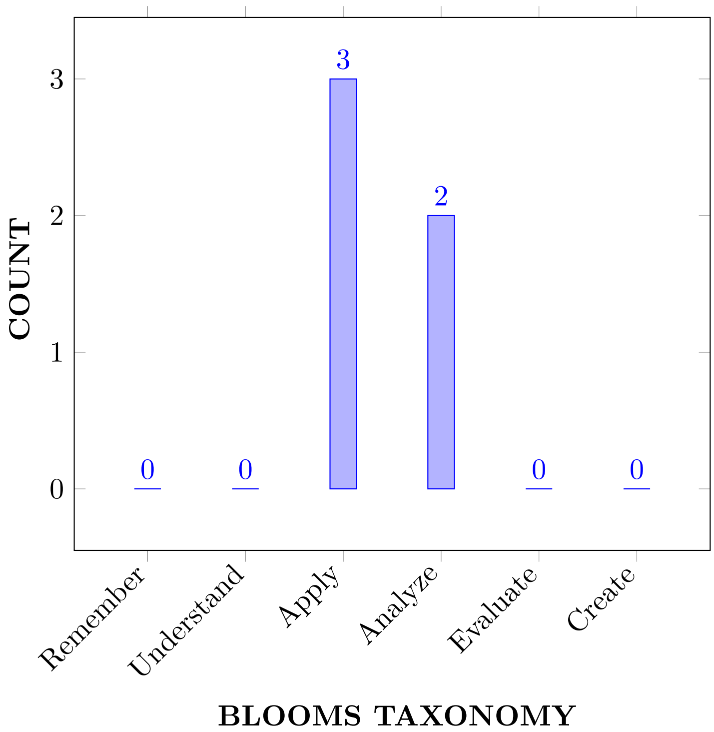
I	The functioning of programmable logic controller (PLC), its I/O modules and usage of these devices in an automation system.
II	The interfacing of input and output devices of a process with PLC and control of these devices automatically.
III	The programming of PLC using relay ladder diagram programming method and interfacing of PLC with Human Machine Interface (HMI) and Variable Frequency Drive (VFD).

VII COURSE OUTCOMES:

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

CO 1	**Use** PLC timers and Counters for delaying a particular control process and counting the production rate in an industrial system.. .	Analyze
CO 2	**Design** a system for starting, speed control and braking of DC/AC motors using PLC digital module.	Apply
CO 3	**Measure** the temperature, speed, voltage and current using PLC analog module to control the operation of motors, relays and circuit breakers.	Analyze
CO 4	**Construct** PLC based automatic traffic signal system to control the vehicle congestion at a three-way or four-way road junction.	Apply
CO 5	**Develop** the ladder diagram logic programs for lift control, solar tracking and fault annunciation 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 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 PROGRAM SPECIFIC OUTCOMES:

Program Specific Outcomes	
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.
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.

X 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 /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 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	Hands on practice /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	Hands on practice /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 / 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.	3	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.	3	Lab Exercises / 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	Lab Exercises / CIE / SEE

3 = High; 2 = Medium; 1 = Low

XI HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involved in Power generation, Transmission, Distribution and Utilization.	2	Hands on practice /CIE / SEE
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	2	Hands on practice /CIE / SEE
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.	3	Hands on practice /CIE / SEE

3 = High; 2 = Medium; 1 = Low

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	**Classify** the various software timers and counters according to their usage by basic **mathematical principles** and **apply** them in an industrial process.	3
	PO 2	**Use** the Delta make WPLsoft software for writing the ladder diagram for on-delay, off-delay and up and updown counters for a particular process in an industry.	4

	PO 4	**Design** the real time experiments using the software timers and counters by applying the principles of engineering sciences	4
	PO 5	**Use** the Delta make WPLsoft software for writing the ladder diagram for on-delay, off-delay used for delaying a particular operation of a process in an industry and counters for counting the number of products produced.	1
	PO 6	**Apply** the timers and counters for protecting a system in an industry and provide the safety to the people and industry personnel.	2
	PO 8	**Write** the worksheets after completion of an experiment in laboratory by following the ethical principles	2
	PO 9	**Make use of** a team of members and function effectively and do the experiment in the laboratory .	8
	PO 10	**Wrtie** the worksheets for a particulary laboratory experiment and asnwers theviva voce questions asked by the laboratory incharge and some times even give a seminar on a topic given by the subject teacher.	4
	PO 12	**Recognize** the need of programmable logic controllers in an industrial automation system and gain the knowledge in the laboratory and use it in life long technical change.	5
	PSO 3	**Explicit** the software timers in Delta make WPLsoft software and **adopt** them to **program** a PLC used in an industrial automation process	5
CO 2	PO 1	**Remembe**r the starting methods, speed control methods and braking methods of an induction motor using the **electrical engineering scientific principles and methodologies** and **apply** them to control the motor.	3
	PO 2	**Understand** the purpose of using a motor in an industrial process and **state the problem** and **identify and apply** the appropriate solution either to start or brake the motor or to control the speed of motor.	4
	PO 3	**Analyze** the starting, speed control and braking of induction motor using programmable logic controllers	3
	PO 5	**Write** a ladder diagram program in WPLSoft software using relevant contactors and timers to start, control and brake the three phase induction motor.	1
	PO 6	**Apply** the timers and counters for protecting a system in an industry and provide the safety to the people and industry personnel.	2
	PO 8	**Write** the worksheets after completion of an experiment in laboratory by following the ethical principles	2
	PO 9	**Make use of** a team of members and function effectively and do the experiment in the laboratory .	8
	PO 10	**Wrtie** the worksheets for a particulary laboratory experiment and asnwers theviva voce questions asked by the laboratory incharge and some times even give a seminar on a topic given by the subject teacher.	4

	PSO 2	**Focus** on the components required for designing a speed control or braking method for a motor using the principles of engineering sciences and mathematics..	4
	PSO 3	**Gain** the Hands-on skills on PLc and HMI and how to interface them with the motor and control the motor accordingly	5
CO 3	PO 1	**Understand** the measuring principles of temperature, speed, current, voltage etc., using the **engineering principles** and **appl**y them to control a certain process in an industry.	3
	PO 2	**Identify the problem** of a process in an industry and **analyze** it to select a suitable motor using the **principles of engineering.**	4
	PO 4	**investigate** a process in an industry and **analyze** it to select a suitable starting or braking method for a motor using the **principles of engineering.**	6
	PO 5	**Develop** a ladder diagram program to start, control or brake a three phase induction motor using a WPLSoft software.	1
	PO 6	**Apply** the timers and counters for protecting a system in an industry and provide the safety to the people and industry personnel.	2
	PO 8	**Write** the worksheets after completion of an experiment in laboratory by following the ethical principles	2
	PO 9	**Make use of** a team of members and function effectively and do the experiment in the laboratory .	8
	PO 10	**Wrtie** the worksheets for a particulary laboratory experiment and asnwers theviva voce questions asked by the laboratory incharge and some times even give a seminar on a topic given by the subject teacher.	4
	PO 12	**Recognize** the need of programmable logic controllers in an industrial automation system and gain the knowledge in the laboratory and use it in life long technical change.	5
	PSO 1	**Design** a control system for control of voltage, current, temperature and speed of motro with in the prescribed limits	2
	PSO 2	**Focus** on the components required or sensors required for controlling of different physical parameters like temperature, speed etc.	5
	PSO 3	**Interface** the various types of sensors with PLC to measure the analog input quantities like temperature, speed, voltage, current etc., **analyze** the working of software tools and get the hands-on skills of using them.	5
CO 4	PO 1	**Understand** the traffic signal control process using **basic scientific principles.**	3

	PO 2	**Anlayze** the traffic at a particular location, **understand** the need of traffic signals and **design** a system that controls the traffic lights at a three way or four way road junctions to ensure the **safety of public.** .	4
	PO 5	**Use** the Delta make WPLsoft software and write the ladder diagram program to control the traffic lights at a road junction with more accurately and precisely.	1
	PO 6	**Apply** the timers and counters for protecting a system in an industry and provide the safety to the people and industry personnel.	2
	PO 8	**Write** the worksheets after completion of an experiment in laboratory by following the ethical principles	2
	PO 9	**Make use of** a team of members and function effectively and do the experiment in the laboratory .	8
	PO 10	**Wrtie** the worksheets for a particulary laboratory experiment and asnwers theviva voce questions asked by the laboratory incharge and some times even give a seminar on a topic given by the subject teacher.	4
	PSO 3	**Gain** the hands-on skills on PLC, HMI and construct a traffic signal control system for a three way or four way juction	5
CO 5	PO 1	**Understand** the operation of a temperature control system, solar tracking system and electrical fault detection system using the **electrical engineering principles and methodologies.**	3
	PO 2	**Analyze** the operation of a temperature control system, solar tracking system and electrical fault detection system using the **electrical engineering principles and methodologies.** and solve the problems associated with those systems	4
	PO 3	**Identify** the purpose of a temperature control system in an industry and **design** a system which maintains the temperature within specified limits. Also, **measure** and **analyze** the electrical current and voltage taken by the equipment in industry and **develop** a system which makes these variables within limits.	3
	PO 5	**Interface** the temperature sensor, proximity sensor, potential transformer and current r transformer with PLC and write a relay ladder logic in WPLsoft software to measure temperature, speed, voltage and currents.	1
	PO 6	**Apply** the timers and counters for protecting a system in an industry and provide the safety to the people and industry personnel.	2
	PO 8	**Write** the worksheets after completion of an experiment in laboratory by following the ethical principles	2
	PO 9	**Make use of** a team of members and function effectively and do the experiment in the laboratory .	8

	PO 10	**Wrtie** the worksheets for a particulary laboratory experiment and asnwers theviva voce questions asked by the laboratory incharge and some times even give a seminar on a topic given by the subject teacher.	4
	PSO 2	**Use** the thyristror drive for conversion of AC to DC and feed it to DC motor for controlling the speed of DC motor.	5
	PSO 3	**Gain** the hands-on skills PLC, HMI and opertion of temperature control system, fault announciation system and solar tracking system	5

XIII 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	PO 4	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	2	-	3	3	3	-	3	-	-	3
CO 2	3	2	1	-	3	2	-	3	3	3	-	-	-	1	3
CO 3	3	2	-	2	3	2	-	3	3	3	-	3	2	2	3
CO 4	3	2	-	-	3	2	-	3	3	3	-	-	-	-	3
CO 5	3	2	1	-	3	2	-	3	3	3	-	-	-	2	3

XIV ASSESSMENT METHODOLOGY - DIRECT:

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

XV ASSESSMENT METHODOLOGY- INDIRECT:

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

XVI SYLLABUS:

WEEK I	**STAR - DELTA STARTER**
Star-delta starter for 3- phase squirrel cage induction motor using programmable logic controller.	
WEEK II	**AUTOMATIC FORWARD AND REVERSE CONTROL**
Automatic forward and reverse control of 3- phase induction motor using PLC.	

WEEK III	FAULT ANNUNCIATION SYSTEM
Fault annunciation system using programmable logic controller.	
WEEK IV	TEMPERATURE CONTROL SYSTEM
Temperature control system using programmable logic controllers and PT100.	
WEEK V	PLUGGING
Braking of a squirrel cage induction motor by plugging using programmable logic controller.	
WEEK VI	CONTROL OF LIFT
Control of lift using programmable logic controller.	
WEEK VII	TRAFFIC SIGNAL CONTROL
Traffic signal control using programmable logic controller.	
WEEK VIII	IMPLEMENTATION OF TIMERS
Implementation of ON - delay and OFF - delay timers using PLC.	
WEEK IX	SOLAR TRACKING
Solar tracking using programmable logic controller.	
WEEK X	DIRECT ONLINE STARTER
Direct online starter for AC motor implementation using programmable logic controller.	
WEEK XI	UP DOWN COUNTER
Implementation of up down counter to count the objects in a store using PLC.	
WEEK XII	DIGITAL CLOCK
Implementation of 24 hour digital clock using programmable logic controller.	
WEEK XIII	TIMERS
Implementation of on delay, off delay and retentive timer using programmable logic controller.	
WEEK XIV	SEQUENTIAL CONTROL
Sequential control of three motors with a time delay using programmable logic controller.	

TEXTBOOKS

1. John R. Hack Worth, Frederick D. Hack Worth, Jr., “Programmable logic controllers: programming methods and applications”, Pearson Education, 4th edition, 2008.

2. W. Bolton “Programmable logic controllers”, Newnes Elsevier , 4th edition, 2006.

REFERENCE BOOKS:

1. Luis A. Bryan, E. A. Bryan, “Programmable Controllers theory and implementation”, American technical publisher, 4th edition, 2002.

2. Frank D. Petruzella, “Programmable logic controllers”, Tata McGraw hill, 3th edition, 2010.

XVII 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	Star - delta starter.	CO 5	T1: 11.2
2	Automatic forward and reverse control	CO 5	T1: 11.1 -11.5

3	Fault annunciation system	CO 6, CO 8	T2: 13.3
4	Temperature control system	CO 6	T1:14.1
5	Plugging	CO 5	T1: 11.3
6	Control of lift	CO 8	T1: 11.1 -11.5
7	Traffic signal control	CO 7	T2: 9.1-9.4
8	Implementation of timers	CO 1	T2: 9.1-9.4
9	Solar tracking	CO 6, CO 8	T1:14.4
10	Direct online starter	CO 5	T1: 11.1
11	Up down counter	CO 2	T2:10.3
12	Digital clock	CO 3	T2:10.1-10.5
13	Timers	CO 1	T2: 9.1-9.4
14	Sequential control	CO 4	T1:14.2

XVIII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Motor Control:** Speed control of three phase induction motor
2	**Motor Control:** Speed control of DC motor
3	**Line Protecton:** Over voltage and under voltage protection
4	**Line Protecton:** Over Current Protection
5	**Reservoir control:** Water level control in a reservoir
6	**Motor Control:**Speed control of induction motor using PLC and VFD

Signature of Course Coordinator **HOD,EEE**
Mr. P Mabuhussain
Assistant Professor, EEE

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**

PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions 5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	**10**
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**

PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**
PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**

PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project. 6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	**12**
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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**
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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Power Systems Protection**				
Course Code	AEE014				
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. T. Mahesh, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE004	III	DC Machines and Transformers
B.Tech	AEE007	IV	AC Machines

II COURSE OVERVIEW:

The main objective of the course is to provide an overview of the principles and schemes for protecting power lines, transformers, buses, generators. It provides in depth knowledge of various types of relays and circuit breakers. It includes protection against over voltages in power system using lighting arrestors and insulation co-ordination.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
UTILIZATION OF ELECTRICAL POWER	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
70 %	Understand
20 %	Apply
0 %	Analyze

VI COURSE OBJECTIVES:

The students will try to learn:

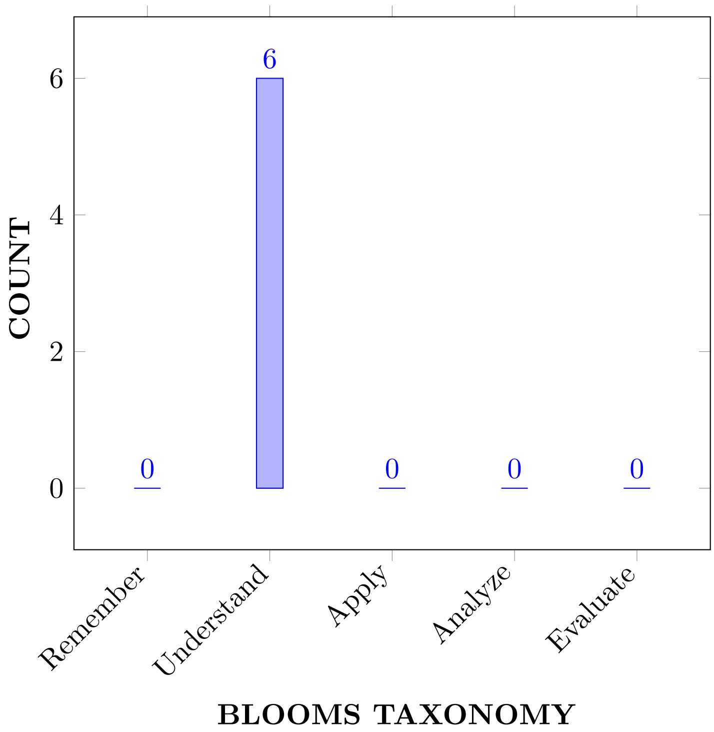
I	Theory, construction, applications of types circuit breakers, Relays for protection of generators, transformers and protection of feeders from over- voltages and other hazards.
II	Applications of the main components used in power system protection for electric machines, transformers, bus bars, overhead and underground feeders.
III	The skills to design the feasible protection systems needed for each main part of a power system.

VII COURSE OUTCOMES:

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

CO 1	**Describe** types of existing circuit breakers, their design and constructional details used for the protection of power system under different mal condition.	Understand
CO 2	**Explain** construction and working of various types relays for detection of fault and disconnection of a faulty section.	Understand
CO 3	**Classify** substations based on operating voltages and their circuit elements helps in provide reliable supply for the consumers.	Understand
CO 4	**Summarize** protection schemes of feeder and bus-bars that plays an effective role in protection of transmission lines.	Understand
CO 5	**Outline** protection schemes of generator and transformer against open and short circuit faults for maintaining continuous supply.	Understand
CO 6	**Classify** types of lightening arrestors for the protection of power system network from over voltages in order to provide uninterruptable power supply.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		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.	1	SEE/CIE/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	SEE/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	SEE /CIE/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	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	3	-
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development.	-	-

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	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** to classify various Learning Process: Error Correction Learning, Memory Based Learning, Hebbian Learning, Competitive, Boltzmann Learning	3
	PO 2	**Identify the problem statement** Single Layer Perceptron: Adaptive Filtering Problem, Unconstrained Organization Techniques, Linear Least Square Filters, Least Mean Square Algorithm	2
CO 2	PO 1	**Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principles** and derive the Back Propagation Learning and Accelerated Convergence formulae	3

	PO 2	Analyze the performance parameters of Back Propagation Algorithm XOR Problem, Heuristics, Output, Representation and Decision Rule, Computer Experiment, Feature Detection **first principles of Mathematics and engineering sciences.**	2
CO 3	PO 1	Identify various learning Rate Annealing Techniques, Perceptron: convergence theorem **using principles of mathematics, science, and engineering fundamentals.**	3
CO 4	PO 1	Apply the knowledge of different for techniques (**scientific Principles and mathematical principles**) for Hessian Matrix, Generalization, Cross Validation and describe different performance parameters.	3
	PO 2	Determine the parameters and Network Pruning Techniques **using first principles and Mathematics and Engineering sciences.**	2
	PO 5	Illustrate Neuro Dynamical Models, Manipulation of Attractors as a Recurrent Network Paradigm Hopfield Models to **solve complex engineering problems.**	1
CO 5	PO 1	Understand the advantages of Bayes Classifier for a Gaussian Environment and Multilayer Perceptron **using the fundamentals of engineering and mathematical equations**	3
CO 6	PO 1	Analyze Recurrent Network Paradigm Hopfield Models **using fundamentals of science &and engineering fundamentals.**	3
	PO 2	Categorize the Adaptive Patter in **complex engineering problems.**	3
	PO 3	Investigate and define a problem and identify Learning Vector Quantization including **environmental and sustainability limitations, health and safety and risk assessment issues**	2

Note: For Key Attributes refer **Annexure - I**

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

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

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	100	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	100	80	-	-	80	-	-	-	-	-	-		-	-	-
CO 5	100		-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	100	70	60	-	-	-	-	-	-	-	-		-	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

2 - 40 % <C < 60% –Moderate

1-5 <C$\leq$ 40% – Low/ Slight

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

COURSE OUTCOMES	**PROGRAM OUTCOMES**												**PSO'S**		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	3		-	3	-	-	-	-	-	-		-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	3	2	-	-	-	-	-	-	-	-		-	-	-
TOTAL	18	10	2	-	3	-	-	-	-	-	-	-	-	-	-
AVERAGE	3	3	2	-	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 Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**CIRCUIT BREAKERS**
	Circuit Breakers: Elementary principles of arc interruption, restriking and recovery voltages, restriking phenomenon, average, maximum and rate of rise of restriking voltage, current chopping and resistance switching, circuit breaker ratings and specifications, auto reclosures, description and operation of various types of circuit breakers, minimum oil circuit breakers, air blast circuit breakers, vacuum and SF6 circuit breakers, numerical problems.
MODULE II	**ELECTROMAGNETIC, STATIC AND NUMERICAL RELAYS**
	Electromagnetic relays: Principle of operation and construction of attracted armature, balanced beam, induction disc and induction cup relays; Relays classification: instantaneous, definite minimum time and inverse definite minimum time relays over current / under voltage relays, direction relays, differential relays and percentage differential relays, universal torque equation; Distance relays: Impedance, reactance, mho and offset mho relays, characteristics of distance relays; Static relays: Overview of static relay, block diagram, operating principle and comparison, static relays versus electromagnetic relays; Numerical relays: Introduction, block diagram of numerical relay, sampling theorem, anti-aliasing filter, block diagram of phasor measurement unit and intelligent electronic device, data acquisition systems and numerical relaying algorithms, applications and numerical problems.
MODULE III	**SUBSTATIONS AND PROTECTION OF FEEDER / BUS BAR**

	Indoor and outdoor substations: Substations layout, bus bar arrangements like single, sectionalized, main and transfer bus bar system with relevant diagrams; Gas insulated substation (GIS): Types, single line diagram, constructional aspects of GIS, Installation, maintenance, advantages, comparison of GIS with air insulated substations. Indoor and outdoor substations: Substations layout, bus bar arrangements like single, sectionalized, main and transfer bus bar system with relevant diagrams; Gas insulated substation (GIS): Types, single line diagram, constructional aspects of GIS, Installation, maintenance, advantages, comparison of GIS with air insulated substations.
MODULE IV	**GENERATOR AND TRANSFORMER PROTECTION**
	Generator protection: Protection of generators against stator faults, rotor faults, and abnormal conditions, restricted earth fault and inter turn fault protection, numerical problems on percentage winding unprotected; Transformer protection: Percentage differential protections, numerical problem on design of current transformers ratio, buchholz protection.
MODULE V	**PROTECTION AGAINST OVER VOLTAGES**
	Neuro Dynamics: Dynamical Systems, Stability of Equilibrium States, Attractors, Neuro Dynamical Models, Manipulation of Attractors as a Recurrent Network Paradigm Hopfield Models – Hopfield Models, Computer Experiment

TEXTBOOKS

1. Sunil S Rao, "Switchgear and Protection", Khanna Publishers, 1st Edition, 2013.

REFERENCE BOOKS:

1. Paithankar, S R Bhide, "Fundamentals of Power System Protection", PHI, 1st Edition, 2003.
2. C LWadhwa, "Electrical Power Systems", New Age international (P) Limited, 6th Edition, 2010.
3. VK Mehta," Principles of power systems", S Chand Publications, 4th Edition, 2009.

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
1-2	Understand the Elementary principles of arc interruption	CO 1, CO 2	T2: T2: 1.1 R2: 1.1
3-4	Understand the concept restriking and recovery voltages, restriking phenomenon, average, maximum and rate of rise of restriking voltage	CO 2	T2: 4.1 R2: 1.6
5-6	Analyze average, maximum and rate of rise of restriking voltage with examples	CO 2	T2: 4.2 R2: 1.6
7-8	Explain concept of the current chopping.	CO 2	T2: 5.1 R2: 1.7

9-10	Understand the concept of resistance switching	CO 2	T2: 5.3 R2: 1.7 3
11-12	Understand the operation of various types of circuit breakers such as minimum oil circuit breakers.	CO 3	T2: 5.5 R2: 1.7
13-14	Explain the concept of vacuum.	CO 3	T2: 4.5 R2: 1.7.1
15-16	Explain the concept of SF6 circuit breaker.	CO 3	T2: 4.12 R2: 1.15
17-18	Analyze examples on recovery, rate of rise of restriking voltage	CO 2	T2: 4.9 R2: 1.8
19-20	Understand the Principle of operation and construction of attracted armature.	CO 4	T2: 4.9 R2: 1.10
21-22	Explain the operation of balanced beam.	CO 3	R2: 2.7
23-24	Explain the operation induction disc.	CO 1	T2: 2.3 R2: 1.4
25-26	List out types of relays and discuss briefly on instantaneous, definite minimum time and inverse relay	CO 1	T2: 4.6 R2: 1.4
27-28	Understand the concept of definite minimum time relays	CO 4	T2: 6.1 R2: 5.1
29-30	Understand the concept over current / under voltage relays.	CO 4	T2:6.1.1
31-32	Explain the working of direction relays.	CO 4	T2: 6.1.2 R2: 5.1.2
33-34	Explain the working of differential relays	CO 4	T2: 6.1.2 R2: 5.1.2
35-36	Explain the working of percentage differential relays.	CO 4	T2: 6.3.1 R2: 5.2
37-40	Derive universal torque equation; and discuss briefly on distance relay.	CO 4	T2: 6.3.2 R2: 5.4
41-42	Explain operation and characteristics of Impedance relay	CO 4	T2: 6.3.2 R2: 5.4
43-46	Explain operation and characteristics reactance relay.	CO 4	T2: 6.7.1 R2:5.5

Signature of Course Coordinator **HOD,EEE**
Mr. T. Mahesh, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
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).** **"**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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Power System Operation and Control**				
Course Code	AEEB28				
Program	B.Tech				
Semester	VII				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. Narender Reddy Kedika, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB22	VI	Power System Analysis

II COURSE OVERVIEW:

This course deals with the concept of power system management to meet load demand at optimal operating cost and various ways in controlling electrical power generation of Thermal and Hydrothermal plants and modeling of electrical and hydraulic. This course also gives the knowledge of Load Frequency Control in multi areas and classification of Loads and its Compensation. This course address the various real time issues like Power Factor and its improvement.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power System Operation and Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
20%	Understand
60%	Apply
20%	Analyze

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE) and 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 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.

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

COURSE OBJECTIVES:
The students will try to learn:

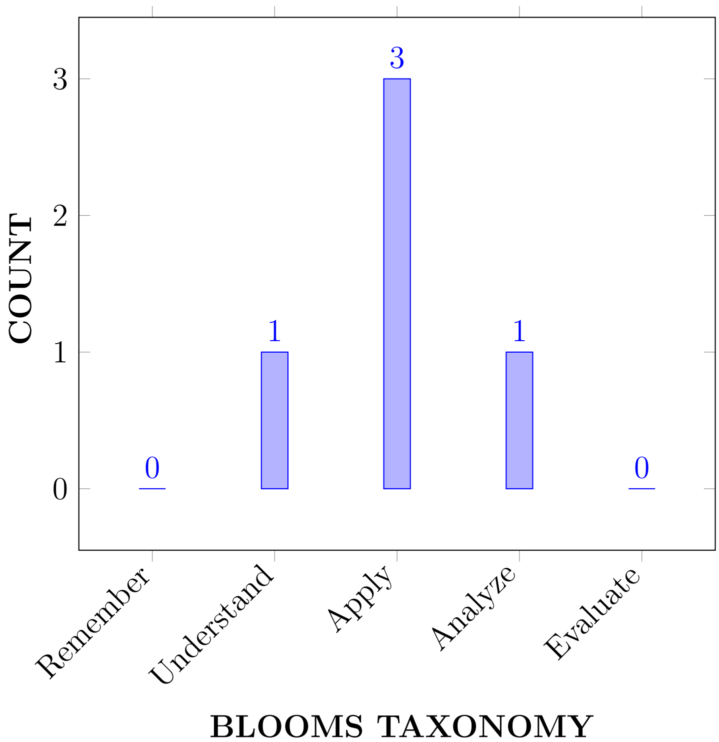
I	The economic operation of Thermal and Hydro Power Systems.
II	The solid foundation in mathematical and engineering fundamentals required to control the governing system in Turbine models.
III	The optimization techniques used in the power system and Load Frequency Control (LFC).
IV	The Power Factor Control and Reactive Power Control in Transmission Systems.
V	The Load Compensation technique for different Loads.

VI COURSE OUTCOMES:

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

CO 1	**Solve** the optimum load scheduling with various constraints in Thermal and Hydro power Stations using conventional optimization techniques and general transmission line loss formula.	Apply
CO 2	**Develop** the mathematical models of the mechanical and electrical components in the power generation for deriving the transfer function of the power system.	Apply
CO 3	**Distinguish** single area and two area load frequency control for minimizing the transient and steady state deviations using various controllers.	Analyze
CO 4	**Choose** different types of compensating equipment for controlling voltage, reactive power and power factor for improving the reliability in compensated and uncompensated transmission lines.	Apply
CO 5	**Interpret** the types of loads in the power systems from their characteristic factors.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VII 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

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	AAT/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	AAT/CIE/SEE

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	AAT/CIE/SEE
PO4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	AAT/CIE/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	AAT/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.	1	AAT/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.	1	AAT/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.	1	AAT/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.	1	AAT/CIE/SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, develop fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	2	AAT/CIE/SEE
PSO 2	Focus on the components of electrical drives with its converter topologies, for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	1	AAT/CIE/SEE

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Recollect** (knowledge) the basic concept of generation of electricity from Thermal and Hydrothermal power stations and (understand) the importance fundamentals of optimal operation of Generating plants by applying the principles of **mathematics and science**.	3
	PO 2	**Identify** the optimum problem and analyse heat rate curve, cost curve, incremental fuel and production costs, input-output characteristic **using the first principles of mathematics and engineering sciences**.	6
	PO 3	**Design** the solution for optimal operation of the power system to meet the specified needs with appropriate consideration **for societal and environmental considerations**.	2
	PO 4	**Analyze** and interpret the data of optimal scheduling of thermal and hydro power stations obtained by various research methods and knowledge to conduct **investigation of complex problems**.	2
	PO 6	**Apply** the knowledge of optimal scheduling of power stations for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**.	2
	PO 7	**Understand** the need for optimal operation and Unit Commitment of power generating systems to reduce the impact of oxides of carbon, sulphur and nitrogen **on the environment** .	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of optimal scheduling of power stations	2

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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 based on optimal scheduling problems in power generation plants.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of efficient power generation scheduling.	2
	PSO 1	**Develop**(understand) the optimal scheduling of thermal and hydro power stations **involving power generation**.	4
	PSO 2	**Understands** the Unit Commitment **and** conventional optimization techniques by **focus on the components of system in specific applications of industry and academia**	2
CO 2	PO 1	**Recall** the knowledge on the various Components in generating plants **engineering fundamentals**.	3
	PO 2	**Describe** the mechanical and electrical components involved in the operation of power systems using the **first principles of mathematics and engineering sciences**.	6
	PO 3	**Design** the mathematical models of the mechanical and electrical components and develop the **solutions for complex Engineering**.	2
	PO 6	**Apply** the knowledge of optimal operation of generators in power stations for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**.	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of optimal design of power generation components	2
	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 based on mathematical modelling of power generation plant components.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of efficient power generation components designing.	2
	PSO 1	**Develop** the mathematical models of the mechanical and electrical components in operation of power systems **to derive the transfer function of systems involved in power generation**.	1

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 3	PO 1	**Understand** the modeling of excitation systems system **knowledge of engineering fundamentals related to electrical machines**.	2
	PO 2	**Describe** the fundamental characteristics of an excitation system **using the first principles of mathematics and engineering sciences**.	2
	PO 3	**Design** the mathematical models of the mechanical and electrical components and develop the **solutions using complex Engineering**.	3
	PO 4	**Analyze** the mathematical models of the mechanical and electrical components and develop the **solutions using complex Engineering**.	3
	PO 6	**Apply** the knowledge of load frequency control in power systems for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**.	2
	PO 7	**Understand** the need for load frequency control in power systems to reduce the impact of oxides of carbon, sulphur and nitrogen produced during power generation **on the environment** .	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of load frequency control in power systems	3
	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 based on load frequency control in single and two area system.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of efficient frequency control strategies.	3
	PSO 1	**Design** the load frequency control for single area and two area **to minimize deviations and errors involving power transmission and distribution**.	4
CO 4	PO 1	Understanding the concepts of voltage, powerfactor and reactive power control in the power systems using **basic fundamentals of mathematics, electrical engineering**.	2
	PO 2	**Analyze** the importance of controlling voltage and reactive power for stable operation of the power system **using first principles of science and mathematics**	7
	PO 3	Design the compensating equipment for control of voltage and reactive power problem and develop **solutions using complex Engineering**.	2

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	**Analyze** the need for reactive power in the power system and associated problems on power delivery and develop the **solutions using complex Engineering**.	2
	PO 6	**Apply** the knowledge of reactive power control in power systems for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**.	2
	PO 7	**Understand** the effect of reactive power control and powerfactor control in power systems to reduce the impact of oxides of carbon, sulphur and nitrogen produced during power generation **on the environment** .	1
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of control of reactive power and power factor in power systems	2
	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 based on reactive power control and power factor control.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of quality of the power.	2
	PSO 2	**Identify** various reactive power compensating equipment and topologies **for specific applications of industry and energy management**	2
CO 5	PO 1	**Illustrate** different types of loads and their characteristics using the **knowledge of Electrical Engineering fundamentals**	2
	PO 2	**Analyze** the voltage drop and power loss in a distribution system using the **solutions for complex engineering problems**.	5
	PO 3	**Design** various methods for load compensation and develop the **solutions for complex Engineering**.	3
	PO 6	**Apply** the knowledge of load compensation in power stations for assessment of societial and safety issues **with responsibilities relevant to the professional engineering practice**.	2
	PO 9	Function effectively as an individual, and as a member or leader in diverse teams for analyzing the importance of load compensation in power generation.	2

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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 based on load compensation and different types of loads.	1
	PO 12	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of efficient load compensation.	2
	PSO 2	**Identify** various reactive power load compensating mathods and topologies **for specific applications of industry and energy management**	2

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

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

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO(s)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	60	20	18.2	-	40	66.7	-	16.7	20	-	25	80	18.2	-
CO 2	100	60	20	-	-	40	-	-	16.7	20	-	25	20	-	-
CO 3	66.7	20	30	27.3	-	40	33.3	-	25	20	-	37.5	80	-	-
CO 4	66.7	70	20	18.2	-	40	33.3	-	16.7	20	-	25	-	18.2	-
CO 5	66.7	50	30	-	-	40	-	-	16.7	20	-	25	-	18.2	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO(s)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	1	1	-	2	2	-	1	1	-	1	3	1	-
CO 2	3	3	1	-	-	2	-	-	1	1	-	1	1	-	-
CO 3	3	1	1	1	-	2	1	-	1	1	-	1	3	-	-
CO 4	3	3	1	1	-	2	1	-	1	1	-	1	-	1	-
CO 5	3	2	1	-	-	2	-	-	1	1	-	1	-	1	-
TOTAL	15	12	5	3	-	10	4	-	5	5	-	5	7	3	-
AVERAGE	3	2.4	1	1		2	1.3		1	1		1	2.3	1	

XV 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	-	-	-	-	-

XVI ASSESSMENT METHODOLOGY-INDIRECT:

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

XVII SYLLABUS:

UNIT I	**ECONOMIC OPERATION OF POWER SYSTEMS**
	Optimal scheduling of thermal power system: Optimal operation of generators in thermal power stations, heat rate curve, cost curve, incremental fuel and production costs, input output characteristics, optimum generation allocation without and with transmission line losses coefficients, general transmission line loss formula, unit commitment; Optimal scheduling of hydrothermal system: Hydroelectric power plant models, scheduling problems, short term hydro thermal scheduling problem.
UNIT II	**MODELING OF GOVERNOR, TURBINE AND EXCITATION SYSTEMS**
	Modeling of governor: Mathematical modeling of speed governing system, derivation of small signal transfer function; Modeling of turbine: First order turbine model, block diagram representation of steam turbines and approximate linear models; Modeling of excitation system: Fundamental characteristics of an excitation system, transfer function, block diagram representation of IEEE type-1 model.
UNIT III	**SINGLE AREA AND TWO AREA LOAD FREQUENCY CONTROL**

	Load frequency control of single area system: Necessity of keeping frequency constant, definitions of control area, single area control, block diagram representation of an isolated power system, steady state analysis, dynamic response, uncontrolled case. Load frequency control of two area system: Uncontrolled case and controlled case, tie line bias control; Load frequency controllers: Proportional plus integral control of single area and its block diagram representation, steady state response, load frequency control and economic dispatch.
UNIT IV	**COMPENSATION FOR POWER FACTOR IMPROVEMENT AND REACTIVE POWER CONTROL**
	Voltage control: Equipment for voltage control, effect of series capacitors, line drop compensation, effect of AVR, power factor control using different types of power capacitors, shunt and series capacitors, effect of shunt capacitors (fixed and switched), power factor correction, capacitor allocation, economic justification, procedure to determine the best capacitor location; Reactive power control: Reactive power compensation in transmission systems, advantages and disadvantages of different types of compensating equipment for transmission systems; Uncompensated and compensated transmission lines: Shunt and series compensation.
UNIT V	**LOAD COMPENSATION**
	Load Compensation: characteristics of loads, factors associated with loads, relation between the load factor and loss factor; specifications of load compensator; Classification of loads: Residential, commercial, agricultural and industrial and their characteristics.

TEXTBOOKS

1. Sivanagaraju, S., et al.,Power system operation and control, Pearson Education India, 2009

2. Turan Gonen, Electric Power Distribution system, Engineering, McGraw-hill Book Company, 2007

3. Timothy J. E. Miller, Reactive power control in Electrical systems, Wiley-Interscience Publication, 1982

4. V K Mehta & Rohit Mehta, Principles of Power System, S Chand, 2015.

REFERENCE BOOKS:

1. Singh S. N., Electric Power Generation, Transmission and Distribution, Prentice Hall of India Pvt. Ltd., New Delhi, Second Edition, 2002.

2. Turan Gonen, Electrical Power Distribution System Engineering, CRC Press, Third Edition, 2014.

3. Kamaraju V., Electrical Power Distribution Systems, TMH, Publication, Edition, 2009.

4. Elgerd O. I., Electrical Energy Systems Theory, Tata McGraw-Hill, Second Edition, 2007.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108/104/108104052/

2. https://nptel.ac.in/courses/108/101/108101040/

COURSE WEB PAGE:

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO(s)	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	-
CONTENT DELIVERY (THEORY)			
1	Introduction to power system operations and control	CO 1	T1:5-6
2	Optimal scheduling of thermal power system	CO 1	T1: 25-26
3	Characteristic Curves (heat rate curve, cost curve, Incremental fuel and production costs)	CO 1	T1: 26-28
4	Input-Output characteristics and Optimum generation allocation without transmission line losses coefficients	CO 1	T1: 26-28
5	Optimum generation allocation with transmission line losses coefficients	CO 1	T1: 26-28
6	General transmission line loss formula and Unit commitment.	CO 1	T1: 30-32
7	Hydroelectric power plant models	CO 1	T1: 30-32
8	Short term hydro thermal scheduling problem.	CO 1	T1: 30-32
9	Mathematical modeling of speed governing system	CO 2	T3:312-318
10	Derivation of small signal transfer function	CO 2	T3:312-318
11	Modeling of steam turbine	CO 2	T3:312-318
12	Block diagram representation of steam turbines	CO 2	T3:312-318
13	First order turbine model	CO 2	T3:312-318
14	Modeling of excitation system	CO 2	T3:322-326
15	Fundamental characteristics of an excitation system and Transfer function.	CO 2	T3:319
16	Block diagram representation of IEEE type-1 model.	CO 2	T2:11.5 R2:17.5
17	Load frequency control of single area system	CO 3	T1:84-85
18	Necessity of keeping frequency constant and Definitions of control areas (Single area & Two-area)	CO 3	T1:327-330
19	Block diagram representation of an isolated power system.	CO 3	T1:327-330
20	Steady-State and Dynamic response Analysis for uncontrolled case.	CO 3	T1:327-330

21	Load frequency control of two area system controlled and uncontrolled case	CO 3	T1:327-330
22	Load frequency control of a two area system: tie line bias control	CO 3	T1:58-59
23	Proportional plus integral control of single area control	CO 3	T1:58-59
24	Two area control block diagram representation	CO 3	T1 :60-62
25	Steady-state response in a two area system	CO 3	T1 :63-64
26	Load frequency control in a two area system	CO 3	T1 :65-68
27	Economic Dispatch	CO 4	T1:296
28	Equipment for voltage control	CO 4	T2:383 – 385
29	Impact of series capacitors and Automatic Voltage Regulators	CO 4	T2:383 – 385
30	Power factor control using different types of power capacitors (shunt and series capacitors)	CO 4	T2:383
31	Impact of switched and fixed shunt capacitors	CO 4	T1: 330-345
32	Power factor correction	CO 4	T2:337
33	Optimum location of capacitor and economic justification	CO 4	T2:342-345
34	Reactive power control	CO 4	T2:342-345
35	Different types of compensating equipment for transmission systems	CO 4	T2:337
36	Difference between compensated and uncompensated transmission lines.	CO 4	T2:325-327
37	Shunt and series reactive power compensation	CO 4	T2:325-327
38	Load Compensation	CO 5	T2:325-327
39	Characteristics of loads and factors associated with loads	CO 5	T2:25
40	Load factor and Loss factor, Classification of loads and their characteristics.	CO 5	T2:26-28
PROBLEM SOLVING/ CASE STUDIES			
41	Problems on incremental fuel cost and production cost.	CO 1	T1: 52-83
42	Problems on load sharing between the units based on governor droop characteristics	CO 1	T1: 282-286
43	Problems on optimum generation allocation with transmission line loss coefficients	CO 1	T1: 52-83
44	Problems on optimum generation allocation without transmission line loss coefficients	CO 1	T1: 108-135
45	Problems on transmission loss formula in terms of B-coefficients	CO 1	T1: 124-135
46	Mathematical models of turbine, generator and governing system	CO 2	T1: 310-313
47	Problems on single area and two area control	CO 3	T1: 346-358

48	Problems on change in generation levels of the units.	CO 4	T1: 346-358
49	Problems on change in steady state frequency and line losses in single area system	CO 4	T1: 282-286
50	Problems on deviation in frequency of the units.	CO 4	T1: 282-286
51	Problems on change in steady state frequency and line losses in two-area system	CO 4	T1: 346-358
52	Problems based on power factor improvement	CO 4	T1:405-414
53	Problems on defining the most economical power factor	CO 4	T1:405-414
54	Problems on the requirement of the capacitor ratings for power factor correction	CO 5	T1:405-414
55	Problems on annual power losses in the distribution systems	CO 5	T1:435-438
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Definitions on optimal scheduling of power plants	CO 1	T1-26 to 28
57	Definitions on mathematical modeling	CO 2	T3-321 to 318
58	Definitions on load frequency control	CO 3	T1-327 to 330
59	Definitions on voltage and reactive power control	CO 4	T2-342 to 345
60	Definitions on load compensation	CO 5	T2-206 to 208
DISCUSSION OF QUESTION BANK			
61	Economic operation of power systems	CO 1	R4:2.1
62	Modeling of governor, turbine and excitation systems	CO 2	T4:7.3
63	Economic operation of power systems	CO 3	R4:5.1
64	Compensation for power factor improvement and reactive power control	CO 4	T1:7.5
65	Load compensation	CO 5	T1: 4.1

Course Coordinator **HOD,EEE**
Dr. Narender Reddy Kedika, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF(s)
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

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

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Course Title	**ELECTRICAL SAFETY AND SAFETY MANAGEMENT**				
Course Code	AEEB41				
Program	B.Tech				
Semester	VII	EEE			
Course Type	Professional Elective - III				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms. A. Srikanth, Assistant Professor				

I COURSE OVERVIEW:

Electrical safety and safety management is often the responsibility, such as facilities, risk or health & safety officers to prevent electrical hazards in the workplace. This situation results in a number of deaths in the workplace being caused by electrical incidents. This course provides a comprehensive overview of the fundamentals of electrical safety and a systematic set of principles for assessing and managing electrical safety in any business and across all sectors of industry and the public sector, the course is universally applicable, across industries and countries and applicable to the buildings, facilities, equipment and environments associated with a wide range of organizations, irrespective of size, which includes the industrial, commercial and the public sectors. It's provides practical guidance to have a level of knowledge and understanding to manage the risks associated with an electrical system. It will focus on providing a specific procedure for managing electrical safety.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB03	II	Electrical Circuits

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electrical Safety and Safety Management	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	x	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	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 bellow.

The expected percentage of cognitive level of questions in SEE.

10%	Remember
60%	Understand
30 %	Apply
0 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

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

Assessment pattern for CIA

Continuous Internal Examination (CIE):

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

Continuous Internal Examination (CIE):

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 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 bellow

Assessment pattern for AAT

5 Minutes Video	Assignment	Tech-talk	Seminar	Open Ended Experiment
20%	20%	20%	20%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

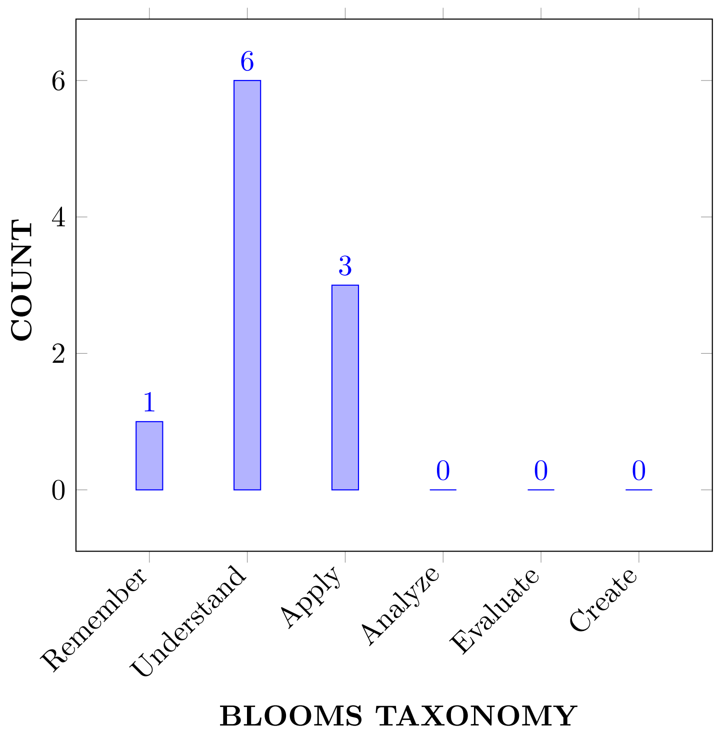
I	Introduce IE rules and its significance in commercial electrical systems.
II	Realize the electrical safety in residential, commercial and industrial installations.
III	Demonstrate installation, testing and commissioning, operation and maintenance.
IV	Summarize the effect of power factor on Quality control and management.

VII COURSE OUTCOMES:

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

CO 1	**Understand** the Indian standard electrical safety frules and their significance .	Remember
CO 2	**Explain** the objectives and precautions of Electrical Safety, effects of Shocks and their Prevention.	Understand
CO 3	**Explain** the Wiring and fitting in residential, commercial, and agricultural.	Remember
CO 4	**Understand** the Do's and Dont's for safety in the use of domestic electrical appliances.	Understand
CO 5	**Interpret** about electrical safety installation and testing fat different places .	Understand
CO 6	**Summarize** the Protective aspects during Installation of Plant and Equipment.	Understand
CO 7	**Understand** about flashovers and corona discharge at transmission and distribution system.	Remember
CO 8	**Describe** the various Electrical Safety in Hazardous Areas, Equipment Earthing and System Neutral Earthing.	Understand
CO 9	**Understand** about Total quality control and management in distribution system.	Apply
CO 10	**Summarize** the power factor improvement in distribution system.	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 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	Assignments
PO 6	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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	1	Research Paper / Quiz / 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	✓	-	✓	-	-	✓	-	-	-	-	-		✓	-	-
CO 7	✓	-	✓	✓	-	-	-	-	-	-	-	-	✓	-	-
CO 8	✓	-	✓	✓	-	-	-	-	-	-	-	-	✓	-	-
CO 9	✓	-	✓	-	-	✓	-	-	-	-	-	-	✓		- -
CO 10	✓	-	✓	✓	-	-	-	-	-	-	-	-	✓	-	-

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

COURSE OUT COMES	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key Competencies**
CO 1	**PO 1**	Recall about the over voltages in power system for protecting electrical equipment knowledge of mathematics, science and engineering fundamentals.	2
	PO 3	Investigate the charge formation techniques used for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration	3
CO 2	**PO 1**	Analyze various components involved and their functionality using principles of mathematics, science and engineering fundamentals.	3
	PO 3	Design solutions for variable breakdown operation, system design features for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration.	7

	PO 4	Understand various dielectric material strength, analysis and interpretation of data, and synthesis of the information.	5
	PSO 1	Utilizing different types of dielectrics modern techniques commercializing the system.	1
CO 3	**PO 1**	Provide knowledge about dielectric material characteristics and classify of breakdown strength systems with basic fundamentals of science, and engineering fundamentals.	3
	PO 3	Identify and manage their with stand levels of various dielectric materials that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	6
	PSO 1	Make use of composite dielectrics as another source of aid to power system.	1
CO 4	**PO 1**	Equip with required skills to for the design of circuits for generating high voltages and currents the fundamentals of mathematics, science, and engineering fundamentals.	3
	PO 3	Design the solution for problems of voltage doublers and multiplier circuits	7
	PO 6	Understanding various methods to generate high voltage and current analysis and interpretation of data, and synthesis of the information.	5
	PSO 1	Understand the importance of high voltage generation for measuring of magnitudes in power system.	1
CO 5	**PO 1**	Summarize various techniques used for generating impulse voltages with the knowledge of mathematics, science and engineering fundamentals.	3
	PO 3	Explain the controlling and generation of impulse voltage and current for triggering of impulse generator the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	7
	PO 4	Outline the triggering of impulse generators including design of experiments, analysis and interpretation of data, and synthesis of the information.	1
	PSO 1	Recognize the importance of various generating impulse voltages and currents need of testing various apparatus.	1
CO 6	**PO 1**	Use the basics of mathematics, science and engineering fundamentals for measuring high voltages and currents.	3

	PO 3	Extend the measuring of voltages and currents methods including design of experiments, analysis and interpretation of data, and synthesis of the information.	5
	PO 6	Design the solution for problems of electric field calculation for ensuring safety to the personal and equipment.	7
	PSO 1	Understand the maximum measuring voltages and currents for modern power systems with safety of operations	1
CO 7	**PO 1**	Estimate the value of over voltages for protecting the electrical apparatus using the principles of mathematics and engineering fundamentals.	3
	PO 3	Design the solution for problems of harmonics and resonance conditions	7
	PO 4	Inference various numerical and analytical methods of electric fields analysis and interpretation of data, and synthesis of the information.	4
	PSO 1	Summarize and controlling of impulse waves in power system.	1
CO 8	**PO 1**	Distinguish different testing techniques by applying basic knowledge of science and engineering fundamentals.	2
	PO 3	Understanding the insulation coordination levels according to the necessities.	5
	PO 4	Utilize insulation coordination levels for protecting power system design of experiments, analysis and interpretation of data, and synthesis of the information.	3
	PSO 1	Understand the basic impulse level BIL of electrical power system	1
CO 9	**PO 1**	Summarize power quality issues mitigation techniques use for non disruptive testing's with the help of basic fundamentals of mathematics science and engineering fundamentals.	3
	PO 3	Utilize various non disruptive test techniques of high voltage that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	6
	PO 6	Describe the performance of various electrical apparatus to testing high voltage for interpretation of data, and synthesis of the information.	2
	PSO 1	Summarize the transient conditions with the required electrical power system.	1

CO 10	**PO 1**	Outline the control and protection and their impact on power systems with the help of basic fundamentals of mathematics science and engineering fundamentals.	3
	PO 3	Relate the insulation coordination and extra high voltage power system for protecting the system the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	6
	PO 4	Demonstrate various methods to suppress the over voltages design of experiments, analysis and interpretation of data, and synthesis of the information.	1
	PSO 1	Focus on the protection for operation and control of over voltages and extra voltages system.	1

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

COURSE	**Program Outcomes/ No. of Key Competencies Matched**												**PSO'S**		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	2	-	3	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	-	7	5	-	-	-	-	-	-	-	-	1	-	-
CO 3	3	-	6	-	-	-	-	-	-	-	-	-	1	-	-
CO 4	3	-	7	-	-	5	-	-	-	-	-		1	-	-
CO 5	3	-	7	1	-	-	-	-	-	-	-	-	1	-	-
CO 6	3	-	-	5	-	7	-	-	-	-	-		1	-	-
CO 7	3	-	6	4	-	-	-	-	-	-	-	-	1	-	-
CO 8	2	-	5	3	-	-	-	-	-	-	-	-	1	-	-
CO 9	3	-	6	-	-	3	-	-	-	-	-	-	1	-	-
CO 10	3	-	6	1	-	-	-	-	-	-	-	-	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	66.7	-	30	-	-	-	-	-	-	-	-		-	-	-
CO 2	100	-	70	45	-	-	-	-	-	-	-	-	9	-	-
CO 3	100	-	60	-	-	-	-	-	-	-	-	-	9	-	-
CO 4	100	-	70	-	-	45	-	-	-	-	-	-	9	-	-
CO 5	100	-	70	9	-	-	-	-	-	-	-	-	9	-	-
CO 6	100	-	70		-	45	-	-	-	-	-		9	-	-
CO 7	100	-	60	36.3	-	-	-	-	-	-	-	-	9	-	-

CO 8	66.7	-	50	27.2	-	-	-	-	-	-	-	-	9	-	-
CO 9	100	-	60	-	-	27.2	-	-	-	-	-	-	9	-	-
CO 10	100	-	60	9	-	-	-	-	-	-	-	-	9	-	-

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	-	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	3	2	-	-	-	-	-	-	-	-	1	-	-
CO 3	3	-	2	-	-	-	-	-	-	-	-	-	1	-	-
CO 4	3	-	3	-	-	2	-	-	-	-	-	-	1	-	-
CO 5	3	-	3	1	-	-	-	-	-	-	-	-	1	-	-
CO 6	3	-	3	-	-	2	-	-	-	-	-		1	-	-
CO 7	3	-	2	2	-	-	-	-	-	-	-	-	1	-	-
CO 8	3	-	1	1	-	-	-	-	-	-	-	-	1	-	-
CO 9	3	-	2	-	-	1	-	-	-	-	-	-	1	-	-
CO 10	3	-	2	1	-	-	-	-	-	-	-	-	1	-	-
TOTAL	30	-	22	7	-	5	-	-	-	-	-	-	-	9	-
AVERAGE	3	-	3	2	-	2	-	-	-	-	-	-	-	1	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1,PO 3, PO 4	SEE Exams	PO 1,PO 3, PO 4	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	PO 6	Open Ended Experiments	-
Assignments	PO 1,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	**REVIEW OF IE RULES AND ACTS AND THEIR SIGNIFICANCE**
	Objective and scope: Ground clearances and section clearances, standards on electrical safety, safe limits of current, voltage; earthing of system neutral, codes of conduct, rules regarding first - aid and fire fighting facility.
MODULE II	**ELECTRICAL SAFETY IN RESIDENTIAL, COMMERCIAL AND AGRICULTURAL INSTALLATIONS**
	Wiring and fitting: Domestic appliances, water tap giving shock, shock from wet wall, fan Firing shock, multi-storied building, Temporary installations, Agricultural pump installation, Do's and Don'ts for safety in the use of domestic electrical appliances..
MODULE III	**SAFETY DURING INSTALLATION, TESTING AND COMMISSIONING, OPERATION AND MAINTENANCE**
	Safety during Installation: Preliminary preparations, safe sequence, risk of plant and equipment, safety documentation, field quality and safety Protective Equipment: Personal protective equipment, safety clearance notice, safety precautions, safe guards for operators, safety.
MODULE IV	**ELECTRICAL SAFETY IN HAZARDOUS AREAS**
	Hazardous zones: class0, 1 and 2 spark, flash overs and corona discharge and functional requirements, Specifications of electrical plants, equipments for hazardous locations, Classification of equipment enclosure for various hazardous gases and vapours, classification of equipment / enclosure for hazardous locations.
MODULE V	**ELECTRICAL SAFETY IN DISTRIBUTION SYSTEM**
	Total quality control and management: Importance of high load factor, Disadvantages of low power factor, Causes of low P.F., power factor improvement, equipments, Importance of P.F. improvement.

TEXTBOOKS

1. S. Rao, Prof. H.L. Saluja, "Electrical safety, fire safety Engg and safety management", Khanna Publishers, New Delhi, 1988.

2. Pradeep Chaturvedi, "Energy management policy, planning and utilization", Concept Publishing company,New Delhi, 1997.

REFERENCE BOOKS:

1. Nagrath. I.J. and Kothari. D.P. "Power System Engineering", Tata McGrawHill Publishing company Ltd. New Delhi, 1998.

2. R. K. Jain and Sunil S. Rao, "Industrial Safety, Health and Environment Management Systems", Khanna Publishers, 1st Edition, 2000.

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
1	Introduction on electrical safety and safety management	CO 1	T1:8.1 R2:7.5
2	Ground clearances and section clearances	CO 1	T1:8.1 R2:7.5
3	Standards on electrical safety	CO 1	T1:8.2 R2:7.8
4	Safe limits of current, voltage	CO 2	T1:8.2 R2:7.8
5	Earthing of system neutral	CO 2	T1:8.2 R2:7.3
6	Rules regarding first aid	CO 2	T1:1.6 R2:7.10
7	Firefighting facility	CO 2	T1:2.1 R2:1.0-1.1
8	Wiring and fitting – Domestic appliances	CO 3	T1:2.2 R2:1.1
9	Water tap giving shock	CO 3	T1:2.3-2.4 R2:1.2
10	Shock from wet wall	CO 3	T1:2.10 R2:1.7
11	Fan firing shock	CO 3	T1:3.1-3.2 R2:1.11
12	Multi-storied building	CO 4	T1:3.2 R2:1.11
13	Temporary installations	CO 4	T1:4.1-4.2 R2:1.14
14	Agricultural pump installation	CO 4	T1:4. R2:1.14
15	Dos and Donts for safety in the use of domestic electrical appliances	CO 4	T1:4 R2:1.14
16	Preliminary preparations	CO 5	T1:4. R2:1.14
17	Safe sequence	CO 5	T1:6.1 R2:2.1-2.3
18	Risk of plant and equipment	CO 5	T1:6.1 R2:2.1-2.3
19	Safety documentation	CO 5	T1:6.2 R2:2.4
20	Field quality and safety	CO 6	T1:6.2 R2:2.4
21	Personal protective equipment	CO 6	T1:6.3 R2:3.2
22	Safety clearance notice	CO 6	T1:6.3 R2:3.2
23	Safety precautions	CO 6	T1:6.5 R2:3.7
24	Safeguards for operators	CO 6	T1:6.5 R2:3.7
25	Safety during installation	CO 6	T1:7.1-7.2 R2:4.1-4.6
26	Hazardous zones	CO 7	T1:7.1-7.2 R2:4.1-4.6
27	Class 0,1 and 2	CO 7	T1:7.2-7.3 R2:4.1-4.6
28	Spark	CO 7	T1:7.2-7.3 R2:4.1-4.6

29	Flashovers	CO 7	T1:7.2-7.3 R2:4.1-4.6
30	Corona discharge	CO 8	T1:7.4 R2:6.11
31	Functional requirements	CO 8	T1:7.4 R2:6.11
32	Specifications of electrical plants	CO 8	T1:8.1 R2:7.2
33	Equipment's for hazardous locations	CO 8	T1:8.2 R2:7.6
34	Classification of equipment enclosure for various hazardous gases and vapours	CO 9	T1:8.2 R2:7.8
35	Classification of equipment/enclosure for hazardous locations.	CO 9	T1:8.2 R2:7.8
36	Total quality control and management	CO 9	T1:8.2 R2:7.8
37	Importance of high load factor	CO 9	T1:8.3 R2:7.2
38	Disadvantages of low power factor	CO 10	T1:8.3 R2:7.2
39	Causes of low P.F	CO 10	T1:7.9 R2:7.2
40	Power factor improvement	CO 10	T1:7.9 R2:7.2
41	Equipment's	CO 10	T1:9.2 R2:7.2
42	Importance of P.F. improvement	CO 10	T1:9.2 R2:7.2

Signature of Course Coordinator **HOD,EEE**
Ms. A. Srikanth, Assistant Professor

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**High Voltage Engineering**				
Course Code	AEEB47				
Program	B. Tech.				
Semester	VII				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mrs K Harshini, Assistant Professor,EEE				

I COURSE OVERVIEW:

This course enables Planning, operation and Testing of High voltage Electrical devices. High voltage engineering deals with different mediums of insulation and break down Phenomenon, generation of high DC and AC voltage, measurement Techniques of high AC and DC voltages, testing of insulation under all types of conditions using generated high DC and AC voltages.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS006	I	Engineering Physics
B.Tech	AEE006	III	Electro Magnetic Field Theory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
High Voltage Engineering	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE 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
66.7 %	Understand
33.3%	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
50%	50%	-

VI COURSE OBJECTIVES:

The students will try to learn:

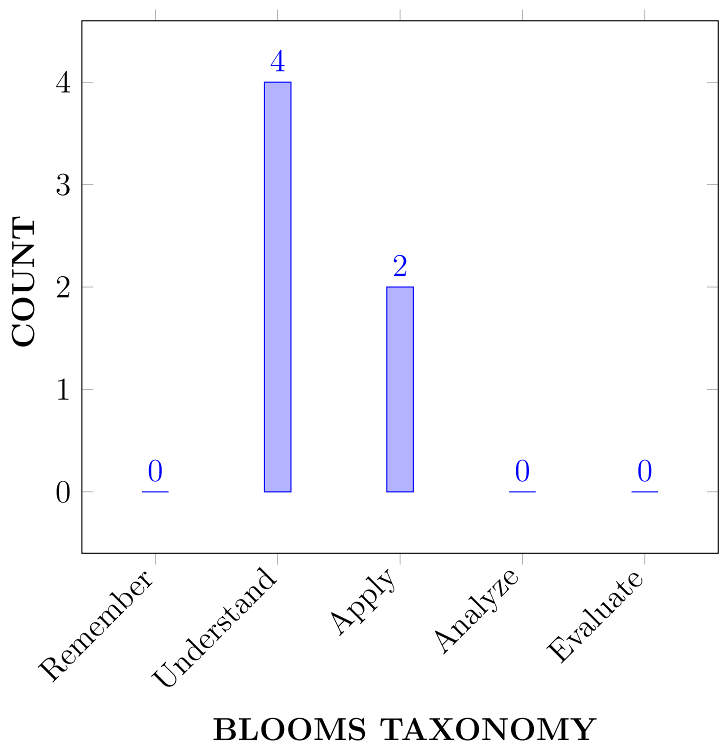
I	The breakdown phenomena in gas, liquid and solid dielectric materials used in the high voltage devices.
II	The circuit design and operation for generation of high DC, AC and impulse voltages.
III	The different methods for measurement and testing of equipments used in the high voltage engineering.

VII COURSE OUTCOMES:

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

CO 1	**Infer** the protection methods against over voltages and working of lightning arrester for protecting various equipments in power system.	Understand
CO 2	**Illustarte** the breakdown phenomena of various types of dielectric materials to measure their strength in an insulating medium.	Understand
CO 3	**Explain** the methods of generation of impulse voltage and currents for controlling and triggering of impulse generators.	Understand
CO 4	**Apply** analytical and numerical techniques of measuring voltages and currents accurately calculations in high voltage systems.	Apply
CO 5	**Make use of** various nondestructive test techniques used for testing of high voltage electrical apparatus.	Apply
CO 6	**Outline** the principles of insulation co-ordination on high voltage and Extra high voltage power systems for suppressing the over voltages	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	2	CIE/Quiz/AAT
PO 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 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.	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 SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Design, develop fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	1	Research Paper / Quiz / AAT

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on the components of electrical drives with its converter topologies, for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	1	Research Paper / Quiz / 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 about the over voltages in power system for protecting electrical equipment knowledge of mathematics, science and engineering fundamentals.	2
	PO 2	Analyze complex Problems on charge formation techniques using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 6	Understands the concept of charge formation techniques and over voltages their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of over voltages to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of over voltages of system should be able to communicate effectively on engineering activities	2
	PO 12	Recognize the types of over voltages and charge formation is what we use in daily life through the preparation and ability in personal development.	3
	PSO 1	Design and operate over voltage controlling techniques in electrical systems in order to protect the system.	1
	PSO 2	Understands over voltage and charge formation of a system involving transmission and distribution of Electrical Energy	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	**PO 1**	Provide knowledge about dielectric material characteristics and classify of breakdown strength systems with basic fundamentals of science, and engineering fundamentals.	3
	PO 2	Analyze complex Problems on breakdown strength systems using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Identify and manage their with stand levels of various dielectric materials that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	6
	PO 6	Understands the concept of classify of breakdown strength systems and dielectric material their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 10	Understands the basics classify of breakdown strength systems should be able to communicate effectively on engineering activities	2
CO 3	**PO 1**	Summarize various techniques used for generating impulse voltages with the knowledge of mathematics, science and engineering fundamentals.	3
	PO 2	Analyse complex Problems on generating impulse voltages using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Explain the controlling and generation of impulse voltage and current for triggering of impulse generator the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	7
	PO 6	Understands the concept of generating impulse voltages their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of generating impulse voltages over voltages to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of generating impulse voltages should be able to communicate effectively on engineering activities	2
	PSO 1	Design and operate generating impulse voltages in electrical systems in order to protect the system.	1
	PSO 2	Recognize the importance of various generating impulse voltages and currents need of testing various apparatus.	1
CO 4	**PO 1**	Estimate the value of measurement of over voltages for protecting the electrical apparatus using the principles of mathematics and engineering fundamentals.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Analyze complex Problems on breakdown strength systems using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Design the solution for problems of harmonics and resonance conditions	7
	PO 6	Understands the concept of measurement of impulse voltages their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of measurement of impulse voltages over voltages to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of measurement of impulse voltages should be able to communicate effectively on engineering activities	2
	PSO 1	Design and operate measurement of impulse voltages in electrical systems in order to protect the system.	1
	PSO 2	Summarize and controlling of impulse waves in power system.	1
CO 5	**PO 1**	Summarize power quality issues mitigation techniques use for non disruptive testing's with the help of basic fundamentals of mathematics science and engineering fundamentals.	3
	PO 2	Analyze complex Problems on power quality issues mitigation techniques using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Utilize various non disruptive test techniques of high voltage that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	6
	PO 6	Understands the concept of disruptive test techniques of high voltage their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of disruptive test techniques of high voltage to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PO 10	Understands the basics of mdisruptive test techniques of high voltage should be able to communicate effectively on engineering activities	2
	PSO 1	Design and operate transient conditions in electrical systems in order to protect the system.	1
	PSO 2	Summarize the transient conditions with the required electrical power system.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	**PO 1**	Outline the control and protection and their impact on power systems with the help of basic fundamentals of mathematics science and engineering fundamentals.	3
	PO 2	Analyze complex Problems on insulation of extra high voltage power system using first principles of mathematics, natural sciences, and engineering sciences.	3
	PO 3	Relate the insulation coordination and extra high voltage power system for protecting the system the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	6
	PO 6	Understands the concept of insulation coordination and extra high voltage power system for protecting their applications to the contextual knowledge to assess societal engineering practice.	3
	PO 8	Knowledge of disruptive test techniques of high voltage to use their application to professional ethics and responsibilities and norms of the Engineering practice	3
	PSO 1	Focus on the protection for operation and control of over voltages and extra voltages system.	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	7	-	-	-	3	-	2	-	2	-	2	2	3	-
CO 2	3	3	7	-	-	3	-	-	-	3	-	-	-	-	-
CO 3	3	5	7	-	-	3	-	1	-	2	-	-	3	3	-
CO 4	3	4	7	-	-	3	-	2	-	2	-	-	3	4	-
CO 5	3	5	7	-	-	3	-	2	-	2	-	-	3	4	-
CO 6	3	4	3	-	-	4	-	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	66.7	70	-	-	-	60	-	66.7	-	40	-	25	40	9.09	
CO 2	100	30	70	-	-	60	-	100	-	60	-	-	-	-	-
CO 3	100	50	70	-	-	60	-	33.3	-	40	-	-	20	18.2	-
CO 4	100	40	70	-	-	60	-	66.7	-	40	-	-	40	9.09	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 5	100	50	70	-	-	60	-	66.6	-	40	-	-	40	18.2	-
CO 6	100	40	30	-	-	80	-	33.3	-	-	-	-	20	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	2	-	-	-	2	-	1	-	1	-	1	2	1	-
CO 2	2	2	2	-	-	2	-	-	-	1	-	-	-	-	-
CO 3	3	2	2	-	-	2	-	1	-	1	-	-	1	2	-
CO 4	3	3	3	-	-	2	-	1	-	1	-	-	2	1	-
CO 5	3	2	2	-	-	2	-	1	-	1	-	-	2	2	-
CO 6	2	1	1	-	-	3	-	1	-	-	-	-	1	-	-
TOTAL	15	12	10	-	-	13	-	5	-	5	-	1	8	6	-
AVERAGE	2.5	2	1.6	-	-	2.2	-	1	-	1	-	1	1.6	1.5	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS
	Origin of over voltages: Causes of over voltages and their effects on power system, lightning, switching surges and temporary over voltages, corona and its effects, reflection and refraction of travelling waves, Protection against over voltages.

MODULE II	**DIELECTRIC BREAKDOWN**
	Breakdown of dielectrics: Gaseous breakdown in uniform and non uniform fields, corona discharges, breakdown of vacuum, conduction and breakdown in pure and commercial liquids, maintenance of oil quality, breakdown mechanisms in solid and composite dielectrics.
MODULE III	**GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS**
	High AC, DC voltages and currents: Generation of high DC, AC and impulse voltages and currents. Triggering: Triggering and control of impulse generators.
MODULE IV	**MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS**
	High voltage and current measurement: High resistance with series ammeter, dividers, resistance, capacitance and mixed dividers, peak voltmeter, generating voltmeters, capacitance voltage Transformers, electrostatic voltmeters, sphere gaps, high current shunts, digital techniques in high voltage measurement.
MODULE V	**HIGH VOLTAGE TESTING AND INSULATION COORDINATION**
	Testing: High voltage testing of electrical power apparatus as per international and Indian standards, power frequency, impulse voltage and dc testing of insulators, circuit breakers, bushings, isolators and transformers, insulation coordination.

TEXTBOOKS

1. 1. S Naidu, V Kamaraju, "High Voltage Engineering", Tata McGraw-Hill, 5th Edition, 2013.

2. E Kuffel, W S Zaengl, J Kuffel, "High voltage Engineering fundamentals", Newnes, 2nd Edition Elsevier, New Delhi, 2005.

3. Subir Ray, "An Introduction to High Voltage Engineering", PHI Learning Private Limited, New Delhi, 2nd Edition, 2013

REFERENCE BOOKS:

1. L L Alston, "High Voltage Technology", Oxford University Press, 1st Indian Edition, 2011.

2. C L Wadhwa, "High Voltage Engineering", New Age International Publishers, 3rd Edition, 2010

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
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	Causes of over voltages and their effect	CO 1	T1:1.1
2	Understand switching surges, temporary over voltages.	CO 1	T1:1.1
3	Corona and its effects.	CO 1	T1:1.4-1.6
4	Reflection and refraction of travelling waves	CO 1	T1: 2.4
5	Protection against over voltages	CO 1	T1:2.2
6	Understand Natural causes for over voltages	CO 1	T1:2.2
7	Characteristics of the lightning strokes	CO 1	T1:2.4
8	Switching over voltages	CO 1	T1:2.2
9	Various methods for protection of Transmission lines against Lightning over voltages	CO 1	T1:2.5
10	Surge diverters and Surge modifiers	CO 1	T1:2.5
11	Discuss gases as insulating media, collision process	CO 2	T1: 3.1-3.2
12	Explain Primary ionization process.	CO 2	T1: 1..2
13	Corona discharges, breakdown of vacuum	CO 2	T1 :2.6
14	Breakdown of solid dielectrics	CO 2	T1 :2.6
15	Breakdown in pure and commercial liquids.	CO 2	T1 :5.1-5.2
16	Secondary Ionization process.	CO 2	T1 :5.1-5.2
17	Statement of Townsend's criteria	CO 2	T1: 5.3
18	Circuits for Generation of High Direct Current Voltages.	CO 3	T1: 5.3
19	Discuss Methods to Generation of Impulse Voltages.	CO 3	T1: 5.3
20	Impulse voltages and currents	CO 3	T1: 5.4
21	Full& half Wave rectifier circuit for high DC voltage generation	CO 3	T1: 5.5
22	Cascade transformer to generate high AC voltage	CO 2	T1: 5.5
23	Principle of Hall generator	CO 4	T1:5.8
24	Tripping control of impulse generators.	CO 4	T1: 6.1 -6.2
25	Measurement of high AC Voltages.	CO 4	T1: 6.3 -6.5
26	Measurement of High Direct Current voltages.	CO 4	T1: 7.1 -7.2

27	Measurement of High impulse voltages	CO 4	T1: 7.3
28	Extra High Voltage power systems.	CO 5	T1: 5.6
29	Measurement of D.C Resistivity.	CO 5	T1: 8.1 -8.2
30	Capacitance Voltage Transformers	CO 5	T1: 8.2
31	Electrostatic Voltmeters	CO 5	T1: 8.4
32	Digital Techniques in High Voltage Measurement	CO 5	T1: 8.4
33	Sphere Gaps and High Current Shunts.	CO 4	T1: 9.1-9.4
34	High voltage testing of electrical power apparatus	CO 4	T1: 8.1 -8.2
35	Observe breakdown phenomenon of circuit breakers.	CO 6	T1: 12.1-12.2
36	Power Frequency	CO 6	T1: 12.3-12.4
37	Impulse Voltage and DC Testing Of Insulators	CO 6	T1: 12.4
38	Importance of insulation co-ordination in power system.	CO 6	T1: 12.6
39	Partial discharge test on high voltage cables	CO 6	T1:12.7
40	Transformers insulation coordination.	CO 5	T1:10.3
PROBLEM SOLVING/ CASE STUDIES			
41	Find the voltage rise at the junction due to the surge	CO 1	R1: 2.6
42	Determine the value of the reflected and refracted voltages and current Waves at the junction	CO 1	R1: 2.6
43	Determine the critical descriptive voltage at which corona will occur.	CO 1	R1: 3.2
44	The breakdown strength of air be for small gaps and large gaps	CO 2	R1: 3.2
45	Develop the streamer theory of gas insulation.	CO 2	R1: 4.4 Pg No 195-198
46	Differentiate between short term breakdown and from long term breakdown in composite Di-electric	CO 2	R1: 4.4 Pg No 198-209
47	Calculate ripple percentage, Voltage regulation and optimum number of stages for minimum regulation.	CO 3	R1:5.3 Pg No 285-292
48	Find the wavefront and wave Tail times of the impulse wave produced	CO 3	R1:6.4 Pg No 339-347
49	Calculate the peak current and waveshape of the output current of the generator	CO 3	R1:7.3 Pg No 417-427
50	Determine the value of R and C if the time constant of RC circuit given.	CO 3	R1:7.4 Pg No 452-465

51	Determine the mutual inductance of coil R and C of the integrating circuit.	CO 3	R1:7.3 Pg No 417-427
52	Determine the capacitance of the generating voltmeter	CO 4	R1:10.3 Pg No 594-597
53	Outlinethe relationship betweeni) Disruptive discharge voltage (ii)Creepage distance (iii) Impulse voltage CO 5 (iv)100%flashover voltage.	CO 4	R1: 10.4 Pg No 661-671
54	Draw Chubb-Fortescue Circuit for measurement of peak value of AC voltages	CO 5	R1: 9.2
55	Estimate the values of mutual inductance, resistance, and capacitance to be connected	CO 6	R1: 10.7 Pg No 630-639
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Lighting Strokes, Ferranti Effect, Air Density Factor, Travelling Wave	CO 1	T1: 2.4
57	Thermal breakdown, Electro Chemical Breakdown, electro negative gases, Townsend's second ionization co-efficient	CO 2	T1: 3.1-3.2
58	Voltage Multiplier Circuit, transient voltage, voltage doublers Circuit.	CO 3	T1: 6.3 -6.5
59	Capacitance Voltage Dividers, Current Transformers, potential Dividers.	CO 4	T1: 8.1 -8.2
60	Surge diverter, Partial discharge, Disruptive discharge voltage.	CO 5, CO 6	T1: 12.3-12.4
DISCUSSION OF QUESTION BANK			
61	Various methods to control switching over voltages, lightning arrestor, Corona discharge	CO 1	T1: 2.4
62	Townsend's current growth equation, Streamer theory, breakdown strength of air	CO 2	T1: 3.1-3.2
63	Maximum output voltage of The generator, ripple percentage, Resonant transformer, Voltage regulation, COCK-ROFTWALTON	CO 3	T1: 6.3 -6.5
64	Measurement of high voltages, Capacitance of the generating voltmeter, Generating voltmeter	CO 4	T1: 8.1 -8.2
65	High Voltage Tests, Impulse testing, power frequency tests	CO 5, CO 6	T1: 12.3-12.4

Signature of Course Coordinator **HOD,EEE**

Mrs K Harshini, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF(s)
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences **(Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 **(Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

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

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Power Quality and FACTS**				
Course Code	AEEB49				
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. T. Ravi Babu, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB20	V	Power Electronics
B.Tech	AEEB22	VI	Power System Analysis

II COURSE OVERVIEW:

The course deals with the basic concepts of power quality problems. The Course also deals with the various issues affecting power quality, their production, monitoring and suppression. The reactive and active power management is discussed in association with FACTS controllers in electrical distribution systems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power Quality and FACTS	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
20%	Remember
20%	Understand
20%	Apply
40 %	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:

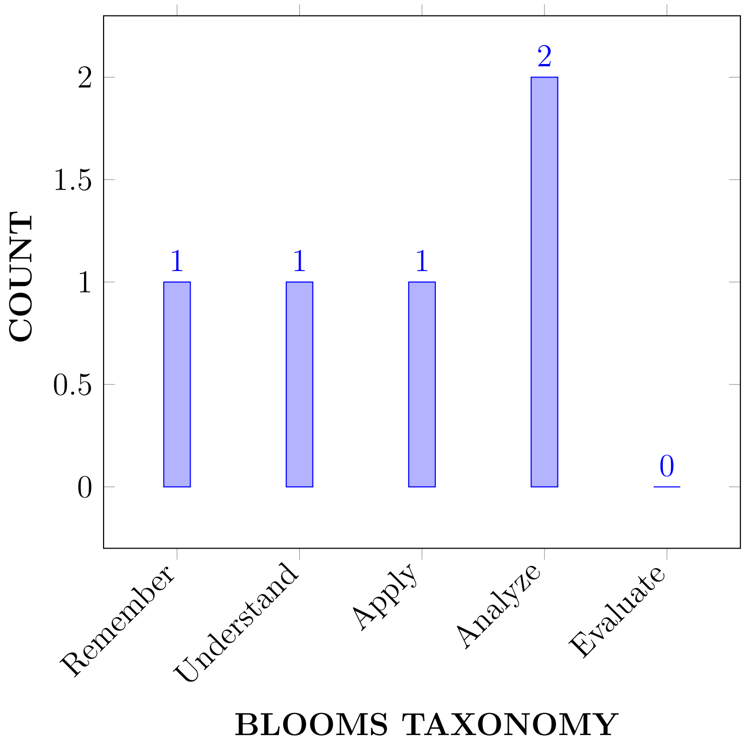
I	Gain knowledge on various sources of power quality disturbances, power quality issues.
II	The need of custom power devices for measure the power quality.
III	The concept, types, and applications of FACTS controllers in power transmission systems.
IV	The various control strategies and functioning of series and shunt compensators to improve the power quality.
V	The suitable custom power devices for enhancement of power quality.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the sources of various power quality issues and their impact in distribution system.	Apply
CO 2	**Analyze** the methodologies and control strategies for enhancing quality of power in sensitive loads with various custom power devices	Analyze
CO 3	**Illustrate** the types of FACTS controllers for enhancing the power transfer capabilities for stable operation of power system.	Understand
CO 4	**Select** the various types of compensators with its control schemes for improving quality of power in transmission system.	Remember
CO 5	**Analyze** the application of FACTS devices for power flow control and stability improvement.	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

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	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.	3	SEE/CIE/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	SEE/CIE/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	2	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development	2	-
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.	2	-

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Applyl** the knowledge of mathematics, science, engineering fundamentals for identify the sources of various **power quality problems in distribution system.**.	2
	PO 2	**Review** research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics for Understand the factors that causes the harmonics and their effect **on the power system.**.	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 2	**Apply** the Components of Electrical Drives with its Converter topologies **electrical power in power systems**	4
CO 2	PO 1	**Explain** the operating principles of renewable energy sources using **science and engineering fundamentals**	2
	PSO 2	**Apply** the knowledge of science, engineering fundamentals in order to analyze the methodology to improve the power quality for sensitive loads by various mitigating custom power devices. **by various mitigating custom power devices.**.	4
CO 3	PO 1	**Recall** power flow in transmission lines for stable operation of power systems for **using principles of mathematics, science and engineering fundamentals.**.	2
	PO 2	**Understand** the reactance, load impedance performance of the overall electric power system for **analyzing the behavior of complex electrical components.**.	4
	PSO 2	**Understand**the importance of controllers **according to the necessities**.	4
CO 4	PO 1	**Demonstrate** the Static VAR Compensator, its configuration **using basics engineering sciences**.	2
	PO 2	**Analyze** the encompassing capabilities of voltage regulation, series compensation, and phase shifting **in electrical components.**.	4
	PO 3	**Mode** l the SSSC involves power flow Studies which include the calculation of bulbar voltage, branch loadings, and real, reactive transmission losses.**according to the necessities.**	6
	PSO 3	**Understand** the importance of controllers **according to the necessities.**.	4
CO 5	PO 1	**Recall** theknowledge about the real and reactive power flow in the lines in order to maximize the power transmission **using basics of mathematics and engineering sciences.**.	2
	PO 2	**Understand** the importance of controllers **according to the necessities.**.	4
	PO 5	**Analyze** the Static Synchronous Compensator (STATCOM) and Thyristor Controlled Series Capacitor (TCSC) **for load flow and transient stability studies analyzing the behavior of complex electrical components.**	1
	PSO 3	**Outline** Simulation control techniques to requirements **of the employer**.	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	6	-	-	-	-	-	-	-	-	-		-	4	-
CO 2	2	-	-	-	-	-	-	-	-	-	-	-	-	4	-
CO 3	2	4	-	-	-	-	-	-	-	-	-		-	4	-
CO 4	2	4	6	-		-	-	-	-	-	-		-	-	4
CO 5	2	4	-	-	1	-	-	-	-	-	-		-	-	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	66.6	60.0	-	-	-	-	-	-	-	-	-		-	36.3	-
CO 2	66.6	-	-	-	-	-	-	-	-	-	-	-	-	36.3	-
CO 3	66.6	40.0	-	-		-	-	-	-	-	-		-	36.4	-
CO 4	66.6	40.0	54.5	-		-	-	-	-	-	-		-	-	57.1
CO 5	66.6	40.0		-	100	-	-	-	-	-	-		-	-	57.1

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	-
CO 2	3	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 3	3	1	-	-		-	-	-	-	-	-		-	1	-
CO 4	3	1	2	-		-	-	-	-	-	-		-	-	2
CO 5	3	1	-	-	3	-	-	-	-	-	-		-	-	2
TOTAL	15	6	2	-	3	-	-	-	-	-	-	-	-	3	4
AVERAGE	3	1.5	2	-	3	-	-	-	-	-	-	-	-	1	2

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	-

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**POWER QUALITY ISSUES IN DISTRIBUTION SYSTEMS**
	Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency, unbalance, sags, swells, interruptions, wave-form distortions: harmonics, noise, notching, dc offsets, fluctuations, flicker and its measurement, Tolerance of Equipment: CBEMA curve.
MODULE II	**CUSTOM POWER DEVICES**
	Dynamic Voltage Restorer: Working Principle and control strategies, harmonics and unbalance mitigation in distribution systems using DSTATCOM and shunt active filters, unified power quality conditioner (UPQC), working principle, capabilities and control strategies.
MODULE III	**FACTS CONCEPTS**
	Solar:Basics of AC transmission, principles of conventional reactive power compensators. Introduction to FACTS, flow of power in AC parallel paths, meshed systems, basic types of FACTS controllers, definitions of FACTS controllers, brief description of FACTS controllers.
MODULE IV	**STATIC SHUNT AND SERIES COMPENSATORS**
	Shunt compensation - objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators- SVC, STATCOM, SVC and STATCOM comparison. Series compensation, objectives of series compensation, thyristor switched series capacitors (TCSC), static series synchronous compensator (SSSC), power angle characteristics, basic operating control schemes.
MODULE V	**APPLICATION OF FACTS DEVICES**
	Application of FACTS devices for power-flow control and stability improvement. Simulation example of power swing damping in a single-machine infinite bus system using a TCSC. Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM.

TEXTBOOKS

1. Narain G.Hingorani, Laszi Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE press, Delhi, 2nd Edition, 2001.

2. Roger C Dugan, Mark F Mc Granaghan, Surya Santoso, H.WayneBeaty, Electrical Power Systems Quality, TMH Education Pvt. Ltd., 3rd Edition, 2012.

REFERENCE BOOKS:

1. Math H J Bollen, “Understanding Power quality problems”, IEEE Press, 2nd Edition, 2007.

2. Arindam Ghosh,Gerard Ledwich , “Power Quality Enhancement using Custom Power Devices”, Kluwer Academic Publishers, 2nd Edition, 2002.

3. Mohan Mathur, Rajiv K Varma, “Thyristor - based FACTS Controllers for Electrical Transmission Systems”, A John Wiley and Sons Publications, 2nd Edition, 2002.

WEB REFERENCES:

1. https://pdfroom.com
2. https://www.technicalbookspdf.com

COURSE WEB PAGE:

1. https://www.iare.ac.in/sites/default/files/Courses-description/EEE- Power Quality and FACTS

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	-	lms.iare.ac.in
	CONTENT DELIVERY (THEORY)		
2	Introduction to Power Quality.	CO1	T2: 1.1
3	Power Quality issues, evaluations.	CO1	T2: 1.8
4	Different types of Transients.	CO1	T2: 2.3
5	Transient over voltages.	CO1	T2: 2.4
6	Harmonics generated in the transmission systems.	CO1	T2: 3.3
7	Voltage sag, Voltage Swells.	CO1	T2: 3.4
8	Long Interruptions.	CO1	T2: 3.5
9	Short Interruptions.	CO1	T2: 3.6
10	Voltage Fluctuations, flicker and its measurement.	CO1	T2: 5.1
11	Tolerance of Equipment: CBEMA curve.	CO1	T2: 5.2
12	Dynamic Voltage Restorer: Working Principle	CO2	R 2:9.1
13	Control strategies of Dynamic Voltage Restorer	CO2	R 2:9.3
14	Distribution Static Synchronous Compensator(D-STATCOM): Topology, Principle of Operation	CO2	R 2:8.1
15	harmonics and unbalance mitigation in distribution systems using DSTATCOM	CO2	R 2:8.5 R2:3.5
16	Active Filtering System	CO2	R 2:9.5
17	Series Active Power Filter (SAPF)	CO2	R 2:9.7
18	Parallel Active Power Filter (PAPF)	CO2	R 2:9.8
19	Unified Power Quality Conditioner (UPQC) working principle	CO2	R 2:10.1
20	Unified Power Quality Conditioner (UPQC)capabilities and control strategies	CO2	R 2:10.4
21	Review off Basics of Power Transmission Networks	CO2	T1:1.1
22	Principles of conventional reactive power compensators.	CO2	T1:1.2
23	Introduction to FACTS and Power Systems Distribution.	CO3	T1:1.3

24	Power flow in parallel paths.	CO3	T1:1.2.1
25	Basic Types of FACTS controllers	CO3	T1:1.6
26	Definitions of FACTS controllers.	CO3	T1:1.7.1
27	Brief description of FACTS controllers	CO3	T1:1.7.2
28	Objectives of shunt compensation	CO4	T1:5.1
29	Methods of controllable VAR generation	CO4	T1:5.2
30	static VAR compensators- SVC, STATCOM	CO4	T1:5.3
31	Comparion between STATCOM and SVC	CO4	T1:5.4
32	V-I Characteristics of SVC and STATCOM	CO4	T1:5.52
33	SVC and STATCOM functions under dynamic situation for shunt compensation along with appropriate diagrams and characteristics	CO4	T1:6.1
34	Objectives of series compensation	CO4	T1:6.1
35	Thyristor Switched Series Capacitors (TSSC)	CO4	T1:6.2.2
36	Static Synchronous Series Compensator (SSSC)	CO4	T1:6.2.2
37	Transmitted power versus Transmission Angle characteristic	CO4	T1:6.3.2
38	Application of FACTS devices for power-flow control and stability improvement	CO5	T1:10.1
39	Simulation example of power swing damping in a single-machine infinite bus system using a TCSC	CO5	T1:10.1
40	Introduction and planning Aspects	CO5	T1:10.2.1
41	Functional Specifications	CO5	T1:10.2.2
42	Design and Operarional Aspects	CO5	T1:10.2.3
43	Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM	CO5	T1:10.3
44	Introduction and planning Aspects	CO5	T1:10.3.1
45	STATCOM design summary	CO5	T1:10.3.2
46	Steady-State,Dynamic Performance	CO5	T1:10.3.3
DISCUSSION OF DEFINITION AND TERMINOLOGY			
47	Definition of Power Quality	CO1	T2: 1.1
48	Define shunt active filter	CO2	R 2 :9.8
49	Define FACTS	CO3	T1:1.1
50	Define Series Compensation?	CO4	T1:5.4
51	Demonstrate the various FACTS applications to steady state power system problems	CO5	T1:10.3
DISCUSSION OF QUESTION BANK			
52	Module I: Power quality terms	CO1	T2: 1.1
53	Module -II: D-STATCOM,DVR	CO2	R 2: 9.1
54	Module - III:Types of FACTS controllers	CO3	T1: 1.1
55	Module - IV:SVC,STATCOM,TSSC and SSSC	CO4	T1:6.1
56	Module - V:Simulatiomn of STATCOM,TCSC devices	CO5	T1:10.2

Course Coordinator **HOD,EEE**
Mr T. Ravi Babu, Assistant Professor

ANNEXURE - I

KEY ATTRIBUTES FOR ASSESSING PROGRAM OUTCOMES

PO Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
PO 1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems **(Engineering Knowledge).** Knowledge, understanding and application of 1. Scientific principles and methodology. 2. Mathematical principles. 3. Own and / or other engineering disciplines to integrate / support study of their own engineering discipline.	3
PO 2	Identify, formulate, review research literature, and analyse complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences (**Problem Analysis).** 1. Problem or opportunity identification 2. Problem statement and system definition 3. Problem formulation and abstraction 4. Information and data collection 5. Model translation 6. Validation 7. Experimental design 8. Solution development or experimentation / Implementation 9. Interpretation of results 10. Documentation	**10**
PO 3	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 (**Design/Development of Solutions).** 1. Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues 2. Understand customer and user needs and the importance of considerations such as aesthetics 3. Identify and manage cost drivers 4. Use creativity to establish innovative solutions	**10**

	5. Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal 6. Manage the design process and evaluate outcomes. 7. Knowledge and understanding of commercial and economic context of engineering processes 8. Knowledge of management techniques which may be used to achieve engineering objectives within that context 9. Understanding of the requirement for engineering activities to promote sustainable development 10. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues	
PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (**Conduct Investigations of Complex Problems).** 1. Knowledge of characteristics of particular materials, equipment, processes, or products 2. Workshop and laboratory skills 3. Understanding of contexts in which engineering knowledge can be applied (example, operations and management, technology development, etc.) 4. Understanding use of technical literature and other information sources Awareness of nature of intellectual property and contractual issues 5. Understanding of appropriate codes of practice and industry standards 6. Awareness of quality issues 7. Ability to work with technical uncertainty 8. Understanding of engineering principles and the ability to apply them to analyse key engineering processes 9. Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modeling techniques 10. Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems 11. Understanding of and ability to apply a systems approach to engineering problems.	**11**
PO 5	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 **(Modern Tool Usage).** 1. Computer software / simulation packages / diagnostic equipment / technical library resources / literature search tools.	**1**

PO 6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (**The Engineer and Society).** 1. Knowledge and understanding of commercial and economic context of engineering processes 2. Knowledge of management techniques which may be used to achieve engineering objectives within that context 3. Understanding of the requirement for engineering activities to promote sustainable development 4. Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues 5. Understanding of the need for a high level of professional and ethical conduct in engineering.	**5**
PO 7	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (**Environment and Sustainability).** Impact of the professional Engineering solutions (Not technical) 1. Socio economic 2. Political 3. Environmental	**3**
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (**Ethics).** 1. Comprises four components: ability to make informed ethical choices, knowledge of professional codes of ethics, evaluates the ethical dimensions of professional practice, and demonstrates ethical behavior. 2. Stood up for what they believed in 3. High degree of trust and integrity	**3**
PO 9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (**Individual and Teamwork).** 1. Independence 2. Maturity – requiring only the achievement of goals to drive their performance 3. Self-direction (take a vaguely defined problem and systematically work to resolution) 4. Teams are used during the classroom periods, in the hands-on labs, and in the design projects. 5. Some teams change for eight-week industry oriented Mini-Project, and for the seventeen -week design project.	**12**

	6. Instruction on effective teamwork and project management is provided along with an appropriate textbook for reference 7. Teamwork is important not only for helping the students know their classmates but also in completing assignments. 8. Students also are responsible for evaluating each other's performance, which is then reflected in the final grade. 9. Subjective evidence from senior students shows that the friendships and teamwork extends into the Junior years, and for some of those students, the friendships continue into the workplace after graduation 10. Ability to work with all levels of people in an organization 11. Ability to get along with others 12. Demonstrated ability to work well with a team	
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).** "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**
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 (**Project Management and Finance).** 1. Scope Statement 2. Critical Success Factors 3. Deliverables 4. Work Breakdown Structure 5. Schedule 6. Budget 7. Quality 8. Human Resources Plan 9. Stakeholder List 10. Communication 11. Risk Register 12. Procurement Plan	**12**

PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (**Life - Long Learning).** 1. Project management professional certification / MBA 2. Begin work on advanced degree 3. Keeping current in CSE and advanced engineering concepts 4. Personal continuing education efforts 5. Ongoing learning – stays up with industry trends/ new technology 6. Continued personal development 7. Have learned at least 2-3 new significant skills 8. Have taken up to 80 hours (2 weeks) training per year	**8**

ANNEXURE - II

KEY ATTRIBUTES FOR ASSESSING PROGRAM SPECIFIC OUTCOMES

PSO Number	PSO Statement / Key Competencies Features (KCF)	No. of KCF(s)
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization. 1. Operate, control and protect electrical power system. 2. Validate the interconnected power system. 3. Ensure reliable, efficient and compliant operation of electrical systems. 4. Familiarize the safety, legal and health norms in electrical system. 5. Adopt the engineering professional code and conduct.	**5**
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development. 1. Control the electric drives for renewable and non-renewable energy sources. 2. Fabricate converters with various components and control topologies. 3. Synthesis, systematic procedure to examine electrical components/machines using software tools. 4. Inspect, survey and analyze energy flow. 5. Control and manage the power generation and utilization. 6. Familiarize the safety, legal and health norms in electrical system. 7. Adopt the engineering professional code and conduct. 8. Explore autonomous power 9. Evolve into green energy and assess results 10. Realize energy policies and education 11. Potential contribution of clean energy for rural development.	**11**

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. Explicit software and programming tools for electrical systems. 2. Adopt technical library resources and literature search. 3. Model, program for operation and control of electrical systems. 4. Constitute the systems employed for motion control. 5. Interface automation tools. 6. Research, analysis, problem solving and presentation using software aids. 7. Programming and hands-on skills to meet requirements of global environment.	**7**

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**HVDC TRANSMISSION**				
Course Code	AEEB43				
Program	B.Tech				
Semester	VII	EEE			
Course Type	Proffesional Elective				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms. B. Manogna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB20	V	Power Electronics
B.Tech	AEEB22	VI	Power System Analysis

II COURSE OVERVIEW:

This subject deals with the importance of HVDC transmission, analysis of HVDC Converters, Harmonics and Filters, Reactive power control and Power factor improvements of the system. It also deals with basic modeling and analysis of HVDC system power flow regulation.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
HVDC Tansmission	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	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 Table: 1.

Percentage of Cognitive Level	Blooms Taxonomy Level
20%	Remember
40 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

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	Open Ended Experiment
50%	50%	-%

VI COURSE OBJECTIVES:

The students will try to learn:

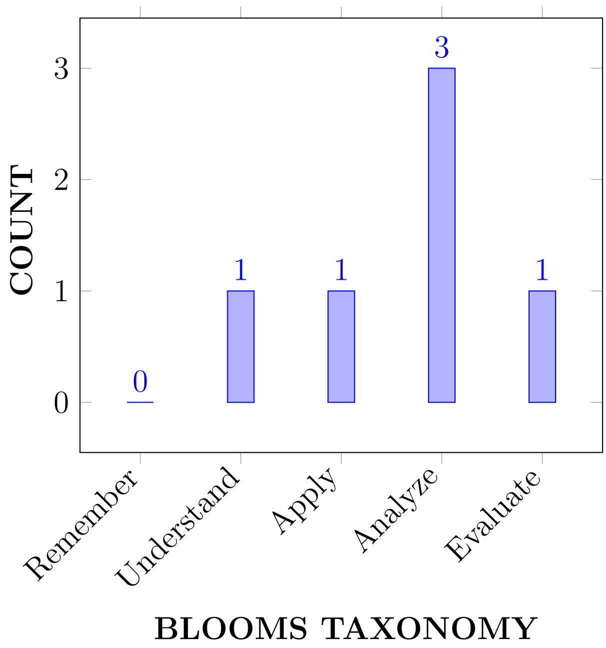
I	The basic concepts of HVDC system, components used in HVDC system and advantages of DC over AC transmission systems.
II	The analysis of Line Commuted Converter and Voltage Source Converter with and without effect of commutation overlap.
III	The functioning of components of HVDC system and various controlling techniques for stability enhancement in HVDC links.
IV	The modelling and interactions of AC/DC system and know the operation and control of various MTDC systems.

VII COURSE OUTCOMES:

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

CO 1	**Identify** economic and technical advantages of HVDC system in transmission system.	Apply
CO 2	**Analyze** Current Source Converters and Voltage Source Converters in HVDC transmission system.	Analyze
CO 3	**Evaluate** performance metrics of six and twelve pulse converters for HVDC converter configuration.	Evaluate
CO 4	**Analyze** real and reactive power control techniques for controlling the firing angle of converters.	Analyze
CO 5	**Understand** voltage stability enhancement using HVDC for power transmission between unsynchronized AC systems..	Understand
CO 6	**Analyze** multi- terminal and modular multi- terminal DC systems for high voltage and high-power 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.
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/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	2	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/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	AAT

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 1	Exploit the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work.	3	Assignment and Seminars

PSO 2	Identify the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering, and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally.	2	Presentation on real-world problems

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
CO 1	PO 1	Recollect (knowledge) the basic concept of generation of electricity and (understand) the importance fundamentals of Alterating and Direct currents in **mathematics and science**.	3
	PO 2	**Identify** the optimum problem in AC transmission system and analyse economic, technical and reliability advantages **using the first principles of mathematics and engineering sciences**.	3
CO 2	PO 1	**Understand** the Line commuted converters and Voltage Source converters and apply the Engineering fundamentals using **principles of mathematics science and engineering fundamentals**.	3
	PO 2	**Model** converter circuits by using **complex Engineering problems** Analyses and develop the solution for conversion process using **using principles of mathematics and engineering sciences**.	2
CO 3	PO 1	**Understand** the concepts of six pulse and twelve pulse converters using **the knowledge of mathematics, science, and engineering fundamentals**.	2

	PO 3	**Apply** the knowledge of three phase bridge converters in **designing** Graetz circuit using specific assumptions and analyzing the advantage of 12 pulse converter over 6 pulse considering the **complex problems** of harmonics.	2
	PSO 1	**Make use of experimental tools for innovation** to assess the behaviour of of converter stations **to obtain desired knowledge for higher studies**.	2
CO 4	PO 3	**Identify** the need for reactive power requirement **(complex problem)** caused due to line commutation of converters and **design system components** (reactive power sources) for better voltage control	2
	PO 5	Understand the characteristics of inverter and the need for **appropriate VAR compensation** to meet the reactive power requirement and **select and model** the proper components (static var systems) for better voltage control	2
CO 5	PO 1	**Understand** the basic concepts voltage and frequency control applying the **knowledge of engineering fundamentals** for obtaining full control over power transmission.	3
	PO 3	**Recognize** the need for stability enhancement in HVDC systems by **modelling the controllers**, expressing the controller equations and obtain solutions for complex engineering problems.	3
	PSO 2	**Analyze** the inability of a power system to maintain acceptable voltages in all busses and applying the **knowledge of high voltage engineering** design techniques to enhance voltage stability.	2
CO 6	PO 1	**Understands** the concepts of multi terminal high voltage DC transmission system for flexible control of active and reactive power for **applying in Scientific principles and methodology.**	2
	PO 2	**Analyze** the capacitor location and Reactive power control and design **solutions for complex engineering problems**.	3

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	3	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 3	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-

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 4	-	-	2	-	2	-	-	-	-	-	-		-	-	-
CO 5	3	-	3	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	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	30	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	100.0	20.0	-	-	-	-	-	-	-	-	-	-	100	-	-
CO 3	66.7	-	20.0	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	30.0	-	20.0	-	-	-	-	-	-		-	-	-
CO 5	100.0	-	30.0	-	-	-	-	-	-	-	-	-	-	100	-
CO 6	66.7	30.0	-	-	-	-	-	-	-	-	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	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	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 3	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	2	-	2	-	-	-	-	-	-		-	-	-
CO 5	3	-	3	-	-	-	-	-	-	-	-	-	-	2	-
CO 6	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18	11	13	-	4		-	-	-	-	-	-	2	4	-
AVERAGE	2.5	2.7	2.6		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	X
Assignments	✓				

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**DC TRANSMISSION TECHNOLOGY**
	Introduction to HVDC transmission systems: Comparison of AC and DC transmission (economics, technical performance and reliability), components of a HVDC system, types of HVDC links, application of DC transmission, Line Commutated Converter and Voltage Source Converter based systems.
MODULE II	**ANALYSIS OF LINE COMMUTED AND VOLTAGE SOURCE CONVERTERS**
	Line Commutated Converters (LCCs): Six pulse converter, analysis neglecting commutation overlap, harmonics, twelve pulse converters: Inverter operation, effect of commutation overlap, expressions for average DC voltage, AC current and reactive power absorbed by the converters, Effect of commutation failure, misfire and current extinction in LCC links; Voltage Source Converters (VSCs): two and three - level VSCs. PWM schemes: selective harmonic elimination, sinusoidal pulse width modulation, analysis of a six pulse converter, equations in the rotating frame, real and reactive power control using a VSC.
MODULE III	**CONTROL OF HVDC SYSTEM**
	HVDC system control: Principles of link control in a LCC HVDC system, control hierarchy, firing angle controls: phase-locked loop, current and extinction angle control, starting and stopping of a link, higher level controllers power control, frequency control, stability controllers, reactive power control, principles of link control in a VSC HVDC system: power flow and DC voltage control, reactive power control, AC voltage regulation. Components of HVDC systems: Smoothing reactors, reactive power sources and filters in LCC HVDC systems DC line, corona effects, insulators, transient over-voltages, DC line faults in LCC systems, DC line faults in VSC systems, DC breakers, monopolar operation, ground electrodes.

MODULE IV	**STABILITY ENHANCEMENT USING HVDC CONTROL**
	Basic Concepts of stability enhancement: Power system angular, voltage and frequency stability, power modulation, basic principles, synchronous and asynchronous links, voltage stability problem in AC, DC systems.
MODULE V	**MTDC LINKS**
	Introduction to MTDC links: Multi-terminal and multi in-feed Systems, series and parallel MTDC systems using LCCs, MTDC systems using VSCs, modern trends in HVDC Technology and introduction to modular multi level converters.

TEXTBOOKS

1. 1. K R Padiyar, "HVDC Power Transmission Systems: Technology and system Interactions", New Age International (P) Limited, 1st Edition, 1999.

2. 2. S Rao, "EHVAC and HVDC Transmission Engineering and Practice", PHI, 3rd Edition, 1990.

REFERENCE BOOKS:

1. J Arrillaga, "High Voltage Direct Current Transmission", Peter Peregrinus Ltd., 1st Edition 1983.

2. E W Kimbark, "Direct Current Transmission", Vol.1, Wiley-Interscience, 1st Edition 1971.

3. E Uhlmann, "Power Transmission by Direct Current", B S Publications, 1st Edition, 1975.

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 Objectives, Course Outcomes, CO-PO Mapping, Blooms Taxonomy, CO Articulation Matrix		
	CONTENT DELIVERY (THEORY		
1	Understand the basic concepts of DC power transmission technology.	CO 1	T1:5-6
2	Analyse Economical advantages of HVDC transmission.	CO 1	T1: 25-26
3	Understand the technical and reliability advantages of DC over AC Transmission.	CO 1	T1: 26-28
4	Understand the layout of HVDC system and analyse Terminal equipment of HVDC	CO 1	T1: 26-28
5	Application of DC transmission system	CO 1	T1: 26-28
6	Reliability of HVDC systems, limitation of HVDC transmission	CO 1	T1: 30-32

7	Modern trends in DC transmission	CO 1	T3:312-318
8	Analyze different types of HVDC links	CO 1	T3:312-318
9	Understand the concepts of Line commuted converters and voltage source converters.	CO 4	T3:322-326
10	Analyze the working of LCC and VSC based HVDC system.	CO 2	T3:319
11	Choice of converter in HVDC systems.	CO 2	T2:11.5 R2:17.5
12	Analysis of 6 pulse converter with commutation overlap	CO 3	T2:11.5 R2:17.5
13	Analysis of 6 pulse converter without commutation overlap	CO 3	T1:84-85
14	Analysis of 12 pulse converter with commutation overlap	CO 3	T1:327-330
15	Analysis of 12 pulse converter without commutation overlap	CO 3	T1:327-330
16	Features of rectification circuit for HVDC transmission	CO 3	T1:327-330
17	Output voltage waveforms in rectification process	CO 3	T1:327-330
18	Output voltage waveforms in inverter operation	CO 3	T1:58-59
19	Analysis of two and thee pulse voltage source converters	CO 3	T1:58-59
20	Understand selective harmonic elimination.	CO 3	T1 :60-62
21	Analysis of various PWM schemes, Sinusoidal pulse width modulation.	CO 3	T1 :63-64
22	Real and reactive power control using VSC	CO 3	T1 :65-68
23	Principles of HDC link control	CO 3	T1:296
24	Analysis of firing angle controls of HVDC system.	CO 4	T2:383 – 385
25	Understand the concepts of starting and stopping of DC links	CO 4	T2:383 – 385
26	Analysis of various higher level controller in HVDC systems.	CO 4	T2:383
27	Understand the importance of smoothing reactors, reactive power sources and filters in LCC HVDC system.	CO 4	T1: 330-345
28	Analysis of DC line faults in LCC and VSC HVDC systems	CO 5	T2:337
29	Understand the concept of Power system angular stability	CO 5	T2:342-345
30	Analysis of voltage and frequency stability	CO 6	T2:342-345
31	Concepts of synchronous and asynchronous links in HVDC systems.	CO 6	T2:337
32	Understand the concepts of Multi terminal and multi infeed systems.	CO 6	T2:325-327

33	Analysis of series and parallel MTDC systems using LCC.	CO 4	T2:325-327
34	Analysis of series and parallel MTDC systems using LCC.	CO 4	T2:25
35	Planning for HVDC transmission, modern trends in DC transmission	CO 4	T2:26-28
36	Analysis of Modular multi level converter.	CO 5	T2:29-31
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Analyse Economical advantages of HVDC transmission.	CO 1	T1: 25-26
2	Analyze the working of LCC and VSC based HVDC system.	CO 2	T3:319
3	Analysis of 6 pulse converter with commutation overlap	CO 3	T2:11.5 R2:17.5
4	Analysis of 6 pulse converter without commutation overlap	CO 3	T1:84-85
5	Analysis of 12 pulse converter with commutation overlap	CO 3	T1:327-330
6	Analysis of 12 pulse converter without commutation overlap	CO 3	T1:327-330
7	Analysis of various PWM schemes, Sinusoidal pulse width modulation.	CO 3	T1 :63-64
8	Analysis of firing angle controls of HVDC system.	CO 4	T2:383 – 385
9	Analysis of various higher level controller in HVDC systems.	CO 4	T2:383
10	Analysis of series and parallel MTDC systems using LCC.	CO 4	T2:325-327
11	Analysis of series and parallel MTDC systems using LCC.	CO 4	T2:25
12	Analysis of Modular multi level converter.	CO 5	T2:29-31
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	List out the applications of HVDC?	CO 1	T1:5-6
2	What are the types of transmission system?	CO 1	T1:5-6
3	State the comparison of AC & DC transmission system?	CO 2	T3:319
4	What are the disadvantages in HVDC transmission?	CO 3	T2:11.5 R2:17.5
5	State the economic advantages in HVDC transmission?	CO 4	T2:325-327
6	What are the types of DC link?	CO 4	T2:325-327
7	What are the limitations of EHVAC transmission?	CO 5	T2:337
8	What are the types of dc links?	CO 6	T2:337
9	What are the assumptions made to simplify the analysis of Gratez circuit?	CO 5	T2:337
10	Mention the various modes of operation of rectifier characteristics.	CO 3	T2:11.5 R2:17.5
11	Mention the various modes of operation of inverter characteristics.	CO 3	T2:11.5 R2:17.5

12	Draw the diagram of 12 pulse converter circuit.	CO 6	T2:337
13	Why series and parallel operation of thyristor in HVDC transmission?	CO 6	T2:337
DISCUSSION OF QUESTION BANK			
1	DC TRANSMISSION TECHNOLOGY	CO 1,2	T1: 25-26
2	ANALYSIS OF LINE COMMUTED AND VOLTAGE SOURCE CONVERTERS	CO 3	T3:319
3	CONTROL OF HVDC SYSTEM	CO 4	T2:11.5
4	STABILITY ENHANCEMENT USING HVDC CONTROL	CO 5	T2:342-345
5	MTDC LINKS	CO 6	T2:337

Signature of Course Coordinator **HOD,EEE**
Ms. B. Manogna, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Course Title	**ELECTRICAL POWER SYSTEMS LABORATORY**				
Course Code	AEEB29				
Program	B.Tech				
Semester	VII	EEE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. T Mahesh, Assistant Professor				

I COURSE OVERVIEW:

Power system protection laboratory is to provide an overview of the principles of protection devices such as miniature circuit breaker, High rupturing fuse and relays. This course focuses on the functioning of protective circuits under fault conditions of transmission lines, feeders and analyze theirperformance. This course also includesprotection of system components from overloads, the probability of fires and other catastrophic system failures can be minimized.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE007	IV	AC machines

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Electrical Power Systems 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: 1The 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:

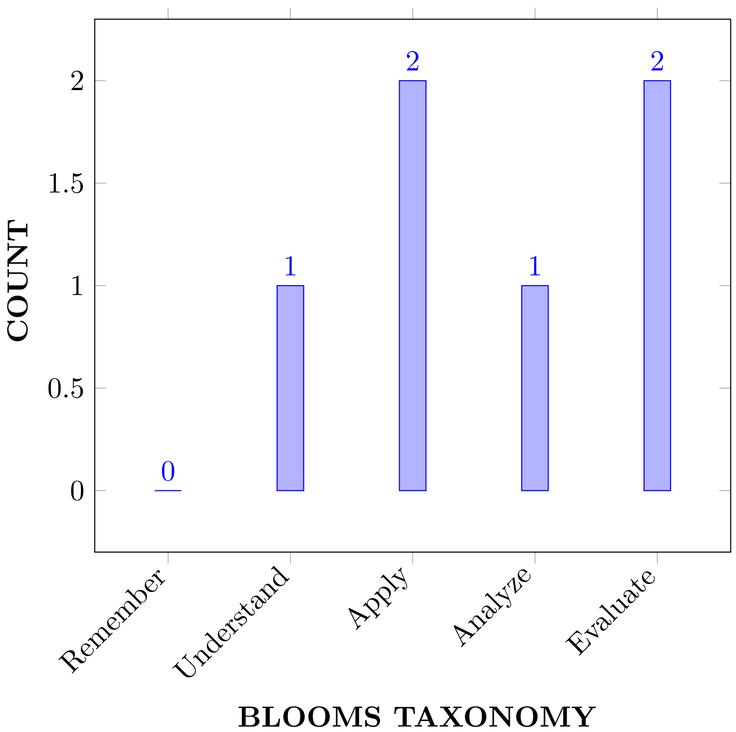
I	The importance of protection in electrical power system and working of fundamental protective devices.
II	The transmission line parameters, surge impedance loading, efficiency, voltage regulation, observe and minimize the Ferranti effect which occurs in voltage of a transmission lines operating conditions.
III	The various distance schemes in over current protection of feeders under three-phase faults.
IV	The necessity of finding sequence components of alternators by using direct and indirect methods.

VII COURSE OUTCOMES:

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

CO 1	**Examine** the functioning of miniature circuit breaker (MCB) and fuse to plot time-current characteristics.	Analyze
CO 2	**Compute** generalized circuit parameters and surge impedance loading in terms of input and output parameters to analyse performance of a transmission line.	Evaluate
CO 3	**Identify** suitable compensation technique to stabilize and mitigateFerranti effect in atransmission line.	Apply
CO 4	**Understand** the concept of voltage improvement by reactive power control using tap changing transformer.	Understand
CO 5	**Describe** the performance of a transmission line by calculating its efficiency and regulation.	Evaluate
CO 6	**Describe** the working of impedance relay, overcurrent relay during normal and abnormal fault conditions for protection of transmission line.	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.	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	Day -to- Day evaluation sheets
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 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.s	2	Lab Experiments / CIE / SEE

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization.	2	Lab Experiments / 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	Observe the functionality (knowledge) of protective devices for voltage current characteristics using **principles of mathematics and engineering science**	2
	PO 2	Understand the given power protective device application **problem statement by analyzing complex engineering problems**	4
	PO 3	Identify the transmission line parameters and its the importance of for analyzing electrical networks using **environment, safety and risk**	2
CO 2	PO 1	Evaluate the transmission line parameters and its the importance of for analyzing electrical networks using **principles of Mathematics, Science and Engineering**	2

	PO 4	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.	3
CO 3	PO 1	Understand (**knowledge**) the need of Shunt compensation circuits using textbfprinciples of Mathematics, Science and Engineering	3
	PO 4	Recognizethe Ferranti effect by observing sending end and receiving end voltages and understand the corresponding context of the engineering knowledge, technical uncertainty**of the transmission line.**	3
	PSO 1	Compute the **limits on type of transmission and contributed to the power system protection**	2
CO 4	PO 1	Understand necessity of voltage profile improvement of transmission line **using the knowledge of mathematics and engineering fundamentals.**	2
	PO 2	Demonstrate the operation tap changing transformer in voltage profile improvement using by **analyzing complex engineering problems**	4
	PO 4	Formulate and Evaluate the inverter circuits with **Converter Topologies for Energy Conversion**	2
CO 5	PO 1	Calculate efficiency and voltage regulation of single phase transmission line by **analyzing complex engineering problems**	4
	PSO 1	Compute the **limits on type of transmission and contributed to the power system protection**	2
CO 6	PO 1	Apply (knowledge) the relay characteristics for the operation of relays by using the principles by **Mathematics and Engineering fundamentals.**	2
	PO 2	Understand the applications of relays in the protection by electrical system by **analyzing complex engineering problems**	4
	PO 4	Understand the applications of relays in the protection by electrical system by **analyzing complex engineering problems.**	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 4	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	PO 1, PO 2, PO 3, PO 4, PSO 1	SEE Exams	PO 1,PO 2, PO 3, PO4 PSO 1	Seminars	-
Laboratory Practices	PO 1,PO 2, PO 3, 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	**CHARACTERISTICS OF AN MCB**
	Plotting the Characteristics of Miniature Circuit Breaker (MCB).
WEEK II	**CHARACTERISTICS OF FUSE AND THERMAL OVERLOAD PROTECTION**
	Study of characteristics of High Rupturing Capacity (HRC) fuse and tripping of bimetallic thermal overload protection and its characteristics.
WEEK III	**ABCD PARAMETERS OF TRANSMISSION LINE**
	Measurement of ABCD parameters of a transmission line
WEEK IV	**FERRANTI EFFECT IN A TRANSMISSION LINE**
	Study of Ferranti effect in a the transmission line
WEEK V	**SURGE IMPEDANCE LOADING**
	Study of Surge Impedance Loading (SIL) of a transmission line.
WEEK VI	**EFFECT OF SHUNT COMPENSATION**
	Determine shunt compensation to counteract the voltage rise on no load and zero regulation at different loads in a transmission line.
WEEK VII	**VOLTAGE PROFILE IMPROVEMENT USING TAP CHANGING TRANSFORMER**
	Study of voltage improvement by reactive power control using tap changing transformer.
WEEK VIII	**EFFICIENCY AND REGULATION OF A TRANSMISSION LINE**

	Determine the performance of a transmission line by calculating its efficiency and regulation..
WEEK IX	**PERFORMANCE OF IMPEDANCE RELAY**
	Study the working principle of impedance relay and its effect during faults in a transmissionline.
WEEK X	**PERFORMANCE OF OVER CURRENT RELAY**
	Study the working principle of over current relay and its effect during faults in a transmission line.
WEEK XI	**EARTH FAULT PROTECTION**
	Study of earth fault detection methods and various earth fault protection schemes.
WEEK XII	**FEEDER PROTECTION**
	Study the various protection schemes in radial feeder under various fault conditions.
WEEK XIII	**MEASURMENT OF SEQUENCE IMPEDANCES OF SYNCHRONOUS MACHINE**
	Measurement of positive, negative and zero sequence impedances of synchronous machine by using direct method and fault analysis method.
WEEK XIV	**STRING EFFICIENCY OF INSULATORS**
	Determination of string efficiency in a string of insulators.

TEXTBOOKS

1. Sunil S Rao, "Switchgear and Protection", Khanna Publishers, 1st Edition, 2013.
2. Badari Ram, D N Viswakarma, "Power System Protection and Switchgear", TMH Publications, 1 st Edition, 2001.
3. B L Soni, Gupta, Bhatnagar, Chakrabarthy, "Power System Engineering", Dhanpat Rai Co, 3 rd Edition, 2007.
4. T S Madhava Rao, "Power system protection: static relays", McGraw-Hill Companies, 2 nd Edition, 1989.

REFERENCE BOOKS:

1. Paithankar, S R Bhide, "Fundamentals of Power System Protection", PHI, 1st Edition, 2003.
2. C LWadhwa, "Electrical Power Systems", New Age international (P) Limited, 6th Edition, 2010.
3. VK Mehta, "Principles of power systems", S Chand Publications, 4th 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	Characteristics of Miniature Circuit Breaker.	CO 1	R1: 1.2
2	Study of characteristics of High Rupturing Capacity (HRC) fuse and tripping of bimetallic thermal overload protection and its characteristics.	CO 1	T1: 3.11

3	ABCD parameters of transmission line.	CO 2	T1: 4.8
4	Ferranti effect of a transmission line.	CO 2	T1: 4.8
5	Surge Impedance Loading (SIL) of transmission line.	CO 2	T1: 5.5
6	Determine shunt compensation to counteract the voltage rise on no load and zero regulation at different loads in a transmission line	CO 3	TR3: 5.5
7	Study of voltage improvement by reactive power control using tap changing transformer.	CO 4	T3: 8.3
8	Determine the performance of a transmission line by calculating its efficiency and regulation.	CO 5	R2: 8.3
9	Study the working principle of impedance relay and its effect during faults in a transmission line.	CO 6	T1: 9.2
10	Understand the working principle of over current relay and its effect during faults in a transmission line.	CO 6	T1: 10.2
11	Study of earth fault detection methods and various earth fault protection schemes.	CO 5	T1:10.7
12	Understand the various protection schemes in radial feeder under various fault conditions.	CO 5	T1:10.6
13	Measurement of positive, negative and zero sequence impedances of synchronous machine by using direct method and fault analysis method.	CO 6	T1:10.7
14	Determination of string efficiency in a string of insulators.	CO 6	T1:10.8

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**System Parameter Calculation:** Design of three phase transmission line using distributed resistance, inductance and capacitance.
2	**Fault Compensation:** Determine generalized circuit parameters, observe Ferranti effect, effect of surge impedance loading on a transmission line.
3	**Balanced Three-Phase System** Measurement of sequence impedances of synchronous machine by using simulation software.
4	**Renewable Energy System:** Design of renewable based grid connected power systems using simulation software.
5	**Transmission Line:** Design and develop 400kv, 300kmlong transmission line using simulation tools

Signature of Course Coordinator **HOD,EEE**
Mr. T Mahesh, Assistant Professor

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

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION

Course Title	**POWER SYSTEM SIMULATION LABORATORY**				
Course Code	AEEB30				
Program	B.Tech				
Semester	VII	EEE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. A Naresh Kumar, Assistant Professor				

I COURSE OVERVIEW:

The power system simulation laboratory introduces the program skills using PSCAD and MATLAB through experiments. This laboratory gives emphasis on single line diagram, load flow anlayis, different power protection schemes, fault analysis and various power quality issues using simulation. PSCAD provides key building custom models in any electrical engineering related applications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB22	VI	Power System Analysis

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power System 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 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:

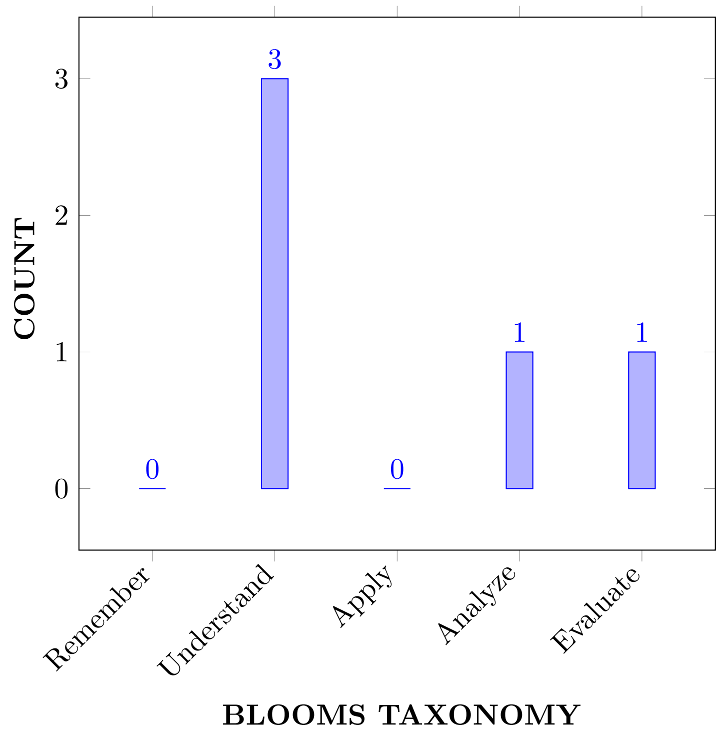
I	Simulate transmission lines using PSCAD software to analyze faults in transmission system.
II	Demonstrate load flow studies using static load flow methods using MATLAB.
III	Analyze transient state stability in power systems

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the programming concepts of simulation tools for obtaining parameters of a typical transmission line and modelling	Understand
CO 2	**Illustrate** the formation of bus admittance matrices by adding one element at a time for load flow studies	Understand
CO 3	**Interpret** the symmetrical and unsymmetrical faults for transmission linesusing digital simulation	Understand
CO 4	**Evaluate** the transient response using numerical methods in RLC circuit and infinite bus systems	Evaluate
CO 5	**Analyze** the transformer inrush current for unbalanced three phase parameters	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	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	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
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	Day -to- Day evaluation sheets

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, Develop, Fabricate and Commission the Electrical Systems involving Power generation, Transmission, Distribution and Utilization	2	Lab Exercises
PSO 2	Focus on the Components of Electrical Drives with its Converter Topologies for Energy Conversion, Management and Auditing in Specific applications of Industry and Sustainable Rural Development	2	Lab Exercises
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.	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	Observe the functionality **(knowledge)** of parameters of a typical transmission line and modelling using principles of mathematics and engineering science **principles of Mathematics and Engineering**	3
	PO 2	Understand the given power system components application **problem statement by analyzing complex engineering problems**	3
CO 2	PO 1	Illustrate the formation of bus admittance matrices using principles of mathematics and engineering science	3

	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
CO 3	PO 1	Apply **(knowledge)** the symmetrical and unsymmetrical faultsby using the **principles of mathematics, engineering science.**	3
	PO 2	Understand the given the symmetrical and unsymmetrical faultsby **analyzing complex engineering problems**	3
	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
CO 4	PO 1	Understand the transient response for RLC circuit using**principles of mathematics and engineering science**	3
	PO 2	Illustrate the transient response for RLC circuit by **analyzing complex engineering problems**	3
CO 5	PO 2	Formulate and Evaluate the unbalanced three phase parameter**Topologies for Energy Conversion**	3
	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
	PSO 3	Formulate and Evaluate the unbalanced three phase parameter **Topologies for Energy Conversion**	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

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	**FORMATION OF BUS ADMITTANCE AND IMPEDANCE MATRICES**
	Formation of bus admittance matrices by adding one element at a time and also write a program for Zbus building algorithm using MATLAB.
WEEK II	**LOAD FLOW SOLUTION USING GAUSS SEIDEL METHOD**
	Write a MATLAB program for load flow studies without and with generator buses using Gauss Seidel Method.
WEEK III	**LOAD FLOW SOLUTION USING NEWTON RAPHSON AND FDLF METHOD**
	Write a MATLAB program for load flow studies using Newton Raphson and Fast Decoupled Load Flow (FDLF) method.
WEEK IV	**POWER SYSTEM FAULT ANALYSIS**
	Analysis of symmetrical and unsymmetrical faults using symmetrical components using MATLAB.
WEEK V	**POINT BY POINT METHOD**
	Development of MATLAB program for Transient stability analysis of single machine infinite bus and multi machine system by point by point method.
WEEK VI	**TRANSIENT RESPONSE OF RLC CIRCUIT**
	Obtain transient response of RLC circuit using PSCAD.
WEEK VII	**THREE PHASE SHORT CIRCUIT ANALYSIS IN A SYNCHRONOUS MACHINE**
	Analyze symmetrical faults and short circuit studies in a given synchronous machine using PSCAD.
WEEK VIII	**STUDY OF TRANSMISSION SYSTEM AND SHORT CIRCUIT ANALYSIS OF 9 BUS SYSTEM**
	Study of simple transmission system and also Perform short circuit analysis on IEEE 9 bus system using PSCAD.
WEEK IX	**TRANSFORMER INRUSH CURRENT**

	Determination of transformer inrush current under unbalanced three phase parameters using PSCAD.
WEEK X	**SMALL SIGNAL STABILITY ANALYSIS**
	Development of PSCAD Model for stability analysis of single machine-infinite bus with STATCOM.
WEEK XI	**TRANSMISSION LINE PARAMETERS**
	Obtaining parameters of a typical transmission line and modelling it in PSCAD.
WEEK XII	**LOAD FREQUENCY CONTROL**
	Obtain the frequency response of single and two area power system using PSCAD
WEEK XIII	**POWER QUALITY**
	Familiarization with PSCAD and Understanding of Reactive power and power factor correction in AC circuits. Current harmonics drawn by power electronics interface.
WEEK XIV	**DISTANCE PROTECTION**
	Development of PSCAD model to study the distance protection scheme in long transmission line

TEXTBOOKS

1. M D Singh, K B Kanchandhani, "Power Electronics", Tata Mc Graw Hill Publishing Company, 2nd Edition, 1998.
2. Dr. P S Bimbhra, "Power Electronics", Khanna Publishers, 5th Edition, 2012.
3. Ned Mohan, Tore M Undeland, William P Robbins, "Power Electronics: Converters, Applications and Design", 3rd Edition, John Wiley and sons, 2002.
4. M H Rashid, "Power Electronics, Circuits, Devices and Applications", Pearson, 3rd Edition, 2001.

REFERENCE BOOKS:

1. Vedam Subramanyam, "Power Electronics", New Age International Limited, 2nd Edition, 2006.
2. P C Sen, "Power Electronics", Tata McGraw-Hill Publishing, 1st Edition, 1987.
3. G K Dubey, S R Doradra, A Joshi, R M K Sinha, "Thyristorised Power Controllers", New Age International Limited, 2nd Edition, 2008.
4. V R Moorthi, "Power Electronics Devices", Oxford University Press, 4th Edition, 2005.

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	Formation of bus admittance matrices by adding one element at a time and also write a program for Zbus building algorithm using MATLAB.	CO 1	R1: 1.2
2	Write a MATLAB program for load flow studies without and with generator buses using Gauss Seidel Method.	CO 2	R2: 3.5

3	Write a MATLAB program for load flow studies using Newton Raphson and Fast Decoupled Load Flow (FDLF) method.	CO 3	R1: 3.4
4	Analysis of symmetrical and unsymmetrical faults using symmetrical components using MATLAB.	CO 4	R1: 2.2
5	Development of MATLAB program for Transient stability analysis of single machine infinite bus and multi machine system by point by point method	CO 5	R1: 2.4
6	Obtain transient response of RLC circuit using PSCAD.	CO 2	R3: 4.5
7	Analyze symmetrical faults and short circuit studies in a given synchronous machine using PSCAD.	CO 5	R3: 4.6
8	Study of simple transmission system and also Perform short circuit analysis on IEEE 9 bus system using PSCAD.	CO 5	R2: 5.1
9	Determination of transformer inrush current under unbalanced three phase parameters using PSCAD.	CO 5	R2: 5.2
10	Development of PSCAD Model for stability analysis of single machine-infinite bus with STATCOM.	CO 1	R1: 7.1
11	Obtaining parameters of a typical transmission line and modelling it in PSCAD.	CO 2	R1:7.2
12	Obtain the frequency response of single and two area power system using PSCAD	CO 4	R1:7.3
13	Familiarization with PSCAD and Understanding of Reactive power and power factor correction in AC circuits. Current harmonics drawn by power electronics interface.	CO 4	R1:7.2
14	Development of PSCAD model to study the distance protection scheme in long transmission line.	CO 3	R1:7.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Numerical relays:** Design numerical relays using MATLAB and PSCAD
2	**Renewable energy conversion:** Design of transmission lines used in renewable energy conversion with simulation software

Signature of Course Coordinator **HOD,EEE**
Mr. A Naresh Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION

Course Title	**ELECTRIC AND HYBRID VEHICLES**				
Course Code	AEEB54				
Program	B.Tech				
Semester	VIII	EEE			
Course Type	Professional Elective				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms Shaik Ruksana Begam, Assistant Professor				

I COURSE OVERVIEW:

Electric and Hybrid Vehicles course deals with technical knowledge and practical expertise in commercial automobile technologies. As a part of this course, design, component selection and sizing at both system and vehicle level with a special focus on drives, battery modeling and control has been elaborated. A comprehensive overview of Electric and Hybrid Vehicles is emphasized on configuration, main issues and energy management strategies. This course also concludes with different control schemes used in motor drives and energy management systems.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AEE004	III	DC Machines and Transformers
UG	AEE007	IV	AC Machines
UG	AEE013	VI	Solid State Electric Motor Drives

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
ELECTRIC AND HYBRID VEHICLES	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	✓	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
20%	Remember
40 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

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 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 center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

Concept Video	Tech-talk	Open Ended Experiment
50%	50%	-%

VI COURSE OBJECTIVES:

The students will try to learn:

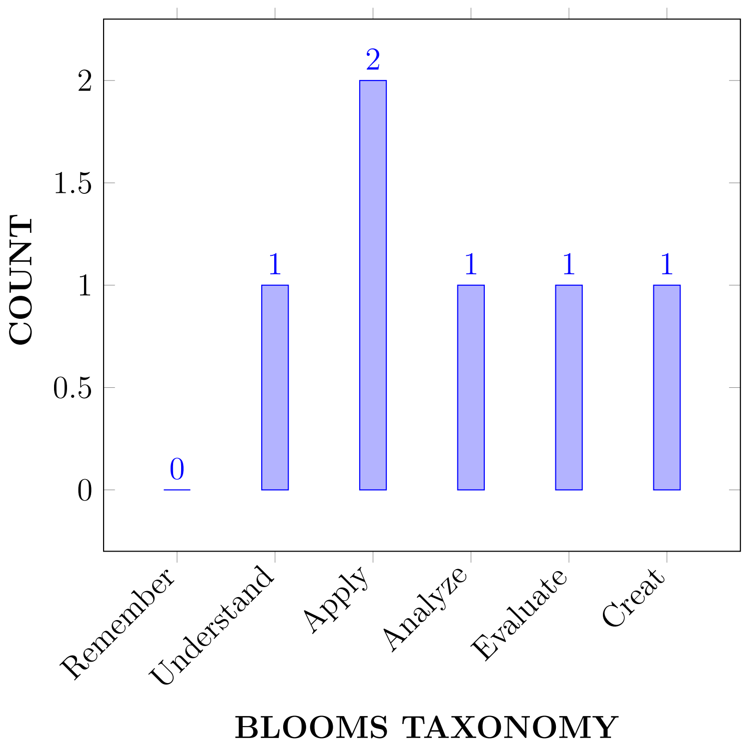
I	The concepts of modeling, design, and development of energy storage systems in hybrid electric vehicles.
II	The importance of hybrid electric vehicles to address the issues associated with environmental pollution and energy crisis.
III	The need of rapid control prototyping techniques to design and validate HEV high level and low level control system.
IV	The Know-how and aptitude towards future trends in Hybrid Electric Vehicles.

VII COURSE OUTCOMES:

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

CO 1	**Summarize** the various topologies and modeling techniques used in electric and hybrid vehicles for performance analysis.	Understand
CO 2	**Analyze** cost-effectiveness of different types of hybrid drive-trains for transmitting power to driving wheels.	Analyze
CO 3	**Demonstrate** the configuration and control of Electric motor drives for maximizing speed and torque.	Evaluate
CO 4	**Choose** the hybridization of Energy Storage Systems for reducing size.	Apply
CO 5	**Select** suitable Energy Storage Systems and drive train components for optimizing energy management.	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.	1	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 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	Assignments

PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development.	3	CIE/Quiz/AAT
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	SEE/ CIE, AAT, QUIZ

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Design, develop, fabricate and commission the electrical systems involving power generation, transmission, distribution and utilization.	1	CIE / Quiz / AAT
PSO 2	Focus on the components of electrical drives with its converter topologies for energy conversion, management and auditing in specific applications of industry and sustainable rural development.	3	CIE / Quiz / AAT
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	3	CIE / Quiz / 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	✓	✓	-	-	-	-	-	-	-	-	-	✓	-	✓	-

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** hybrid electric vehicles concepts in **Engineering knowledge, understanding and applications.**	1
	PO 2	Problem Analysis of hybrid electric vehicle concepts by identification, and system definition.	4
	PO 7	Understand the impact of the social and Environmental impacts of Hybrid and Electric vehicles for Environment and sustainability	2
CO 2	PO 1	Apply the impact of modern drive-trains on Engineering knowledge, understanding and applications	4
	PO 2	Problem Analysis of modern drive-trains by identification, definition, formulation, information and validation for decarburization of energy supply.	1
	PSO 2	Focus on electrical drives with its converter topologies on energy conversion, management and auditing in specific applications.	1
CO 3	PO 1	Apply modeling techniques in hybrid electric vehicles for Engineering knowledge, understanding and applications.	1
	PO 2	Problem Analysis for modeling and performing analysis in hybrid electric vehicles by problem identification, system definition, formulation, data collection, model translation and validation	1
	PO 3	Design Solution for modeling and performance analysis of electric vehicles by defining problem, understand user needs, identify cost drivers, manage design process and evaluate outcomes	1
	PO 5	Use of MATLAB software in modeling and simulation of hybrid electric vehicles.	1
	PSO 1	Simulate and/or fabricate/commission the electrical systems involving utilization of electrical energy.	1
	PSO 3	Gain the hands-on competency skills in use of computing tools necessary for entry level position to meet the requirements.	1
CO 4	PO 1	Develop electric drive-trains in hybrid electric vehicles for Engineering knowledge, understanding and applications.	1
	PO 2	Problem Analysis in identifying electric drive-trains by problem identification, system definition, formulation.	1

	PO 7	Understand the impact of Fuel efficiency for Hybrid storage systems in social and environmental contexts, and need for sustainable development.	2
	PSO 2	Focus on the components of electrical drives with its converter topologies for energy management and auditing in transmitting power to driving wheels.	2
CO 5	PO 1	Develop electric drive-trains in hybrid electric vehicles for Engineering knowledge, understanding and applications.	1
	PO 2	Problem Analysisin identifying electric drive-trains by problem identification, system definition, formulation.	6
	PSO 1	Analyze vehicle load force for sizing drive system in utilization of electrical energy.	1
	PSO 2	Focus on the components of electrical drives with its converter topologies for energy management and auditing for fuel efficiency.	2

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

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

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

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	33	20	-	-	-	-	30	-	-	-	-		-	-	-
CO 2	33	50	-	-	-	-	-	-	-	-	-	-	-	100	-
CO 3	33	60	40	-	100	-	-	-	-	-	-	-	16	-	-
CO 4	33	30	-	-	100	-	30	-	-	-	-	20	-	100	-
CO 5	33	30	-	-	-	-	-	-	-	-	-	20	-	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	1	1	-	-	-	-	3	-	-	-	-		-	-	-
CO 2	1	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO 3	1	3	2	-	3	-	-	-	-	-	-	-	1	-	3
CO 4	1	1	-	-	3	-	3	-	-	-	-	2	-	3	-
CO 5	1	1	-	-	-	-	-	-	-	-	-	2	-	3	-
TOTAL	13	18	4	-	6	-	6	-	-	-	-	4	4	21	6
AVERAGE	1.2	1.6	2	-	3	-	3	-	-	-	-	2	1	3	3

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO1, PO2, PO3, PO5, PO7, PO12, PSO1, PSO2, PSO3	SEE Exams	PO1, PO2, PO3, PO5, PO7, PO12, PSO1, PSO2, PSO3	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	PO5, PSO3	5 Minutes Video	PO 3	Open Ended Experiments	-
Assignments	PO 1				

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

XVII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental impact hybrid and electric vehicles, impact of modern drive-trains on energy supplies; Conventional Vehicles: Basics of performance, vehicle power source characterization, transmission characteristics, and mathematical models to vehicle performance.
MODULE II	**HYBRID ELECTRIC DRIVE TRAINS**
	Hybrid Electric Drive trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive train topologies, fuel efficiency analysis; Electric Drive trains: Basic concept of electric traction, introduction to various electric drive train topologies, power flow control in electric drive train topologies, fuel efficiency analysis.
MODULE III	**ELECTRIC MOTORS FOR HYBRID ELECTRIC VEHICLES**
	Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, configuration and control of DC motor drives, configuration and control of Induction Motor drives. Configuration and control of permanent magnet motor drives, configuration and control of switch reluctance motor drives, drive system efficiency.
MODULE IV	**ENERGY STORAGE**
	Energy Storage: Introduction to energy storage requirements in hybrid and electric vehicles, Battery based energy storage and its analysis, fuel cell based energy storage and its analysis, super capacitor based energy storage and its analysis, flywheel based energy storage and its analysis, hybridization of different energy storage devices; sizing the drive system: matching the electric machine and the internal combustion engine (ICE), sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, communications, supporting subsystems.
MODULE V	**ENERGY MANAGEMENT STRATEGIES**
	Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

TEXTBOOKS

1. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2ndEdition,2003.

2. James Larminie, John Lowry, "Electric Vehicle Technology", Wiley publications, 1stEdition,2003.

3. Mehrdad Ehsani, YimiGao, Sebastian E Gay, Ali Emadi," Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals Theory and Design", CRC Press, 2ndEdition,2004.

REFERENCE BOOKS:

1. B D McNicol, D A J Rand, "Power Sources for Electric Vehicles", Elsevier publications, 1 stEdition,1998.
2. Seth Leitman, "Build Your Own Electric Vehicle" McGraw-Hill, 1 stEdition,2013.
3. Jeffrey Gonder, Tony Markel, "Energy Management Strategies for Plug-In Hybrid Electric Vehicles", 2007-01- 0290, National Renewable Energy Laboratory

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			
	CONTENT DELIVERY (THEORY)		
1	Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental import hybrid and electric vehicles.	CO1	T1: 1.1, 1.2
2	impact of modern drive-trains on energy supplies	CO2	T1: 1.2
3	Conventional Vehicles: Basics of performance, vehicle power source characterization	CO1	T1: 1.2
4	Transmission characteristics	CO1	T1: 1.3
5	Mathematical models to vehicle performance	CO1	T1: 3.6
6	Hybrid Electric Drive trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies	CO2	T1: 1.1
7	Power flow control in hybrid drive train topologies, fuel efficiency analysis	CO2	T1: 1.1, T1: 3.8
8	Electric Drive trains: Basic concept of electric traction, introduction to various electric drive train topologies	CO2	T1: 4.2,4.3
9	Power flow control in electric drive train topologies	CO3	T1: 4.2,4.3 T2:26.10
10	Fuel efficiency analysis	CO3	T1: 4.4
11	Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles	CO3	R2: 4.7
12	Configuration and control of DC motor drives	CO3	T1: 4.9
13	Configuration and control of Induction Motor drives	CO3	T1: 4.9

14	Configuration and control of permanent magnet motor drives	CO3	T1: 5.1,5.4
15	Configuration and control of switch reluctance motor drives	CO3	T1: 5
16	Drive system efficiency	CO3	T1: 5.1
17	Energy Storage: Introduction to energy storage requirements in hybrid and electric vehicles	CO4	T1: 6.1,6.4,6.5
18	Battery based energy storage and its analysis, fuel cell based energy storage and its analysis	CO4	T1: 6.1
19	Super capacitor based energy storage and its analysis, flywheel based energy storage and its analysis	CO4	T1: 6.1
20	Hybridization of different energy storage devices;	C04	T1: 6.9, 6.10, 6.11
21	Sizing the drive system: matching the electric machine and the internal combustion engine (ICE),	CO3	T1: 6.13
22	Sizing the propulsion motor, sizing the power electronics	CO3	R1: 6.14
23	Selecting the energy storage technology	CO4	T1 : 9
24	Communications, supporting subsystems	CO5	T1: 9.5
25	Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles	CO5	R2: 9.6 R3: 1.5, 1.9
26	Classification of different energy management strategies	CO5	T1: 9.1 R3: 2.6
27	Comparison of different energy management strategies	CO5	T1: 9.1 R3: 4.3, 4.8
28	Management strategies	CO5	R1: 9.9 R3:5.8, 5.11
29	Implementation issues of energy management strategies	CO5	T1 : 9.1
30	Implementation issues of energy management strategies	CO5	T1 : 9.1
PROBLEM SOLVING/ CASE STUDIES			
1	Mathematical models to describe vehicle performance	CO 1	R2:7.5
2	Fuel efficiency analysis in hybrid drive trains	CO 2	R2:7.5
3	Fuel efficiency analysis in electric drive trains	CO2	T1 : 9
4	Drive system efficiency	CO 3	R2:7.5
5	Battery based energy storage system analysis	CO 4	T1: 6.1,6.4,6.5
6	Fuel cell based energy storage system analysis	CO 4	T1: 6.13
7	Super capacitor based energy storage system analysis	CO 4	T1 : 9
8	Flywheel based energy storage system analysis	CO 4	T1: 6.1,6.4,6.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Define Hybrid Electric Vehicles?	CO 1	T1: 9.5

2	What is Electric Vehicles?	CO 1	R4:2.1
3	Define Conventional Vehicles?	CO 1	T1: 9.5
4	What is Hybrid Electric Drive Train?	CO 2	R4:2.1
5	Define Hybrid Traction?	CO 2	T1 : 9
6	What are hybrid drivetrain topologies	CO 2	T1: 9.5
7	Define Electric Propulsion system	CO 3	R4:2.1
8	What is an Induction motor?	CO 3	R4:2.1
9	What is the principle of induction motor?	CO 3	R4:2.1
10	What is meant by regenerative braking?	CO 3	R4:2.1
11	How does a permanent magnet motor work?	CO 3	R2: 9.6
12	What is Electric Battery	CO 4	R4:2.1
13	Define Super Capacitor?	CO 4	R2: 9.6
14	What is the principle of lithium ion battery?	CO 4	R2: 9.6
DISCUSSION OF QUESTION BANK			
1	Mathematical models to vehicle performance	CO 1	R4:2.1
2	Hybrid Electric Drive trains	CO 2	T4:7.3
3	Induction motor	CO 3	R4:5.1
4	Electric Battery	CO 4	T1:7.5
5	Energy management	CO 5	T1: 4.1

Signature of Course Coordinator **HOD,EEE**
Ms. Shaik Ruksana Begam Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Course Title	**INTELLECTUAL PROPERTY RIGHTS**				
Course Code	AHSB22				
Program	B.Tech				
Semester	VIII	ECE			
Course Type	Open Elective				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. B Ravi Kumar, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	-	-	-

II COURSE OVERVIEW:

This course provides the protection given to inventers or creators of intellectual products with moral and commercial values. It covers general agreement on tariffs and trade, patents, copy rights and trademarks and it represents the potential future economic benefits to the intellectual property owner or authorized user.

III MARKS DISTRIBUTION:

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

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
15%	Remember
35 %	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), 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:

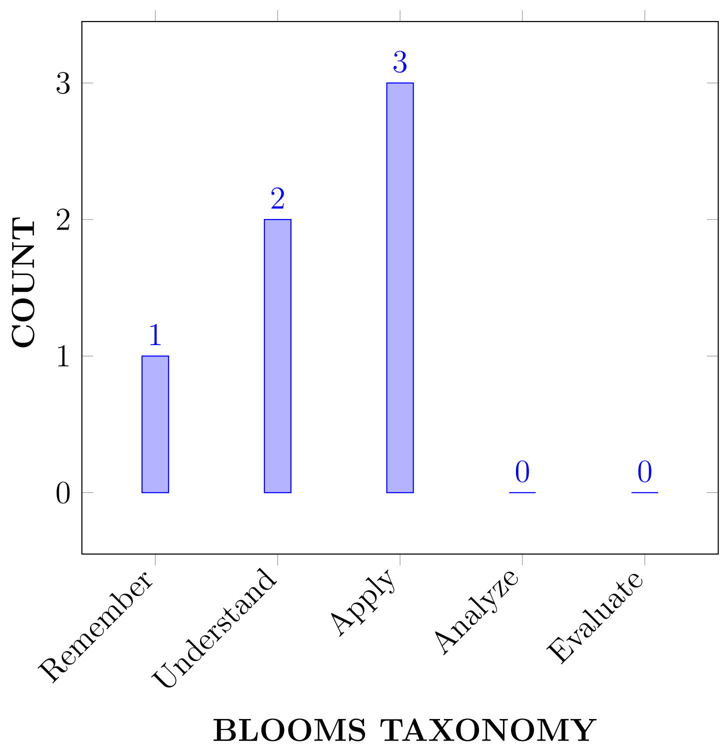
I	The knowledge on world trade organization, trade agreements and investments.
II	The importance of intellectual property rights to develop trade mark law, copy right law and patent law.
III	The new developments in the law of intellectual property rights in order to bring progressive changes towards a free market society and international trade practices under the Trade Related Intellectual Property Rights Agreement (TRIPS

VII COURSE OUTCOMES:

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

CO 1	**Classify** the general agreement on tariffs and trade (GATT) eight rounds for the substantial reduction of tariffs and other barriers of trade.	Remember
CO 2	**Identify** the world trade organization agreements for trade related intellectual property rights and investments.	Understand
CO 3	**Relate** the World Intellectual Property organization to protect intellectual property rules and policies.	Understand
CO 4	**Demonstrate** the legal procedure and document for claiming patent of invention.	Apply
CO 5	**Infer** the geographical Indications of international development of law for policy and legal issues .	Apply
CO 6	**Utilize** the new international developments for trademarks law, copyright law and patent law.	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 6	**The engineer and society:** 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 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	Seminar
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.	2	Seminar
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	Seminar

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	**Build** Embedded Software and Digital Circuit Development platform for Robotics, Embedded Systems and Signal Processing Applications.	-	-
PSO 2	**Focus** on the Application Specific Integrated Circuit (ASIC) prototype designs, Virtual Instrumentation and System on Chip (SOC) designs.	-	-
PSO 3	**Make use of** High Frequency Structure Simulator (HFSS) for modeling and evaluating the patch and smart antennas for wired and wireless communication applications.	-	-

3 = High; 2 = Medium; 1 = Low

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 different types of Intellectual Properties (IPs), the right of ownership, scope of protection as well as the ways to create and to extract value from IP	1
CO 2	**PO 6**	Explain how to derive value from IP and leverage its value in new product and service development	2
	PO 10	Identify the purpose in category of marks under which the trademark registration is made internationally	1
CO 3	**PO 8**	Explain how to derive value from IP and leverage its value in new product and service development	3
	PO 10	Identify the purpose in category of marks under which the trademark registration is made internationally	1
CO 4	**PO 6**	Explore on the legal management of IP and understanding of real life practice of IPM	2
	PO 8	Explain how to derive value from IP and leverage its value in new product and service development	3
	PO 10	Identify the purpose in category of marks under which the trademark registration is made internationally	2
	PO 12	Understand the trademark evaluation and registration process	6
CO 5	**PO 1**	Explore on the legal management of IP and understanding of real life practice of IPM	2
	PO 8	Extend on various IPR components and process of filing.	3
	PO 10	Describe the precautious steps to be taken to prevent infringement of proprietary rights in products and technology development	2
	PO 12	Extend the fundamentals of copyright law and originality of material and rights of reproduction.	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	**PO 1**	Explore on the legal management of IP and understanding of real life practice of IPM	2
	PO 6	Illustrate international copyright law with respect to ownership and registration of copyright	2
	PO 8	Summarize the trade secrets determination, misappropriation, protection for submission and litigation	3
	PO 10	Understand the different IP management (IPM) approaches and describing how pioneering firms initiate, implement and manage IPM programs	2
	PO 12	Analyze the new international developments in trademarks law, copyright law and patent law	6

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	-	-	-	-	-	-	-	-	20	-	-	-	-	-
CO 2	-	-	-	-	-	40	-	-	-	20	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	100	-	20	-	-	-	-	-
CO 4	-	-	-	-	-	40	-	100	-	40	-	50	-	-	-
CO 5	66.7	-	-	-	-	-	-	100	-	40	-	50	-	-	-
CO 6	66.7	-	-	-	-	40	-	100	-	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	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	3	-	1	-	-	-	-	-
CO 4	-	-	-	-	-	2	-	3	-	2	-	2	-	-	-
CO 5	3	-	-	-	-	-	-	3	-	2	-	2	-	-	-
CO 6	3	-	-	-	-	2	-	3	-	2	-	2	-	-	-
TOTAL	7	-	-	-	-	6	-	12	-	-9	-	6	-	-	-
AVERAGE	2.33	-	-	-	-	2	-	3	-	1.5	-	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**
	General agreement on tariffs and trade (GATT) eight rounds: Uruguay round, world trade organization: structure, technology transfer, dispute resolution mechanism, Doha declaration world trade organization agreements including trade related intellectual properties rights and trade related investment measures.
MODULE II	**WORLD INTELLECTUAL PROPERTY ORGANIZATION**
	Paris convention, Bern convention, Budapest treaty, Madrid agreement, huge agreement.
MODULE III	**PATENTS**
	Historical background of intellectual property rights, introduction, definition and classification of intellectual property, patents, patentable and non-patentable inventions. Legal requirements for patents, types of patent applications, patent document: specification and claims, important procedural aspects, management of intellectual property rights assets and intellectual property portfolio, commercial exploitation of intellectual property.
MODULE IV	**DESIGNS AND GEOGRAPHICAL INDICATIONS**
	Designs: basic requirements, procedure, convention application term, date, geographical indication: definition, what can be registered, who can apply, rights, term, restrictions.

MODULE V	**TRADEMARK AND COPYRIGHTS**
	Definition, classification of trademarks, classifications of goods and services, Vienna classification, trademarks procedure, trademarks enforcement: infringement and passing off, remedies, copyrights, term of copyrights, and procedure of copyright assignment of copyright, copyright infringement remedies.

TEXTBOOKS

1. P. K. Vasudeva,World Trade Organization: Implications on Indian Economy, Pearson Education,2015.
2. P.KrishnaRao, WTO, Text and cases, Excel Books, 2015.
3. Carlos M.Correa- Intellectual property rights, The WTO and Developing countries-Zed books

REFERENCE BOOKS:

1. Yuan S W, "Foundations of fluid Mechanics", Prentice-Hall, 2nd Edition, 1987.

WEB REFERENCES:

1. Caves, Frankel, Jones, World Trade and Payments-An Introduction, Pearson4. Education, 2015.
2. Carlos M.Correa- Intellectual property rights, The WTO and Developing countries-Zed books.
3. Peter-Tobias stoll, Jan busche, Katrianarend- WTO- Trade –related aspects of IPR-Library of Congress

COURSE WEB PAGE:

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
1	General agreement on tariffs and trade (GATT) eight rounds	CO 1	T1:1.4-1.5
2	Uruguay round	CO 1	T1:1.4-1.5
3	World trade organization: structure	CO 1	T1:2.4-2.5
4	Technology transfer	CO 1	T1:2.4-2.5
5	Dispute resolution mechanism	CO 1	T1:2.4-2.5

6	Doha declaration	CO 2	T1:2.6-2.6.8; R2: 5.8-5.10
7	world trade organization agreements	CO 2	T1:2.6-2.6.8; R2: 5.8-5.10
8	Trade related intellectual properties rights	CO 2	T1:3.1-3.6
9	Paris convention	CO 2	T1:3.1-3.6
10	Bern convention	CO 2	T1:3.1-3.6
11	Budapest treaty	CO 2	T1:3.1-3.6
12	Madrid agreement	CO 3	T1:3.1-3.6
13	Hague agreement	CO 3	T1:3.1-3.6
14	Historical background of intellectual property rights	CO 3	T1:3.1-3.8
15	introduction, definition and classification of intellectual property	CO 3	T1:3.1-3.8
16	Patents, patentable and non-patentable inventions	CO 3	T1:3.1-3.8
17	Legal requirements for patents	CO 3	T1:3.1-3.8; R2: 7.4-7.5
18	Types of patent applications	CO 3	T1:3.1-3.8; R2: 7.4-7.5
19	patent document: specification and claims	CO 3	T1:3.1-3.8; R2: 7.4-7.5
20	important procedural aspects	CO 3	T1:3.1-3.8; R2: 7.4-7.5
21	management of intellectual property rights assets	CO 4	T1:4.1-4.6
22	intellectual property portfolio	CO 4	T1:4.1-4.6
23	Commercial exploitation of intellectual property	CO 4	T1:4.1-4.6
24	Designs: basic requirements	CO 4	T1:4.1-4.6
25	Designs: Procedure	CO 4	T1:4.1-4.6
26	Designs: Convention application term, date	CO 5	T1:10.1-10.6

27	Geographical indication: definition	CO 5	T1:10.1-10.6
28	What can be registered	CO 5	T1:10.1-10.6
29	Who can apply	CO 5	T1:10.1-10.6
30	Rights, term, restrictions	CO 5	T1:10.1-10.6 ; T1:9.1-9.6
31	TRADEMARK AND COPYRIGHTS: Definition, classification of trademarks	CO 5	T1:10.1-10.6; T1:9.1-9.6
32	Classifications of goods and services	CO 5	T1:9.1-9.6
33	Vienna classification	CO 5	T1:9.1-9.6
34	Trademarks procedure	CO 5	T1:9.1-9.6
35	Trademarks enforcement: infringement and passing off , remedies	CO61	T1:8.1-8.3 ; R2: 7.4-7.5
36	copyrights, term of copyrights	CO 6	T1:8.1-8.3; R2: 7.4-7.5
37	procedure of copyright	CO 6	T1:8.1-8.3; R2: 7.4-7.5
38	Assignment of copyright	CO 6	T1-8.1-8.1.7
39	Copyright infringement remedies	CO 6	T1-8.1-8.1.7
40	Copyright infringement remedies	CO 6	T1-8.1-8.1.7
PROBLEM SOLVING/ CASE STUDIES			
1	Trademarks	CO 2	T1:2.6-2.6.8; R2: 5.8-5.10
2	Copyrights	CO 3	T1:3.1-3.6
3	Which are the types of geographical indication/?	CO 2	T1:3.1-3.6
4	How many geographical indications are there in India/?	CO 2	T1:3.1-3.6
5	What means intellectual property/?	CO 3	T1:3.1-3.6
6	What is IPR and its features/?	CO 3	T1:3.1-3.8

7	What is a violation of intellectual property/?	CO 3	T1:3.1-3.8
8	What is trademark with example/?	CO 3	T1:4.1-4.6
9	What are the two categories of intellectual property/?	CO 3	T1:4.1-4.6
10	What happened in the Uruguay Round/?	CO 4	T1:4.1-4.6
11	What was a result of the Uruguay Round quizlet/?	CO 5	T1:10.1-10.6
12	What is the purpose of WIPO/?	CO 5	T1:10.1-10.6
13	How many countries are in WIPO/?	CO5	T1:10.1-10.6
14	What is the difference between a geographical indication and a trademark/?	CO 6	T1:8.1-8.3; R2: 7.4-7.5
15	What trademark means/?	CO 6	T1:8.1-8.3; R2: 7.4-7.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	What is World Trade Organization (WTO)/?	CO 1	T1:1.4-1.5
2	What is the purpose of WIPO/?	CO 3	T1:3.1-3.8
3	What means intellectual property/?	CO 4	T1:4.1-4.6
4	What do you mean by geographical indications/?	CO 5	T1:10.1-10.6
5	What trademark means/?	CO 6	T1:8.1-8.3; R2: 7.4-7.5
DISCUSSION OF QUESTION BANK			
1	Explain why agencies responsible for intellectual property registration with any two examples.	CO 2	T1:1.4-1.5
2	What is patent/? How the patents are related with intellectual property rights/?	CO 3	T1:3.1-3.8
3	Explain with one real time example the patentable and non-patentable inventions.	CO 4	T1:3.1-3.8; R2: 7.4-7.5

4	How intellectual property is helpful to the society and what are the legal requirements are needed for patents/?	CO 5	T1:10.1-10.6
5	What is the most important criteria for an applicant who seek to register a geographical indication/?	CO 6	T1:8.1-8.3; R2: 7.4-7.5

Signature of Course Coordinator **HOD,ECE**
DR. B Ravi Kumar, Associate Professor