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

COURSE DESCRIPTION

Department	**ELECTRONICS AND COMMUNICATION ENGINEERING**				
Course Title	**COMPLEX ANALYSIS AND SPECIAL FUNCTIONS**				
Course Code	AHSB05				
Program	B. Tech				
Semester	III				
Course Type	Foundation				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Ms. L Indira, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	Basic Principles of complex functions and probabilities

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 complex functions and differentiation, complex integration, power series expansion of complex function and special functions. The mathematical skills derived from this course form a necessary base to analytical and design concepts encountered in the program.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Complex Analysis and Special Functions	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
25 %	Understand
75 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 20 marks for continuous internal examination (CIE), 05 marks for quiz and 05 marks for alternative assessment tool

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	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
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

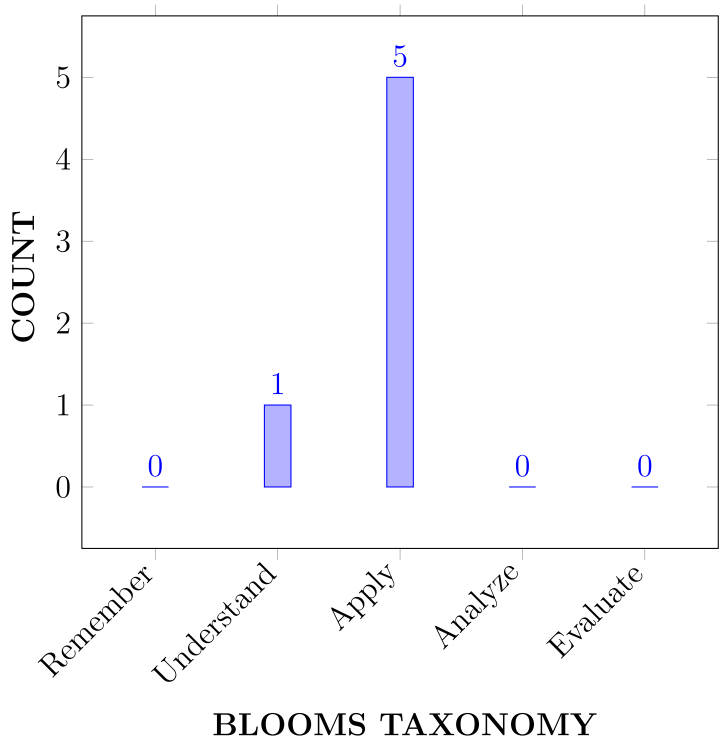
I	The applications of complex variable and conformal mapping in two dimensional complex potential theories.
II	The fundamental calculus theorems and criteria for the independent path on contour integral used in problems of engineering
III	The concepts of special functions and its application for solving the partial differential equation in mathematical physics and engineering.
IV	The Mathematics of combinatorial enumeration by using generating functions and Complex analysis for understanding the numerical growth rates..

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.	Understand
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 poles of real and complex analytic functions over closed curves.	Apply
CO 5	**Determine** the characteristics of special functions for obtaining the proper and improper integrals for obtaining the proper and improper integrals.	Apply
CO 6	**Apply** the role of Bessel functions in the process of obtaining the series solutions for second order differential equation	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Formulate and evaluate the applications in the field of Intelligent Embedded and Semiconductor technologies.	-	-
PSO 2	Focus on the practical experience of ASIC prototype designs, Virtual instrumentation and SOC designs.	-	-
PSO 3	Build the Embedded hardware design and software programming skills for entry level job positions to meet the requirements of employers	-	-

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**	Identify the characteristics of beta and gamma functions as a generalization to the elementary factorial function (knowledge) and applicability for solving improper integrals by applying the principles of mathematics..	3
	PO 2	Identify the given problem and formulate relationship between beta and gamma functions (knowledge) and their applicability for solving improper integrals by transforming by applying the principles of mathematics.	1
CO 6	**PO 1**	Recognize the Bessel functions as series solution of second order differential equation (knowledge) and find its generating function and use it to prove some useful standard results and recurrence relations by applying the principles of mathematics.	3
	PO 2	Identify the given problem and formulate relationship between beta and gamma functions (knowledge) and their applicability for solving improper integrals by transforming by applying the principles of mathematics.	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	2	4	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	-	-	2		-	-	-	-	-	-		2	2	-
CO 5	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	4	-	-	-	-	-	-	-	-	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

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

XVI ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	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 differentiation and integration:**
	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 $\int\limits_0^{2\pi} f(\cos\theta, \sin\theta)d\theta$ and $\int\limits_0^{\infty} f(x)dx$
MODULE IV	**SPECIAL FUNCTIONS-I**
	Improper integrals; Beta and Gamma functions: Definitions; Properties of Beta and Gamma function; Standard forms of Beta functions; Relationship between Beta and Gamma functions
MODULE V	**SPECIAL FUNCTIONS-II**
	Bessel's Differential equation: Bessel function, properties of Bessel function, Recurrence relations of Bessel function, Generating function and Orthogonality of Bessel function, Trigonometric expansions involving Bessel function.

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	In Out Come Based Education student should Identify curves and regions in the complex planedefined by simple expressions. Describe basic properties of complex integration and having the ability to compute such integrals. Decide when and where a given function is analytic and be able to find it series developement. Describe conformal mappings between various plane regions. Present the central ideas in the solution of Dirichlets problem. Able to Classify Singularities and Poles of Complex functions. Relate improper integrals with beta and gamma functions. Idenatify the role of Bessel functions for solving differential equations.		
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	Definite integrals of the Type -I	CO 5	T2: 7.14, R1:1.6
22	Indefinite integrals of Type-II	CO5	T2: 7.14, R1:1.6
23	Improper integrals; Beta and Gamma functions	CO5	T2: 7.14, R1:1.6
24	Definitions; Properties of Beta	CO5	T2: 7.14, R1:1.6
25	Standard forms1,2,3 of Beta functions	CO 5	T2: 16.6, R1:7.36
26	Standard forms 4,5,6, ,of Beta functions;	CO 5	T2: 16.8, R1:7.41
27	Definitions; Properties Gamma function	CO 5	T2: 16.9, R1:7.42
28	Relationship between beta and gamma functions	CO 6	T2: 16.9, R1:7.42
29	Theorems of gamma functions	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	Problems related to beta functions	CO5	T2: 7.14, R1:1.6
33	Problems related to gamma functions	CO5	T2: 7.15,R1:16.5
34	Properties of Beta and Gamma function	CO8, CO9	T2:11.3 R1:16.5

35	Bessel's Differential equation: Bessel function, properties of Bessel function	CO5	T2: 16.5 R1:7.32
36	Solutions of Bessel differential equation by power series method.	CO 6	T2: 16.6 R1:16.9
37	Generating function	CO 5	T2: 11.4 ,R1:16.18
38	Recurrence relations-I,II,III of Bessel function	CO6	T2: 16.8, R1:7.41
39	Recurrence relations IV,V,VI of Bessel function	CO 6	T1:17.5-17.6, R1:16.3.1
40	Generating function	CO 6	T2: 16.9, R1:7.422
41	Orthogonality of Bessel function	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	PSolving problems on Cauchy's Residues Theorem	CO 5	T2: 16.9, R1:7.42
53	Solving problems on Definite integrals of the type -I,II	CO 5	T2: 16.9, R1:7.42
54	Solving problems on Trigonometric expansions involving Bessel function	CO 6	T2: 16.9, R1:7.42
55	Solving problems on beta and gamma 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 special functions-I module IV	CO 5	T1:15.2 , R1:6.6
61	Definitions and Terminology on special functions-II module V	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 1,2	T1:12.3, R1:4.4
63	Discussion of Question Bank of Module II complex integration	CO 3	T1:12.5, R1:8.8
64	Discussion of Question Bank of Module III power series expansion of complex function	CO4	T1:15.1, R1:7.4
65	Discussion of Question Bank of Module IV special functions-I	CO 5	T2: 7.15, R1:1.65
66	Discussion of Question Bank of Module V special functions-I	CO 6	T2: 16.9, R1:7.42

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

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

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Electronic Devices and Circuits**				
Course Code	AECB06				
Program	B.Tech				
Semester	III	ECE			
Course Type	Core				
Regulation	IARE-UG20				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. D Khalandar Basha, Assistant Professor				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:

This course provides the constructional features and principle of operation of the basic semiconductor devices such as diodes, bipolar and unipolar transistors. It intended to provide the different biasing configurations of the semiconductor devices to provide temperature stability. Analytical skills to configure semiconductor devices for the applications - rectifiers, clippers, voltage regulators, clampers and amplifiers.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electronic Devices and Circuits	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
50%	Understand
33%	Apply
17%	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for continuous internal examination (CIE) 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:

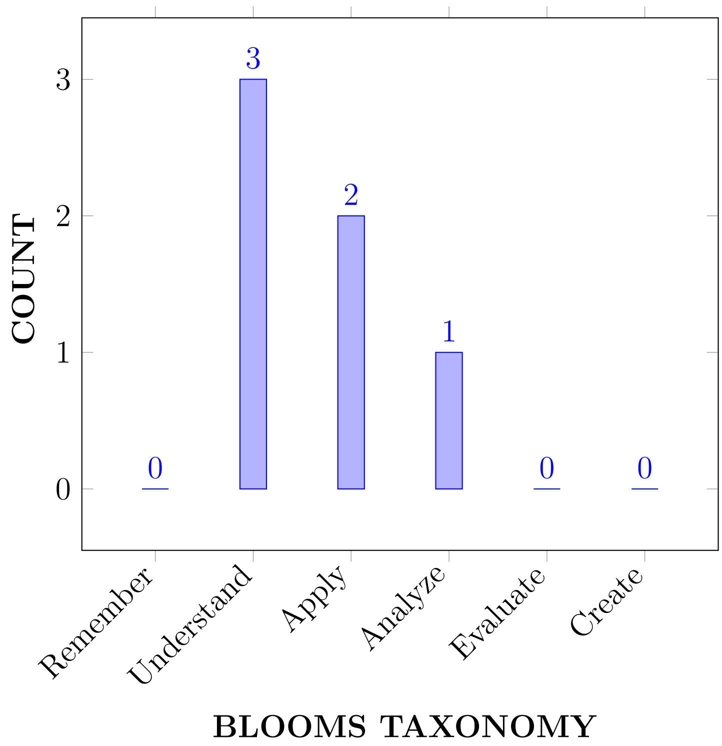
I	The operational principles, characteristics of semiconductor devices and circuits for rectification, amplification, conditioning and voltage regularization of signals.
II	The analytical skills needed to model analog and digital integrated circuits (IC) at discrete and micro circuit level.
III	The foundations of basic electronic circuits necessary for building complex electronic hardware.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the characteristics of semiconductor devices for determining the device parameters such as resistances, current gain and voltage gain.	Understand
CO 2	**Apply** the pn junction characteristics for the diode applications such as switch,rectifiers, Clippers and Clampers.	Apply
CO 3	**Examine** DC and AC load line analysis of BJT and FET amplifiers for optimal operating level regardless of input, load placed on the device.	Analyze
CO 4	**Extend** the biasing techniques for bipolar and uni-polar transistor amplifier circuits considering stability condition for establishing a proper operating point.	Understand
CO 5	**Utilize** low frequency model for estimation of the characteristic parameters of BJT, FET amplifier circuits.	Apply
CO 6	**Demonstrate** the working principle of special purpose semiconductor diodes and transistors for triggering and voltage regulation 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.	2	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 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.	2	AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Illustrate the volt-ampere characteristics **(knowledge)** of semiconductor devices to derive **mathematical model** for diode current, static and dynamic resistance by applying the principles of **mathematics** and **science for solving complex engineering problems.**	2
	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 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 2	PO 1	Apply **(knowledge)** the pn junction characteristics for the diode applications of diode as switch, clippers, Clampers and rectifiers by **analyzing complex engineering problems** using the principles of **mathematics, engineering science**	2
	PO 2	Understand the given the diode application **problem statement** and finding the **solution implementation** of rectifier circuits by **analyzing complex engineering problems**	4
	PO 3	Design solutions for **complex engineering problems** and **design system components** of **diode applications** that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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 1	Formulate and Evaluate the rectifier circuit applications in the field of Intelligent Embedded and Semiconductor technologies	1
CO 3	PO 1	Explain (Understand) DC and AC load line analysis of different amplifiers for optimal operating level by applying **mathematics, science engineering for complex engineering problems.**	2
	PO 2	Understand the given **problem statement** for DC and AC load line analysis using **complex problem analysis by the principles of mathematics and engineering sciences.**	4
	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 4	PO 1	Design (knowledge) the various biasing techniques for BJT, JFET and MOSFETs amplifier circuits for stable operation by applying **mathematics, science and engineering fundamentals for complex engineering problems.**	3
	PO 2	Understand the **problem statement** of biasing techniques for BJT, JFET and MOSFETs amplifier and formulate a proper operating point in **complex problem analysis using mathematics.**	4
	PO 3	Design solutions for **complex engineering problems** and **design system components** of **BJT and FET amplifiers** that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	4
	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 5	PO 1	Estimate (Knowledge) the characteristic parameters of BJT, FET amplifier circuits for **solving complex engineering problems** using low frequency model by applying **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	Analyze small signal analysis **problem statements** of BJT, FET amplifier circuits using **mathematics principles.**	4
	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 6	PO 1	Demonstrate (Understand) the working principle (knowledge) of special purpose semiconductor devices and transistors like Zener diode, Tunnel diode, SCR, UJT and Photo Diode for applications like triggering and voltage regulation by applying **science for engineering problems.**	1
	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

***Note**: Refer appendix-I for key competencies

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	1	1	1
CO 1	2	3	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 2	2	4	5	-	-	-	-	-	-	2	-	-	1	-	-
CO 3	2	4	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 4	3	4	4	-	-	-	-	-	-	2	-	-	-	-	-
CO 5	3	4	-	-	-	-	-	-	-	2	-	-	-		-
CO 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
CO 1	66.7	30.0	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 2	66.7	40.0	50.0	-	-	-	-	-	-	40	-	-	50	-	-
CO 3	66.7	40.0	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 4	100	40.0	40.0	-	-	-	-	-	-	40	-	-	-	-	-
CO 5	100	40.0	-	-	-	-	-	-	-	40	-	-	-		-
CO 6	33.3	-	-	-	-	-	-	-	-	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	1	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	2	2	-	-	-	-	-	-	1	-	-	2	-	-
CO 3	3	2	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 4	3	2	2	-	-	-	-	-	-	1	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	1	-	-	-		-
CO 6	1	-	-	-	-	-	-	-	-	1	-	-	-		-
TOTAL	**16**	**9**	**4**	**-**	**-**	**-**	**-**	**-**	**-**	**6**	**-**	**-**	**2**	**-**	**-**
AVERAGE	**2.7**	**1.8**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**2**	**-**	**-**

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

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	**DIODE AND APPLICATIONS**
	Diode - Static and Dynamic resistances, Equivalent circuit, Load line analysis, Diffusion and Transition Capacitances, Diode Applications: Switch-Switching times. Rectifier - Half Wave Rectifier, Full Wave Rectifier, Bridge Rectifier, Rectifiers With Capacitive Filter, Clippers-Clipping at two independent levels, Clampers-Clamping Operation, types, Clamping Circuit Theorem, Comparators.
MODULE II	**BIPOLAR JUNCTION TRANSISTOR (BJT)**
	Principle of Operation and characteristics - Common Emitter, Common Base, Common Collector Configurations, Operating point, DC & AC load lines, Transistor Hybrid parameter model, Determination of h-parameters from transistor characteristics, Conversion of h-parameters.
MODULE III	**TRANSISTOR BIASING AND STABILIZATION**
	Bias Stability, Fixed Bias, Collector to Base bias, Self-Bias, Bias Compensation using Diodes and Transistors. **Analysis and Design of Small Signal Low Frequency BJT Amplifiers:** Analysis of CE, CC, CB Amplifiers and CE Amplifier with emitter resistance, low frequency response of BJT Amplifiers, effect of coupling and bypass capacitors on CE Amplifier.
MODULE IV	**JUNCTION FIELD EFFECT TRANSISTOR**
	Construction, Principle of Operation, Pinch-Off Voltage, Volt- Ampere Characteristic, comparison of BJT and FET, Biasing of FET, FET as Voltage Variable Resistor, MOSFET Construction and its Characteristics in Enhancement and Depletion modes.
MODULE V	**FET AMPLIFIERS**
	Small Signal Model, Analysis of CS, CD, CG JFET Amplifiers. Basic Concepts of MOSFET Amplifiers. **Special Purpose Devices:** Zener Diode - Characteristics, Voltage Regulator; Principle of Operation - SCR, Tunnel diode, UJT, Varactor Diode.

TEXTBOOKS

1. S Salivahanan, N Suresh Kumar " Electronic Devices and Circuits", 2nd Edition, 2018, McGraw Hill Education.
2. J. Millman and Christos C. Halkias, "Integrated Electronics", International Student Edition , 2008, Tata McGraw Hill Publications.
3. David A. Bell, "Electronic Devices and Circuits", 5th Edition, Oxford University Press.

REFERENCE BOOKS:

1. R.L. Boylestad and Louis Nashelsky, "Electronic Devices and Circuits", 9th Edition, 2006, PEI/PHI.
2. B.P.Singh, Rekha Singh, "Electronic Devices and Circuits", 2nd Edition, 2013, Pearson Publisher.

3. K. Lal Kishore, “Electronic Devices and Circuits”, 2nd Edition, 2005,BS Publisher.
4. Anil K. Maini and Varsha Agarwal, “Electronic Devices and Circuits”, 1stEdition, 2009, Wiley India Pvt. Ltd.

COURSE WEB PAGE:
https://lms.iare.ac.in/index?route=course/details&course id=350

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&courseid=350
	CONTENT DELIVERY (THEORY)		
2	pn Junction Formation, Biasing of pn Junction and its characteristics	CO 1	T1: 2.1
3	Diode Resistances, Equivalent circuit	CO 1	T1: 2.6
5	Load line analysis , Diffusion and Transition Capacitances	CO 1	T1: 2.7
6	Half Wave Rectifier	CO 2	T1: 3.2.1
7	Full Wave Rectifier	CO 2	T1: 3.2.2.
8	Bridge Rectifier	CO 2	T1: 3.2.3
9	Rectifiers With Capacitive Filter	CO 2	T1: 3.6
11	Positive peak and negative peak Clippers operation	CO 2	T1: 6.15
12	Clipping at two independent levels	CO 2	T1:5.13-5.14 R5: 8.2
14	Positive peak and negative peak Clampers	CO 2	R5: 8.5-8.6
15	Clamping Circuit Theorem	CO 3	R5: 8.5-8.6
17	Principle of Operation of BJT	CO 1	T1: 4.2
19	Common Emitter Configuration with characteristics	CO 1	T1: 4.4
20	Common Base Configuration with characteristics	CO 1	T1: 4.4
21	Common Collector Configuration with characteristics	CO 1	T1: 4.4
22	Transistor current components and relation among current gains	CO 1	T1: 4.3
23	Operating point, DC & AC load lines	CO 3	T1: 5.2, 5.3
25	Transistor Hybrid parameter model	CO 5	T1: 6.3
26	Transistor biasing and stabilization	CO 4	T1: 5.4, 5.5
27	Fixed Bias	CO 4	T1: 5.4.1
29	Collector to Base bias	CO 4	T1: 7.2-7.3
31	Self-Bias	CO 4	T1:5.4.3

33	Bias Compensation using Diodes and Transistors	CO 4	T1: 5.6
34	Exact Analysis of transistor amplifier using low frequency model	CO 5	T1: 6.6
35	Approximate Analysis of transistor amplifier using low frequency model	CO 5	T1:6.8
36	Analysis of CE amplifier with emitter resistance using low frequency model	CO 5	T1:6.9
39	Effect of coupling and bypass capacitors on CE Amplifier	CO 5	T1:6.13
40	Construction, Principle of Operation of JFET, Comparison of BJT and FET	CO 1	T1:4.12
42	Volt- Ampere Characteristic of JFET, Pinch-Off Voltage	CO 1	T1:4.13
43	Biasing of FET	CO 4	T1: 5.9
44	MOSFET Construction and its Characteristics in Enhancement mode	CO 1	T1: 4.15
45	MOSFET Construction and its Characteristics in Depletion mode	CO 1	T1:4.16
46	Analysis of generalized JFET Amplifier	CO 5	T1: 6.15
47	Analysis of CS JFET Amplifier	CO 5	T1:6.16
49	Analysis of CD JFET Amplifier	CO 5	T1:6.17
51	Analysis of CG JFET Amplifier	CO 5	T1: 6.18
53	Zener Diode - Characteristics, Voltage Regulator	CO 6	T1: 2.9,2.11
54	Principle of Operation - SCR	CO 6	T1: 2.16
55	Tunnel diode	CO 6	T1: 2.12
56	UJT operation ,Varactor Diode operation	CO 6	T1: 2.19,2.18
PROBLEM SOLVING/ CASE STUDIES			
4	Related to Diode current and its resistance calculation	CO 1	T1: 2.3
10	Rectifier parameters estimation	CO 2	T2:2.6
13	Clipper circuits	CO 2	T2:2.9
16	Clamper circuits	CO 2	T2:2.10
24	Load line analysis of BJT	CO 3	T2:5.3
18	Current gain of transistor configuration	CO 1	T1:4.3
28	Transistor fixed biasing	CO 4	T2:5.4.1
30	Transistor collector to base biasing	CO 4	T2:5.4.3
32	Transistor self-biasing	CO 4	T1:5.4.5
37	CE Transistor amplifier analysis	CO 5	T1:6.14
38	CB Transistor amplifier analysis	CO 5	T1:6.14
39	CC Transistor amplifier analysis	CO 5	T1:6.14
47	CS Amplifier analysis	CO 5	T1:6.16
49	CD Amplifier analysis	CO 5	T1: 6.17 R5: 4.4
52	Zener diode regulator	CO 6	T1: 2.11
DISCUSSION OF DEFINITION AND TERMINOLOGY			

57	Diode applications	CO 1, CO 2	DT
58	Bipolar Junction Transistor (BJT)	CO 1	DT
59	Transistor biasing and stabilization	CO 3, CO 4	DT
60	Junction field effect transistor	CO 1	DT
61	FET amplifiers	CO 5, CO 6	DT
DISCUSSION OF QUESTION BANK			
57	Diode applications	CO 1, CO 2	DT
58	Bipolar Junction Transistor (BJT)	CO 1	DT
59	Transistor biasing and stabilization	CO 3, CO 4	DT
60	Junction field effect transistor	CO 1	DT
61	FET amplifiers	CO 5, CO 6	DT

Signature of Course Coordinator **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**
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**

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

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Digital System Design**				
Course Code	AECB07				
Program	B.Tech				
Semester	III				
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr. V Vijay , Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE002	II	Electrical circuits

II COURSE OVERVIEW:

The course will make them learn the basic theory of switching circuits and their applications in detail. Starting from a problem statement they will learn to design circuits of logic gates that have a specified relationship between signals at the input and output terminals. They will be able to design combinational and sequential circuits. They will learn to design counters, adders, sequence detectors. This course provides a platform for advanced courses like computer architecture, microprocessors & microcontrollers and VLSI design. Greater emphasis is placed on the use of programmable logic devices and State machines.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Digital System Design	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentation	✓	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 units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10 %	Remember
50 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, 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.

VI COURSE OBJECTIVES:

The students will try to learn:

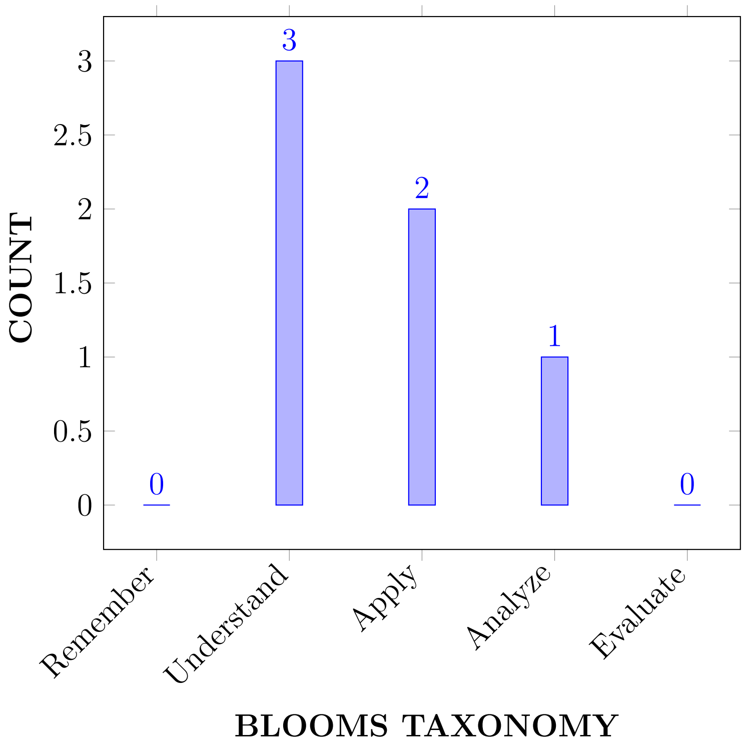
I	Simplification of the logic functions using boolean algebraic theorems and techniques.
II	Implementation of conventional combinational and sequential circuits.
III	The exploration of the logic families and semiconductor memories.
IV	The realization of the micro and macro circuits using VHDL programming.

VII COURSE OUTCOMES:

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

CO 1	**Outline** binary arithmetic operations and optimize boolean functions using karnaugh and tabulation method.	Understand
CO 2	**Apply** combinational circuits for realization of basic building blocks of conventional electronic circuits.	Apply
CO 3	**Interpret** the knowledge of flip-flops and latches in synchronous and asynchronous modules for memory storing applications.	Understand
CO 4	**Extend** the logic design techniques for ECL, TTL and CMOS methodologies for designing the fundamental gate level modelling.	Understand
CO 5	**Extend** the characteristics of logic families and PLDs to enhance the design skills indigital integrated circuits.	Apply
CO 6	**Evaluate** synthesis and simulation of VHDL modules for implementing combinational and sequential circuits.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Focus on the practical experience of ASIC prototype designs, virtual instrumentation and SoC designs.	-	-
PSO 2	Focus on the practical experience of ASIC prototype designs, virtual instrumentation and SoC designs.	2	SEE / CIE / AAT
PSO 3	Focus on the practical experience of ASIC prototype designs, virtual instrumentation and SoC designs.	-	-

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, Boolean operations, code conversion code by applying its **own engineering discipline, science principles and methodology.**	2
	PO 2	Understand the given **problem statement** and **formulate** the design (complex) engineering problems in detecting and correcting errors in the received data in **reaching substantiated conclusions by the interpretation of results.**	4
	PO 10	Understand the given **problem statement** and **communicate** the novel implementation to get it **published in the scientific community.**	1
CO 2	PO 1	Demonstrate the design procedures of various adder circuits with **own engineering discipline, science principles and methodology.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems on adder circuit design **translate the information** into the model using type of adder from the provided **information and data, develop solutions** based on the functionality of the circuit, **validate** the output of the circuit in reaching substantiated conclusions by the **interpretation of results.**	7
	PO 3	**Understand the customer needs, use creativity and manage design process** in realization of combinational circuits using logic gates and **evaluate outcomes.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 4	**Design** various combinational circuits which are basic requirement of various systems using **design of experiments, analysis and interpretation of data.**	2
	PO 10	Understand the given **problem statement** and **communicate** the novel implementation to get it **published in the scientific community.**	1
CO 3	PO 1	Compare the asynchronous counters using design procedure of sequential circuit and excitation tables of flip – flops with **own engineering discipline, mathematical and science principles and methodology.**	3
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems on adder circuit design **translate the information** into the model using type of adder from the provided **information and data**, develop solutions based on the functionality of the circuit, **validate** the output of the circuit in reaching substantiated conclusions by the **interpretation of results.**	6
	PO 3	Design of a clocked flip-flop conversion from one type of flip-flop to another, registers and counters **mathematics, science and engineering fundamentals.**	3
	PO 4	Use research-based knowledge on design of asynchronous counters analysis and interpretation of data.	2
	PO 10	Understand the given **problem statement** and **communicate** the novel implementation to get it **published in the scientific community.**	1
	PSO 2	**Design counter design for** application specific integrated circuit (ASIC) prototype designs, system on chip (SoC) designs	2
CO 4	PO 1	Build tristate TTL, ECL, CMOS families and their interfacing for **memory element designs** using **complex features of logic families.**	3
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems on adder circuit design **translate the information** into the model using type of adder from the provided **information and data**, develop solutions based on the functionality of the circuit, **validate** the output of the circuit in reaching substantiated conclusions by the **interpretation of results.**	7

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 3	Design universal gates using the design mechanisms of TTL, ECL, CMOS using the **basic transistor models** of corresponding logic families.	1
	PO 4	Implement tristate TTL, ECL, CMOS families and their **interfacing** with **memory elements.**	2
	PO 10	Understand the given **problem statement** and **communicate** the novel implementation to get it **published in the scientific community.**	1
CO 5	PO 1	Explore the concept of programmable logic devices for understanding architectural blocks of FPGA using the **own engineering discipline, science principles and methodology.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems on adder circuit design **translate the information** into the model using type of adder from the provided **information and data**, develop solutions based on the functionality of the circuit, **validate** the output of the circuit in reaching substantiated conclusions by the **interpretation of results.**	7
	PO 3	Develop digital gates based on customer needs for design of universal gates using the design mechanisms of TTL, ECL, and CMOS using the **basic transistor models** of corresponding logic families.	1
	PO 4	Implement tristate TTL, ECL, CMOS families and their **interfacing** with **Memory elements.**	2
	PO 10	Understand the given **problem statement** and **communicate** the novel implementation to get it **published in the scientific community.**	1
CO 6	PO 1	Understand data types and objects, dataflow, behavioral and structural modeling for realizing the hardware modeling of the sequential, combinational blocks using the **own engineering discipline, Science principles and methodology.**	2
	PO 2	Understand the given **problem statement** and **formulate** the design (complex) engineering problems of digital logic design, **translate the information** into hardware circuit programming from provided **information and data, develop solutions** based on the simulation result, **validate** the results **reaching substantiated conclusions** by the **interpretation of results.**	7
	PO 3	**Develop** digital system design **based on customer needs for design of** combinational, sequential circuits and **evaluate outcomes of the designs.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
	PO 4	**Use knowledge of** VHDL programming, **able to identify, classify and describe performance of** digital designs for various logical operations using **laboratory skills and analysis.**	2
	PO 10	Understand the given **problem statement** and **communicate** the novel implementation to get it **published in the scientific community.**	1
	PSO 2	Apply digital circuit design in various fields such as application specific integrated circuit (ASIC) prototype designs, system on chip (SoC) designs	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	2	4	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	2	7	3	2	-	-	-	-	-	1	-	-	-	-	-
CO 3	3	6	3	2	-	-	-	-	-	1	-	-	-	1	-
CO 4	2	7	1	2	-	-	-	-	-	1	-	-	-	-	-
CO 5	2	7	3	2	-	-	-	-	-	1	-	-	-	1	-
CO 6	2	7	1	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
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	67	40	-	-	-	-	-	-	-	20	-	-	-	-	-
CO 2	67	70	30	30	-	-	-	-	-	20	-	-	-	-	-
CO 3	100	60	30	18	-	-	-	-	-	20	-	-	-	50	-
CO 4	67	70	10	18	-	-	-	-	-	20	-	-	-	-	-
CO 5	67	70	30	18	-	-	-	-	-	20	-	-	-	50	-
CO 6	67	70	10	18	-	-	-	-	-	20	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	3	1	1	-	-	-	-	-	1	-	-	-	-	-
CO 3	3	3	1	1	-	-	-	-	-	1	-	-	-	2	-
CO 4	3	3	1	1	-	-	-	-	-	1	-	-	-	-	-
CO 5	3	3	1	1	-	-	-	-	-	1	-	-	-	2	-
CO 6	3	2	1	1	-	-	-	-	-	1	-	-	-	-	-
TOTAL	18	16	5	5	0	0	0	0	0	6	0	0	0	4	0
AVERAGE	**3**	**2.7**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**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	**LOGIC SIMPLIFICATION AND COMBINATIONAL LOGICDESIGN**
	Review of boolean algebra and De Morgan's theorem, SOP & POS forms, canonical forms, karnaughmaps up to 6 variables, binary codes, code conversion.
MODULE II	**MSI DEVICES**

	MSI devices like comparators, multiplexers, encoder, decoder, driver & multiplexed display, half and full adders, subtractors, serial and parallel adders, BCD adder, barrel shifter and ALU
MODULE III	**SEQUENTIAL LOGIC DESIGN**
	Building blocks like S-R, JK and Master-Slave JK FF, edge triggered FF, ripple and synchronous counters, shift registers. Finite state machines, design of synchronous FSM, algorithmic state machines charts. Designing synchronous circuits like pulse train generator, pseudo random binary sequence generator, clock generation
MODULE IV	**LOGIC FAMILIES AND SEMICONDUCTOR MEMORIES**
	TTL NAND gate, specifications, noise margin, propagation delay, fan-in, fan-out, tristate TTL, ECL, CMOS families and their interfacing, memory elements, concept of programmable logic devices like FPGA. Logic implementation using programmable devices.
MODULE V	**VLSI DESIGN FLOW**
	Design entry: schematic, FSM & HDL, different modeling styles in VHDL, data types and objects, dataflow, behavioral and structural modeling, synthesis and simulation VHDL constructs and codes for combinational and sequential circuits.

TEXTBOOKS

1. R.P. Jain, "Modern digital Electronics", Tata McGraw Hill, 4th Edition, 2009.
2. Douglas Perry, "VHDL", Tata McGraw Hill, 4th Edition, 2002.
3. W.H. Gothmann, "Digital Electronics- An introduction to theory and practice", PHI, 2nd Edition,2006.

REFERENCE BOOKS:

1. D.V. Hall, "Digital Circuits and Systems", Tata McGraw Hill, 1989.
2. Charles Roth, "Digital System Design using VHDL", Tata McGraw Hill 2nd Edition 2012.

WEB REFERENCES:

1. http://www.igniteengineers.com
2. http://www.ocw.nthu.edu.tw
3. http://www.uotechnology.edu.iq

COURSE WEB PAGE:

1. lms.iare.ac.in/index?route=course/details&course_id=406

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
0	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO - PO Mapping	-	https://lms.iare.ac.in/index?route=course/details&course_id=406
CONTENT DELIVERY (THEORY)			
1	Introduction to number systems	CO 1	T1:1.1 to 1.5 R1:3.1 to 3.5
2	Base conversion methods	CO 1	T1:2.1 to 2.6 R2:2.8 to 3.5
CONTENT DELIVERY (THEORY)			
3	Complements of numbers	CO 1	T1:4.1 to 4.9 R2:2.1 to 2.4
4	Codes- binary codes	CO 1	T1:6.1 to 6.5 R2:7.1 to 7.7
5	BCD code and its properties	CO 1	T1:8.1 to 8.4 R2:4.1 to 4.8
6	Unit distance code	CO 1	T1:8.8 to 8.9 R2:3.3 to 3.7
7	Alphanumeric codes	CO 1	T2:3.1 to 3.2 R2: 2.7 to 2.9
8	Error detecting and correcting codes	CO 1	T2:4.1 to 4.9
9	Basic theorems and its properties	CO 1	T2:5.1 to 5.2 R1:3.1 to 3.5
10	Switching functions	CO 1	T2:5.3 to 5.5 R2:5.1 to 5.8
11	Canonical form	CO 1	T2:3.1 to 3.5 R1:2.1 to 2.5
12	Standard form	CO 1	T2:3.1 to 3.6 R2:2.8 to 3.5
13	Algebraic simplification of digital logic gates	CO 1	T2:4.1 to 4.9 R2:2.1 to 2.4
14	Properties of XOR gates	CO 1	T2:6.1 to 6.5 R2:7.1 to 7.7
15	Universal gates	CO 2	T2:7.1 to 7.4 R2:4.1 to 4.8
16	Multilevel NAND/NOR realizations	CO 2	T2:7.8 to 7.9 R2:3.3 to 3.7

17	Combinational design	CO 2	T3:3.1 to 3.2 R2: 2.7 to 2.9
18	Arithmetic circuits- adders	CO 2	T3:4.1 to 4.8
19	Subtractors	CO 2	T3:5.1 to 5.2 R1:3.1 to 3.5
20	Serial adder	CO 2	T3:5.3 to 5.5 R2:5.1 to 5.8
21	1's complement subtractor	CO 2	T3:6.1 to 6.5 R1:3.1 to 3.5
22	2's complement subtractor	CO 2	T3:6.6 to 6.8 R2:2.8 to 3.5
23	Combinational and sequential circuits	CO 2	T3:6.9 to 6.10 R2:2.1 to 2.4
24	The binary cell	CO 3	T3:7.1 to 7.5 R2:7.1 to 7.7
25	The fundamentals of sequential machine operation	CO 3	T3:7.6 to 7.7 R2:4.1 to 4.8
26	Flip-flop	CO 3	T3:7.8 to 7.10 R2:3.3 to 3.7
27	D-Latch Flip-flop	CO 3	T3:7.11 to 7.12 R2: 2.7 to 2.9
28	Clocked T Flip-flop	CO 3	T1:4.1 to 4.9
29	Clocked JK flip-flop	CO 4	T1:5.1 to 5.2 R1:3.1 to 3.5
30	Design of a clocked flip-flop conversion from one type of flip-flop to another	CO 4	T1:5.3 to 5.5 R2:5.1 to 5.8
31	Registers and counters	CO 4	T1:1.1 to 1.5 R1:3.1 to 3.5
32	Analyze TTL NAND gate, specifications	CO 4	T1:2.1 to 2.6 R2:2.8 to 3.5
33	Noise margin, propagation delay	CO 5	T1:4.1 to 4.9 R2:2.1 to 2.4
34	Fan-in, fan-out	CO 5	T1:6.1 to 6.5 R2:7.1 to 7.7
35	Implement tristate TTL, ECL.	CO 5	T2:5.1 to 5.4 R2:4.1 to 4.8
36	CMOS families and their interfacing, memory elements	CO 6	T1:2.8 R2:3.3 to 3.7
37	Understand concept of programmable logic devices like FPGA	CO 6	T3:3.7 to 3.8 R2: 2.7 to 2.9
38	Logic implementation using programmable devices	CO 6	T3:4.1 to 4.9
39	Design entry: Schematic, FSM & HDL, different modeling styles in VHDL	CO 6	T3:5.1 to 5.2 R1:3.1 to 3.5

40	Understand data types and objects, dataflow, behavioral and structural modeling	CO 6	T3:5.3 to 5.5 R2:5.1 to 5.8
PROBLEM SOLVING/ CASE STUDIES			
41	Multilevel NAND/NOR realizations	CO 1	T1:1.1 to 1.5 R1:3.1 to 3.5
42	Combinational design	CO 1	T1:2.1 to 2.6 R2:2.8 to 3.5
43	Arithmetic circuits-adders	CO 1	T1:4.1 to 4.9 R2:2.1 to 2.4
44	1's complement subtractor	CO 2	T1:6.1 to 6.5 R2:7.1 to 7.7
45	2's complement subtractor	CO 2	T2:5.1 to 5.4 R2:4.1 to 4.8
46	Combinational and sequential circuits	CO 3	T1:2.8 to 2.9 R2:3.3 to 3.7
47	Clocked T Flip-flop	CO 3	T3:3.7 to 3.8 R2: 2.7 to 2.9
48	Clocked JK flip-flop	CO 4	T1:4.1 to 4.9
49	Design of a clocked flip-flop conversion	CO 4	T1:5.1 to 5.2 R1:3.1 to 3.5
50	Registers and counters	CO 5	T1:5.3 to 5.5 R2:5.1 to 5.8
51	Analyze TTL NAND gate, specifications	CO 5	T1:1.1 to 1.5 R1:3.1 to 3.5
52	Implement tristate TTL, ECL	CO 5	T1:2.1 to 2.6 R2:2.8 to 3.5
53	CMOS families, memory elements	CO 6	T1:4.1 to 4.9 R2:2.1 to 2.4
54	Programmable logic devices.	CO 6	T1:6.1 to 6.5 R2:7.1 to 7.7
55	Schematic, FSM & HDL, different modeling styles in VHDL.	CO 6	T2:5.1 to 5.4 R2:4.1 to 4.8
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Universal gates	CO 1	T1:1.1 to 1.5 R1:3.1 to 3.5
57	Multilevel NAND/NOR realizations	CO 2	T1:2.1 to 2.6 R2:2.8 to 3.5
58	Combinational design	CO 4	T1:4.1 to 4.9 R2:2.1 to 2.4
59	Arithmetic circuits-adders	CO 5	T1:6.1 to 6.5 R2:7.1 to 7.7
60	Logic implementation using programmable devices	CO 6	T2:5.1 to 5.4 R2:4.1 to 4.8
DISCUSSION OF QUESTION BANK			

61	Design of a clocked flip-flop conversion	CO 1	T1:1.1 to 1.5 R1:3.1 to 3.5
62	Registers and counters	CO 2	T1:2.1 to 2.6 R2:2.8 to 3.5
63	Analyze TTL NAND gate, specifications	CO 3	T1:4.1 to 4.9 R2:2.1 to 2.4
64	Implement tristate TTL, ECL.	CO 4	T1:6.1 to 6.5 R2:7.1 to 7.7
65	CMOS families, memory elements	CO 5	T2:5.1 to 5.4 R2:4.1 to 4.8

Course Coordinator **HOD, ECE**
Dr. V Vijay , 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**

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

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Probability Theory and Stochastic Process**				
Course Code	AECB08				
Program	B.Tech				
Semester	III				
Course Type	Foundation				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mrs G.Mary swarna latha, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB02	I	Linear algebra and calculus
B.Tech	AHSB11	II	Mathematical Transform Techniques

II COURSE OVERVIEW:

Stochastic or random processes are mathematical objects defined on probability space. The study of these processes is of primary importance in all science and engineering specializations. This course comprises two parts. The first part introduces the fundamental principles of probability theory and random variables necessary to understand the stochastic processes. The second part introduces the basic concepts of random processes, random signals, and their interaction with the electrical or electronic systems. The course forms the basis for the next level courses of an electronics engineer such as analog communication, digital communication and digital signal processing, radar systems and digital image processing. It is also useful for a data science engineer in designing the machine learning algorithms.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Probability Theory and Stochastic Process	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
0%	Remember
58 %	Understand
25%	Apply
17 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE) and 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, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table

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

VI COURSE OBJECTIVES:

The students will try to learn:

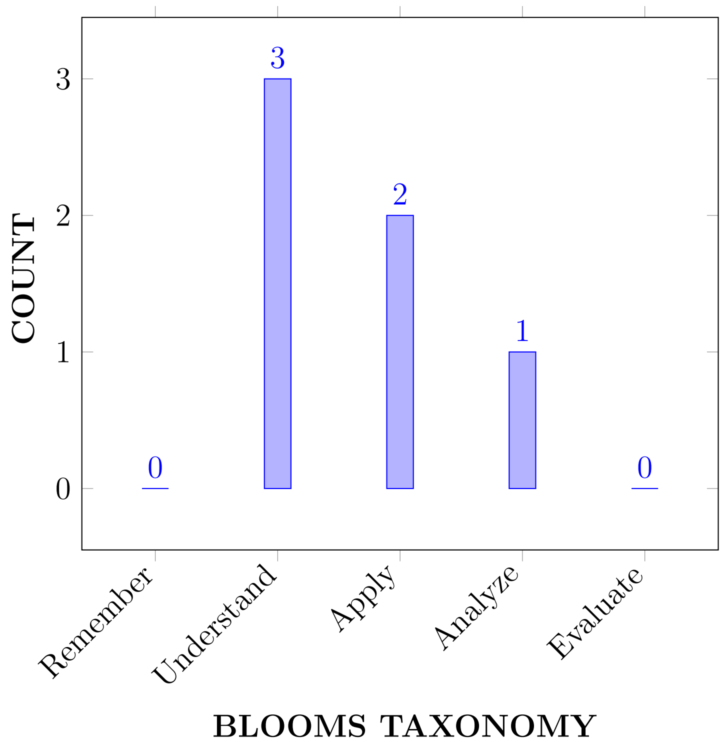
I	The fundamental concepts of the 1-dimensional and 2-dimensional random variables and their characterization in probability space.
II	The stationary random process, its framework and application for analyzing random signals and noises.
III	The characteristics of 1-dimensional stationary random signals in time and frequency domains.
IV	Analysis of the response of a linear time invariant (LTI) system driven by 1-dimensional stationary random signals useful for subsequent design and analysis of communication systems.

VII COURSE OUTCOMES:

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

CO 1	**Infer** the concepts of the random experiment, event probability, joint event probability, and conditional event probability for proving the Bayes theorem and for computing complex event probabilities and independence of multiple events.	Understand
CO 2	**Explain** the concept of random variable, the probability distribution function, probability density function and operations on single random variable to analytically derive the moments.	Understand
CO 3	**Develop** joint distribution, density function, expectation operator and transformations for multiple random variables using the concept of single random variable.	Apply
CO 4	**Extend** the random variable concept to random process and its sample functions for demonstrating the time domain and frequency domain characteristics.	Understand
CO 5	**Develop** analytically the auto-power and cross- power spectral densities to solve the related problems of random processes using correlation functions and the Fourier transform.	Apply
CO 6	**Analyze** the response of a linear time invariant (LTI) system driven by stationary random processes using the time domain and frequency domain description of random processes.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/CIE/Quiz
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/Quiz
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/Quiz
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	SEE/CIE/Quiz

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	Make use of High Frequency Structure Simulator (HFSS) for modeling and evaluating the Patch and Smart Antennas for Wired and Wireless Communication Applications.	2	AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Make use of(knowledge) the concepts of the random experiment, sample space, and appreciate (understand) the meaning of event probability, joint event probability, and conditional event probability for (apply) proving the Bayes theorem and for demonstrating (understanding) the random variables using the **mathematical principles** and **scientific methodology** to support the study of next-level courses such as communications, digital signal processing, (**own engineering discipline**) etc.	3
	PO 2	Demonstrate(understand) the physical significance of the correlation and covariance functions, and **identify**, formulate,(apply)and **state a(complex) problem**, to **develop (apply)**solution using inversion of correlation/ covariance matrices in certain areas of communication **(problems)** and **interpret and document the results**.	6
	PO 3	Develop the solutions for **complex Engineering problems** and **design system components** using the Bayes theorem, understand **customer and user needs** and identify the **cost limitations** for the selection of parameters, **use creativity** in applying the methods of model analyses for **innovative solutions** for the use of Baye's theorem.	6
	PO 10	Demonstrate the ability to communicate effectively in **writing** design documentation and make effective presentations.	1
	PSO 3	Develop conditional event probability for the implementation of total probability and Bayes theorem in **wired and wireless communication applications**.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO 1	Define (knowledge) a random variable using (knowledge) a real mapping function of outcomes of a random experiment into a random variable, define (knowledge) the probabilities and (understand) the continuous/discrete probability density function and distribution function for characterizing (knowledge, understand) various types of density functions such as Gaussian, Rayleigh, Poisson, etc. using the **mathematical principles** and **scientific methodology** to support(understand) their applications in next-level Courses of the program. (**own engineering discipline**).	3
	PO 2	Demonstrate(understand) the random variable as a statistical average operation to **identify, formulate,(apply)and state a(complex) problem**, to develop (apply)solution using appropriate expectation operations in certain areas of communication (problems).	3
	PO 3	Make use of distribution and density functions for **customer and user needs** and identify the **cost limitations** for the selection of parameters, **use creativity** in applying the methods of model analyses for **innovative solutions** for the analysis of noise in communications.	4
	PO 10	Demonstrate the ability to communicate effectively in **writing** design documentation and make effective presentations.	1
	PSO 3	Explain distribution and density functions of standard random variables for **wired and wireless communication applications**.	1
CO 3	PO 1	Define (knowledge) the transformation and/or the expectation operation on random variables and their functions, to formulate the definition of moments of a random variable using **mathematical principles** and demonstrate (understand) the use of the characteristic and moment generating functions(knowledge) to analytically derive the standard moments(by means of **scientific principles and methodology**) useful for identifying (understand) various noises encountered in communication systems and electronic circuits to support the other courses of the program(**own engineering discipline**).	3
	PO 2	Demonstrate(understand) the physical significance of the characteristic and moment generating functions and develop (apply) the Nth order standard and central moments using the above functions to **identify, formulate and state a problem, and develop solution** that uses moments as features and **interpret and document the results**.	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	Develop the solutions for **complex Engineering problems** and **design system components** using the multiple random variables, understand **customer and user needs** and identify the **cost limitations** for the selection of parameters, **use creativity** in applying the methods of model analyses for the use of multiple random variables.	5
	PO 10	Demonstrate the ability to communicate effectively in **writing** design documentation and make effective presentations.	1
	PSO 3	Explain joint distribution and density functions of standard random variables for **wired and wireless communication applications**.	1
CO 4	PO 1	Define (knowledge)the random process as the extension (understand) of scalar random variables using **mathematical principles** and explain (understand) the meaning of correlation and co variance using **scientific principles and methodology** and interpret (understand) them for supporting the study of interdisciplinary courses such as digital image processing (**own engineering discipline**) and data sciences (other engineering disciplines).	3
	PO 2	Demonstrate(understand) the physical significance of the random process and develop (apply) the Nth order distribution and density functions using the random variable concept to **identify, formulate and state a problem, and develop solution** that uses co-variance and correlation as features.	5
	PO 3	Develop the solutions for **complex Engineering problems** and **design system components** using the random process, understand **customer and user needs** and identify the **cost limitations** for the selection of parameters, **use creativity** in applying the methods of model analyses the use of random process.	5
	PO 10	Demonstrate the ability to communicate effectively in **writing** design documentation and make effective presentations.	1
	PSO 3	Explain random process for finding co variance and correlation in **wired and wireless communication applications**.	1
CO 5	PO 1	Relate (understand) the correlation and co-variance (knowledge) of random process to the linear and time invariant systems using the **mathematical principles** and demonstrate (understand) the system response and its physical significance using **scientific methodology and integrate** these concepts into the study of communication systems **(own engineering discipline)** and (complex) signal processing systems.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Demonstrate(understand) the physical significance of the random process and develop (apply) the reponse of LTI system using the random process concept to **identify, formulate and state a problem, and develop solution** that uses co-variance and correlation as features.	5
	PO 3	Develop solutions for **complex Engineering problems** and **design system components** using random process for **customer and user needs** and identify the **cost limitations** for the selection of parameters, **use creativity** in applying the methods of model analyses for the analysis of linear time invariant systems in time domain.	5
	PO 10	Demonstrate the ability to communicate effectively in **writing** design documentation and make effective presentations.	1
	PSO 3	Explain random process for finding co variance and correlation for response of an LTI system in **wired and wireless communication applications**.	1
CO 6	PO 1	Define (knowledge) the auto power spectral density and cross power spectral density functions, to formulate the response of LTI systems using **mathematical principles** and demonstrate (understand) the use of the joint characteristic and joint moment generating functions(knowledge) to analytically derive the power spectral densities of the LTI system (by means of **scientific principles and methodology** and for supporting(**own engineering discipline**) some image processing algorithms.	3
	PO 2	Demonstrate(understand) the physical significance of the random process and develop (apply) the response of LTI system in frequency domain using the random process concept to **identify and develop solution** that uses Fourier transform properties.	2
	PO 3	Develop the solutions for **complex Engineering problems** and **design system components** using the power spectral density functions, understand **customer and user needs**	3
	PO 10	Demonstrate the ability to communicate effectively in **writing** design documentation and make effective presentations.	1
	PSO 3	Explain random process for finding power spectral density functions for the response of LTI systems in **wired and wireless communication applications**.	1

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES/KEY COMPETENCIES												PSO'S		
	PO 1	PO 2	PO 3	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	6	6	-	-	-	-	-	-	1	-		-	-	1
CO 2	3	3	4	-	-	-	-	-	-	1	-	-	-	-	1
CO 3	3	6	5	-	-	-	-	-	-	1	-	-	-	-	1
CO 4	3	5	5	-	-	-	-	-	-	1	-		-	-	1
CO 5	3	5	5	-	-	-	-	-	-	1	-	-	-	-	1
CO 6	3	2	3	-	-	-	-	-	-	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	100	60	60	-	-	-	-	-	-	20	-	-	-	-	50
CO 2	100	30	40	-	-	-	-	-	-	20	-	-	-	-	50
CO 3	100	60	50	-	-	-	-	-	-	20	-	-	-	-	50
CO 4	100	50	50	-		-	-	-	-	20	-		-	-	50
CO 5	100	50	50	-	-	-	-	-	-	20	-	-	-	-	50
CO 6	100	20	30	-	-	-	-	-	-	20	-	-	-	-	50

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	3	-	-	-	-	-	-	1	-	-	-	-	2
CO 2	3	1	1	-	-	-	-	-	-	1	-	-	-	-	2
CO 3	3	3	2	-	-	-	-	-	-	1	-	-	-	-	2
CO 4	3	2	2	-	-	-	-	-	-	1	-	-	-	-	2
CO 5	3	2	2	-	-	-	-	-	-	1	-	-	-	-	2
CO 6	3	1	1	-	-	-	-	-	-	1	-	-	-	-	2
TOTAL	36	11	14	-	-	-	-	-	-	-	-	-	-	-	10

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AVERAGE	3	2.75	2.33	-	-	-	-	-	-	-	-	-	-	-	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	**PROBABILITY, RANDOM VARIABLES AND OPERATIONS ON RANDOM VARIABLES**
	Random Experiments, Sample Spaces, Events, Probability, Axioms, Joint, Conditional and Total Probabilities, Bay's Theorem, Independent Events. Random Variables: Definition, Conditions for mapping function of a Random Variable, Types of Random Variable, Distribution and Density functions: Definition and Properties, Binomial, Poisson, Uniform, Gaussian, Exponential, Rayleigh, random variables, Methods of defining Conditioning Event, Conditional Distribution, Conditional Density and their Properties, Expected Value of a Random Variable, Function of a Random Variable, Standard and Central Moments, Variance and Skew, Chebychev's Inequality
MODULE II	**SINGLE RANDOM VARIABLE TRANSFORMATIONS-MULTIPLE RANDOM VARIABLES**
	Characteristic Function, Moment Generating Function, Monotonic and Non-monotonic Transformations of Single Random Variables (Continuous and Discrete), Vector Random Variables, Joint Distribution Function and its Properties, Marginal Distribution Functions, Joint Density Function and its Properties, Marginal Density Functions, Conditional Distribution and Density – Point Conditioning, Conditional Distribution and Density – Interval conditioning, Statistical Independence, Sum of Two and more Random Variables, Central Limit Theorem: Equal and Unequal Distribution.
MODULE III	**OPERATIONS ON MULTIPLE RANDOM VARIABLES – EXPECTATIONS**

	PART:1 Expected value of a function of multiple random variables, Correlation and Covariance , Correlation Coefficient, Joint Moments about the origin, Joint Central moments, Joint characteristic function, Joint moment generating function. PART:2 Jointly Gaussian random variables: Two random variables case and N random variable case, Properties, Transformations of Multiple Random Variables, Jacobian Matrix, Linear Transformations of Gaussian Random Variables
MODULE IV	**RANDOM PROCESSES – TEMPORAL CHARACTERISTICS**
	Random Process: Definition and Classification, Distribution and Density Functions, Stationarity and Statistical Independence., First- Order, Second-Order , Wide-Sense Stationarities (N-Order) and Strict-Sense Stationarity, Time Averages andErgodicity, Mean-Ergodic and Correlation- Ergodic Processes, Autocorrelation Function and Its Properties, Cross-Correlation Function and Its Properties, Covariance Functions, Gaussian and Poisson Random Processes. Response of Linear Systems to Random Process input, Mean and MS value of System Response, Autocorrelation Function of Response, Cross- Correlation between Input and Output.
MODULE V	**RANDOM PROCESSES – SPECTRAL CHARACTERISTICS**
	Power Density Spectrum: Definition and Properties, Relationship between Power Density Spectrum and Autocorrelation Function, Cross Power Spectral Density: Definition and Properties, Relationship between Cross-Power Spectrum and Cross-Correlation Function, System Evaluation using Random Noise, Spectral Characteristics of System Response: Power Density Spectrum of Response, Cross-Power Density Spectra of Input and Output, Noise Bandwidth, White and Colored Noises.

TEXTBOOKS

1. Peyton Z. Peebles, "Probability, Random Variables and Random Signal Principles", Tata McGraw Hill, 4th Edition, 2001.

REFERENCE BOOKS:

1. Y. Mallikarjuna Reddy, "1. Probability Theory and Stochastic Processes ", University Press, 4thEdition, 2013.

2. Athanasios Papoulis and S. Unnikrishna Pillai, "2. Probability, Random Variables and Stochastic Processes ",PHI, 4th Edition,2002.

3. K .Murugesan, P. Guruswamy, "3. Probability, Statistics and Random Processes",, Anuradha Agencies, 3rd Edition,2003.

4. Bruce Hajck,"4. Random Processes for Engineers,Cambridge University Press,2015Signals, Systems & Communications - B.P. Lathi, B.S. Publications,2003.

WEB REFERENCES:

1. https://nptel.ac.in/courses/111/102/111102111/

2. https://lms.iare.ac.in/index?route=course/details&course_id=358

COURSE WEB PAGE:

https://www.iare.ac.in/?q=courses/r18-auto-ece/
probability-theory-and-stochastic-process

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=358
CONTENT DELIVERY (THEORY)			
1	Probability, axioms, joint, conditional probabilities	CO 1	T1:1.1-1.5, R1:1.1-1.9
2	Total probabilities, Bay's theorem	CO 1	T1:1.1-1.5, R1:1.1-1.9
3	Random variables, types of random variable	CO 2	T1:2.0-2.1
4	Distribution and density functions: definition and properties	CO 2	T1:2.2-2.5, R1:2.3-2.4
5	Binomial, Poisson, Uniform random variables	CO 2	T1:2.2-2.5, R1:2.3-2.4
6	Gaussian, Exponential, Rayleigh, random variables	CO 2	T1:2.2-2.5, R1:2.3-2.4
7	Conditional distribution, conditional density and their properties	CO 2	T1:2.6, R1:2.7
8	Expected Value of a Random Variable	CO 2	T1:3.0-3.2, R1: 3.3-3.5
9	Standard and Central Moments, Variance and Skew	CO 2	T1:3.0-3.2, R1: 3.3-3.5
10	Chebychev's Inequality	CO 2	T1:3.0-3.2, R1: 3.3-3.5

11	Characteristic function, moment generating function properties	CO 2	T1:3.3, R1: 3.6
12	Monotonic transformations of Single random variables.	CO 2	T1:3.4, R1: 3.8
13	Non-monotonic transformations of single random variables (continuous and discrete)	CO 2	T1:3.4, R1: 3.8
14	Random Vector ,Joint distribution function and its properties, marginal distribution functions	CO 3	T1:4.0-4.4, R2: 4.2-4.3
15	Joint density function and its properties, marginal density functions	CO 3	T1:4.0-4.4, R2: 4.2-4.3
16	Conditional distribution and density – point conditioning, interval conditioning	CO 3	T1:4.5, R2: 4.4
17	Statistical independence, Sum of two and more random variables	CO 3	T1:4.5, R2: 4.4
18	Central limit theorem	CO 3	T1:4.6-4.7, R1: 4.6-4.7
19	Expected value of a function of multiple random variables ,Correlation and covariance , correlation coefficient	CO 3	T1:5.0-5.1, R1: 5.2-5.3
20	Joint moments about the origin, joint central moments	CO 3	T1:5.2, R1: 5.4-5.5
21	Joint characteristic function, Joint moment generating function	CO 3	T1:5.2, R1: 5.4-5.5
22	Jointly Gaussian random variables,2 and N random variable case	CO 3	T1:5.3, R1: 5.6
23	Transformations of multiple random variables	CO 3	T1:5.4-5.5, R1: 5.7-5.9
24	Linear transformations of Gaussian random variables	CO 3	T1:5.4-5.5, R1: 5.7-5.9
25	Random Process: Classification	CO 4	T1:5.4-5.6, R1: 6.2-6.6
26	Stationarity and statistical independence of random process	CO 4	T1:6.1-6.2, R1: 6.7-6.9
27	Wide-sense stationarities (N-Order) and Strict-sense stationarity	CO 4	T1:6.1-6.2, R1: 6.7-6.9
28	Time Averages and Ergodicity	CO 4	T1:6.1-6.2, R1: 6.7-6.9

29	Autocorrelation Function and Its Properties	CO 4	T1:6.3, R1: 6.10-6.12
30	Covariance Functions, Cross-correlation function and its Properties	CO 4	T1:6.4, R1: 6.10-6.12
31	Gaussian and Poisson random processes	CO 4	T1:6.5, R1: 6.10-6.12
32	Mean and mean square value of system Response	CO 5	T1:6.6, R1: 6.10-6.12
33	Autocorrelation Function of Response, Cross- Correlation between Input and Output	CO 5	T1:8.2 ,R1: 8.2-8.3
34	Power density spectrum and properties	CO 6	T1:7.1-7.2, R1: 7.2-7.5
35	Cross Power spectral density: definition and properties	CO 6	T1:7.3-7.4, R1: 7.5-7.6
36	Relationship between power density spectrum and autocorrelation function	CO 6	T1:7.1-7.2, R1: 7.2-7.5
37	Relationship between Cross-power Spectrum and Cross-correlation function	CO 6	T1:7.3-7.4, R1: 7.5-7.6
38	System evaluation using random noise	CO 6	T1:8.3-8.4, R1: 8.3-8.4
39	Power density spectrum of response, Cross-power density spectra of input and output	CO 6	T1:8.3-8.4, R1: 8.3-8.4
40	Noise Bandwidth, White and Colored Noises.	CO 6	T1:8.5-8.7, R1: 8.8, 8.17
PROBLEM SOLVING/ CASE STUDIES			
41	Numerical problems on Probability, Total probability, Posterior probability	CO 1	T1:1
42	Numerical problems on distribution and density function of random variable	CO 2	T1:2
43	Numerical problems on Mean ,variance and skew for the given random variable.	CO 3	T1:3
44	Numerical problems on characteristic function and moment generating function	CO 3	T1:3
45	Numerical problems on Transformation of random variables	CO 3	T1:3
46	Numerical problems on joint distribution and marginal distribution	CO 4	T1:4

47	Numerical problems on joint density and marginal density function	CO 4	T1:4
48	Numerical problems on density function of sum of 2 random variables	CO 5	T1:4
49	Numerical problems on joint characteristic function and joint moment generating function	CO 6	T1:5
50	Numerical problems on linear transformation of Gaussian random variables	CO 7	T1:5
51	Numerical problems on stationarity of random process	CO 8	T1:6
52	Numerical problems on Gaussian and Poisson random process	CO 8	T1:6
53	Numerical problems on correlation function and properties	CO 9	T1:6
54	Numerical problems on power spectral density calculation	CO 10	T1:7
55	Numerical problems on power spectral density of a system output	CO 12	T1:8
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Probability and random variable	CO 1, CO 2,CO 3	T1:1,2,3
57	Multiple random variables	CO 4,CO 5,CO 6	T1:4,5
58	Characteristic function and moment generating function for single and multiple random variables.	CO 3,CO 6	T1:3,5
59	Random process and auto correlation function	CO 8,CO 9	T1:6
60	Power spectral density, output of linear system	CO 10,CO 11	T1:7,8
DISCUSSION OF QUESTION BANK			
61	Probability and random variable	CO 1, CO 2,CO 3	T1:1,2,3
62	Multiple random variables	CO 4,CO 5,CO 6	T1:4,5
63	Transformation of random variables	CO 3,CO 6	T1:3,5
64	Stationarity and auto correlation function	CO 8,CO 9	T1:6
65	Power spectral density	CO 10,CO 11	T1:7,8

Signature of Course Coordinator **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**
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**

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

ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE DESCRIPTION

Course Title	**ELECTRONIC DEVICES AND CIRCUITS LABORATORY**				
Course Code	AECB09				
Program	B.Tech				
Semester	III	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Mr. Naresh B, Assistant Professor				

I COURSE OVERVIEW:

This course provides the hands-on experience by examining the electrical characteristics of various semiconductor devices and measuring instruments. Analyze the characteristics of semiconductor diodes, BJT, FET and its applications. Provides the capability to use simulation tools for performing various analysis of semiconductor devices applications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB10	I	Engineering Physics Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electonic Devices and Circuits Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

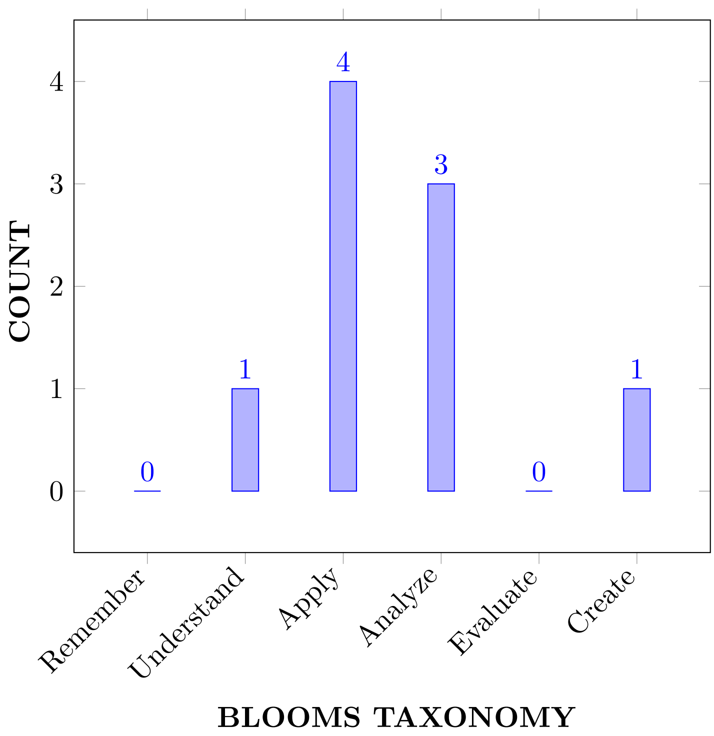
I	The engineering skills using breadboard circuit design with electronic devices and components.
II	The behavior and characteristics of basic electronic devices and semiconductors.
III	The basic electronic devices necessary for construction of analog and digital circuits.

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** electronic measuring instruments for measuring voltage, current, frequency and phase of the various signals.	Understand
CO 2	**Apply** the volt-ampere characteristics of pn junction diode, Zener diode for finding cut-in voltage, static and dynamic resistances.	Apply
CO 3	**Apply** the pn junction characteristics for the diode applications such as half wave rectifier and full wave rectifier.	Apply
CO 4	**Analyze** the input and output characteristics of transistor configurations for determining the input - output resistances.	Analyze
CO 5	**Analyze** BJT and FET amplifiers for estimating the voltage gain and Current gain.	Analyze
CO 6	**Calculate** the intrinsic stand-off ratio of the uni junction transistor using volt – ampere characteristics.	Apply
CO 7	**Determine** holding, latching current and break over voltage of silicon controlled rectifier using volt – ampere characteristics.	Apply
CO 8	**Examine** the V-I characteristics of FET for measuring the transconductance and drain resistance.	Analyze
CO 9	**Design** basic electronic circuits using active transistors.	Create

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Lab exercises/CIE/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab exercises/CIE/SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	Lab exercises
PO 10	**Design/Development of Solutions:** 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

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.	1	Lab exercises/CIE/SEE

3 = High; 2 = Medium; 1 = Low

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 2	Observe the functionality (knowledge) of electronic instruments for calculating amplitude, current and frequency using **principles of mathematics and engineering science**	1

CO 2	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, Science and Engineering**	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**, make **effective presentations**, and give and receive clear instructions.	4
CO 3	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 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.	4
	PSO 1	**Formulate** and **Evaluate** the rectifier circuits applications in the field of Intelligent Embedded and Semiconductor technologies	2
CO 4	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 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	4
CO 5	PO 2	Analyze the BJT and FET amplifier using common emitter , common collector, Common source and Common Drain amplifier for **Problem formulation** to Estimate the voltage gain and current gain of by applying the **principles of mathematics**	2

	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling the basic electronic circuits using active transistors in **multisim simulation tool** to complex Engineering activities with an understanding of the limitations.	1
	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	4
CO 6	PO 2	Illustrate the volt-ampere characteristics **(knowledge**) of uni junction transistor for calculating intrinsic standoff ratio by applying **science for engineering problems**.	1
	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	4
CO 7	PO 2	Illustrate the volt-ampere characteristics **(knowledge)** of silicon controlled rectifier for analyzing latching, holding currents and breakdown voltage by applying **science for engineering problems.**	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**, make **effective presentations**, and give and receive clear instructions	4
CO 8	PO 2	Understand the given **problem statement** and **formulate** the threshold voltage from the volt-ampere characteristics of the FET devices using principles of mathematics and engineering science	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**, make **effective presentations**, and give and receive clear instructions	4
CO 9	PO 2	Understand the **problem statemen**t of electronic circuits using active transistors in **complex problem analysis using mathematics.**	2
	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling the basic electronic circuits using active transistors in **multisim simulation tool** to complex Engineering activities with an understanding of the limitations.	1
	PO 9	Function effectively as an **individual** , and as a member or leader in diverse **teams** for Designing basic electronic circuits using active transistors.	8
	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	4
	PSO 1	**Formulate** and **Evaluate** basic electronic circuits using active transistor applications in the field of Intelligent Embedded and Semiconductor technologies	2

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

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

CO 4	1			3	
CO 5	1	3		3	
CO 6	2			3	
CO 7	1			3	
CO 8	1			3	
CO 9	1	3	3	3	3

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**ELECTRONIC WORKSHOP PRACTICE**
	Identification, specifications, testing of R, L, C components (Color Codes), potentiometers, switches (SPDT, DPDT and DIP), coils, gang condensers, relays, bread boards, PCBs, identification, specifications and testing of active devices, diodes, BJTs, low power JFETs, MOSFETs, power transistors, LEDs, LCDs, optoelectronic devices, SCR, UJT, DIACs
WEEK II	**ELECTRONIC WORKSHOP PRACTICE**
	Study and operation of a. Multimeters (Analog and Digital) b. Function Generator c. Regulated Power Supplies d. Study and Operation of CRO
WEEK III	**PN DIODE CHARACTERISTICS**
	Verification of V-I characteristics of PN diode and calculate static and dynamic resistance using hardware and digital simulation.
WEEK IV	**ZENER DIODE CHARACTERISTICS AND VOLTAGE REGULATOR**
	Verification of V-I characteristics of Zener diode and perform Zener diode as a Voltage regulator using hardware and digital simulation.

WEEK V	**HALF WAVE RECTIFIER**
	Verification of half wave rectifier without and with filters using hardware and digital simulation.
WEEK VI	**FULL WAVE RECTIFIER**
	Verification of Full Wave Rectifier without and with filters using hardware and digital simulation.
WEEK VII	**TRANSISTOR CB CHARACTERISTICS**
	Verification of Input and Output characteristics of CB configuration using hardware and digital simulation.
WEEK VIII	**TRANSISTOR CE CHARACTERISTICS**
	Verification of Input and Output Characteristics of CE configuration using hardware and digital simulation
WEEK IX	**FREQUENCY RESPONSE OF CE AMPLIFIER**
	Determine the Gain and Bandwidth of CE amplifier using hardware and digital simulation.
WEEK X	**FREQUENCY RESPONSE OF CC AMPLIFIER**
	Determine the Gain and Bandwidth of CC amplifier using hardware and digital simulation.
WEEK XI	**UJT CHARACTERISTICS**
	Verification of V-I Characteristics of UJT using hardware and digital simulation
WEEK XII	**SCR CHARACTERISTICS**
	Verification of V-I Characteristics of SCR using hardware and digital simulation.
WEEK XIII	**FET CHARACTERISTICS**
	Verification of V-I Characteristics of FET using digital simulation.
WEEK XIV	**FREQUENCY RESPONSE OF CS AMPLIFIER**
	Determine the Gain and Bandwidth of CS amplifier using digital simulation.
WEEK XV	**FREQUENCY RESPONSE OF CD AMPLIFIER**
	Determine the Gain and Bandwidth of CD amplifier using digital simulation.

TEXTBOOKS

1. J. Millman, C.C.Halkias, Millman's, "Integrated Electronics", Tata McGraw Hill, 2nd Edition, 2001.

2. J.Millman, C.C.Halkias and satyabrata Jit, "Millman's Electronic Devices and circuits", Tata McGraw Hill, 2nd edition, 1998

REFERENCE BOOKS:

1. Mohammad Rashid, "Electronic Devices and Circuits", Cengage learning, 1st Edition, 2014.

2. David A. Bell, "Electronic Devices and Circuits", Oxford University Press, 5th 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	Electronic workshop practice.	CO 1	
2	pn diode characteristics.	CO 2	T1: 3.1
3	Zener diode characteristics and voltage regulator	CO 2	T1: 3.11
4	Half wave rectifier	CO 3	T1: 4.6
5	Full wave rectifier.	CO 3	T1: 4.8
6	Transistor CB characteristics	CO 4	T1: 5.5
7	Transistor CE characteristics	CO 4	T1: 5.6
8	Frequency response of CE amplifier.	CO 5 CO 9	T1: 8.3
9	Frequency response of CE amplifier.	CO 5 CO 9	T1: 8.3
10	UJT characteristics.	CO 6	T1: 9.2
11	SCR characteristics	CO 7	T1:9.3
12	FET characteristics	CO 8	T1:10.6
13	Frequency response of CS amplifier	CO 5 CO 9	T1: 10.7
14	Frequency response of CD amplifier	CO 5 CO 9	T1: 10.7

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Probing Further Experiments
1	Design high pass filter using bipolar junction transistor to produce the gain of 150.
2	Construct and verify the JFET's ability to behave as a voltage-controlled current regulator.
3	Design and verify the functionality of waveform clipper using Zener diode.
4	Construct and verify Battery Charger using SCR
5	Design the relaxation oscillator using Uni Junction Transistor.
6	Plot the V-I Characteristics of germanium diode and find the cut in voltage of diode.
7	Design diode acts as switch and plot the switching times of diode.
8	Design a zener voltage regulator circuit to drive a load of 6V, 100mW from an unregulated input supply of V_{min} = 8V, V_{max} = 12V using a 6V zener diode?
9	Design square wave generator using zener diode.
10	Design for a Zener Transistor series voltage regulator circuit to drive a load of 6V, 1W, from a supply of 10V with a ±3V ripple voltage
11	Design half wave rectifier with an applied input a.c. power is 100 watts, and it is to deliver an output power is 40 watts.

12	Design half wave rectifier with an a.c. supply of 230 V is applied through a transformer of turn ratio 10:1. Observe the output d.c. voltage, peak inverse voltage and identify dc output voltage if transformer turns ratio changed to 20:1.
13	Design a full wave rectifier with step down transformer and center tapped transformer. Justify the operation.
14	Design Full wave rectifier with capacitive filter using 10uF and 1uF. Observe the ripple factor.
15	Describe, based on your observations, the I-V curves of npn transistor. At approximately what collector-emitter voltage (V_{CE}) does the transition from saturation to active region occur?
16	Demonstrate the characteristics of Common base PNP transistor to determine the h parameters.
17	Design a Sustainable Relay Driving Circuit Using BJT.
18	Design an electronic switch using CE configuration.
19	Measure the DC voltages to make sure the BJT is in the forward active region. If it's not in forward active, adjust your resistor values to compensate.
20	Measure the voltage gain. Adjust the input signal from your wavetek to approximately 10mV amplitude, with a frequency of 100 kHz. What is the voltage swing?
21	Connect the common collector amplifier circuit you designed. Set the values of capacitors C1, C2, and C3 to 1uF each. Set R_L to be 1 kΩ and the supply voltage to 15V DC. Measure the DC bias voltages on the base, emitter and the collector. Calculate the collector current. Compare the measured voltages with the design intent and calculation. Tabulate the measured versus the calculated bias voltages and current.
22	Measure the frequency response of the amplifier starting from 100 Hz. change the test frequency to cover the upper cut-off frequency of the amplifier. Throughout the measurement of the frequency response, apply low input signal levels (in the order of few milli-Volts) to ensure that the output signal is not distorted. Monitor both input and output waveforms on the oscilloscope.
23	Design and observe the characteristics of relaxation oscillator using Uni-Junction Transistor.
24	Design Voltage sensing with a unijunction transistor and observe the characteristics.
25	Design battery charger circuit using silicon control rectifier.
26	Observe the characteristics of RC half wave and full wave Firing Circuit using silicon control rectifier.
27	Obtain the transistor drain characteristics in the saturated region, by applying the V_{MAX} is 40V, I_{MAX} is 20 mA and P_{MAX} is 0.4W.
28	Junction field-effect transistors (JFETs) are normally-on devices, the natural state of their channels being passable to electric currents. Thus, a state of cutoff will only occur on command from an external source. Explain what must be done to a JFET, specifically, to drive it into a state of cutoff.
29	Build the CS amplifier circuit using $V_{DD} = V_{SS} = 5$ V. Select 50 kΩ potentiometer and adjust it to obtain 250 µA bias current. Select $R_S = 10$ kΩ.
30	Obtain the frequency response of MOSFET amplifier in common source configuration.
31	Design and Plot the frequency response of single stage RC coupled amplifier using JFET.

32	Design a MOSFET amplifier and plot frequency response based on the given specifications. Both the input and the output should be AC coupled. Dual Supply Voltage = ±5V Load Resistance, R_L = 100Ω 0-to-Peak Output Swing is gtreaterthan or equal to 2V Voltage Gain= 50 Input Resistance= 10kΩ

Signature of Course Coordinator
Mr. Naresh B, Assistant Professor **HOD,ECE**

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

COURSE DESCRIPTION

Department	**ELECTRONICS AND COMMUNICATION ENGINEERING**				
Course Title	**DIGITAL SYSTEM DESIGN LABORATORY**				
Course Code	AECB10				
Program	B.Tech				
Semester	III	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Ms C V P Supradeepthi, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	**Course Code**	**Semester**	**Prerequisites**	**Credits**
B.Tech	AECB07	III	Digital System Design	3

II COURSE OVERVIEW:

The laboratory strives in exploring the logic design and related fields. Digital logic testers are used to provide students with practical training and familiarize themselves with the various functions of logic gates and using integrated components to complete circuitry functions and develop an interest in digital logic and enlighten them in the abilities of deduction. The lab allows students to conduct actual gate-level experiments on combinational and sequential circuits to increase student interest and develop skills to design digital gates using VHDL.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Digital System Design 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

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 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1	Lab 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.	3	Lab Experiments / CIE / SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on the Application Specific Integrated Circuit (ASIC) Prototype designs, Virtual Instrumentation and System on Chip (SOC) designs.	2	Lab Experiments / CIE / SEE

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to learn:

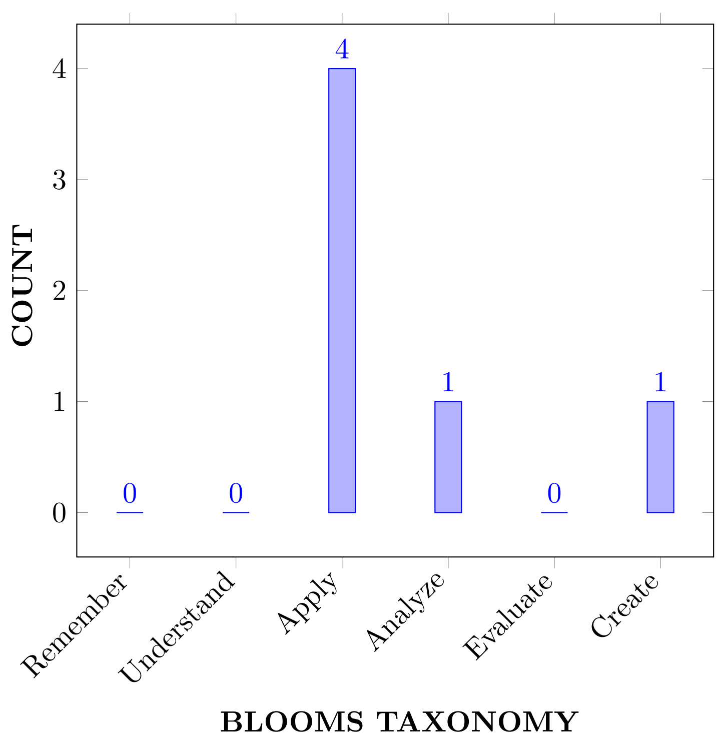
I	Design and simulate the combinational logic circuits using HDL code.
II	Model the sequential circuits and simulate using HDL code.
III	Implementation of basic real time applications and verify the outputs using FPGA.

IX COURSE OUTCOMES:

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

CO No	Course Outcomes	Knowledge Level (Bloom's Taxonomy)
CO 1	**Apply** the concept of Boolean algebra to verify the truth table of various expressions using logic gates in Hardware Description Language. .	Apply
CO 2	**Make use** of dataflow, structural and behavioral modelling styles of HDL for simulating the combinational logic circuits.	Apply
CO 3	**Analyze** the SR flip flop, JK flip flop, D flip flop, T flip flops for functional simulation and timing analysis.	analyze
CO 4	**Build** the universal shift registers, counters using the flip flops..	Apply
CO 5	**Examine** a finite state machine for detection of sequence.	Apply
CO 6	**Design** the real time applications like traffic light controller, chess clock controller FSM, elevator operations using FPGA kit.	Create

COURSE KNOWLEDGE COMPETENCY LEVEL



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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Apply the knowledge of boolean algebra (mathematics, science, engineering fundamentals)** to understand the function of logic gates	1
	PO 2	**Identify** the importance of basic gates in the optimization of **conventional Boolean** formulas in general and **digital circuits**	3
	PO 5	**Create** a program for boolean expressions in VHDL and verify the outputs using the tool.	1
	PO 10	**Able to communicate effectively** on engineering activities	1
CO 2	PO 1	**Understand the knowledge ofcombinational circuits (mathematics, science, engineering fundamentals)** for simulating circuits in data flow,structural and behavioral modelling styles	1
	PO 2	**Identify and analyse complex engineering** the combinational circuits like adders, encoder/decoders multiplexers/demultiplexers, code converters, ALU **(complex engineering problems)** using the principles of dataflow, structural, behavioral modelling style**(science)** and simulate the design to **validate** the results	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	**Design** solutions for combinational circuits**(complex engineering problems)** like adders, encoder/decoders multiplexers/demultiplexers, code converters, ALU.	3
	PO 5	**Simulate** the combinational circuits in VHDL using data flow or structural or behavioral models using **vivado tool**	1
	PO 10	**Able to communicate effectively** on engineering activities	1
CO 3	PO 2	**Analyze(complex engineering)** bi-stable elements flip-flops SR flipflop, JK flip flop, D flip dlop, T flip flop and illustrate the excitation tables of different flip flops for memory storage elements.	3
	PO 5	**Verify** the functional simulation and timing analysis of different outputs using hard description language in **Vivado tool**.	1
	PO 10	**Able to communicate effectively** on engineering activities	1
CO 4	PO 1	**Apply the knowledge of mathematics, science, engineering fundamentals** to design universal shift registers	1
	PO 2	**Identify** the functionality of **(complex engineering problems)**to design shift registers and counters using flip flops by **applying engineering fundamentals and science**	4
	PO 5	**Analyze** the various flip flops for functional simulation and timing analysis using hard ware description language in **Vivado tool**.	1
	PO 10	**Able to communicate effectively** on engineering activities	1
CO 5	PO 2	**Illustrate** about finite state machine and design FSM for the given sequence by applying principles of mealy/moore machine concepts**(science and engineering fundamentals)**.	3
	PO 3	**Design** finite state machine**(complex engineering problems)** using mealey and moore machines which will be used in real time applications.	3
	PO 5	**Model**the finite state machines and verify functional simulation using hard ware description language in **Vivado tool**	1
	PO 10	**Able to communicate effectively** on engineering activities	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 2	Develop the finite state machine by applying the **fundamental of mealy and moore models**	1
CO 6	PO 2	**Identify and formulate** for basic real time applications of the digital circuits and design using **mathematical principles for solving complex engineering problems**	3
	PO 3	**Design** basic real time applications of the digital circuits like traffic light controller ,chess clock controller, elevator **(complex engineering problems)**	2
	PO 5	**Build** the real time applications of digital circuits and simulate using hardware description language in **Vivado tool.**	1
	PO 9	Function effectively as an **apply basic principles** to create for apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling the digital circuits lifelong applications such as digital equipment and in many applications where signals are derived from digital circuits	2
	PO 10	**Able to communicate effectively** on engineering activities	1
	PSO 2	**Develop** basic real time applications of the digital circuits by applying the **fundamental blocks** of shift registers.	2

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

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	1	3	-	-	1	-	-	-	-	1	-	-	-	-	-
CO 2	1	5	3	-	1	-	-	-	-	1	-	-	-	-	-
CO 3	-	3	-	-	1	-	-	-	-	1	-	-	-	-	-
CO 4	1	4	-	-	1	-	-	-	-	1	-	-	-	-	-
CO 5	-	3	3	-	1	-	-	-	-	1	-	-	-	2	-
CO 6	-	4	2	-	1	-	-	-	2	1	-	-	-	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
	3	**10**	**10**	**11**	**1**	**5**	**3**	**3**	**12**	**5**	**12**	**8**	**2**	**2**	**2**
CO 1	33.3	30	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 2	33.3	50	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 3	-	30	30	-	-	-	-	-	-	40	-	-	-	-	-
CO 4	33.3	40	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 5	-	30	30	-	-	-	-	-	-	40	-	-	-	50	-
CO 6	-	40	20	-	-	-	-	-	16	40	-	-	-	50	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

0 - $0 \leq$ C$\leq$ 5% – No correlation
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	-	-	-	-	-
CO 2	1	2	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 3	-	1	1	-	-	-	-	-	-	1	-	-	-	-	-
CO 4	1	2	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 5	-	1	1	-	-	-	-	-	-	1	-	-	-	2	-
CO 6	-	2	1	-	-	-	-	-	1	1	-	-	-	2	-
TOTAL	**3**	**9**	**3**	**0**	**0**	**0**	**0**	**0**	**1**	**6**	**0**	**0**	**0**	**4**	**0**
AVERAGE	**1**	**1.5**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**2**	**0**

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 2	SEE Exams	PO 1, PO 2, PO 5	Seminars	PO1, PO12	Assignments	-
Laboratory Practices	PO 2, PO 3, PO 5	Student Viva		Mini Project	-	Certification	
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-	-	-

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

Week-1	**REALIZATION OF A BOOLEAN FUNCTION**
	Design and simulate the HDL code to realize three and four variable Boolean functions.
Week-2	**DESIGN OF DECODER AND ENCODER**
	Design and simulate the HDL code for the following combinational circuits (a) 3 to 8 Decoder 8 to 3 Encoder (With priority and without priority) .
Week-3	**DESIGN OF MULTIPLEXER AND DE MULTIPLEXER**
	Design and simulate the HDL code for the following combinational circuits (a) Multiplexer (b) De-multiplexer
Week-4	**DESIGN OF CODE CONVERTERS**
	Design and simulate the HDL code for the following combinational circuits (a) 4- Bit binary to gray code converter (b) 4- Bit gray to binary code converter (c) Comparator
Week-5	**FULL ADDER AND FULL SUBTRACTOR DESIGN MODELLING**
	Write a HDL code to describe the functions of a full Adder and subtractor Using three modeling styles
Week-6	**DESIGN OF 8 BIT ALU**
	Design a model to implement 8-bit ALU functionality.
Week-7	**HDL MODEL FOR FLIP FLOPS**
	Write HDL codes for the flip-flops - SR, D, JK, T Flip flops.
Week-8	**DESIGN OF COUNTERS**
	Write a HDL code for the following counters (a) Binary counter (b) BCD counter (Synchronous reset and asynchronous reset)
Week-9	**HDL CODE FOR UNIVERSAL SHIFT REGISTER.**
	Design and simulate the HDL code for universal shift register.
Week-10	**HDL CODE FOR CARRY LOOK AHEAD ADDER.**
	Design and simulate the HDL code for carry look ahead adder.
Week-11	**HDL CODE TO DETECT A SEQUENCE.**
	Write a HDL code to detect the sequence 1010101.
Week-12	**CHESS CLOCK CONTROLLER FSM USING HDL**
	Design a chess clock controller FSM using HDL and simulate the code.
Week-13	**TRAFFIC LIGHT CONTROLLER USING HDL**
	Design a traffic light controller using HDL and simulate the code.
Week-14	**ELEVATOR DESIGN USING HDL CODE.**
	Write HDL code to simulate Elevator operations and simulate the code.

TEXT BOOKS

1. Douglas Perry, "VHDL", Tata McGraw Hill, 4th Edition, 2002.
2. W.H. Gothmann, "Digital Electronics- An introduction to theory and practice", PHI, 2nd Edition,2006.

REFERENCE BOOKS

1. D.V. Hall, "Digital Circuits and Systems", Tata McGraw Hill, 1989.
2. Charles Roth, "Digital System Design using VHDL", Tata McGraw Hill 2nd Edition 2012

XIX 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	Design and simulate the HDL code to realize three and four variable Boolean functions	CO 1	T1 13.2
2	Design and simulate the HDL code for the following combinational circuits (a) 3 to 8 Decoder (b) 8 to 3 Encoder (With priority and without priority)	CO 2	T1 14.5
3	Design and simulate the HDL code for the following combinational circuits (a) Multiplexer (b) De-multiplexer	CO 2	T1 14.8
4	Design and simulate the HDL code for the following combinational circuits (a) 4- Bit binary to gray code converter (b) 4- Bit gray to binary code converter (c) Comparator	CO 2	T1 15.5 -15.9
5	Write a HDL code to describe the functions of a full Adder and subtractor Using three modeling styles	CO 2	T1 15.17
6	Design a model to implement 8-bit ALU functionality	CO 2	T1 15.16
7	Write HDL codes for the flip-flops - SR, D, JK, T	CO 3	T1 16.1, T1 16.8
8	Write a HDL code for the following counters (a) Binary counter (b) BCD counter (Synchronous reset and asynchronous reset)	CO 4	R1 4.1
9	Design and simulate the HDL code for universal shift register	CO 4	R1 4.2
10	Design and simulate the HDL code for carry look ahead adder	CO 2	R1 4.3
11	Write a HDL code to detect the sequence 1010101	CO 5	R2 4.6
12	Design a traffic light controller using HDL	CO 6	R2 4.10
13	Design a chess clock controller FSM using HDL	CO 6	R2 5.6
14	Write HDL code to simulate Elevator operations	CO 6	R2 5.9

XX EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Implementation of binary multiplier and simulate using simulation tool
2	Design a stepper motor/lcd controller and implement

Signature of Course Coordinator **HOD,ECE**
Ms. C V P Supradeepthi, Assistant Professor

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

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Analog and Pulse Circuits**				
Course Code	AECB11				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. S Lakshmanachari, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB03	II	Electrical Circuits
B.Tech	AECB06	III	Electronic Devices and Circuits

II COURSE OVERVIEW:

This course provides circuit analysis to design high frequency amplifiers and wave shaping circuits using discrete components. It covers on multistage amplifiers, power amplifiers, feedback concepts, sampling gates and multivibrators. Analog electronics are widely used in radio and audio equipment and in many applications where signals are derived from analog sensors and transducers.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Analog and Pulse Circuits	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
50 %	Understand
25 %	Apply
15 %	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:

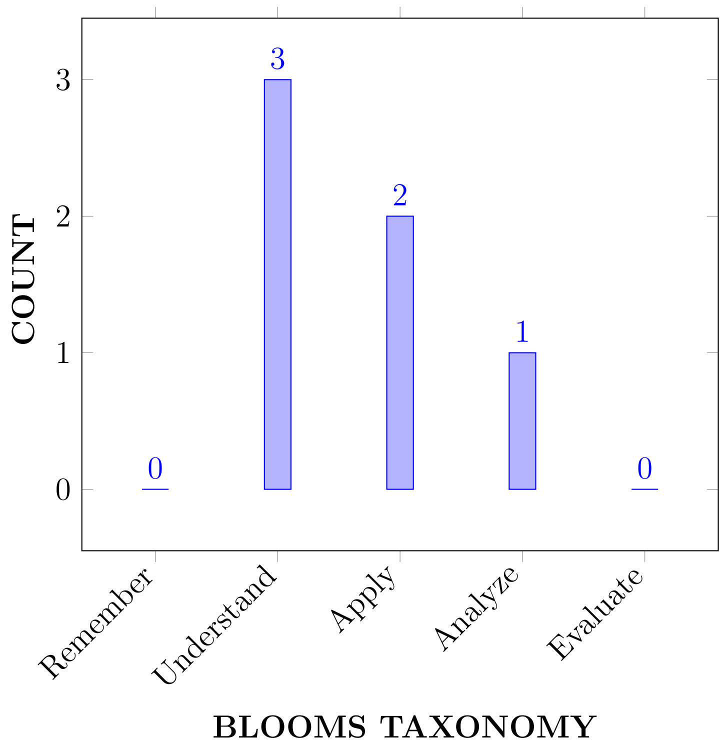
I	The design and analysis of transistor amplifiers using low frequency and high frequency signals.
II	The response for a linear wave shaping circuits of low pass filter and high pass filters.
III	The generation of non-linear oscillations by using regenerative feedback circuit for multivibrators.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** Bipolar Junction Transistor (BJT) amplifier circuits and their frequency responses at low, mid and high frequencies for determining amplifier characteristics.	Understand
CO 2	**Summarize** the concept of feedback in amplifiers for the distinction between negative and positive feedback.	Understand
CO 3	**Obtain** the expression to find frequency of oscillations for RC and LC type oscillator circuits.	Understand
CO 4	**Identify** the suitable large signal amplifiers or power amplifiers for practical applications with given specifications.	Apply
CO 5	**Analyze** the response of linear and non-linear wave shaping circuits for impulse and pulse inputs with different time constants.	Analyze
CO 6	**Build** bistable, monostable and astable multivibrator circuits using transistors for 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.

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	1	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 2	Focus on the Application Specific Integrated Circuit (ASIC) prototype designs, Virtual Instrumentation and System on Chip (SOC) designs.	3	AAT

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Illustrate** Bipolar Junction Transistor (BJT) amplifier circuits and their frequency responses at low, mid and high frequencies for determining amplifier characteristics by applying **engineering fundamentals** to the solution of complex engineering problems.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Identify the problems** in Bipolar Junction Transistor (BJT) amplifier circuits then **formulate problem statement** based on the **Information provided** to analyze complex engineering problems using first principles of mathematics, natural sciences, and engineering sciences.	4
	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 2	PO 1	**Describe** various types of feedback amplifiers like voltage series, voltage shunt, current series and current shunt by applying **knowledge of mathematics** and **engineering fundamentals** to the solution of complex engineering problems.	2
	PO 2	**Understand** the given **problem statement** and **formulate** the complex engineering problems of feedback amplifiers from the provided **information, develop solutions** based on the functionality of the circuit, **validate** the output of the circuit in reaching substantiated conclusions by the **interpretation of results.**	6
	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	**Obtain** the expression to find frequency of oscillations for different oscillator circuits by applying **knowledge of mathematics** and **engineering fundamentals** to the solution of complex engineering problems.	2
	PO 2	**Understand** the **problem statement** of RC oscillators and **formulate** the complex engineering problems of RC oscillators from the provided **information, develop solutions** based on the functionality of the circuit, **validate** the output of the circuit in reaching substantiated conclusions by the **interpretation of results.**	6
	PO 3	**Design** solutions for complex engineering problems and design system components of oscillators that **meet the specified customer and user needs** with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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 2	Focus on the **Application Specific Integrated Circuit (ASIC) prototype designs** using analog and pulse circuits in the field of analog electronics.	1
CO 4	PO 1	**Identify** the suitable large signal amplifiers for practical applications with given specifications by applying the **knowledge of mathematics** and **engineering fundamentals** to the solution of complex engineering problems.	2
	PO 2	**Understand** the **problems of power amplifiers** and **formulate** the solutions of power amplifiers for practical applications with **given specifications** to analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and engineering sciences.	4
	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 5	PO 1	**Analyze** the response of linear and non-linear wave shaping circuits for impulse and pulse inputs with different time constants by applying the **knowledge of mathematics** and **engineering fundamentals**, and an engineering specialization to the solution of complex engineering problems.	2
	PO 2	**Understand** the given **problem statement** and **formulate** the expression for percentage tilt from the response of high pass RC circuit for square input using **principles of mathematics** and **engineering science.**	4
	PO 3	**Design** solutions for **complex engineering problems** and **design system components** of **linear and non-linear wave shaping circuit's applications** that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	5
	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 6	PO 1	**Design** the basic electronic circuits using active transistors by applying **mathematics, science** and **engineering fundamentals.**	3
	PO 2	**Identifying the real time problems** in multivibrators then **analyze** the design process to **solve the real time problems** and to find the solution for various applications of multivibrators in real time using first **principles of mathematics, and engineering sciences.**	5
	PO 3	**Design** solutions for **complex engineering problems** and **design system components** of **multivibrators** that **meet the specified needs with appropriate consideration** for the public health and safety, and the cultural, societal, and environmental considerations.	5
	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 2	Focus on the **Application Specific Integrated Circuit (ASIC) prototype designs** and **System on Chip (SOC)** designs for multivibrator applications.	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO / PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	40	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 2	66.7	60	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 3	66.7	60	10	-	-	-	-	-	-	40	-	-	-	50	-
CO 4	66.7	40	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 5	66.7	40	50	-	-	-	-	-	-	40	-	-	-	-	-
CO 6	100	50	50	-	-	-	-	-	-	40	-	-	-	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	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	3	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 3	3	3	1	-	-	-	-	-	-	1	-	-	-	2	-
CO 4	3	1	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 5	3	1	2	-	-	-	-	-	-	1	-	-	-	-	-
CO 6	3	2	2	-	-	-	-	-	-	1	-	-	-	3	-
TOTAL	**16**	**11**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**6**	**0**
AVERAGE	**2.66**	**1.83**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**0**

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**MULTISTAGE 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, f_α, β and unity gain bandwidth, Gain band width product.
MODULE II	**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 .
MODULE III	**OSCILLATORS AND LARGE SIGNAL AMPLIFIERS**
	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, Frequency and amplitude stability of Oscillators, Crystal Oscillator. Class - A Power Amplifier- Series fed and Transformer coupled, Conversion Efficiency, Class - B Power Amplifier- Push Pull and Complimentary Symmetry configurations, Conversion Efficiency, Principle of operation of Class - AB and Class - C Amplifiers. Tuned Amplifiers: Single Tuned Amplifiers – Q-factor, frequency response of tuned amplifiers, Concept of stagger tuning and synchronous tuning.
MODULE IV	**LINEAR WAVE SHAPING AND SAMPLING GATES**
	Linear wave shaping circuits: High pass RC and low pass RC circuits, response to step and square inputs with different time constants, high pass RC circuit as a differentiator, low pass RC circuit as an integrator. Sampling gates: basic operating principle of sampling gate, uni and bi directional sampling gates. .
MODULE V	**MULTIVIBRATORS**
	Multivibrators: Bistable multivibrator, unsymmetrical triggering, symmetricaltriggering; Schmitt trigger; Monostable multivibrator, Astable multivibrator.

TEXT BOOKS

1. Jacob Millman, Christos C Halkias, "Integrated Electronics" McGraw Hill Education, 2ndEdition, 2010.
2. B.N.Yoganarasimhan, "Pulse and Digital Circuits", 2nd Edition, 2011.

REFERENCE BOOKS:

1. Robert L. Boylestead, Louis Nashelsky, "Electronic Devices and Circuits Theory", PearsonEducation, 11th Edition, 2009.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108/108/108108111/

COURSE WEB PAGE:

1. https:://lms.iare.ac.in/index?route=course/details&course_id=192

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=456
CONTENT DELIVERY (THEORY)			
2	Classification of amplifiers	CO 1	T1:1.1-1.4
3	Distortions in amplifiers	CO 1	T1:2.1
4	Different coupling schemes used in amplifiers	CO 1	T1:2.4
5	Frequency response of multistage amplifiers	CO 1	T1:2.4
6	Analysis of multistage amplifiers	CO 1	T1:2.2
7	Cascode amplifier	CO 1	T1:3.2
8	Darlington pair	CO 1	T1:3.3
9	Transistor at High Frequency: Hybrid - model of common emitter transistor model	CO 1	T1:4.1-4.3
10	f_α, β and unity gain bandwidth, Gain band width product	CO 1	T1:4.4-4.7
11	The CE current gain with Load, R_L	CO 1	T1:4.8-4.10
12	Classification of feedback amplifiers	CO 2	T1:4.11,5.1-5.3
13	General characteristics of negative feedback amplifiers	CO 2	T1:6.1-6.3
14	Effect of feedback on amplifier characteristics	CO 2	T1:6.4
15	Voltage series feedback amplifier	CO 2	T1:7.2
16	Voltage shunt feedback amplifier	CO 2	T1:7.2
17	Current series feedback amplifier	CO 2	T1:8.1-8.3
18	Current shunt feedback amplifier	CO 2	T1:8.4-8.5
19	Oscillations and condition for oscillations	CO 3	T1:9.1-9.3
20	RC phase shift and wien-bridge oscillators	CO 3	T1:9.4-9.7
21	LC type oscillators and generalized analysis of LC oscillators	CO 3	T1:10.1
22	Hartley and Colpits oscillators	CO 3	T1:10.2
23	Frequency and amplitude stability of oscillators	CO 3	T1:10.2
24	Class A power amplifier- series fed and transformer coupled, conversion efficiency	CO 4	T1:10.3
25	Class B power amplifier- push pull and complimentary symmetry configurations	CO 4	T1:10.3
26	Principle of operation of Class AB and Class C amplifiers.	CO 4	T1:10.4

S.No	Topics to be covered	CO's	Reference
27	Single tuned amplifiers – Q-factor, frequency response of tuned amplifiers	CO 4	T4:10.1
28	Concept of stagger tuning and synchronous tuning	CO 4	T4:10.2
29	Response of High pass RC circuit to step and square inputs with different time constants	CO 5	T4:10.4
30	Response of Low pass RC circuit to step and square inputs with different time constants	CO 5	T4:10.4
31	Sampling gates: basic operating principle of sampling gate.	CO 5	T4:10.5
32	High pass RC circuit as a differentiator and low pass RC circuit as an integrator	CO 5	T4:10.5
33	Uni and bi-directional sampling gates	CO 5	T4:10.6-10.7
34	Bistable multivibrator	CO 6	T4:10.8
35	Unsymmetrical triggering of Bistable multivibrator	CO 6	T4:10.8
36	Symmetrical triggering of Bistable multivibrator	CO 6	T3:3.12
37	Monostable multivibrator	CO 6	T3:3.12
38	Triggering of Monostable multivibrator	CO 6	T3:3.12
39	Astable multivibrator.	CO 6	T3:3.12
40	Schmitt trigger.	CO 6	T3:3.12
PROBLEM SOLVING/ CASE STUDIES			
41	Analysis of multistage amplifiers	CO 1	T1:2.2
42	Cascode amplifier and Darlington pair	CO 1	T2:1.12
43	Voltage series and voltage shunt feedback amplifiers	CO 2	T1:3.2
44	Current series and current shunt feedback amplifiers	CO 2	T1:3.6
45	Oscillators designing and condition for oscillations	CO 3	T1:3.6
46	Large signal amplifiers	CO 4	T1:4.1
47	Linear wave shaping circuits.	CO 4	T1:4.1-4.8
48	Sampling gates.	CO 5	T1:5.8
49	Designing of Bistable, Monostable and Astable multivibrators.	CO 6	T2:10.4 R2:7.2
50	Designing of Schmitt trigger circuit.	CO 6	T2:10.4 R2:7.2
DISCUSSION ON DEFINITION AND TERMINOLOGY			
51	Multistage amplifiers	CO 1	-
52	Feedback amplifiers	CO 2	-
53	Oscillators and large signal amplifiers	CO 3,CO 4	-
54	Linear wave shaping and sampling gates	CO 5	-
55	Multivibrators	CO 6	-
DISCUSSION ON QUESTION BANK			
56	Multistage amplifiers	CO 1	-

S.No	Topics to be covered	CO's	Reference
57	Feedback amplifiers	CO 2	-
58	Oscillators and large signal amplifiers	CO 3, CO 4	-
59	Linear wave shaping and sampling gates	CO 5	-
60	Multivibrators	CO 6	-

Signature of Course Coordinator **HOD, ECE**

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

COURSE DESCRIPTION

<table>
<tr><td>Department</td><td colspan="5">Electronics and Communication Engineering</td></tr>
<tr><td>Course Title</td><td colspan="5">Analog Communications</td></tr>
<tr><td>Course Code</td><td colspan="5">AECB12</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td colspan="5">IV</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>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Dr. P. Munasamy, Professor</td></tr>
</table>

I COURSE OVERVIEW:

Analog communications emphasizes on generation, transmission and reception of audio, video and telephony signals. The course covers representation of signals in time and frequency domain, need of modulation and an effect of noises on the performance of communication systems. Analog communication system principles are used for real world applications of Radio and TV broadcasting systems.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB06	III	Electronic Devices and Circuits
B.Tech	AECB08	III	Probability Theory and Stochastic Process

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Analog Communications	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
50 %	Understand
33 %	Apply
17 %	Analyze
0%	Evaluate
0%	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 10 marks for Alternative Assessment Tool (AAT).

Component	Theory		Total Marks
Type of Assessment	CIE Exam	AAT	
CIA Marks	20	10	30

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

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, 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:

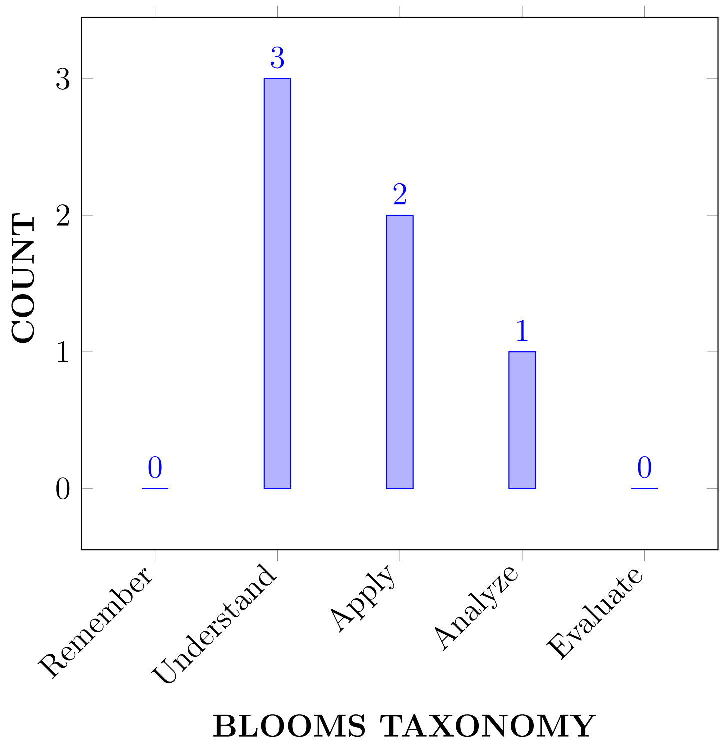
I	The elementary signals, fundamental elements of analog communication systems.
II	The need of modulation, generation and detection techniques of analog and pulse modulation systems.
III	The influence of external and internal noises on the performance of communication systems.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the fundamental equations, generation and detection techniques of amplitude modulations for video signal transmission systems..	Understand
CO 2	**Compare** bandwidth, power requirements, efficiency for AM and FM analog communication systems	Analyze
CO 3	**Outline** the generation and detection techniques of frequency modulated waves used for audio signal transmission systems.	Understand
CO 4	**Calculate** Signal to Noise Ratio (SNR) and noise figure for analysis of amplitude and frequency modulation techniques.	Apply
CO 5	**Make use of** the working principles of AM , FM receivers to measure selectivity, sensitivity, fidelity and signal to noise ratio.	Apply
CO 6	**Interpret** the generation and detection techniques of pulse modulations for introducing digital communications, A/D converters.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE / CIE / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	SEE / CIE / AAT
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
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 3	**Make use of** High Frequency Structure Simulator (HFSS) for modeling and evaluating the patch and smart antennas for wired and wireless communication applications.	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:

(COs)	POs / PSOs	Justification for mapping (Students will be able to)	No. of key competencies
CO 1	PO 1	**Explain** the basic concepts, need of modulation and fundamental elements i.e transmitter,receiver,channel by applying the **mathematical principles,science and engineering fundamentals.**	3
	PO 2	**Identify, formulate, review research** literature for generation and detection techniques of amplitude modulations and **translate** the **information** into the **graphical form** from the provided information and data, develop solutions based on inputs of analog communication systems. .	5
	PO 3	**Design** modulations required for 5g,6g technologies for **complex Engineering problems** and **customer needs** design system components using **creativity** by **innovative solutions**,and implementing them with modern tools such as cadence software, mentor graphics, synopsis.	3
	PO 10	Students to communicate effectively with the engineering community, **write** effective **reports** and documentation, make effective presentations, and give and receive clear instructions.	2
	PSO 3	Develop modulator and demodulator for Wired and Wireless Communication Applications.	2
CO 2	PO 1	Compare AM and FM analog communication systems and calculate bandwidth, power requirements, efficiency and noise using **science and mathematical principles** for solving complex **engineering problems**	3
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of power, bandwidth requirements of various modulated waves translate the information into the required form from the provided **information and data,** develop **solutions** based on inputs	5
	PO 3	**Design** orthogonal modulations schemes required for 5g,6g technologies in terms of bandwidth, power,efficiency for **complex Engineering problems** and **customer needs** design system components using **creativity** by **innovative solutions** for modern communication technologies	3
	PO 10	Students to communicate effectively with the engineering community, **write** effective **reports** and documentation, make effective presentations, and give and receive clear instructions.	2
	PSO 3	**Develop** modulator and demodulator for **Wired and Wireless** Communication Applications.	2

CO 3	PO 1	**Interpret** the generation and detection techniques of frequency modulated waves by using **mathematical,science principles and engineering problems**	3
	PO 2	**Identify, formulate,** review research literature for generation and detection techniques of frequency modulation techniques and **translate** the **information** into the graphical form from the provided information and data, **develop solutions** based on inputs of analog communication systems.	5
	PO 3	**Design** solutions for generation and detection of present generation modulation schemes for **complex Engineering problems** by doing **innovative solution** and implementing them using **modern tools** such as cadence software, mentor graphics, synopsis with reduction in **cost constraints.**	3
	PO 10	Students to communicate effectively with the engineering community, **write** effective **reports** and documentation, make effective presentations, and give and receive clear instructions.	2
	PSO 3	**Develop** modulator and demodulator for **Wired and Wireless** Communication Applications.	2
CO 4	PO 1	**Interpret** the internal and extrenal noise sources which effects the communication system by using **mathematical principles and engineering problems**	3
	PO 2	**Understand** the given **problem statement** and **formulate** the (complex) engineering problems of noise effect for different modulations , **translate** the information into calculation of signal to noise ratio from the provided **information and data, develop** solutions based on inputs	5
	PO 10	Students to communicate effectively with the engineering community, **write** effective **reports** and documentation, make effective presentations, and give and receive clear instructions.	2
	PSO 3	**Develop** smart antennas for 5g and 6g communictaions , **disaster effected areas, miltary applications**	2
CO 5	PO 1	**Judge** the performance of the working principles and operations of TRF and super heterodyne receivers using **mathematics and scientific and engineering methodologies.**	3
	PO 2	**Understand** the given **problem statement and formulate** the **complex engineering** problems of characteristics of a good receiver, **translate** the information into various parameters from the provided **information and data**, **develop** solutions based on inputs	5

	PO 3	**Design** solutions for **environmental constraints** for communication systems by doing **innovative solution** and **implementing** them using modern tools such as cadence software, mentor graphics, synopsis.	3
	PO 10	Students to communicate effectively with the engineering community, **write** effective **reports** and documentation, make effective presentations, and give and receive clear instructions.	2
	PSO 3	**Develop** smart antennas for 5g and 6g communictaions , **disaster effected areas, miltary applications**	2
CO 6	PO 1	**Understand** the generation and detection techniques of pulse modulation techniques by using **mathematics,science and engineering fundamentals**	3
	PO 2	**Understand** the given **problem statement and formulate** the (complex) **engineering problems** of pulse modulations and **translate** the **information** into various parameters from the provided information and data, **develop** solutions based on inputs.	5
	PO 10	Students to communicate effectively with the engineering community, **write** effective **reports** and documentation, make effective presentations, and give and receive clear instructions.	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	5	3	-	-	-	-	-	-	2	-	-	-	-	2
CO 2	3	5	3	-	-	-	-	-	-	2	-	-	-	-	2
CO 3	3	5	3	-	-	-	-	-	-	2	-	-	-	-	2
CO 4	3	5	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 5	3	5	3	-	-	-	-	-	-	2	-	-	-	-	2
CO 6	3	5	-	-	-	-	-	-	-	2	-		-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 3	100	50	30	-	-	-	-	-	-	40	-	-	-	-	100
CO 4	100	50	-	-	-	-	-	-	-	40	-		-	-	-
CO 5	100	50	30	-	-	-	-	-	-	40	-	-	-	-	100
CO 6	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	1	-	-	-	-	-	-	1	-	-	-	-	2
CO 2	3	2	1	-	-	-	-	-	-	1	-	-	-	-	2
CO 3	3	2	1	-	-	-	-	-	-	1	-	-	-	-	2
CO 4	3	2	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 5	3	2	1	-	-	-	-	-	-	1	-	-	-	-	2
CO 6	3	2	-	-	-	-	-	-	-	1	-	-	-	-	-
TOTAL	**18**	**12**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**8**
AVERAGE	**3**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**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	**AMPLITUDE MODULATION**

	Introduction to communication system, Need for modulation, Frequency Division Multiplexing , Amplitude Modulation, Definition, Time domain and frequency domain description, single tone modulation, power relations in AM waves, Generation of AM waves, square law Modulator, Switching modulator, Detection of AM Waves; Square law detector, Envelope detector, Double side band suppressed carrier modulators, time domain and frequency domain description, Generation of DSBSC Waves, Balanced Modulators, Ring Modulator, Coherent detection of DSB-SC Modulated waves, COSTAS Loop.
MODULE II	**SSB MODULATION**
	SSB Modulation: Frequency domain description, Frequency discrimination method for generation of AM SSB Modulated Wave, Time domain description, Phase discrimination method for generating AM SSB Modulated waves. Demodulation of SSB Waves, Vestigial side band modulation: Frequency description, Generation of VSB Modulated wave, Time domain description, Envelop detection of a VSB Wave pulse Carrier, Comparison of AM Techniques, Applications of different AM Systems.
MODULE III	**ANGLE MODULATION**
	Basic concepts, Frequency Modulation: Single tone frequency modulation, Spectrum Analysis of Sinusoidal FM Wave, Narrow band FM, Wide band FM, Constant Average Power. Transmission bandwidth of FM Wave - Generation of FM Waves, Direct FM, Detection of FM Waves: Balanced Frequency discriminator, Zero crossing detector, Phase locked loop, Comparison of FM and AM.
MODULE IV	**NOISE IN ANALOG COMMUNICATION SYSTEM** Types of Noise: Resistive (Thermal) Noise Source, Shot noise, Extraterrestrial Noise, Arbitrary Noise Sources, White Noise,Narrowband Noise- In phase and quadrature phase components and its Properties,
	Modeling of Noise Sources, Average Noise Bandwidth, Effective Noise Temperature, Average Noise Figures, Average Noise Figure of cascaded networks.Noise in DSB and SSB System Noise in AM System, Noise in Angle Modulation System, Noise Triangle in Angle Modulation System, Pre-emphasis and de-emphasis.
MODULE V	**RECEIVERS**
	Receiver Types -Tuned radio frequency receiver, Superhetrodyne receiver, RF section and Characteristics - Frequency changing and tracking, Intermediate frequency, AGC, FM Receiver, Comparison with AM Receiver, Amplitude limiting. Pulse Modulation: Types of Pulse modulation, PAM (Single polarity, double polarity) PWM: Generation and demodulation of PWM, PPM, Generation and demodulation of PPM, Time Division Multiplexing.

TEXTBOOKS

1. S. S. Haykin, "Communication Systems", Wiley Eastern, 2nd Edition, 2006.
2. Taub, Schilling, "Principles of Communication Systems", Tata McGraw-Hill, 4th Edition, 2013.

REFERENCE BOOKS:

1. B.P. Lathi, "Communication Systems, BS Publication", 2nd Edition, 2006.
2. John G. Proakis, Masond, Salehi, "Fundamentals of Communication Systems", PEA, 1st Edition,2006

3. George Kennedy, Bernard Davis, “Electronics and Communication System”, Tata McGraw Hill, 5th Edition, 2011.

WEB REFERENCES:

1. https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-ee46

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index?route=course/details&course_id=73

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=73
CONTENT DELIVERY (THEORY)			
2	Introduction to communication system and need for modulation	CO 1	T2 –2.1 to 2.2
3	Time domain and frequency domain description of amplitude modulation	CO 1	TI –1.1 to 2.5
4	Power relations in AM waves	CO 1	T3 –1.1 to 1.1.6
5	Generation of AM waves, square law Modulator, Switching modulator	CO 1	T3 –3.2 to 3.3.4
6	Detection of AM Waves; Square law detector, Envelope detector	CO 1	R1 –3.3, T3-8.3 to 8.4
7	Time domain and frequency domain description of DSBSC	CO 2	T3 – 3.4
8	Generation of DSBSC Waves, Balanced Modulators, Ring Modulator.	CO 2	T3 –3.4.1 to3.4.2, T3 –8.2.
9	Coherent detection of DSB-SC Modulated waves, COSTAS Loop.	CO 2	T3 –3.5.1 to 3.5.2
10	Time and frequency Division Multiplexing	CO 3	T3 – 4.1 to 4.3.4
11	Time domain and frequency domain description of SSBSC	CO 3	T3 -4.4 to 4.4.5, T2 – 2.14
12	Frequency discrimination method for generation of SSBSC	CO 5	T3 –9.1 to 9.5.2

13	Phase discrimination method for generation of SSBSC	CO 4	R3 –6.1
14	Demodulation of SSB Waves	CO 4	R3 –6.2 to 6.4.6
15	Time domain and frequency domain description of VSBSC	CO 3	T2 -6.2 to 6.3
16	Generation of VSB Modulated wave	CO 4	T3 – 1.2 to 1.2.3
17	Envelop detection of a VSB Wave pulse Carrier	CO 4	T3 –1.2.4 to 1.4.8
18	Comparison of AM techniques, applications of different AM Systems.	CO 4	TI –1.1 to 2.5
19	Frequency modulation basic concepts and Single tone frequency modulation	CO 4	T3 –1.1 to 1.1.6
20	Spectrum Analysis of Sinusoidal FM Wave	CO 4	T3 –3.2 to 3.3.4
21	Narrow band FM, wide band FM, Constant Average Power.	CO 4	R1 –3.3, T3-8.3 to 8.4
22	Transmission bandwidth of FM Wave	CO 4	T3 – 3.4
23	Generation of FM Waves, Direct FM and indirect FM	CO 4	T3 –3.4.1 to3.4.2, T3 –8.2.
24	Detection of FM waves :Balanced Frequency discriminator	CO 4	T3 –3.5.1 to 3.5.2
25	Phase locked loop,	CO 4	T3 – 4.1 to 4.3.4
26	Zero crossing detector, Comparison of FM and AM.	CO 4	T3 -4.4 to 4.4.5, T2 – 2.14
27	Noise and different types of noise sources	CO 5	T3 –9.1 to 9.5.2
28	Narrowband noise- In phase and quadrature phase components	CO 5	R3 –6.1
29	Narrow band FM, wide band FM, Constant Average Power.	CO 6	R3 –6.2 to 6.4.6
30	Average noise bandwidth, Effective noise Temperature, Average noise figures	CO 5	T2 -6.2 to 6.3
31	Average Noise Figure of cascaded networks	CO 6	T3 – 1.2 to 1.2.3
32	Noise in AM System	CO 6	T3 –1.2.4 to 1.4.8
33	Noise in DSB and SSB Systems.	CO 7	TI –1.1 to 2.5
34	Noise in Angle Modulation System	CO 7	T3 –1.1 to 1.1.6
35	Pre-emphasis and de-emphasis.	CO 8	TI –1.1 to 2.5
36	Tuned radio frequency receiver,	CO 8	T3 –1.1 to 1.1.6
37	Super hetrodyne receiver, RF section and Characteristics	CO 9	TI –1.1 to 2.5

38	Intermediate frequency, AGC circuits	CO 9	T3 –1.1 to 1.1.6
39	FM receiver, comparison with AM receiver	CO 10	T3 –3.5.1 to 3.5.2
40	PAM generation and demodulation	CO 10	T3 – 4.1 to 4.3.4
41	Generation and demodulation of PWM	CO 10	T3 – 4.1 to 4.3.4
42	Generation and demodulation of PPM	CO 10	T3 – 4.1 to 4.3.4
PROBLEM SOLVING/ CASE STUDIES			
42	Power, current, voltage relations in AM wave	CO 1	TI –1.1 to 2.5
43	Design of envelope detector circuit	CO 1	TI –1.1 to 2.5
44	Time domain and frequency domain equations of AM wave	CO 2	T3 – 3.4
45	Time domain and frequency domain equations of DSBSC.	CO 5	T3 -4.4 to 4.4.5, T2 – 2.14
46	Time domain and frequency domain equations of SSBSC.	CO 4	R3 –6.2 to 6.4.6
47	Time domain and frequency domain equations of FM.	CO 4	T2 -6.2 to 6.3
48	Bandwidth and power calculation of FM wave	CO 4	T2 -6.2 to 6.3
49	Resistive (Thermal) Noise Source, Shot noise	CO 6	T3 –9.1 to 9.5.2
50	Average Noise Bandwidth, Effective Noise Temperature, Average oise Figures	CO 5	R3 –6.1
51	Average Noise Figure of cascaded networks	CO 7	TI –1.1 to 2.5
52	Noise in AM System,DSBSC,SSBSC	CO 9	T3 –3.5.1 to 3.5.2
53	Noise in Angle Modulation System	CO 10	T3 – 4.1 to 4.3.4
54	Tuned radio frequency receiver	CO 10	T3 – 4.1 to 4.3.4
55	Super hetrodyne receiver	CO 10	T3 – 4.1 to 4.3.4
56	Time Division Multiplexing.	CO 10	T3 – 4.1 to 4.3.4
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Amplitude modulation generation and detection	CO 4	T3 –9.1 to 9.5.2
57	DSBSC ,SSBSC generation and demodulation	CO 4	R3 –6.2 to 6.4.6
58	Angle Modulation	CO 6	T3 –3.5.1 to3.5.2
59	Receivers	CO 9	T3 – 4.1 to 4.3.4

DISCUSSION OF QUESTION BANK			
60	Amplitude modulation generation and detection	CO 1,2, 3	R4:2.1
61	DSBSC ,SSBSC generation and demodulation	CO 4,11	T4:7.3
62	Angle Modulation	CO 6,7	R4:5.1
63	Receivers	CO 8,11	T1:7.5

Signature of Course Coordinator **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	**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	Electronics and communication Engineering				
Course Title	Electromagnetic Waves and Transmission Lines				
Course Code	AECB13				
Program	B.Tech				
Semester	IV				
Course Type	Core				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Dr. D Srikar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB02	1	Linear Algebra and Calculus
B.Tech	AHSB03	1	Engineering Physics

II COURSE OVERVIEW:

Electromagnetic Waves and Transmission Lines gives the necessary information about the formation of magnetic fields when electric current flows and structures to conduct electromagnetic waves. It covers the fundamental concepts of electro-magnetic wave theory and introduces the basic laws of electromagnetic fields, time varying Maxwell's equations, wave propagation and transmission lines. It provides a platform for advanced courses such as antennas and wave propagation, microwave engineering, transmission via wired links and optical fiber networks.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Electromagnetic Theory and Transmission Lines	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 units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
50%	Understand
25%	Apply
15%	Analyze
0%	Evaluate
0%	Create

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

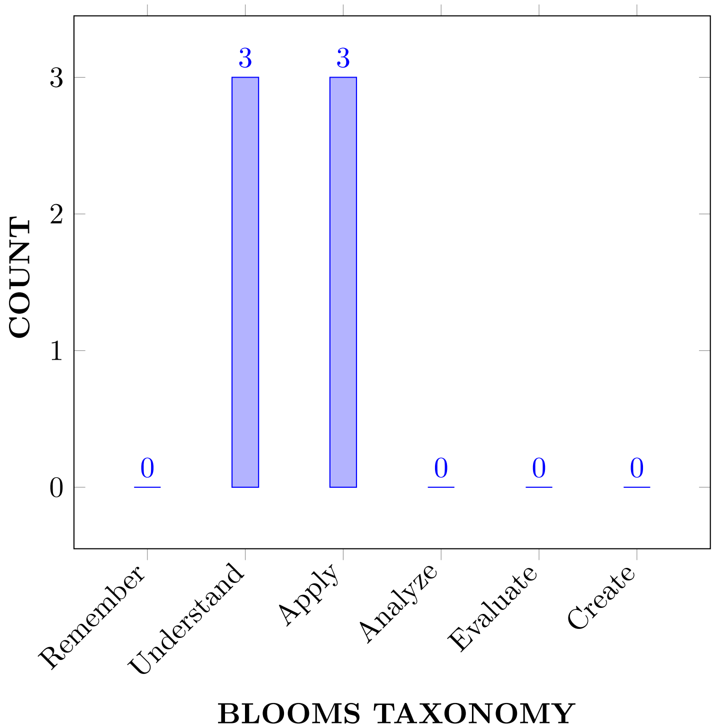
I	The basic concepts required to understand various engineering applications involving electromagnetic fields.
II	The wave propagation characteristics of electromagnetic wave in bounded and unbounded media.
III	The basic theory of transmission lines, appropriate tools (smith chart) to analyze transmission lines.

VII COURSE OUTCOMES:

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

CO 1	**Describe** fundamental laws (Coulomb's and Gauss's) of electrostatic fields to evaluate the field intensity and flux density of continuous charge distributions.	Understand
CO 2	**Demonstrate** Biot-Savart's law and Ampere's circuit law to determine forces due to magnetic fields.	Understand
CO 3	**Apply** Maxwell's equations and their applications to time varying fields and boundary conditions.	Apply
CO 4	**Construct** the wave equations for both conducting and dielectric media to derive the relation between electric and magnetic field intensities.	Apply
CO 5	**Understand** the propagation of electromagnetic waves through different media using the concept of uniform plane waves.	Understand
CO 6	**Make use of** the smith chart as a graphical tool to solve impedance matching issues in transmission lines.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	Make use of high frequency structure simulator (HFSS) for modeling and evaluating the patch and smart antennas for wired and wireless communication applications.	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	**Explain** fundamental laws of static electric fields to evaluate the field intensity and flux density of various charge distributions **by applying the knowledge of mathematics and engineering fundamentals**	3
	PO 2	**Identify** the fundamental laws of static electric fields to evaluate the field intensity and flux density of various charge distributions **by using principles of mathematics.**	2
CO 2	PO 1	**Apply** the knowledge of mathematics, engineering fundamentals to develop Biot-Savart's law and ampere's circuit law **to determine forces due to magnetic fields.**	3
	PO 2	**Demonstrate** Biot-Savart's law and Ampere's circuit law to determine forces due to magnetic fields **by using the principles of mathematics and engineering sciences.**	2
CO 3	PO 1	**Apply** Maxwell's equations and their application to time varying fields and boundary conditions **to solve complex engineering problems.**	3
	PO 2	**Distinguish** between homogeneous and isotropic boundary conditions **by using the principles of mathematics and engineering sciences.**	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 3	**Analyze** complex engineering problems reaching substantiated conclusions **by applying Maxwell's equations and their application to time varying fields and boundary conditions.**	2
	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.**	2
CO 4	PO 1	**Apply** the knowledge of mathematics, science, engineering fundamentals to construct the wave equations for both conducting and dielectric media **to derive the relation between Electric and Magnetic field intensities.**	3
	PO 2	**Construct** the wave equations for both conducting and dielectric media to derive the relation between Electric and Magnetic field intensities by **using the principles of mathematics and engineering sciences.**	2
	PO 3	**Analyze** complex engineering problems reaching substantiated conclusions **to construct the wave equations for dielectric and conducting media.**	1
CO 5	PO 1	**Understand** the propagation of electromagnetic waves through different media **using the the knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	**Distinguish** wave propagation characteristics through different media **using complex engineering problems.**	2
	PO 3	**Analyze** complex engineering problems that meet the specified needs with appropriate consideration **to describe the wave propagation characteristics.**	1
	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.**	2
CO 6	PO 1	**Describe** the transmission lines, its equivalent circuit and explain their characteristics for various wave lengths **to solve complex engineering problems.**	3
	PO 2	**Make use of** principles of mathematics, natural sciences, and engineering sciences to describe the transmission lines, its equivalent circuit and explain their characteristics **for various wave lengths.**	2
	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.**	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	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 4	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	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
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	100	20	20	-	-	-	-	-	-	-	-	-	-	-	100
CO 4	100	20	10	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	100	20	-	-		-	-	-	-	-	-	-	-	-	100
CO 6	100	100	-	-	-	-	-	-	-	-	-	-	-	-	100

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	2	-	-	-	-	-	-	-	-	-	-	-	2
CO 4	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2
TOTAL	**18**	**12**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**
AVERAGE	**3**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**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	**ELECTROSTATICS**
	Electrostatic fields: Coulomb's law, electric field intensity, fields due to different charge distributions; Electric flux density, gauss law and its applications; Scalar electric potential; Energy density, illustrative problems; Convection and conduction currents; Dielectric constant, isotropic and homogeneous dielectrics; Continuity equation and relaxation time, conductivity, power absorbed in conductor, Poisson's and laplace's equations; Capacitance; Method of images; Illustrative problems.
MODULE II	**MAGNETOSTATICS**
	Magneto statics: Biot-savart law; Ampere's circuital law and applications; Magnetic flux density; Magnetic scalar and vector potentials; Forces due to magnetic fields; Ampere's force law; Magnetic boundary conditions; Inductances and magnetic energy; Illustrative problems. **Maxwell's Equations (Time Varying Fields):** Faraday's law; Inconsistency of ampere's law for Time Varying Fields and definition for Displacement Current density; Maxwell's equations in differential form, integral form and word Statements; Conductors and dielectrics-characterization; Loss Tangent.
MODULE III	**UNIFORM PLANE WAVES**
	Uniform plane waves: Wave equations for conducting and perfect dielectric media; Relation between E and H; Wave propagation in lossless and conducting media; Intrinsic Impedance; Skin Depth; Polarization, Illustrative Problems. **Reflection/refraction of plane waves:** Reflection and refraction at normal incidence, reflection and refraction at oblique incidence; Standing waves; Brewster angle, critical Angle, total internal reflection, surface impedance; Poynting vector & poynting theorem-applications; Power Loss in plane conductor; Illustrative problems.
MODULE IV	**TRANSMISSION LINES CHARACTERISTICS**
	Transmission lines characteristics: Types; Transmission line Parameters; Transmission line Equations; Characteristic Impedance, propagation constant; Phase and group velocities; Infinite line concepts, Loss less /low loss transmission line characterization; condition for distortion less and minimum attenuation in transmission lines; Loading- types of loading; Illustrative problems.

MODULE V	**UHF TRANSMISSION LINES AND APPLICATIONS**
	UHF Transmission Lines & Applications: Input impedance relations; SC and OC Lines; Reflection coefficient, VSWR; UHF Lines as Circuit Elements, $\lambda/4$, $\lambda/2$ and $\lambda/8$ Lines- impedance transformations, significance of Zmin and Zmax ; Smith chart-configuration and applications; Single and double stub matching; Illustrative problems.

TEXTBOOKS

1. Matthew N.O. Sadiku, "Elements of Electromagnetic", Oxford University Press, 4th Edition,2009.
2. E.C. Jordan, K.G. Balmain, "Electromagnetic waves and Radiating Systems", PHIlearning, 2nd Edition, 2000.
3. Umesh Sinha, Satya Prakashan, "Transmission lines and Networks", Tech IndiaPublications, 1st Edition, 2010.

REFERENCE BOOKS:

1. Nathan Ida, "Engineering Electromagnetic", Springer (India) Pvt. Ltd, 2nd Edition,2005
2. William H. Hayt Jr., John A. Buck, "Engineering electromagnetic", Tata McGraw Hill, 7th Edition, 2006.
3. G. Sashibushana Rao, "Electromagnetic Field theory and Transmission Lines, Wiley India,2013.
4. John D. Ryder, "Networks, Lines and Fields", PHI learning, 2nd Edition,1999

WEB REFERENCES:

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

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index?route=course/details&course_id=75

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=75
CONTENT DELIVERY (THEORY)			
2	Remember vector calculus: del operator;	CO 1	T1: 3.1 to 3.8
3	Gradient, divergence and curl of a vector.	CO 1	T1: 3.1 to 3.8
4	Illustrate the concepts of Coulomb's law and Gauss's law to point, line charges.	CO 1	T1: 3.1 to 3.8,
5	Illustrate the concepts of coulomb's law to surface charges.	CO 1	T1: 4.3 to 4.4,4.6,4.7
6	Illustrate the concepts of gauss's law to surface charges.	CO 1	T1: 4.3 to 4.4,4.6,4.7

7	Illustrate the concepts of coulomb's law to volume charges.	CO 1	T1: 3.1 to 3.8
8	Illustrate the concepts of gauss's law to volume charges.	CO 1	T1: 3.1 to 3.8
9	Understand the concepts of Electric flux density.	CO 1	T1: 3.1 to 3.8
10	Remember the concept of Scalar electric potential.	CO 1	T1: 3.1 to 3.8
11	Illustrate the concept of Energy density, problems;	CO 1	T1: 3.1 to 3.8 R2: 1.8 to 1.9
12	Understand the concepts of Conductors and dielectrics-characterization.	CO 1	T1: 3.1 to 3.8 R2: 1.8 to 1.9
13	Convection and conduction currents;	CO 1	T1: 4.3 to 4.4,4.6,4.7
14	Understand the concept of Dielectric constant, isotropic and homogeneous dielectrics; Continuity equation and relaxation time, conductivity.	CO 1	T1: 3.1 to 3.8, R2: 1.8 to 1.9
15	Remember the concept of power absorbed in conductor, Poisson's and Laplace's equations;	CO 1	T1: 4.3 to 4.7, R2: 7.1
16	Remember the concept of Capacitance: Parallel plate, co axial, spherical capacitors	CO 1	T1: 4.3 to 4.4,4.6,4.7, R2-7.1
17	Spherical capacitors	CO 1	T1: 4.3 to 4.4,4.6,4.7
18	Understand the concept of Method of images	CO 1	T1: 4.3 to 4.4,4.6,4.7
19	Remember the concept of Magneto statics: Biot-Savart's law;	CO 2	T1: 4.3 to 4.4,4.6,4.7 R2: 7.1
20	Ampere's circuital law and applications; Magnetic flux density;	CO 2	T1: 4.3 to 4.4,4.6,4.7 R2: 7.1
21	Remember the concept of Magnetic scalar and vector potentials; Forces due to magnetic fields;	CO 2	T1: 4.3 to 4.4,4.6,4.7 R2: 7.1
22	Ampere's force law; Boundary conditions:	CO 2	T1: 4.3 to 4.7 R2:7.1
23	Remember the concept of Dielectric- dielectric, dielectric conductor interfaces;	CO 3	T1: 7.1 to 7.2,4.8,7.6,7.8
24	Inductances and magnetic energy; Illustrative problems;	CO 2	T1: 7.1 to 7.2,4.8,7.6,7.8
25	Maxwell's equations (Time varying fields): Faraday's law;	CO 3	T1: 7.1 to 7.2,4.8,7.6,7.8
26	Inconsistency of ampere's law for time varying fields.	CO 3	T1: 7.1 to 7.2,4.8,7.6,7.8
27	Remember the concept of definition for displacement current density;	CO 3	T1: 7.1 to 7.2,4.8,7.6,7.8
28	Maxwell's equations in differential form, integral form and word Statements.	CO 3	T1: 8.2 to 8.5
29	Uniform plane waves: Wave equations for conducting and perfect dielectric media.	CO 4	T1: 9.2 to 9.3
30	Remember the concept of Relation between E and H; Wave propagation in lossless and conducting media.	CO 4	T1: 9.3 to 9.4
31	Loss tangent, Intrinsic impedance; Skin depth; Polarization, Illustrative problems.	CO 4	T1: 9.4 to 9.5
32	Reflection/refraction of plane waves: Reflection and refraction at normal incidence, reflection and refraction at oblique incidence;	CO 5	T1: 9.5 to 9.6

33	Standing waves; Brewster angle, critical angle, total internal reflection.	CO 5	T1: 9.6 to 9.7
34	Surface impedance	CO 5	T1: 9.7 to 9.8
35	Poynting vector and poynting theorem	CO 5	T1: 9.8 to 9.9
36	Power loss in plane conductor;	CO 5	T1: 9.9 to 9.10
37	Transmission line characteristics: Types; Transmission line parameters;	CO 6	T3: 1.9 to1.12
38	Transmission line equations; Characteristic impedance, propagation constant;	CO 6	T3: 1.9 to1.15
39	Understand the concept of phase and group velocities;	CO 6	T3: 1.9 to1.17
40	Understand the concept of infinite line concepts.	CO 6	T3: 5.4 to 5.5
41	Loss less transmission line characterization.	CO 6	T3: 5.4 to 5.7
PROBLEM SOLVING/ CASE STUDIES			
42	Problems on gauss law	CO 1	T1: 4.2-4.13.
43	Problems on coulomb's law and E	CO 1	T1: 4.2-4.13.
44	Problems on line charge	CO 1	T1: 7.1-7.13
45	Problems on surface and volume charge	CO 1	T1: 7.1-7.13
46	Problems on magnetic energy	CO 2	T1: 9.1-9.8,
47	Problems on H and B	CO 2	T1: 11.2 R2: 10.4
48	Problems on displacement current density	CO 3	T1: 11.3 R2: 10.5
49	Problems on wave equations	CO 4	T1: 11.11-11.12
50	Problems on dielectrics	CO 3	T1: 11.13-11.14
51	Problems on intrinsic impedance	CO 4	T1: 11.18, R2: 10.13
52	Problems on reflection and refraction	CO 5	T1: 11.2 R2: 10.4
53	Problems on poynting theorem	CO 5	T1: 11.3 R2: 10.5
54	Problems on transmission lines	CO 6	T1 :13.6, R2: 12.6
55	Problems on stub matching	CO 6	T1: 13.11, R2: 12.10
56	Problems on lossless transmission lines	CO 6	T1: 13.15, R2: 12.17
DISCUSSION ON DEFINITION AND TERMINOLOGY			
57	Electrostatics	CO 1	T1: 1.1-19- 4.1-4.25
58	Magnetostatics	CO 2	T1: 7.1-7.32
59	Uniform plane waves	CO 5	T1: 8.1-8.10, 9.1-9.6
60	Transmission line characteristics	CO 6	T1: 11.1-11.18
61	UHF Transmission line and applications	CO 6	T1: 13.1-13.25
DISCUSSION ON QUESTION BANK			
57	Electrostatics	CO 1	1.1-19- 4.1-4.25
58	Magnetostatics	CO 2	T1: 7.1-7.32
59	Uniform plane waves	CO 5	T1: 8.1-8.10, 9.1-9.6
60	Transmission line characteristics	CO 6	T1: 11.1-11.18
61	UHF Transmission line and applications	CO 6	T1: 13.1-13.25

Course Coordinator **HOD,ECE**
Dr.D Srikar, 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**

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

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Signals and Systems**				
Course Code	AECB14				
Program	B. Tech				
Semester	FOUR				
Course Type	CORE				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms.V. Bindusree, Assistant professor.				

I COURSE OVERVIEW:

This course integrates the basic concepts of both continuous and discrete time signals and systems. It covers the linear time invariant systems and their analysis in time and frequency domain, mathematical tools, correlation and convolution of signals, sampling techniques. It provides the necessary background needed for understanding the signal processing and communications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB11	III	Mathematical Transform Techniques
B.Tech	AECB08	III	Probability Theory and Stochastic Process

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Signals and Systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
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), 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:

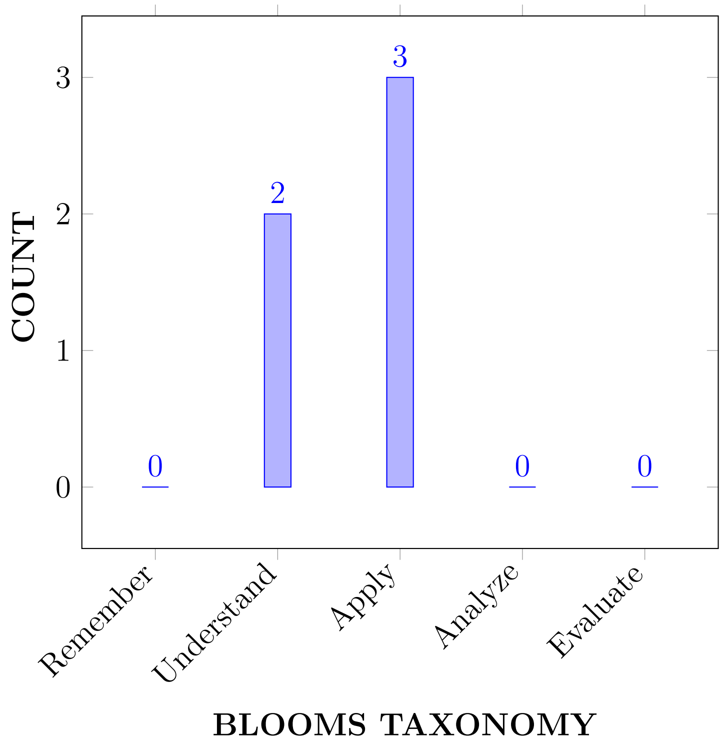
I	The representation, classification and analysis of continuous, discrete time signals in time and frequency domains.
II	The Fourier transform, Laplace and Z- transforms and their properties to analyze the signals and systems
III	The temporal and spectral characteristics of Random process and the extraction of Signal from noise by filtering.
IV	The sampling, quantization and reconstruction requirements for digital signal processing applications

VII COURSE OUTCOMES:

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

CO 1	**Describe** the concept of signals and signal properties for performing mathematical operations on signals.	Understand
CO 2	**Make use of** Fourier series and Fourier transforms for calculating spectral characteristics of periodic and aperiodic signals.	Apply
CO 3	**Utilize** the concept of convolution and correlation to determine the response of an LTI system.	Apply
CO 4	**Classify** the ideal lowpass,high pass,bandpass,ban stop filters for obtaining the behaviour of linear time invarinat system.	Remember
CO 5	**Apply** the Laplace and Z-transforms . for analysing the frequency domain representation of continuous and discrete time signals and systems respectively	Apply
CO 6	**Demonstrate** the procedure for sampling and reconstruction of bandlimited signals by using various sampling techniques.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE / CIE / AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	SEE / CIE / AAT
PO 3	**Design/Development of Solutions:**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	**Conduct Investigations of Complex Problems:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	Lab related Exercises

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	2	Quiz

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Classify (knowledge)** basic concepts of signals such as exponential, sinusoidal, impulse, unit step and signum for performing mathematical operations on signals **mathematical operations on signals** by applying the **principles of science for engineering problems.**	2
	PO 2	**Understand** the given **problem statement** and **formulate** the orthogonal signals from the vector algebra using **principles of mathematics and engineering science.**	4
	PO 10	Demonstrate the ablility to communicate effectively in **writing** design documentation and make effective presentation	1
CO 2	PO 2	**Understand** the given **problem statement** and **identification** of the Fourier transform and apply the **problem formulation**of spectral characteristics of continuous time aperiodic signals and **design** the frequency response of the given system.	4
	PO 5	**Develop** the Fourier transform of magnitude and phase using **Modern tools and analyze to complex engineering problems.**	1
	PO 10	Demonstrate the ablility to communicate effectively in **writing** design documentation and make effective presentation	1
	PSO 1	**Develop** the capability to **analyze** the Fourier transform properties of continuous time signals by **implementing** the frequency response.	2

Course Outcomes	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key competencies matched.**
CO 3	PO 1	**Extend** (knowledge, understand, apply) the linearity and time invariance concepts to linear time invariant system for **analyzing** the behavior of LTI system in both time and frequency domains by applying the **principles of mathematics** and **science for engineering problems.**	3
	PO 2	**Demonstrate** and **develop** the given problem statement, **identification** and **formulate** to **design** simple LTI system in both time and frequency domains. 5	2
	PO 10	Demonstrate the ablility to communicate effectively in **writing** design documentation and make effective presentation	1
CO 4	PO 2	**Understand** the given **problem statement and formulate** the (Complex) engineering problems of continuous time and discrete time systems such as Laplace and Z transform from the provided information and data.	2
	PO 5	**Design** various transform techniques like Laplace and Z transform using **modern tools** such as MATLAB software	1
	PO 10	Demonstrate the ablility to communicate effectively in **writing** design documentation and make effective presentation	1
	PSO 1	**Develop** the capability to **analyze** the continuous time and discrete signals by **implementing** the Region of convergence.	2
CO 5	PO 1	**Understand** the sampling theorem for band limited and bandpass signals and reconstruction of samples by filtering methods by applying the the **principles of mathematics** and science for **engineering problems**.	2
	PO 10	Demonstrate the ablility to communicate effectively in **writing** design documentation and make effective presentation	1
CO 6	PO 1	**Understand** the sampling theorem for band limited and bandpass signals and reconstruction of samples by filtering methods by applying the the **principles of mathematics** and science for **engineering problems**.	2
	PO 10	Demonstrate the ablility to communicate effectively in **writing** design documentation and make effective presentation	1

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	Program Outcomes												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	66.7	40	-	-	-	-	-	-	-	10	-		-	-	-
CO 2	-	40	-	-	20	-	-	-	-	10	-	-	100	-	-
CO 3	100	40	-	-	-	-	-	-	-	10	-	-	-	-	-
CO 4	66.7	-	-	-	-	-	-	-	-	10	-	-	-	-	-
CO 5	-	40	40	-	100	-	-	-	-	10	-		100	-	-
CO 6	40	-	-	-	-	-	-	-	-	10	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

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

COURSE OUTCOMES	Program Outcomes												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	-	-	-	-	-	-	-	1	-	-	-	-	
CO 2	-	2	-	-	1	-	-	-	-	1	-	-	3	-	-
CO 3	3	2	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 5	-	2	2	-	3	-	-	-	-	1	-	-	3	-	-
CO 6	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-
TOTAL	8	8	2	-	4	-	-	-	-	6	-	-	6	-	-
AVERAGE	2.6	2	2	-	2	-	-	-	-	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	**SIGNAL ANALYSIS**
	Signal Analysis: Analogy between Vectors and Signals, Orthogonal Signal Space, Signal approximation using Orthogonal functions, Mean Square Error, Closed or complete set of Orthogonal functions, Orthogonally in Complex functions, Exponential and Sinusoidal signals, Concepts of Impulse function, Unit Step function, Signum function.
MODULE II	**FOURIER SERIES**
	Representation of Fourier series, Continuous time periodic signals, Properties of Fourier Series, Dirichlet's conditions, Trigonometric Fourier Series and Exponential Fourier Series, Complex Fourier spectrum. **Fourier Transforms:** Deriving Fourier Transform from Fourier series, Fourier Transform of arbitrary signal, Fourier Transform of standard signals, Fourier Transform of Periodic Signals, Properties of Fourier Transform, Fourier Transform involving Impulse function and Signum function, Introduction to Hilbert Transforms.
MODULE III	**SIGNAL TRANSMISSION THROUGH LINEAR SYSTEMS**
	Linear System, Impulse response, Response of a Linear System, Linear Time Invariant (LTI) System, Linear Time Variant (LTV) System, Transfer function of a LTI System, Filter characteristic of Linear System, Distortion less transmission through a system, Signal bandwidth, System Bandwidth, Ideal LPF, HPF, and BPF characteristics. Causality and Paley-Wiener criterion for physical realization, Relationship between Bandwidth and rise time, Convolution and Correlation of Signals, Concept of convolution in Time domain and Frequency domain, Graphical representation of Convolution.
MODULE IV	**LAPLACE TRANSFORM AND Z-TRANSFORM**
	Laplace Transforms: Laplace Transforms (L.T), Inverse Laplace Transform, Concept of Region of Convergence (ROC) for Laplace Transforms, Properties of L.T, Relation between L.T and F.T of a signal, Laplace Transform of certain signals using waveform synthesis. Z–Transforms: Concept of Z-Transform of a Discrete Sequence, Distinction between Laplace, Fourier and Z Transforms, Region of Convergence in Z-Transform, Constraints on ROC for various classes of signals, Inverse Z-transform, Properties of Z-transforms

MODULE V	SAMPLING THEOREM
	Graphical and analytical proof for Band Limited Signals, Impulse Sampling, Natural and Flat top Sampling, Reconstruction of signal from its samples, Effect of under sampling – Aliasing, Introduction to Band Pass Sampling. Correlation: Cross Correlation and Auto Correlation of Functions, Properties of Correlation Functions, Energy Density Spectrum, Parseval's Theorem, Power Density Spectrum, Relation between Autocorrelation Function and Energy/Power Spectral Density Function, Relation between Convolution and Correlation, Detection of Periodic Signals in the presence of Noise by Correlation, Extraction of Signal from Noise by filtering

TEXTBOOKS

1. Signals, Systems Communications, B.P. Lathi, BS Publications, 2009.
2. Signals and Systems, A.V. Oppenheim, A.S. Willsky and S.H. Nawab ,PHI, 2nd Edition 2009.
3. Digital Signal Processing, Principles, Algorithms, and Applications, John G. Proakis, Dimitris G. Manolakis, Pearson Education / PHI. 2007.

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1. Signals and Systems, Simon Haykin and Van Veen, Wiley, 2nd Edition, 2009.
2. Signals and Signals, Iyer and K. Satya Prasad, Cengage Learning, 2 nd Edition, 2009.
3. Discrete Time Signal Processing, A. V. Oppenheim and R.W. Schaffer, PHI, 2009.
4. Fundamentals of Digital Signal Processing, Loney Ludeman. John Wiley, PHI, 2009.

WEB REFERENCES:

1. https://nptel.ac.in/courses/117/101/117101055/

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	Introduction to signals and systems	CO 1	T1:4.2
2	Concepts of Impulse function, Unit Step function, Signum function, in continuous time	CO 1	T1: 5.1
3	Concepts of Impulse function, Unit Step function, Signum function, in continuous time	CO 1	R3: 1.7
4	Analogy between Vectors and Signals.	CO 2	T1: 6.1-6.6

5	Orthogonal Signal Space, Signal approximation using Orthogonal functions.	CO 2	T1: 6.1-6.6
6	Mean Square Error.	CO 2	T1: 6.1-6.6
7	Closed or complete set of Orthogonal functions.	CO 2	T1: 6.1-6.6
11	Orthogonally in Complex functions	CO 3	T1: 7.5
12	Continuous time periodic signals.	CO 3	T1: 7.7-7.12
13	Continuous time periodic signals.	CO 3	T1: 7.8
14	Dirichlet's conditions, Trigonometric Fourier Series	CO 4	T1: 10.2
15	Exponential Fourier Series, Complex Fourier spectrum.	CO 4	T1:7.7
16	Deriving Fourier Transform from Fourier series, Fourier Transform of arbitrary signal..	CO 5	T1: 7.8-7.10
17	Fourier Transform of Periodic Signals, Properties of Fourier Transform	CO 5	T1: 7.12
20	Linear System, Impulse response, Response of a Linear System, Linear Time Invariant (LTI) System, Linear Time Variant (LTV) System.	CO 7	R4: 4.2
21	Transfer function of a LTI System, Filter characteristic of Linear System, Distortion less transmission through a system .	CO 7	R4: 4.2
22	Signal bandwidth, System Bandwidth,	CO 8	T1: 10.4
23	Ideal LPF, HPF, and BPF characteristics.	CO 8	T1: 10.5
26	Causality and Paley-Wiener criterion for physical realization,	CO 9	T3: 1.5
27	Relationship between Bandwidth and rise time.	CO 9	T3: 1.6
28	Convolution and Correlation of Signals	CO 6	T3: 1.7
29	Concept of convolution in Time domain and Frequency domain, Graphical representation of Convolution	CO 9	T3:1.8
33	Laplace Transforms (L.T Inverse Laplace Transform,	CO 10	T3: 2.7 R3: 4.4
34	Concept of Region of Convergence (ROC) for Laplace Transforms.	CO 10	T3: 2.8 R3: 4.4
35	Properties of L.T, Relation between L.T and F.T of a signal	CO 10	T3: 2.7 R3: 4.4
36	Laplace Transform of certain signals using waveform synthesis.	CO 10	T3: 2.8 R3: 4.4
37	Concept of Z- Transform of a Discrete Sequence.	CO 11	T3: 8.9
38	Distinction between Laplace, Fourier and Z Transforms.	CO 10	T3: 2.7 R3: 4.4
39	Region of Convergence in Z-Transform,	CO 10	T3: 2.8 R3: 4.4
40	Constraints on ROC for various classes of signals, Inverse Z-transform.	CO 11	T3: 8.9
41	Properties of Z-transforms	CO 10	T3: 2.7 R3: 4.4

45	Graphical and analytical proof for Band Limited Signals, Impulse Sampling	CO 11	T3: 8.12-8.13
46	Natural and Flat top Sampling.	CO 11	T3: 9.1-9.2
47	Reconstruction of signal from its samples, Effect of under sampling – Aliasing, Introduction to Band Pass Sampling.	CO 11	T3: 9.3.
48	Cross Correlation and Auto Correlation of Functions, Properties of Correlation Functions	CO 11	T3: 8.12-8.13
49	Energy Density Spectrum, Parseval's Theorem, Power Density Spectrum	CO 11	T3: 9.1-9.2
50	Relation between Autocorrelation Function and Energy/Power Spectral Density Function,	CO 11	T3: 9.3.
51	Relation between Convolution and Correlation.	CO 11	T3: 8.12-8.13
52	Detection of Periodic Signals in the presence of Noise by Correlation, Extraction of Signal from Noise by filtering	CO 11	T3: 9.1-9.2
PROBLEM SOLVING/ CASE STUDIES			
9	Concepts of Impulse function, Unit Step function, Signum function, in continuous time	CO 1	T1: 5.1
10	Orthogonal Signal Space, Signal approximation using Orthogonal functions, Mean Square Error.	CO 1	R3: 1.7
18	Exponential Fourier Series, Complex Fourier spectrum.	CO 2	T1: 6.1-6.6
19	Fourier Transform of Periodic Signals, Properties of Fourier Transform	CO 2	T1: 6.1-6.6
30	Linear System, Impulse response, Response of a Linear System, Linear Time Invariant (LTI) System, Linear Time Variant (LTV) System.	CO 3	T1: 7.7-7.12
31	Signal bandwidth, System Bandwidth, Ideal LPF, HPF, and BPF characteristics.	CO 4	T1: 7.7-7.12
32	Convolution and Correlation of Signals, Concept of convolution in Time domain and Frequency domain, Graphical representation of Convolution	CO 5	T1: 7.7-7.12
42	Properties of L.T, Relation between L.T and F.T of a signal, Laplace Transform of certain signals using waveform synthesis.	CO 5	T1: 7.7-7.12
43	Laplace Transforms (L.T), Inverse Laplace Transform, Concept of Region of Convergence (ROC) for Laplace Transforms.	CO 6	T3: 1.7
44	Region of Convergence in Z-Transform, Constraints on ROC for various classes of signals, Inverse Z-transform, Properties of Z-transforms.	CO 6	T3: 1.7
51	Cross Correlation and Auto Correlation of Functions, Properties of Correlation Functions	CO 7	R4: 4.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Signal analysis	CO 1	T1:4.1
57	Fourier series and Fourier transform	CO 2	T2:4.1
58	signal transmission through linear systems	CO 3	T3:2.1

59	Laplace and Z transform	CO 4	R4: 4.2
60	sampling theorem and reconstruction of filters	CO 5	T2:6.1
DISCUSSION OF QUESTION BANK			
61	Derive the expression for component vector of approximating the function f1(t) over f2(t) and also prove that the component vector becomes zero if the f1(t) and f2(t) are orthogonal.	CO 1	T1:4.1
62	Find the Fourier transform of the signal x(t) = 5cos 5t+10 sin 15t and sketch its magnitude and phase spectra.	CO 2	T2:4.1
63	Compute the output y(t) for a continuous LTI system whose impulse response h(t) and the input x(t) are given by h(t)= e-at u(t) and x(t)= eat u(-t).	CO 3	T3:2.1
64	Determine the initial value and final value of Laplace transform of signal	CO 4	R4: 4.2
65	A filter has an input x(t)= u(t) and transfer function, H(w)=1/(1+jw). Find the ESD of the output?	CO 5	T2:6.1

Signature of Course Coordinator **HOD,ECE**

Ms.V.Bindusree,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**

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**

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

COURSE DESCRIPTION

Department	**ELECTRONICS AND COMMUNICATIONS 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	-	1.5
Course Coordinator	Ms.L Babitha, 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:

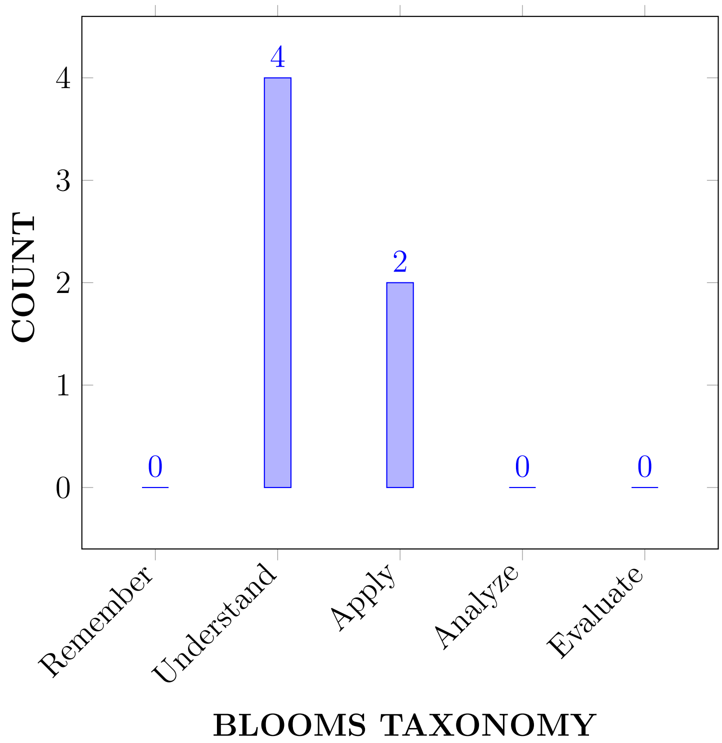
I	The mathematical models of dynamic systems using the concepts of basic sciences.
II	The system performance using time domain and frequency domain analysis for standard inputs.
III	Classification of controllers and compensators as per the desired dynamic response of the system.
IV	The different ways 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	**Professional Skills:** An ability to understand the basic concepts in Electronics and Communication Engineering and to apply them to various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of complex systems.	1	Research Paper / Quiz / AAT
PSO 2	**Problem-solving skills:** An ability to solve complex Electronics and communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.	1	Research Paper / Quiz / AAT
PSO 3	**Successful career and Entrepreneurship:** An understanding of social-awareness and environmental-wisdom along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.	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

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

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 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
	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
	PO 10	Understands the basics of time domain analysis and should be able to communicate effectively on engineering activities	2
	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
	PO 10	Understands the basics of requency domain analysis and various types of system should be able to communicate effectively on engineering activities	2
	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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	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
	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
	PO 10	Understands the basics of state space analysis and various types of system should be able to communicate effectively on engineering activities	2

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	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	-	-	-	2	-	-	1	-	-
CO 4	3	4	7	7	-	3	-	-	-	2	-	-	-	1	-
CO 5	3	5	7	7	-	2	-	3	-	2	-	2	2	2	-
CO 6	3	4	7	-	-	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	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	-	-	20.0	-	-
CO 4	100	66.7	66.7	100	-	60	-	-	-	20	-	-	-	9.09	-
CO 5	100	66.7	66.7	100	-	40	-	100	-	20.0	-	8.3	40.0	18.2	-
CO 6	100	66.7	66.7	-	-	40	-	-	-	20	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	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	-	-	1	-	-
CO 4	3	2	2	3	-	3	-	-	-	1	-	-	-	1	-
CO 5	3	2	2	3	-	1	-	1	-	1	-	1	2	2	-
CO 6	3	2	2	-	-	1	-	-	-	1	-	-	-	-	-
TOTAL	18	15	13	9	-	12	-	2	-	6	-	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,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**

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

AERONAUTICAL ENGINEERING
COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">Analog and Pulse Circuits Laboratory</td></tr>
<tr><td>Course Code</td><td colspan="5">AECB15</td></tr>
<tr><td>Program</td><td colspan="5">B.Tech</td></tr>
<tr><td>Semester</td><td>IV</td><td colspan="4">ECE</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>3</td><td>1.5</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">R. Venkata Sravya, Assistant Professor</td></tr>
</table>

I COURSE OVERVIEW:

The objective of this course is to meet the requirements of practical work meant for circuit designing, analysis and provides hands-on experience by examining the pulse circuits and measuring instruments. This lab covers the analysis of the linear, non-linear wave shaping circuits, oscillators and multivibrators. Students will profciency with the capability to use simulation tools for performing analysis of various amplifer circuits, wave shaping circuits and multivibrator applications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB06	III	Electronic Devices and Circuits

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Analog and Pulse Circuits 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	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.

1. **Experiment Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

I	The basic amplifer circuits using common emitter and common base confgurations.
II	The multivibrator circuits using transistors for real time applications.
III	The principle of oscillation and design of oscillators.
IV	The response of linear and non linear wave shaping circuits for sinusoidal, pulse and ramp inputs.

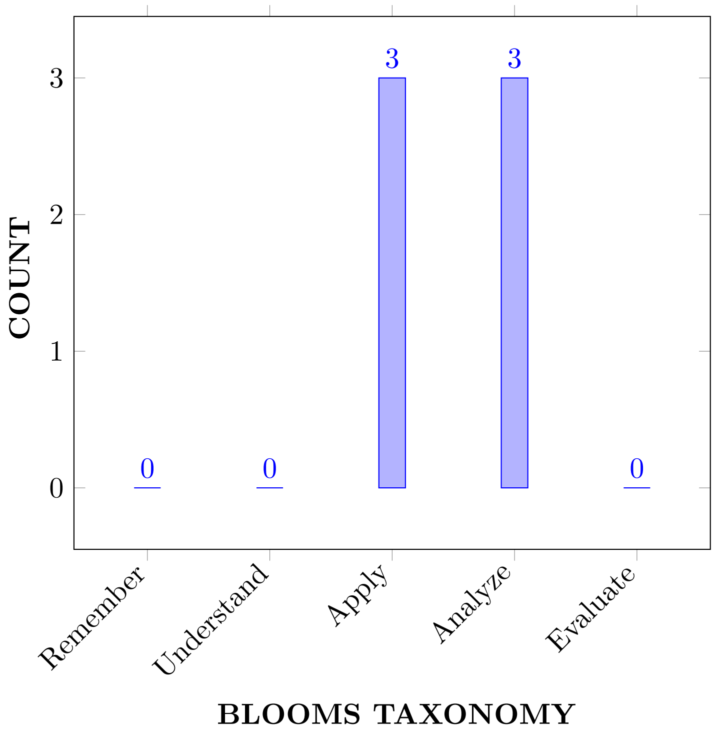
VII COURSE OUTCOMES:

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

CO 1	**Analyze** the single stage and multistage Bipolar Junction Transistor (BJT) amplifers for determining the voltage gain and bandwidth. .	Analyze
CO 2	**Build** linear and non-linear wave shaping circuits to obtain the response for sine and square wave inputs.	Apply
CO 3	**Analyze** voltage series and current shunt feedback amplifer circuits for determining amplifer characteristics.	Analyze
CO 4	**Apply** the barkhausen criteria to oscillators for generating sine wave.	Apply

CO 5	**Examine** the suitable multivibrator to generate non-sinusoidal waveforms for real time applications	Apply
CO 6	**Examine** the frequency response of class-A power amplifers and single tuned voltage amplifer circuits using Bipolar Junction Transistor (BJT).	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 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	2	CIA

PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Experiments/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	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.	1	Lab Experiments/CIE/SEE
PO 10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	Lab Experiments/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.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

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

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Analyze the single stage and multistage Bipolar Junction Transistor (BJT) amplifers for determining the voltage gain and bandwidth by applying knowledge of **mathematics** and **engineering fundamentals**	2
	PO 4	Understand the(given problem statement) single stage and multistage Bipolar Junction Transistor (BJT) amplifers for analysis and interpretation of data, and synthesis of the information to provide valid conclusions	3
	PO 5	**Create,** select, and apply appropriate techniques to obtain the frequency response of single and multi stage amplifer circuits using **NI Multisim software** and calculate gain bandwidth	1
	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 1	Formulate and Evaluate the amplifer applications in the feld of Intelligent Embedded and Semiconductor technologies	1
CO 2	PO 1	Build wave shaping circuits to obtain the response for sine and square wave inputs by applying knowledge of mathematics and engineering fundamentals.	2
	PO 2	Understand the given the wave shaping circuit application problem statement and fnding the solution implementation of wave shaping circuits by analyzing complex engineering problems	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information of the basic embedded modules using different electronic circuits to provide valid conclusions.	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	Make use of voltage series and current shunt feedback amplifer circuits for determining amplifer characteristics by applying knowledge of mathematics and engineering fundamentals	2

	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information of the basic embedded modules using different electronic circuits to provide valid conclusions.	3
	PO 5	Create, select, and apply appropriate techniques to obtain the frequency response of single and multi stage amplifer circuits using NI Multisim software and calculate gain bandwidth.	1
	PO 9	Individual and team work: Function effectively as an individual, and as a member to obtain the readings.	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 4	PO 1	Apply the barkhausen criteria to oscillators for generating sine wave by applying knowledge of science, mathematics and engineering fundamentals	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information of the basic embedded modules using different electronic circuits to provide valid conclusions	3
	PO 5	Create, select, and apply appropriate techniques to obtain the frequency response of single and multi stage amplifer circuits using NI Multisim software and calculate gain bandwidth.	1
	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 5	PO 1	Identify the suitable multivibrator to generate non-sinusoidal waveforms for real time applications by applying knowledge of mathematics and engineering fundamentals.	3
	PO 3	Design solutions for multivibrator circuits to complex engineering problems and design system components or processes that meet the specifed needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information of the basic embedded modules using different electronic circuits to provide valid conclusions	3

	PO 9	Individual and team work: Function effectively as an individual, and as a member to obtain the readings.	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 6	PO 1	Examine the frequency response of class-A power amplifers and single tuned voltage amplifer circuits using Bipolar Junction Transistor (BJT) by applying knowledge of mathematics and engineering fundamentals.	2
	PO 2	Identify, formulate and analyze complex engineering problems of power amplifers reaching substantiated conclusions using frst principles of mathematics, natural sciences, and engineering sciences.	3
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information of the basic embedded modules using different electronic circuits to provide valid conclusions.	3
	PO 5	Create, select, and apply appropriate techniques to obtain the frequency response of single and multi stage amplifer circuits using NI Multisim software and calculate gain bandwidth	1
	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

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

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-1	**BASIC AMPLIFIERS/ LINEAR WAVESHAPING**
	a. Simulate frequency response of common emitter amplifer and common base amplifer. b. Design RC low pass and high pass circuit for different time constants.
WEEK-2	**BASIC AMPLIFIERS/ LINEAR WAVESHAPING**
	a. Design RC low pass and high pass circuit for different time constants. b. Simulate frequency response of common emitter amplifer and common base amplifer
WEEK-3	**TWO STAGE RC COUPLED AMPLIFIER / NON-LINEAR WAVESHAPING**
	a. Simulate frequency response of two stage RC coupled amplifer. b. Design transfer characteristics of clippers and clampers.
WEEK-4	**TWO STAGE RC COUPLED AMPLIFIER / NON-LINEAR WAVESHAPING**
	a. Design transfer characteristics of clippers and clampers. b. Simulate frequency response of two stage RC coupled amplifer.
WEEK-5	**SINGLE TUNED AMPLIFIERS / TRANSISTOR AS A SWITCH**
	a. Simulate a single tuned amplifer. b. Design of transistor as a switch.
WEEK-6	**SINGLE TUNED AMPLIFIERS / TRANSISTOR AS A SWITCH**
	a. Design of transistor as a switch. b. Simulate a single tuned amplifer.
WEEK-7	**FEEDBACK AMPLIFIERS / COMPARATOR**
	a. Simulate voltage series feedback amplifer and current shunt feedback amplifer. b. Design of comparator circuit
WEEK-8	**FEEDBACK AMPLIFIERS / COMPARATOR**
	a. Design of comparator circuit. b. Simulate voltage series feedback amplifer and current shunt feedback amplifer

WEEK-9	**RC PHASE SHIFT OSCILLATOR USING TRANSISTOR / MULTIVIBRATORS**
	a. Simulate sine wave generated for a particular frequency by an RC phase shift oscillator. b. Design different types of multivibrators and plot its waveforms.
WEEK-10	**RC PHASE SHIFT OSCILLATOR USING TRANSISTOR / MULTIVIBRATORS**
	a. Design different types of multivibrators and plot its waveforms. b. Simulate sine wave generated for a particular frequency by an RC phase shift oscillator.
WEEK-11	**OSCILLATORS / SCHMIT TRIGGER**
	a. Design a Schmitt trigger circuit. b. Simulate sine wave generated for a particular frequency by Colpitts and Hartley oscillator.
WEEK-12	**OSCILLATORS / SCHMIT TRIGGER**
	a. Design a Schmitt trigger circuit. b. Simulate sine wave generated for a particular frequency by Colpitts and Hartley oscillator.
WEEK-13	**POWER AMPLIFIERS/ UJT AS A RELAXATION OSCILLATOR**
	a. Simulate class A power amplifer (transformer less) and class B power amplifer. b. Design of UJT as a relaxation oscillator
Week-14	**POWER AMPLIFIERS/ UJT AS A RELAXATION OSCILLATOR** a. Design of UJT as a relaxation oscillator. b. Simulate class A power amplifer (transformer less) and class B power amplifer.

TEXTBOOKS

1. Douglas Perry,"VHDL", Tata McGraw Hill,4th Edition,2002.
2. W.H. Gothmann, "Digital Electronics- An introduction to theory and practice", PHI, 2nd Edition,2006.

REFERENCE BOOKS:

1. D.V. Hall, "Digital Circuits and Systems", Tata McGraw Hill, 1989.
2. Charles Roth, "Digital System Design using VHDL", Tata McGraw Hill 2nd Edition 2012.

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	Simulate frequnecy response of common emitter and common base amplifier.	CO 1	T1-2.1 to 2.7
2	Design RC low pass and high pass circuit for different time constants	CO 2	T.20.1 to 20.2
3	Simulate frequency response of two stage RC coupled amplifer	CO 1	T.8.1 to 8.2
4	Design transfer characteristics of clippers and clampers	CO 2	T.8.3 to 8.7
5	Simulate a single tuned amplifier	CO 6	T.10.1 to 10.10
6	Design of transistor as a switch.	CO 5	T.10.11 to 10.13
7	Simulate voltage series feedback amplifer and current shunt feedback amplifer	CO 3	T.11.11 to 11.5
8	Design of comparator circuit.	CO 5	T.11.6-11.12
9	Simulate sine wave generated for a particular frequency by an RC phase shift oscillator.	CO 4	T.17.1 to 17.6
10	Design different types of multivibrators and plot its waveforms	CO 5	T.14.1 to 14.3
11	Simulate sine wave generated for a particular frequency by Colpitts and Hartley oscillator.	CO 4	T.14.2 to 14.9
12	Design a Schmitt trigger circuit	CO 5	T1.19.1 to 19.3
13	Simulate class A power amplifer (transformer less) and class B power amplifer.	CO 6	T1.6.1 to 6.5
14	Design of UJT as a relaxation oscillator.	CO 4	T1.7.1 to 7.3

XVII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	**Design a Bootstrap sweep circuit**
2	**Design a schmitt trigger circuit**
3	**Design a UJT relaxation oscillator**

Signature of Course Coordinator **HOD,AE**
R. Venkata Sravya, Assistant Professor

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

ELECTRONICS AND COMMUNICATION ENGINEERING

COURSE DESCRIPTION

Course Title	**ANALOG COMMUNICATIONS LABORATORY**				
Course Code	AECB16				
Program	B.Tech				
Semester	IV	ECE			
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Dr.V Siva Nagaraju, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB12	IV	Analog Communications

II COURSE OVERVIEW:

Communications is a vital and rapidly expanding field. Students will familiarize with elements of communication. The lab course consists of analog communications in practice, time domain and the frequency domain. It covers the basic types of analog modulation (AM, DSBSC, and FM . . .) from both MATLAB and equipment based.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Analog Communications 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 concepts like Amplitude modulation, Frequency modulation, demodulation, Phase Locked Loop and multiplexing
II	The generation, detection of pulse analog modulation techniques and receiver characteristics
III	The time and frequency domain analysis of the signals in communication system by using MATLAB tools

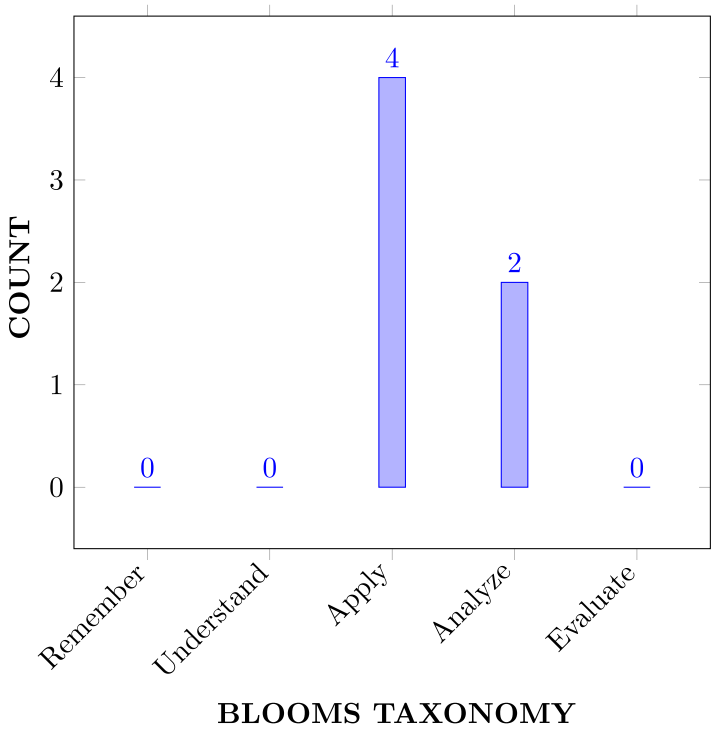
VII COURSE OUTCOMES:

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

CO 1	**Discriminate** the generation and detection of amplitude modulated and frequency modulated signals to calculate the modulation index and frequency deviation	Analyze

CO 2	**Analyze** the working principle for generating and detecting DSBSC and SSBSC modulated wave	Analyze
CO 3	**Distinguish** the time division and frequency division multiplexing techniques for transmitting multiple signals at a time in the communication system	Analyze
CO 4	**Examine** the mixer characteristics of super heterodyne receiver to verify the characteristics of automatic gain control unit	Analyze
CO 5	**Make use of** phase locked loop to verify the operation of frequency synthesizer	Apply
CO 6	**Experiment** with the spectrum analyzer to calculate the bandwidth of AM and FM waveforms from their frequency spectrum	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Lab Exercises/ CIE/ SEE

PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises/ CIE/ SEE
PO 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/ Projects
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	Lab Exercises/ Projects
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/ Projects

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
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	2	Lab Exercises/ CIE/ SEE

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key Competencies**
CO 1	PO 2	**Understand** the given problem statement and **formulate**the modulation index and frequency deviation from the amplitude modulated and frequency modulated waveforms using **principles of mathematics and engineering science**	4
	PO 5	Use **MATLAB** tool to model the basic amplitude and frequency modulation techniques	1
	PO 9	**Team work and as individual** which will enable the student to become a **productive member** of a design team for **completion of assignments, achieving of goals** to drive their performance in the **hands-on labs**	6

	PO 10	Communicate **orally** on modulation and **write** effective reports on modulation index and frequency deviation.	2
CO 2	PO 2	**Identify the problem** and make use of balance modulator and synchronous detector to generate and detect DSBSC modulated waveforms and **interpret the results** for providing solution to the **complex engineering problems**	4
	PO 5	Make use of MATLAB software for writing, simulating the code to generate and detect SSBSC waveform to solve complex engineering activities.	1
	PO 10	Communicate **orally** on DSBSC and **write** effective reports on sideband suppression	2
	PO 12	The student will become aware of the need for lifelong learning and the **upgrading of advanced engineering concepts** by continuing **personal development** and learning at least 2-3 **new significant skills** for the beginning work on **advanced degree**	4
CO 3	PO 2	**Identify and formulate** the principle of multiplexing and de multiplexing **analyze** complex engineering problems in the design of transmitter and receiver of a communication system by applying the **principles of mathematics, natural sciences, and engineering sciences**	5
	PO 5	Select **MATLAB** tools to simulate the code to identify the differences between TDM and FDM	1
	PO 10	**Communicate** orally on multiplexing and de multiplexing and **write** effective reports on TDM and FDM	2
	PO 12	The student will become aware of the need for lifelong learning and the **upgrading of advanced engineering concepts** by continuing **personal development** and **earning at least 2-3 new significant skills** for the beginning work on **advanced degree**	4
	PSO 3	Make use of **HFSS Sim-tel tool** to analyze the Frequency Division Multiplexing in wireless communications	1
CO 4	PO 2	**Analyze** the super heterodyne receiver to **estimate** the characteristics of automatic gain control unit by **applying** the **principles of mathematics, natural sciences, and engineering sciences**	4
	PO 5	Use **MATLAB** software and write and simulate the code to verify the characteristics of mixer to provide solutions for complex Engineering activities with an understanding of the limitations	1

	PO 9	**Team work** and as **individual** which will enable the student to become a **productive member** of a design team for **completion of assignments, achieving of goals** to drive their performance in the **hands-on labs**	6
	PO 10	Communicate **orally** on heterodyning and **write** effective reports on characteristics of automatic gain control	2
	PO 12	The student will become aware of the need for lifelong learning and the **upgrading of advanced engineering concepts** by continuing **personal development** and **earning at least 2-3 new significant skills** for the beginning work on **advanced degree**	4
	PSO 3	Make use of **HFSS Sim-tel tool** to to analyze the analyze the receiver characteristics in wireless communications	1
CO 5	PO 2	**Analyze** the phase locked loop circuit for **Problem formulation** to understand the operation of frequency synthesizer by **applying the principles of mathematics**	4
	PO 5	Use **MATLAB** software and simulate the code to implement the frequency synthesizer using phase locked loop to provide solutions for complex Engineering activities with an understanding of the limitations	1
	PO 9	**Team work** and as **individual** which will enable the student to become a **productive member** of a design team for **completion of assignments, achieving of goals** to drive their performance in the **hands-on labs**	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 on delta modulation	2
	PSO 3	Make use of **HFSS Sim-tel tool** to analyze the operation of frequency synthesizer in wireless communications	1
CO 6	PO 2	**Understand** the requirements (opportunity) of spectrum analyzer in industrial applications **(problem statement)** and calculation of bandwidth from frequency spectrum **(solution)** to **validate** the obtained results in real time environment	4
	PO 9	**Team work** and as **individual** which will enable the student to become a **productive member** of a design team for **completion of assignments, achieving of goals** to drive their performance in the **hands-on labs**	6

	PO 10	Communicate **orally** on spectrum analyzer and **write** effective reports on calculation of bandwidth from frequency spectrum	2

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**LTI SYSTEM AND ITS RESPONSE**
	Verification of linearity, time invariance, stability properties of a given system
WEEK II	**AMPLITUDE MODULATION AND DEMODULATION**
	Generation of amplitude modulation and demodulation using hardware and MATLAB
WEEK III	**DSB-SC MODULATOR and DETECTOR**
	Generation of AM-Double Side Band Suppressed Carrier (DSB-SC) signal using Balanced Modulator and MATLAB
WEEK IV	**SSB-SC MODULATOR and DETECTOR (PHASE SHIFT METHOD)**
	Generation of single side band suppressed carrier modulation and demodulation using hardware and MATLAB
WEEK V	**FREQUENCY MODULATION AND DEMODULATION**
	Generation of frequency modulation and demodulation using hardware and MATLAB
WEEK VI	**PRE-EMPHASIS and DE-EMPHASIS**

	Verification of pre-emphasis and de-emphasis to boost high frequency modulating signal using hardware and MATLAB
WEEK VII	**FREQUENCY DIVISION MULTIPLEXING and DE MULTIPLEXING**
	Construct the frequency division multiplexing and demultiplexing circuit and to verify its operation
WEEKVIII	**TIME DIVISION MULTIPLEXING and DE MULTIPLEXING**
	To study the operation of Time-Division multiplexing
WEEK IX	**AGC CHARACTERISTICS**
	To study the AGC Characteristics
WEEK X	**CHARACTERISTICS OF MIXER**
	To obtain the mixer characteristics of a super heterodyne receiver
WEEK XI	**PHASE LOCKED LOOP**
	To compare the theoretical and practical values of capture range and lock range of phase locked loop
WEEK XII	**GENERATION OF DSBSC USING RING MODULATION**
	To generate AM-Double Side Band Suppressed Carrier (DSB-SC) signal using Ring Modulator
WEEK XIII	**FREQUENCY SYNTHESIZER**
	To study the operation of frequency synthesizer using PLL
WEEK XIV	**SPECTRAL ANALYSIS OF AM AND FM SIGNALS USING SPECTRUM ANALYZER**
	To study the operation of spectrum analyzer

TEXTBOOKS

1. S. S. Haykin, "Communication Systems", Wiley Eastern, 3rd Edition, 2006.
2. Taub, Schilling, "Principles of Communication Systems", Tata McGraw-Hill, 4th Edition, 2013.

REFERENCE BOOKS:

1. B.P. Lathi, "Communication Systems, BS Publication", 2nd Edition, 2006.
2. John G. Proakis, Masond, Salehi, "Fundamentals of Communication Systems", PEA, 1st Edition,2006
3. George Kennedy, Bernard Davis, "Electronics and Communication System", Tata McGraw Hill, 5th Edition, 2011.

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	LTI system and its response	CO 1	T1: 13.2
2	Amplitude Modulation and Demodulation	CO 2	T1: 1.2.4 to 1.4.8, T1: 1.1 to 2.5

3	DSB-SC Modulator and Synchronous Detector	CO 2	T1: 3.2 to 3.3.4, R1: 3.3
4	SSB-SC Modulator and Detector (Phase Shift Method)	CO 2	T1: 3.4.1 to 3.4.2
5	Frequency modulation and demodulation	CO 1	T1: 4.4 to 4.4.5
6	Pre-emphasis and De-emphasis	CO 1	T1: 9.1 to 9.5.2
7	Frequency Division Multiplexing and De multiplexing	CO 3	T1: 6.2 to 6.3
8	Time Division Multiplexing and De multiplexing	CO 3	T2: 6.2 to 6.3
9	AGC Characteristics	CO 4	R3: 6.2 to 6.4.6
10	Characteristics of mixer	CO 5	R3: 6.1
11	Phase locked loop	CO 6	R3: 6.2 to 6.4.6
12	Frequency Synthesizer	CO 5	R3: 6.2 to 6.4.6
13	Generation of DSBSC using ring modulation	CO 2	T1: 3.2 to 3.3.4
14	Spectral analysis of AM and FM signals using spectrum analyzer	CO 6	R4: 5.9

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Implement the modulation and demodulation of Quadrature Amplitude Modulation (QAM).
2	Perform simple processes on speech signals (filtering, frequency translation), and examine their effect on the sound using MATLAB.
3	Design of FM receiver (90.4 MHz)
4	Design a sampling circuit with 5 V p-p amplitude and 100 Hz sine wave and remove aliasing effect
5	Design PAM transmission of voice signal with W = 3kHZ. Calculate transmission bandwidth if fs = 8Khz
6	SYSTEM NOISE CALCULATION: Signal to noise ratio of SSB, DSB, AM for coherent and envelope and square law detection

Signature of Course Coordinator **HOD,ECE**
Dr.V Siva Nagaraju, Associate Professor of ECE

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

ELECTRONICS AND COMMUNICATION ENGINEERING

COURSE DESCRIPTION

Course Title	**SIGNALS AND SYSTEMS LABORATORY**				
Course Code	AECB17				
Program	B.Tech				
Semester	IV	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Chief Coordinator	Ms V. Bindusree, Assistant Professor				

I COURSE OVERVIEW:

This course integrates about the generation of both continuous and discrete time signals, basic operations, and frequency transformations of signals and systems. It covers the linear time invariant systems and their analysis in time and frequency domain. It can apply the concepts to obtain the correlation and convolution between signals and sequences, to find distribution and density functions of random variables. It provides the necessary background needed for understanding the signal processing and communications. This lab provides hands-on experience on implementation of communication systems using MATLAB software.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
B.Tech	AHSB02	I	Linear algebra and claculas	4
B.Tech	AHSB11	II	Mathematical Transform	4
B.Tech	AECB08	III	Probability Theory and Stochastic Processes	4

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
signals and systems	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
-	-	-	-	-	-

B. Programming Based:

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

VI MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
signals and systems	70 Marks	30 Marks	100

VII DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

VIII 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**
-	-	-	-	-	-

B. Programming Based:

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

IX 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.	2	Lab Experiments / CIE / SEE
PO 5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	3	Lab Experiments / CIE / SEE
PO 12	Life-long learning: An ability to align with and upgrade to higher learning and research activities along with engaging in life-long learning.	1	Self Learning

3 = High; 2 = Medium; 1 = Low

X 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

XI COURSE OBJECTIVES:

The students will try to learn:

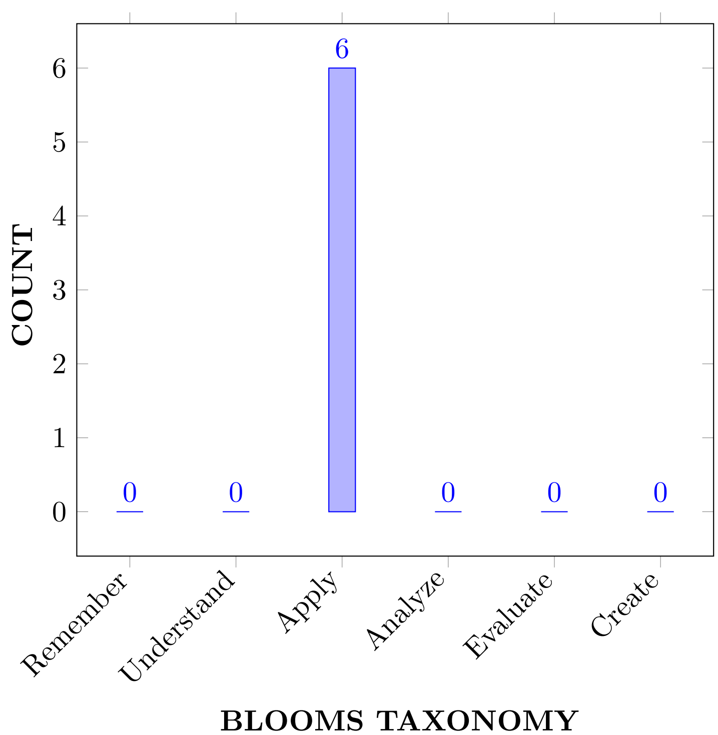
I	The basic syntax of signals, generations and operations of signals and sequences using MATLAB.
II	The spectral characteristics of signals using Fourier, laplace and z transform.
III	The Implementation of convolution and correlation of signals and systems.

XII COURSE OUTCOMES:

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

CO No	Course Outcomes	Knowledge Level (Bloom's Taxonomy)
CO 1	**Realize** the tool basic operations addition, subtraction, multiplication and division on matrices	Apply
CO 2	**Generate** standard signals and sequences for performing operations on various signals	Apply
CO 3	**Determine** Fourier transform, properties of Fourier transform and Inverse Fourier transform of signal and sequence	Apply
CO 4	**Locate** the poles and zeros of transfer function using Laplace and Z transforms.	Apply
CO 5	**Determine** convolution and correlation between signals and sequences for analyzing linear time-invariant systems.	Apply
CO 6	**Compute** mean, mean square and power spectral density of signal to calculate gaussian noise.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



XIII 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**mathematical operations**on matrices by applying the**mathematical principles** and engineering science.	3
	PO 5	**Make use of** MATLAB software to perform matrix manipulation operations.	1
CO 2	PO 2	**Understand** the given problem statement and formulate **mathematical operations** on signals and sequences using principles of **mathematics and engineering science.**	3
	PO 5	**Utilize** software tool to generate and perform operations of signals and sequences.	1
CO 3	PO 2	**Understand** the given **problem statement** and **formulate** the Fourier transform problems of spectral characteristics of continuous time aperiodic signals and analyze the frequency response of the given system.	3
	PO 5	**Make use of** MATLAB software tool to perform the transform technique of Fourier transform and verify the properties of Fourier transform.	1
	PSO 1	**Develop** the capability to **analyze** and apply Fourier Transform and their properties on continuous signals and applications by its **mathematical models**	3
CO 4	PO 2	**Identify** and **determine** the region of convergence of the Laplace and z transform for given causal and noncausal signals.	2
	PO 5	**Identify** and **determine** the Laplace and z transform for given causal and noncausal signals.	1
	PO 12	**Ability** to **understand** the basic concepts of Laplace and z transform apply them to various areas, like Communications, Signal processing.	2
	PS01	**Ability** to **analyze** and apply Laplace and Z Transform and their properties on continuous and discrete signals and applications by its **mathematical models**.	3

CO 5	PO 2	**Explain (Knowledge)** the correlation functions for measuring the similarity of the signals in signal detection for **solving complex engineering problems** using auto and cross correlation functions by applying mathematics, science and**engineering fundamentals**.	3
	PO 5	**Make use of** MATLAB software tool to perform the cross correlation and autocorrelation.	1
	PO 12	**Ability** to **understand** the basic concepts of convolution apply them to various areas, like Electronics, Communications, Signal processing.	2
CO 6	PO 2	**Develop** the capability**analyze** the spectral densities of a given signal using mathematical theorems.	2
	PO 5	**Utilize** the software tool to analyze the energy and power spectral density.	1

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

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

XV 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	-	30	-	-	10	-	-	-	-	-	-	-	-	-	-
CO 2	-	30	-	-	10	-	-	-	-	-	-	-	-	-	-
CO 3	-	30	-	-	10	-	-	-	-	-	-	-	100	-	-
CO 4	-	20	-	-	10	-	-	-	-	-	-	25	100	-	-
CO 5	-	30	-	-	10	-	-	-	-	-	-	25	-	-	-
CO 6	-	20	-	-	10	-	-	-	-	-	-	-	-	-	-

XVI 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	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 3	-	1	-	-	1	-	-	-	-	-	-	-	3	-	-
CO 4	-	1	-	-	1	-	-	-	-	-	-	1	3	-	-
CO 5	-	1	-	-	1	-	-	-	-	-	-	1	-	-	-
CO 6	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
TOTAL	**0**	**6**	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**6**	**0**	**0**
AVERAGE	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**0**	**0**

XVII ASSESSMENT METHODOLOGY DIRECT:

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

XVIII ASSESSMENT METHODOLOGY DIRECT:

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

XIX ASSESSMENT METHODOLOGY INDIRECT:

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

XX 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	-	3	-	-	1	-	-	-	-	-	-		-	-	-
CO 2	-	3	-	-	1	-	-	-	-	-	-	-		-	-
CO 3	-	3	-	-	1	-	-	-	-	-	-	2	2	-	-
CO4	-	2	-	-	1	-	-	-	-	-	-	2	-	-	-
CO 5	-	3	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 6	-	2	-	-	1	-	-	-	-	-	-		-	-	-
CO 7	-	2	-	-	1	-	-	-	-	-	-		-	-	

3 = High; 2 = Medium; 1 = Low

XXI SYLLABUS:

Week-1	**BASIC OPERATIONS ON MATRICES**
	Review basic operations on matrices by using MATLAB
Week-2	**GENERATION OF VARIOUS SIGNALS AND SEQUENCES**
	Generation of various signals and sequences such as unit impulse, sinc, gaussian, exponential, sawtooth, triangular and sinusoidal by using MATLAB.
Week-3	**OPERATIONS ON SIGNALS AND SEQUENCES**
	Operations and signals and sequences such as addition, subtraction, multiplication, scaling, shifting and folding by using MATLAB.
Week-4	**GIBBS PHENOMENON**
	Verification of Gibbs phenomenon by using MATLAB
Week-5	**FOURIER TRANSFORMS AND INVERSE FOURIER TRANSFORM**
	Finding the Fourier transform and inverse Fourier transform of given signal/sequence and plotting its magnitude and phase spectrum by using MATLAB.
Week-6	**PROPERTIES OF FOURIER TRANSFORMS**
	Verify time shifting and scaling, time and differentiation properties of Fourier transforms by using MATLAB.
Week-7	**LAPLACE TRANSFORMS**
	Finding the Laplace transform of a given signal and locate its zeros and poles in s-plane.

Week-8	**Z-TRANSFORMS**
	Finding the Z-transform of a given sequence and locate its zeros and poles in s-plane.
Week-9	**CONVOLUTION BETWEEN SIGNALS AND SEQUENCES**
	Finding convolution between given two signals/sequences by using MATLAB.
Week-10	**AUTO CORRELATION AND CROSS CORRELATION**
	Finding auto correlation and cross correlation between signals and sequences by using MATLAB.
Week-11	**GAUSSIAN NOISE**
	Generation of Gaussian noise, computation of its mean, M.S value and its Skew, kurtosis, and PSD, probability distribution function by using MATLAB.
Week-12	**WIENER -KHINCHINE RELATIONS**
	Verification of Wiener- Khinchine relations using MATLAB.
Week-13	**DISTRIBUTION AND DENSITY FUNCTIONS OF STANDARD RANDOM VARIABLES**
	Finding distribution and density functions of standard random variables and plot them using MATLAB.
Week-14	WIDE SENSE STATIONARY RANDOM PROCESS

TEXTBOOKS

1. Signals, Systems Communications, B.P. Lathi, BS Publications, 2009.
2. Signals and Systems, A.V. Oppenheim, A.S. Willsky and S.H. Nawab ,PHI, 2nd Edition 2009. Digital Signal Processing, Principles, Algorithms, and Applications, John G. Proakis, Dimitris G. Manolakis, Pearson Education / PHI. 2007..

REFERENCE BOOKS:

1. S.Varadarajan, M.M. Prasada Reddy,M.Jithender Reddy," Signals and Systems Introduces MATLAB Programs " I.K International Publishing House Pvt .Ltd,2016.

2. Scott L. Miller, Donald G. Childers," Probability and Random Process: with Applications to Signal Processing and Communications", Elsevier ,2004

3. Krister Ahlersten,"An Introduction to Matlab".BookBoon,2012.

XXII 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	Generate matrices and perform basic operations on matrices using MATLAB.	C0 1	T1-13.2
2	Generate various signals and sequences such as unit impulse, unit step, ramp, sinc and signum.	C0 2	T1 14.5
3	Perform amplitude and time operations on signals and sequences.	C0 3	T1 14.8
4	Verify GIBBS phenomenon.	C0 4	T1 15.5 -15.9
5	Calculate Fourier transform and inverse Fourier transform of given signal and sequence.	C0 5	T1 15.7
6	Verify properties of Fourier transform.	CO 6	T1-11.1 to 11.5
7	Calculate Laplace transform of given signal and locate poles and zeros on S-plane.	CO 7	T1-161 to 16.8
8	Calculate Z transform of given sequence and locate poles and zeros on Z-plane.	CO 8	R44.1
9	Find convolution between given two signals and sequences.	CO 9	R44.2
10	Calculate Auto correlation and Cross correlation between signals and sequences.	CO 10	R44.3
11	Generate Gaussian noise and calculate its mean, mean square, distribution and density functions.	CO 11	R44.6
12	Verify Wiener – Khinchine relationships using MATLAB.	CO 12	R44.10
13	Calculate probability density and distributions functions of a given random variable.	C0 13	R45.6
14	Verify a random process for stationary in wide sense using MATLAB.	C0 14	R45.6

XXIII EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Determine the array matrix using MATLAB software?
2	Find the aperiodic signal if the given input signal is rectangular?
3	How to Add two signasl X , Y where X= [0 1 6 5] and Y will be user defined.
4	How to generate the fourier series coefficients when we are giving the half wave rectifier?
5	Determine the differentiation,integration of DTFT?
6	Verify the frequency-shifting property of the DTFT.
7	verify the transfer function using input and impulse response of the system?.
8	perform convolution between the following signals 1. X(n)=[1 -1 4], h(n) = [-1 2 -3 1]
9	Determine the Auto Correlation and Cross Correlation
10	Detrmine the conditions for Region of convergence in laplace transform?
11	How to add gaussian noise in 1D signal

Signature of Course Coordinator **HOD, ECE**

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

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Antennas and wave propagation**				
Course Code	AECB18				
Program	B.Tech				
Semester	Five				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	1	3		
Course Coordinator	Dr. V.Kishen Ajay Kumar, Associate Professor				

I COURSE OVERVIEW:

This course will cover the fundamentals of antenna, radiation phenomenon, different types of antennas, antenna arrays, antenna measurements and wave propagation (influence of earth's atmosphere on radio waves). Antennas had wide range of application in government and commercial fields and able to design the antennas like Yagi-uda and micro strip

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB13	IV	Electromagnetic waves and transmission lines

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Antennas and Wave Propagation	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOCs
✓	Open Ended Experiments	✓	Techtalk	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
33.33 %	Understand
33.33 %	Apply
33.33 %	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) and 10 marks for Quiz / 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 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

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 3.
Table 3: Assessment pattern for AAT

Concept Video	Tech-talk	Open Ended Experiment
40%	40%	20%

VI COURSE OBJECTIVES:

The students will try to learn:

I	Principles of radiation, antenna parameters and working principle of VHF, UHF and microwave antennas used in communications, broad casting, radar, navigation and similar systems.
II	Familiarize with basic antenna types and common structures, measurement of antenna characteristics and application of antennas over the radio frequency (RF) to micro wave (MW) frequency range.
III	The applications of smart, wideband and ultra wideband antennas for wireless communications, satellite communication, and radar systems.

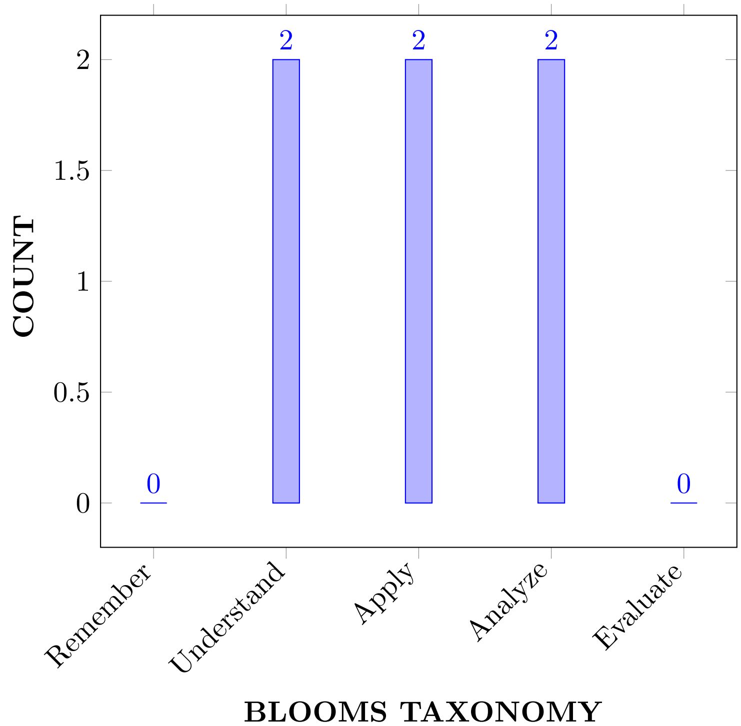
VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the radiation mechanism in wire antennas and retarded potentials using Maxwell's equations.	Understand
CO 2	**Interpret** the radiation characteristics of yagi-uda, horn and helical antennas using radiation pattern in far field region.	Understand
CO3	**Analyze** the radiation characteristics of micro strip and micro wave antennas using electric field distribution.	Analyze
CO 4	**Identify** the radiation patterns of arrays using principle of pattern multiplication.	Apply

CO 5	**Examine** the performance of antennas using the radiation pattern, directivity and gain.	Analyze
CO 6	**Select** the modes of wave propagation using refraction and reflection concepts	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO1	**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
PO2	**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

PO3	**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	**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

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		**Strength**	**Proficiency Assessed by**
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.	1	–

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	**PO'S PSO'S**	**Justification for mapping (Students will be able to)**	**No. of Key Competencies**
CO 1	PO 1	**Understand** the basic parameters of an antenna by **applying** the **mathematical principles** and **own engineering discipline**.	3

	PO 2	**Formulate** the retarded potentials in radiation fields and **analyze** the (potentials) **complex engineering problems** using **principles of mathematics and engineering science**.	5
	PO 10	**Communicate orally** on basic antenna parameters and **write** effective reports on radiation pattern	2
CO 2	PO 1	**Understand** the radiation pattern of Yagi-uda, horn and helical antennas in far field region by **applying the science for engineering problems**	2
	PO 2	**Identify** the given problem in direction finding and formulate field components of wire antennas from the provided **information and data collection** in reaching sustained conclusions by the **interpretation of results** into a new **model translation and validation**	7
	PO 3	**Design solutions** for **complex engineering problems** in Yagi-uda and helical antenna that meet the specified needs for the **public health, safety and environmental considerations**	5
	PO 10	**Communicate orally** on wire antennas and **write** effective reports on antenna design for public health, safety and environment conditions	2
CO 3	PO 1	**Analyze** the radiation properties of micro strip antennas using **mathematical principles and own engineering discipline**. .	2
	PO 2	**Identify** the given problem of the adaptive beam forming in smart antennas and formulate weights of smart antennas from the provided **information and data collection** in reaching **sustained conclusions** by the **interpretation of results** into a new **model translation and validation**	7
	PO 3	**Investigate and define radiation problems** in parabolic antennas and **identify** constraints including **environmental, health and safety** understand **customer and user needs** and the importance of considerations, use **creativity** to establish **innovative solutions** in dipole antennas design, manage the **design process of dipole antennas and evaluate outcomes**.	5
	PO 10	**Communicate orally** on radiation properties of micro strip antennas and **write** effective reports on smart antennas	2
	PSO 3	Make use of **High Frequency Structure Simulator (HFSS)** for modeling the patch and microwave antennas for wired and wireless communication applications	1

CO 4	PO 1	**Illustrate** the multiplication of radiation patterns by understanding the knowledge in solving (complex) engineering problems related to antenna arrays by **applying scientific, mathematical principles and own engineering discipline**.	3
	PO 2	**Identify** the given problem of the narrow beam requirement in point to point communication at higher frequencies and **formulate** the direction of arrival of the incoming signals from the provided **information and data collection** in reaching **sustained conclusions** by the **interpretation of results** into a **new model translation and validation**	7
	PO 3	**Investigate and define radiation problems** for **complex engineering problems** in array antennas, and identify constraints including environmental, health and safety, understand **customer and user needs** and the importance of considerations, use**creativity to establish innovative solutions** in array antennas design, **manage the design process** of array antennas and **evaluate outcomes**	5
	PO 10	**Communicate orally** on radiation properties of micro strip antennas and **write** effective reports on smart antennas	2
	PSO 3	Make use of **High Frequency Structure Simulator (HFSS)** for modeling the array antennas	1
CO 5	PO 1	**Judge** the performance of antennas by measuring the parameters using **mathematical principles and own engineering discipline**	2
	PO 2	**Analyze** the given problem of measuring the characteristics of an antenna and **formulate** the directivity and gain of antenna from the provided **information and data collection** in reaching **sustained conclusions** by the **interpretation** of results into a **new model translation and validation**	7
	PO 3	**Understand** the user needs of antennas for working,**identify** the cost limitations for the selection of parameters, use **creativity** in producing new antenna designs for **innovative solutions** and manage the **design process of antennas and evaluate outcomes**	5
	PO 10	**Communicate orally** on the performance of antennas and **write** effective reports on characteristics of antennas	2

CO 6	PO 1	**Model** the modes of wave propagation through the earth's atmosphere by **applying** the **scientific, mathematical principles and own engineering discipline**	3
	PO 2	**Identify** the importance of wave propagation in wireless communication and **formulate** the maximum usable frequency, virtual height and line of sight from the provided **information** and**data collection** in reaching sustained conclusions by the **interpretation of results**	7
	PO 10	**Communicate orally** on the modes of wave propagation and **write** effective reports on maximum usable frequency and line of sight	2

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

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
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	3	5	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 2	2	7	5	-	-	-	-	-	-	2	-	-	-	-	-
CO 3	2	7	5	-	-	-	-	-	-	2	-	-	-	-	1
CO 4	2	7	5	-	-	-	-	-	-	2	-	-	-	-	1
CO 5	2	7	5	-	-	-	-	-	-	2	-	-	-	-	-
CO 6	3	5	-	-	-	-	-	-	-	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
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	100	50	-	-	-	-	-	-	-	40	-		-	-	-
CO 2	66.6	70	50	-	-	-	-	-	-	40	-	-	-	-	-
CO 3	66.6	70	50	-	-	-	-	-	-	40	-	-	-	-	33.3
CO 4	66.6	70	50	-	-	-	-	-	-	40	-		-	-	33.3
CO 5	66.6	70	50	-	-	-	-	-	-	40	-	-	-	-	-
CO 6	100	50	-	-	-	-	-	-	-	40	-		-	-	-

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
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	3	2	-	-	-	-	-	-	-	1	-		-	-	-
CO 2	3	3	2	-	-	-	-	-	-	1	-	-	-	-	-
CO 3	3	3	2	-	-	-	-	-	-	1	-	-	-	-	2
CO 4	3	3	2	-	-	-	-	-	-	1	-		-	-	2
CO 5	3	3	2	-	-	-	-	-	-	1	-	-	-	-	-
CO 6	3	2	-	-	-	-	-	-	-	1	-	-	-	-	-
TOTAL	18	16	8	-	-	-	-	-	-	6	-	-	-	-	4
AVERAGE	3.0	2.6	2.0	-	-	-	-	-	-	1.0	-	-	-	-	2.0

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 and Experimental Tools in Engineering by Experts		

XVII SYLLABUS:

MODULE I	**ANTENNA BASICS**
	Antenna fundamentals: Introduction, basic antenna parameters-patterns, beam area, radiation intensity, beam efficiency, directivity-gain-resolution, antenna apertures, effective height, illustrative problems, fields from oscillating dipole, field zones, front-to-back ratio, antenna theorems, radiation, retarded potentials, radiation from small electric dipole, quarter wave monopole and half wave dipole, current distributions, field components, radiated power, radiation resistance, loop antennas- introduction, small circular loop, comparison of far fields of small loop and short dipole.
MODULE II	**VHF,UHF AND MICROWAVE ANTENNAS-I**
	Arrays with parasitic elements, Yagi-uda array, folded dipoles and their characteristics, helical antennas-helical geometry, helix modes, practical design considerations for monofilar helical antenna in axial and normal modes, horn antennas- types, Fermat's principle, optimum horns, design considerations of pyramidal horns, illustrative problems.
MODULE III	**VHF,UHF AND MICROWAVE ANTENNAS-II**
	Micro strip Antennas-Introduction, basic characteristics of micro strip antennas, feeding methods, method of analysis, rectangular and circular micro strip antennas, basic concepts of Smart antennas, concepts and benefits of smart antennas, fixed weight beam forming, adaptive beam forming. **Reflector Antennas**- Introduction, paraboloidal reflectors- geometry, pattern characteristics, feed methods lens antennas: introduction, geometry of non-metallic dielectric lenses, zoning, tolerances, applications, slot antenna, Babinet's principle, applications.
MODULE IV	**ANTENNA ARRAYS AND MEASUREMENTS**
	Antenna Arrays: Point sources- definition, patterns, arrays of 2 isotropic sources – different cases, principle of pattern multiplication, uniform linear arrays- broadside arrays, end-fire arrays, EFA with increased directivity, derivation of their characteristics and comparison, BSAs with Non-uniform amplitude distributions, general considerations and binomial arrays, illustrative problems **Antenna Measurements**: Introduction, concepts – Reciprocity, near and far fields, coordinate system, sources of errors patterns to be measured, pattern measurement arrangement directivity measurement, gain measurements (by Comparison, Absolute and 3-Antenna methods)

MODULE V	**RADIO WAVE PROPAGATION**
	Wave Propagation - I: Introduction, definitions, categorizations ,different Modes of Wave Propagation; Ground wave propagation: Introduction, plane earth reflections, , wave tilt, curved earth reflections; Space wave propagation: Introduction, field strength variation with distance and height, effect of earth's curvature, absorption, super refraction, M-curves, duct propagation, scattering phenomena, tropospheric propagation, fading and path loss calculations; Wave propagation – II: Sky wave propagation: Introduction, structure of ionosphere, refraction and reflection of sky waves by ionosphere; ray path, critical frequency, MUF, LUF, OF, virtual height and skip distance; relation between MUF and skip distance; multi-hop propagation

TEXTBOOKS

1. John D. Kraus, Ronald J. Marhefka, Ahmad S. Khan, "Antennas and Wave Propagation", TMH, 4th Edition, 2010.

2. C.A. Balanis, "Antenna Theory", John Wiley and Sons, 2nd Edition, 2001.

REFERENCE BOOKS:

1. E.C. Jordan, K.G. Balmain, "Electromagnetic Waves and Radiating Systems", PHI, 2nd Edition, 2000.

2. E.V.D. Glazier, H.R.L. Lamont, "Transmission and Propagation", Her Majesty's Stationery Office, 1958.

3. F.E. Terman, "Electronic and Radio Engineering", McGraw-Hill, 4th Edition, 1955.

4. K.D. Prasad, SatyaPrakashan, "Antennas and Wave Propagation", Tech India Publications, 1st Edition, 2001.

WEB REFERENCES:

1. https://nptel.ac.in/courses/117/107/117107035/

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index?route=course/detailscourse$_id = 181$

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.	-	https://lms.iare.ac.in/index?route=course/details&course_id=181
CONTENT DELIVERY (THEORY)			
2	Antenna fundamentals: introduction	CO 1	T1: 2.1
3	Basic antenna parameters-patterns, beam area, radiation intensity, beam efficiency, directivity-gain-resolution	CO 1	T1: 2.2-2.8
4	Antenna apertures, effective height, fields from oscillating dipole	CO 1	T1: 2.9-2.10, 2.12
6	Field zones, front-to-back ratio, antenna theorems	CO 1	T1:2.13,21,22
7	Radiation, retarded potentials	CO 1	T1: 4.1-4.2
8	Radiation from small electric dipole	CO 1	T1: 4.3
9	Quarter wave monopole and half wave dipole, current distributions, field components	CO 1	T1: 6.5
11	Radiated power, radiation resistance	CO 1	T1: 6.6 R2-8.1
13	Loop Antennas- introduction, small circular loop, comparison of far fields of small loop and short dipole	CO 1	T1: 7.1-7.3
14	Arrays with parasitic elements, Yagi -uda array	CO 2	T1: 8.6
16	Folded dipoles and their characteristics	CO 2	T1: 8.7
17	Helical antennas-helical geometry, helix modes	CO 2	T1: 8.1-8.4
18	Practical design considerations for mono-filar helical antenna in axial and normal modes, horn antennas-types	CO 2	T1: 8.5-8.9
20	Fermat's principle, optimum horns, design considerations of pyramidal horns	CO 2	T1: 8.9-8.12
22	Micro strip antennas-introduction, basic characteristics of micro strip antennas	CO 3	T1: 14.1-14.4
23	Feeding methods, methods of analysis, rectangular and circular micro strip antennas	CO 3	T1: 14.5-14.6

24	Basic concepts of smart antennas, concepts and benefits of smart antennas, fixed weight beam forming, adaptive beam forming	CO 3	T1: 14.8
25	Reflector Antennas- introduction	CO 3	T1: 9.1-9.3
26	Paraboloidal reflectors- geometry, pattern characteristics, feed methods	CO 3	T1: 9.4-9.10
28	Lens antennas: introduction, geometry of non-metallic dielectric lenses, zoning, tolerances, applications	CO 3	T1: 10.1-10.3
30	Slot antenna, Babinet's principle, applications.	CO 3	T1: 10.4-10.6
31	Antenna arrays: point sources- definition, patterns	CO 4	R3: 7.1
32	Arrays of 2 isotropic sources – different cases	CO 4	R3: 7.2-7.3
33	Principle of pattern multiplication, uniform linear arrays- broadside arrays	CO 4	T1: 5.10-5.11
36	End-fire arrays, EFA with increased directivity, derivation of their characteristics and comparison	CO 4	T1: 5.13
38	BSAs with non-uniform amplitude distributions, general considerations and binomial arrays	CO 4	T1: 5.15
39	Antenna measurements: introduction, concepts –Reciprocity, near and far fields, coordinate system, sources of errors	CO 5	T1: 21.1-21.2
40	Errors patterns to be measured, pattern measurement arrangement, directivity measurement	CO 5	T1: 21.3, 21.5
41	Gain measurements (by comparison, absolute and 3-antenna methods)	CO 5	T1: 21.5
42	Wave propagation - I: introduction, definitions, categorizations, different modes of wave propagation	CO 6	R3:11.1-11.3
43	Ground wave propagation: Introduction, plane earth reflections	CO 6	R3:11.4
44	Wave tilt, curved earth reflections	CO 6	R3:11.5
45	Space wave propagation: introduction	CO 6	R3:11.19
46	Field strength variation with distance and height	CO 6	R3:11.19
48	Effect of earth's curvature, absorption, super refraction, M-curves	CO 6	R4:11.41
49	Duct propagation, scattering phenomena	CO 6	R4:11.31
50	Tropospheric propagation, fading and path loss calculations	CO 6	R4:11.32-33
51	Wave propagation – II: sky wave propagation: introduction, structure of ionosphere	CO 6	R4:11.34
52	Refraction and reflection of sky waves by ionosphere	CO 6	R4:11.34

53	Ray path, critical frequency	CO 6	R4:11.35
55	MUF, virtual height and skip distance	CO 6	R4:11.36
58	Relation between MUF and skip distance	CO 6	R4:11.37
59	LUF, OF, multi-hop propagation	CO 6	R4:11.38
PROBLEM SOLVING/ CASE STUDIES			
5	Problems on effective aperture	CO 1	T1: 2.9-2.10
10	Problems on power radiated by half wave dipole	CO 1	T1:6.5
12	Problems on radiation resistance and radiated power	CO 1	T1:6.6
15	Problems on Yagi- uda antenna	CO 2	T1: 8.6
19	Problems on helical antenna	CO 2	T1:8.1-8.4
21	Problems on horn antenna	CO 2	T1: 9.4-9.10
27	Problems on parabolic reflector	CO 3	T1: 9.4-9.10
29	Problems on lens antenna	CO 3	T1: 10.1-10.3
34	Problems on multiplication pattern	CO 4	T1: 5.10-5.11
35	Problems on broadside array	CO 4	T1: 5.12
37	Problems on end fire array	CO 4	T1: 5.13
47	Problems on field strength	CO 6	R4:11.36
54	Problems on critical frequency	CO 6	R4:11.36
56	Problems on maximum usable frequency	CO 6	R4:11.36
57	Problems on skip distance	CO 6	R4:11.36
DISCUSSION ON DEFINITION AND TERMINOLOGY			
60	Definitions on antenna parameters	CO 1	T1: 2.2-2.8
61	Definitions on basic antennas	CO 2	T1: 7.1-7.3
62	Definitions on array antennas	CO 4	R4:11.1-11.3
63	Definitions on measurements of antenna	CO 5	T1: 2.9-2.10
64	Definitions on modes of radio wave propagation	CO 6	R4:11.7
DISCUSSION ON QUESTION BANK			
65	Gain and radiation intensity of a dipole antenna	CO 1	T1: 2.1-2.22, T1:4.1-4.3, T1:6.5-7.3
66	Operation and working principle of helical antenna	CO 2	T1:8.1 - 8.12
67	Design of parabolic reflector antennas	CO 3	T1: 14.1-14.6, T1:14.8, T1:9.1-9.10
68	Types of arrays and gain measurements	CO 4,CO 5	T1:10.1-10.6, R3:7.1-7.3, T1:21.1-21.6
69	Parameters of sky wave propagation	CO 6	R3:11.1-11.38

Signature of Course Coordinator **HOD,ECE**
Dr.V.Kishen Ajay Kumar, 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 Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
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 Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
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 Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
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 Number	NBA Statement / Key Competencies Features (KCF)	No. of KCF's
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 Number	**NBA Statement / Key Competencies Features (KCF)**	**No. of KCF's**
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**

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

ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE DESCRIPTION

Course Title	LINEAR AND DIGITAL IC APPLICATIONS				
Course Code	AECB19				
Program	B.Tech				
Semester	V	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	3	-	-
Course Coordinator	Dr. G Srihari, Associate Professor				

I COURSE OVERVIEW:

This course deals with the fundamental concepts of operational amplifier, linear non linear application of op-amp and digital Integrated circuits. It covers design and analysis of frequency selective and tuning circuits like oscillators, active filters, Phase locked loops and its use for communication applications. Along with switching applications like that of comparators, learn IC based design of voltage regulators, digital IC's for combination and sequential circuit designs. This course forms the basis for the next level of course VLSI Design.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB11	IV	Analog and Pulse Circuits
B.Tech	AECB07	III	Digital System Design

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Microwave and satellite engineering	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
60 %	Understand
20 %	Apply
10 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool

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

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

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

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

5 Minutes Video	Assignment	Tech-talk	Seminar	Open Ended Experiment
20%	30%	30%	10%	10%

VI COURSE OBJECTIVES:

The students will try to learn:

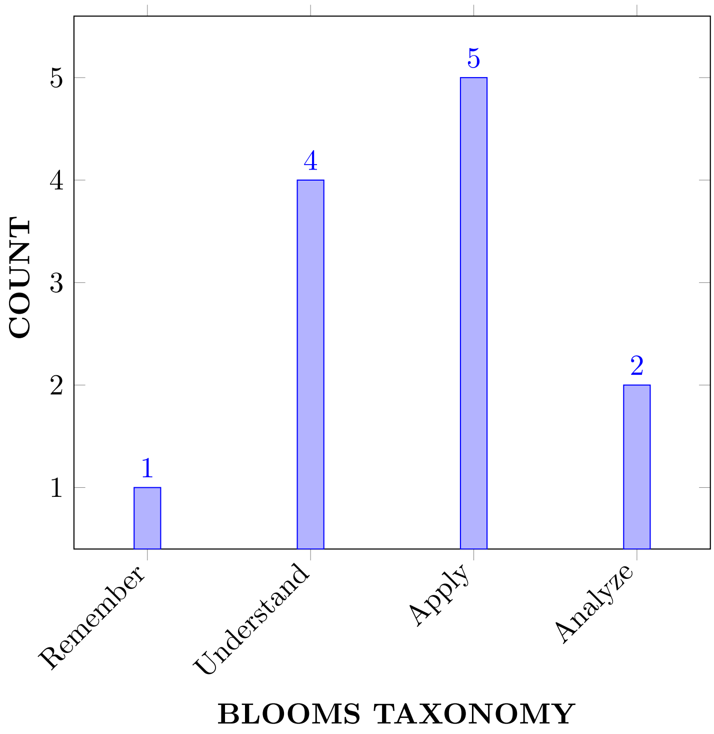
I	The basic building blocks, characteristics and applications of operational amplifier.
II	The functional details of logic families, combinatorial and sequential digital circuits (ICs) used in digital design.
III	Different IC models which are basic for Mixed signal integrated circuits in future.

VII COURSE OUTCOMES:

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

CO 1	**Interpret** the DC and AC analysis of differential amplifiers as a building block of operational amplifier.	Understand
CO 2	**Explain**the specifications of ideal and practical operational amplifier and their DC, AC characteristics.	Understand
CO3	**Build**various linear application circuits such as mathematical operation, wave shaping circuits using op-amp operating with negative feedbackin closed loop configuration.	Analyze
CO 4	**Experiment**with comparator (open loop configuration) and change the characteristics of it by adding feedback to model multivibrators.	Apply
CO 5	**Model**the function generator with variable amplitude and frequency modulation capability using IC 741 Op-amp.	Apply
CO 6	**Demonstrate** importance, types voltage regulators and their applicationsin pulse width modulation, push pull bridges.	Remember
CO 7	**Design**frequency selective circuits using OPAMP for audio and radio frequency ranges.	Analyze
CO 8	**Determine**the function of Phase Locked Loop and their applicationsusing operational amplifier as IC565.	Apply
CO 9	**Explain**the fundamental frequency of monostable and astable Multivibrators using IC555 timer.	Understand
CO 10	**Choose**appropriate Analog to Digital and Digital to Analog converters for data processing in Microprocessor, Digital signal processing and Communication.	Apply
CO 11	**Compare**the digital logic family circuits which are basics for digital gates along with the characteristicsfor digital design.	Understand
CO 12	**Make use of**commercially available sequential and combinational digital ICsto function as Latch, Flip flop, Registers and Counters.	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	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.	1	SEE /CIE, AAT, QUIZ
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, QUIZ

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	SEE/ CIE, AAT, QUIZ

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		**Strength**	**Proficiency Assessed by**
PSO 1	Professional Skills: An ability to understand the basic concepts in Electronics and Communication Engineering and to apply them to various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of complex systems.	2	Seminars and assign-ments
PSO 2	Problem-solving skills: An ability to solve complex Electronics and communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.	-	-
PSO 3	Successful career and Entrepreneurship: An understanding of social-awareness and environmental-wisdom along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.	-	-

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	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	-	-
CO 11	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 12	✓	✓	✓	✓	-	-	-	-	-	-	-	-	✓	-	-

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

Course Outcomes (COs)	POs / PSOs	Justification for mapping (Students will be able to)	No. of key competencies
CO1	PO 1	**Recall** the basic function of transistor and to an extent appreciate the importance of differential amplifier and the characteristics **by applying the own Engineering discipline, Science principles and methodology.**	2
	PO 2	**Calculate** Calculate the AC and DC analysis of differential amplifier in different mode of operations **using Engineering sciences and solution development.**	2
CO2	PO 1	**Recall** Discuss the drawback of using discrete components for design of circuit and appreciate the importance of Op-Amp IC ,its characteristics ,application of open loop Op-Amp **by applying the own Engineering discipline , Science principles and methodology.**	2
	PO 2	**Categorize** the DC, AC characteristics of an operational amplifiers output and using compensation techniques to reduce the effect **using Engineering science and solution development.**	2
CO3	PO 1	**Explain** the importance of feedback and realize linear circuits such as the Inverting and non-inverting amplifier, integrator, differentiator, instrumentation amplifier, AC amplifier using op-amp and the application of that model **using own Engineering discipline, scientific principles and methodology.**	2
	PO 2	**Analyze** various circuit parameters for linear applications of 741 op-amps **using first principle of engineering sciences, experimental design.**	2
	PO4	**Analyze** Distinguish various types Linear circuits such as the Inverting and non-inverting amplifier, integrator, differentiator, instrumentation amplifier and AC amplifier **using design of experiments, analysis and interpretation of data.**	2
CO4	PO 1	**Develop** various time delay circuits; comparators, logarithmic and anti logarithmic amplifier using 741 op-amp **by applying own Engineering discipline, Science principles and methodology.**	2
	PO 2	**Analyze** the nonlinear circuits of op-amp such as comparator and multivibrators **using experimental design and implementation.**	2

	PO 4	**Distinguish** various types non Linear circuits such as the comparator and multivibrators **using design of experiments, analysis and interpretation of data.**	2
	PSO 1	**Make use of** the basic concepts of nonlinear circuits of op-amp to apply them to various areas, **like Communications, Signal processing, VLSI in the design and implementation of complex systems.**	2
CO5	PO 1	**Model** different waveform generators such as square, triangular and sawtooth using operational amplifiers **using the own Engineering discipline, Science principles and methodology.**	2
	PO 2	**Interpret** how to find frequency of oscillations, pulse width and able to change these parameters **based on problem formulation and abstraction.**	2
	PO 4	**Examine** various waveform generators such as triangular, saw tooth and square wave generators **using design of experiments, analysis and interpretation of data.**	2
CO6	PO 1	**Define** how to get a stable dc voltage using voltage regulator and also discuss about three terminal, general purpose, adjustable voltage regulators **using the own Engineering discipline, Science principles and methodology.**	2
	PO 4	**Design** low voltage regulator circuit which are basic requirement of various system **using experimental design and analysis.**	2
	PSO 1	**Apply** voltage regulator circuits in various field such as Electronics, Communications, Signal processing, VLSI, Embedded systems etc., **in the design and implementation of complex systems.**	2
CO7	PO 1	**Outline** the operation of different types of active filters by **using own Engineering discipline, Science principles and methodology.**	3
	PO 2	**Determine** voltage gain expression and study the characteristics of filters **using experimental design, validation and interpret the results.**	3
	PO 3	**Design** system components for frequency selectivity over a wide range of frequency **using innovative solutions and can evaluate outcomes of the circuit.**	2
	PO 4	**Develop** filter designs based on frequency specification requirement for filtering operation **using experiment and analysis.**	2

	PSO 1	**Extend** the focus to understand the innovative and dynamic challenges **involved in filters.**	2
CO8	PO 1	**Demonstrate** the phase locked loop using voltage controlled oscillator, the applications of it **using science, and engineering fundamentals.**	2
	PO 2	**Examine** the lock range, capture range of phase locked loop and able to vary these ranges **in communication application of basics of mathematics and engineering sciences.**	2
	PO 3	**Develop** phase locked loop circuit for solving complex Engineering problems **such as tuners, local oscillator, FM modulators.**	2
	PO 4	**Illustrate** the working functionality of Phase locked loops **using complex problems.**	2
	PO 5	**Design** PLL circuit using modern tools such as cadence software, mentor graphics, synopsis and take necessary steps **to improve the performance of the device.**	2
	PSO 1	**Explain** the application of PLL which is contributing great role **in advanced control systems and communication systems.**	2
CO9	PO 1	**Illustrate** the operation of IC 555 timer and able to calculate frequency of oscillation **using basics of mathematics and engineering sciences.**	2
	PO 2	**Implement** the circuits of astable multivibrator and monostable multivibrator using 555 timers, able to do experimental design for the applications **using astable multivibrator and monostable multivibrator and validate the results.**	2
	PO 3	**Make use of** 555 timer to get stable time delays or oscillations In the design of **system components to establish innovative solutions.**	2
	PO 4	**Design** various timer circuits using research-based knowledge and research methods **including design of experiments.**	2
	PO 5	**Develop** timer circuits using Modern tools and analyze **to complex Engineering activities.**	2
	PSO 1	**Identify** the use of 555 timer circuits in like **Electronics, Communications, Signal processing, VLSI, Embedded systems etc.**	2
CO10	PO 1	**Demonstrate** different data converters for converting analog data to digital data and vice versa **applying basic knowledge of science and engineering fundamentals.**	2
	PO 2	**Illustrate** performance parameter of data converters which are important **for design solutions for complex engineering problems.**	2

	PO 3	**Develop** solution to manage data processing and interfacing applications by establishing innovative solutions **using data converters and can evaluate the outcomes of it.**	2
	PO 4	**Design** data converters on requirement basis **using and find out the unknown parameter with the given specifications.**	2
	PO 5	**Implement** data converters to improve performance **using Modern tools and analyze to complex Engineering activities.**	1
	PSO 1	**Extend** the knowledge of data converter on the **usage in signal processing and communication.**	2
CO11	PO 1	**Build** strong foundation of digital logic families in design of digital ICs **using knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	**Compare** the characteristics of logic families and performance parameters of the circuits realized **using them scientific principles and methodology.**	2
CO12	PO 1	**Build** strong foundation of digital logic families in design of digital ICs **using knowledge of mathematics, science and engineering fundamentals.**	2
	PO 2	**Construct** digital system with sequential and combinational digital ICs **using science and engineering fundamentals, for supporting some VLSI System.**	2
	PO 3	**Design** solutions for complex Engineering problems and design system components using digital system by doing innovative solution and implementing them **using modern tools such as cadence software, mentor graphics, synopsis.**	2
	PO 4	**Examine** sequential and combinational logic circuits design **of experiments, analysis and interpretation of data.**	2
	PO 5	**Inspect** various digital circuits designs **using modern tools such as cadence software, mentor graphics, synopsis.**	2
	PSO 1	**Design** various digital circuits which are used in various areas like Electronics, Communications, Signal processing, VLSI, Embedded systems etc. **in the design and implementation of complex systems.**	2

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

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	66.7	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	66.7	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	66.7	20	-	18.18	-	-	-	-	-	-	-	-	-	-	-
CO 4	66.7	20	-	18.18	-	-	-	-	-	-	-	-	100	-	-
CO 5	66.7	20	-	18.18	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.7	-	-	18.18	-	-	-	-	-	-	-	-	100	-	-
CO 7	100	30	20	18.18	-	-	-	-	-	-	-	-	100	-	-
CO 8	66.7	20	20	18.18	-	-	-	-	-	-	-	-	100	-	-
CO 9	100	20	10	18.18	-	-	-	-	-	-	-	-	100	-	-
CO 10	66.7	20	40	18.18	-	-	-	-	-	-	-	-	100	-	-
CO 11	66.7	20	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 12	66.7	20	30	18.18	-	-	-	-	-	-	-	-	100	-	-

XIV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

COURSE	PROGRAM OUTCOMES												PSO'S		
OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	-	2	-	-	-	-	-	-	-	-	2	-	-
CO 5	2	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	-	-	2	-	-	-	-	-	-	-	-	2	-	-
CO 7	3	3	2	2	-	-	-	-	-	-	-	-	2	-	-
CO 8	2	2	2	2	1	-	-	-	-	-	-	-	2	-	-
CO 9	3	2	1	2	1	-	-	-	-	-	-	-	2	-	-
CO 10	2	2	4	2	1	-	-	-	-	-	-	-	2	-	-
CO 11	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 12	2	2	3	2	1	-	-	-	-	-	-	-	2	-	-
TOTAL	27	23	12	18	4		-	-	-	-	-	-	14	-	-
AVERAGE	2.25	2.09	2.4	2.0	1.0		-	-	-	-	-	-	2.0	-	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO1,PO2	SEE Exams	PO1,PO2, PO4	Seminars	PO9, PO10, PO12
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	PO4	5 Minutes Video	PO5	Open Ended Experiments	PO 12
Assignments	PO1, PO2, PO5				

XVI ASSESSMENT METHODOLOGY INDIRECT:

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

XVII SYLLABUS:

MODULE I	**OPERATIONAL AMPLIFIER**
	Operational Amplifier: Differential Amplifier, DC and AC analysis of dual input balanced output configuration, dual input unbalanced output. Characteristics of Op-amps, Op-amp block diagram, ideal and practical Op-amp specifications. DC characteristics: Input output offset voltages currents, drift. AC characteristics: Frequency response, slew rate, CMRR and PSRR.
MODULE II	**APPLICATIONS OF OPERATIONAL AMPLIFIERS**
	Linear applications of Op-amps: Inverting and non-inverting amplifier, integrator, differentiator, instrumentation amplifier, AC amplifier. Non-linear applications of Op-Amps: Comparators, multi vibrators, triangular, saw tooth, square wave generators, log and anti-log amplifiers. Introduction to voltage regulators, features of 723 Regulator, three terminal voltage regulators.
MODULE III	**ACTIVE FILTERS AND TIMERS**
	Active Filters: Classification of filters, 1st order low pass and high pass filters, 2nd order low pass, high pass, band pass, band reject and all pass filters. Timers: Introduction to 555 timer, functional diagram, mono-stable, astable operations and applications, schmitt trigger. PLL: Introduction, block schematic, principles and description of individual blocks, 565 PLL.
MODULE IV	**DATA CONVERTERS**
	Data converters: Introduction, classification and need of data converters. DAC techniques: weighted resistor DAC, R-2R ladder DAC, inverted R-2R DAC, and IC 1408 DAC. ADC techniques: Flash converters, successive approximation, integrating ADC. DAC/ADC characteristics.
MODULE V	**DIGITAL IC APPLICATIONS**
	Study of digital logic families such as Resistor Transistor Logic (RTL), Diode Transistor Logic (DTL), Transistor Logic (TTL), Emitter Coupled Logic and CMOS. Characteristics of digital logic families containing fan-in, fan-out, power dissipation, propagation delay and noise margin, Familiarity with commonly available 74XX and CMOS 40XX series ICs-Flip Flops (IC 7474, IC 7473), Shift Registers, Universal Shift Register(IC 74194), Synchronous counters (74LS93,74HC163), Decade Counters, (74HC190).

TEXTBOOKS

1. D.RoyChowdhury, "Linear Integrated Circuits", New age international (p) Ltd, 2nd Edition, 2003.

2. Ramakanth A. Gayakwad, "Op-Amps linear ICs", PHI, 3rd Edition, 2003.

3. John F.Wakerly, "Digital Design Principles and Practices", Prentice Hall, 3rd Edition, 2005.

4. M. Morris Mano, Michael D. Ciletti, "Digital Design‖, Pearson Education/PHI, 3rd Edition, 2008.

REFERENCE BOOKS:

1. 1. Salivahanan, "Linear Integrated Circuits and Applications", TMH, 1st Edition, 2008.

XVIII COURSE PLAN:

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

Lecture No	Topics to be covered	CO	Reference
1-3	Discuss the classification of integrated circuits, Package types, temperature ranges and Differential amplifier configurations.	CO 1	T1:2.2 T2:1.2-1.7
4-6	Analyze DC and AC analysis of various configuration of Differential amplifier.	CO 1	T1:2.5 R1:3.4
7-8	Understand differential amplifier stages.	CO 1	T1:2.4
9-10	Understand the DC characteristics of op-amp.	CO 2	T2:1.12-1.13
11-12	Understand the AC characteristics of op-amp.	CO 2	T1:3.2
13-15	Discuss op-amp parameters and measurements.	CO 2	T1:3.3-3.4
16-18	Illustrate the linear applications of op-amp.	CO 3	T1:2.3
19-21	Illustrate the non linear applications of op-amp.	CO 4	T1:11.1-11.5
22-24	Voltage regulators, IC 723	CO 6	T1:2.3
25-29	Derive and analyze 1st order and 2nd order filters.	CO 7	T1:4.8
29-31	Derive and analyze various types of filters.	CO 7	T1:7.2
32-35	Understand the operation of 555 timer and discuss the operation.	CO 8	T1:7.2
36-40	Summarize the operation and applications of multivibrators using 555 timer.	CO 8	T2:10.4 R2:7.2
40-44	UUnderstand the operation of 565 PLL and discuss the operation.	CO 8	T1:8.2-8.5
41	Discuss the classifications of data converters.	CO 9	T1:9.2-9.7
42-43	Discuss and Analyze DAC techniques and characteristics.	CO 10	T1:10.1
44-47	Discuss and Analyze ADC techniques and characteristics.	CO 10	T1:10.2
48-49	Design and analyze the combinational circuits using TTL/CMOS logic.	CO 11	T1:10.3 R2:5.4
50-52	Design and analyze the sequential circuits using TTL/CMOS logic.	CO 11	T1-9.1-9.2
53-55	Design and analyze different types of counters.	CO 12	T3:7.2
56-60	Design and analyze different types of registers.	CO 12	T3:8.4

Signature of Course Coordinator **HOD,ECE**
Dr. G Srihari, Associate Professor

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

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Digital Communications**				
Course Code	AECB20				
Program	B.Tech				
Semester	V				
Course Type	Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr.S.China Venkateswarlu, Professor				

I COURSE OVERVIEW:

This course provides the constructional features of digital communication systems, coding and decoding algorithms. It intended to provide the various digital modulation and demodulation techniques for wired and wireless data transmission. Analytical skills to configure secure digital communications for signal and image processing applications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEC003	III	Probability Theory and Stochastic Process
B.Tech	AEC005	IV	Analog Communications

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Digital Communications	70 Marks	30 Marks	100

IV 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 units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

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

Percentage of Cognitive Level	Blooms Taxonomy Level
10%	Remember
45%	Understand
18%	Apply
27%	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.

VI COURSE OBJECTIVES:

The students will try to learn:

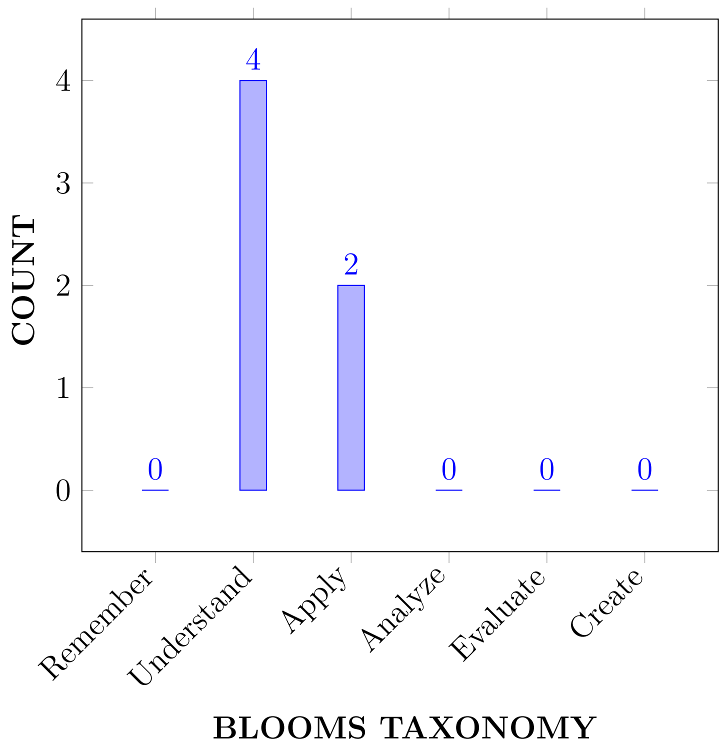
I	The building blocks of digital communication systems such as source coding, channel coding and modulation techniques.
II	The error performance of digital communication system in the presence of noise and other interferences.
III	The applications of spread spectrum techniques in secured digital communication systems.

VII COURSE OUTCOMES:

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

CO 1	**Interpret** the concept of pulse code modulation, demodulation, sampling, quantization and coding for obtaining of digital data..	Understand
CO 2	**Identify** the pulse digital modulation and demodulation techniques using signal space diagrams.	Apply
CO 3	**Explain** pulse shaping of line codes to mitigate inter symbol interference, cross talk using optimum filter, raised cosine filters.	Understand
CO 4	**Outline** the concept of information theory, source coding techniques for average information content in a message.	Understand
CO 5	**Compare** various spread spectrum techniques in terms of frequency hopping.	Understand
CO 6	**Apply** the error detection and error correction technique for digital transmission in noisy environment.	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 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
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 3	**Make use** of high frequency structure simulator for modeling and evaluating the patch and smart antennas for wired and wireless communication applications.	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** (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 10	**Effective presentation and speaking style** (knowledge) the concept of pulse code modulation, demodulation, sampling, quantization and coding (understand) and write subject matter effectively on coding **mathematics, science,** and **for obtaining of digital data**.	1
CO 2	PO 1	**Interpret** (understand) the process of analog to digital conversion to obtain binary data by applying the sampling, quantization **(mathematics, science)** and principles of **engineering fundamentals**	3

	PO 2	**Understand** binary code words in (problem statement) and **formulate** (complex) transmission bandwidth problems related to pulse code modulation and delta modulations to **implementation** (Solution development) differential pulse code modulation from the provided **information** and substantiate with the **interpretation** of variations in the results.	4
	PO 10	**Effective presentation and speaking style** (knowledge) the concept of pulse code modulation, demodulation, sampling, quantization and coding (understand) the pulse digital modulation and demodulation techniques **and write subject matter effectively** and **using signal space diagrams**.	1
CO 3	PO 1	**Identify**(knowledge) pulse digital modulation and demodulation techniques and (understand) signal space diagrams analysis by applying the principles of **mathematics, science, engineering fundamentals**	3
	PO 3	**Develop** pulse digital modulation and demodulation system components, understand **customer and user needs** and identify the **cost limitations** for the selection of parameters, **use creativity** in applying the methods of model analyss for **innovative solutions** for the analysis of modulation techniques.	4
	PO 10	**Effective presentation and speaking style** (knowledge) pulse shaping of line codes to mitigate inter symbol interference, cross talk **and write subject matter effectively on cross talk** and **using optimum filter, raised cosine filters.**.	1
	PSO 3	**Solve** the transmitter and receiver design considerations for modeling and evaluating the patch and smart antennas for wired and **wireless communication** applications.	1
CO 4	PO 1	**Examine** probability of error for amplitude shift keying and phase shift keying for solving (complex) signal to noise ratio by applying the principles of **mathematics, science, engineering fundamentals**	3
	PO 2	**Analyze** the signal power and noise power in digital modulations **(problem statement)** and **formulate** (complex) probability error problems related to **implementation** (solution development) signal to noise ratio from the provided **information** and substantiate with the **interpretation** of variations in the results.	5

	PO 3	**Develop** pulse digital modulation and demodulation system components, to understand signal power and noise power for **customer and user needs** and identify the **cost limitations** for the selection of parameters, use **creativity** in applying the methods of model analyses for **innovative solutions** for the analysis of figure of merit.	4
	PO 10	**Effective presentation and speaking style** (knowledge) the concept of information theory, source coding techniques **and write subject matter effectively** and **for average information content in a message**.	1
	PSO 3	**Compare** (understand) pass band modulation schemes with their signal to noise and figure of merit for wired and **wireless communication** applications.	1
CO 5	PO 1	**Explain** (understand) various line encoding formats for data transmission of a digital signal over a transmission line by applying the principles of **mathematics, science, engineering fundamentals**	3
	PO 10	**Effective presentation and speaking style** (knowledge) various spread spectrum techniques **and write subject matter effectively** and **in terms of Frequency hopping.** .	1
	PSO 3	**Summarize** power spectral densities of various line encoding formats in the process of converting digital data to digital signals for wired and **wireless communication** applications.	1
CO 6	PO 1	**Outline** (knowledge) the significance of pulse shaping to reduce inter-symbol interference in digital communications by applying the principles of **mathematics, science, engineering fundamentals**	3
	PO 10	**Effective presentation and speaking style** (knowledge) the error detection and error correction technique **technique and write subject matter effectively on** and **for digital transmission in noisy environment.** .	1
	PSO 3	**Develop** tree diagrams, trellis diagrams and state diagram for the implementation of convolution codes in wired and **wireless communication** applications.	1

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

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

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

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

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

CO 6	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-
TOTAL	**18**	**4**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**6**
AVERAGE	**3**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**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	**PULSE DIGITAL MODULATION**
	Pulse modulation: analog pulse modulation, types of pulse modulation; pulse amplitude modulation (single polarity, double polarity); generation and demodulation of pulse width modulation; generation and demodulation of pulse position modulation. Introduction: elements of digital communication systems, advantages and disadvantages of digital communication systems, applications; pulse digital modulation: elements of pulse code modulation; sampling, quantization and coding; quantization error, non-uniform quantization and companding; differential pulse code modulation, adaptive differential pulse code modulation; delta modulation and its drawbacks; adaptive delta modulation; comparison of pulse code modulation and delta modulation systems; noise in pulse code modulation and delta modulation systems.

MODULE II	**DIGITAL MODULATION TECHNIQUES**
	Digital Modulation Techniques: Introduction, amplitude shift keying modulator, coherent amplitude shift keying detector, non-coherent amplitude shift keying detector, frequency shift keying, bandwidth and frequency spectrum of frequency shift keying, non-coherent frequency shift keying detector, coherent frequency shift keying detector; phase shift keying, coherent phase shift keying detection; optimal reception of digital signal: baseband signal receiver; probability of error; optimum filter; matched filter, probability of error using matched filter; probability of error for various line encoding formats; correlation receiver; calculation of probability of error for amplitude shift keying, frequency shift keying, phase shift keying.
MODULE III	**BASE BAND TRANSMISSION AND PULSE SHAPING**
	Base band transmission: requirements of a line-encoding format, various line encoding formats: unipolar, polar, bipolar; scrambling techniques: BZ8S, HDB3, computation of power spectral densities of various line encoding formats. pulse shaping: inter symbol interference; pulse shaping to reduce inter symbol interference; nyquist criterion; raised cosine filter; equalization; correlative level coding; duo-binary encoding, modified duo –binary coding; Eye diagrams for amplitude shift keying, frequency shift keying; cross talk.
MODULE IV	**INFORMATION THEORY AND SOURCE CODING**
	Information theory: information, entropy, conditional entropy; mutual information; channel capacity; various mathematical modeling of communication channels and their capacities; hartley shannon law; tradeoff between bandwidth and s/n ratio; source coding: fixed length and variable length source coding schemes, huffman coding; source coding to increase average information per bit; lossy source coding; spread spectrum modulation: use of spread spectrum; direct sequence spread spectrum ; code division multiple access using direct sequence spread spectrum, frequency hopping spread spectrum; pn-sequences: generation and characteristics; synchronization in spread spectrum systems
MODULE V	**LINEAR BLOCK CODES AND CONVOLUTION CODES**
	Linear block codes: introduction to error control coding; matrix description of linear block codes, error detection and error correction capabilities of linear block codes; hamming code; binary cyclic codes algebraic structure, encoding, syndrome calculation and decoding; convolution codes: introduction, encoding of convolution codes; time domain approach; transform domain approach; general approach; state, tree and trellis diagram; decoding using viterbi algorithm; burst error correction: block interleaving and convolution interleaving.

TEXTBOOKS

1. Herbert Taub, Donald L. Schilling , “Principles of Communication Systems”, TMH, 3^{rd} edition,2008
2. K. Sam Shanmugam, “Digital and Analog Communication Systems”, John Wiley and Sons, 2^{rd} Edition, 2005.
3. Simon Haykin, “Digital communications”, John Wiley, 3^{rd} Edition, 2005.

REFERENCE BOOKS:

1. John Proakis, "Digital Communications", TMH, 2^{rd} Edition 1983.
2. B.P.Lathi, "Modern Analog and Digital Communication", Oxford reprint, 3^{rd} Edition, 2004.
3. Singh, Sapre, "Communication Systems Analog and Digital", TMH, 2^{rd} Edition, 2004.

WEB REFERENCES:

1. http://www.igniteengineers.com
2. http://www.ocw.nthu.edu.tw
3. http://www.uotechnology.edu.iq

COURSE WEB PAGE:

1. https://www.iare.ac.in/?q=courses/electronics-and-communication-engineering-autonomous/digital-communications

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=188
	CONTENT DELIVERY (THEORY)		
2	Pulse modulation, generation demodulation of pulse amplitude modulation	CO 1	T1-5.2 to 5.3
3	Generation demodulation of pulse width modulation, pulse position modulation	CO 1	T1-5.4 to 5.5
4	Elements of digital communication system	CO 2	T1-5.5 to 5.8
5	Pulse code modulation generation and detection.	CO 2	T1-5.8 to 5.9
6	Quantization and companding	CO 2	T1-5.11 to 5.12
9	Differential pulse code modulation generation and detection, adaptive differential pulse code modulation generation and detection		T1-5.14 to 5.15
10	Delta modulation, adaptive delta modulation	CO 2	T1-5.16 to 5.16
11	Comparison of pulse code modulation and delta modulation, noise in pulse code modulation and delta modulation systems.	CO 2	T1-5.16 to 5.16

12	Digital modulation techniques ,amplitude shift keying modulator, detector	CO 3	T1-6.1 to 6.3
13	Frequency shift keying modulation and demodulation	CO 3	T1-6.8 to 6.9
15	Binary phase shift keying generation and detection, quadrature phase shift keying modulation and demodulation.	CO 3	T1-6.2 to 6.3
16	Differential phase shift keying transmitter and receiver , differentially encoded phase-shift keying,	CO 3	T1-6.3 to 6.4
18	Optimal reception of digital signal, baseband signal receiver;	CO 3	T1-11.1
19	Probability of error, optimum filter, matched filter	CO 3	T1-11.2 to 11.3
20	Calculation of probability of error for amplitude shift keying modulator.	CO 3	T1-11.2 to 11.3
CONTENT DELIVERY (THEORY)			
21	Calculation of probability of error for frequency shift keying modulation, binary phase shift keying modulation.	CO 3	T1-11.9 to 11.10
22	Requirements of a line encoding format, unipolar, polar coding.	CO 4	R2-7.1 to 7.2
23	Scrambling techniques, binary 8-zero substitution, high-density bipolar order 3.	CO 4	R2-7.4
25	Inter symbol interference, pulse shaping to reduce inter symbol interference	CO 4	R2-7.3
26	Nyquist's criterion, raised cosine filter, equalization;	CO 4	R2-7.3.1 to 7.3.2
27	Duo-binary encoding, modified duo binary coding	CO 4	R2-7.3.3 to 7.3.6
28	Eye diagrams, cross talk.	CO 4	R2-7.6
29	Information theory, entropy, types of entropies	CO 5	T1-13.1 to 13.3
30	Mutual information, channel capacity	CO 5	T1-13.1 to 13.3
32	Fixed length and variable length source coding schemes	CO 5	T1-13.5 to 13.6
33	Huffman coding.	CO 5	T1-13.6 to 13.7
34	Shannon fano coding	CO 5	T1-13.7 to 13.9
37	Lossy source coding, channel coding theorem, hartley shannon law, trade-off between bandwidth and signal to noise ratio.	CO 5	T1-13.8
39	Spread spectrum modulation, direct sequence spread spectrum , frequency-hopping spread spectrum	CO 6	T1-17.1 to 17.2
40	Code division multiple access using direct sequence spread spectrum	CO 6	T1-17.3 to 17.4

41	PN-sequences, generation and characteristics, synchronization in spread spectrum systems.	CO 6	T1-17.6 to 17.7
42	Error control coding, linear block codes	CO 6	T1-13.11
44	Matrix description of linear block codes	CO 6	T1-13.12
45	Error detection and error correction capabilities of linear block codes	CO 6	T1-13.13
46	Hamming codes.	CO 6	T1-13.14
48	Cyclic codes, syndrome calculation	CO 6	T1-13.16 to 13.18
50	Convolution codes	CO 6	T1-13.19
52	Time domain approach; transform domain approach	CO 6	T1-13.19
53	State diagram , tree diagram	CO 6	T1-13.20
54	Trellis diagram, Viterbi algorithm	CO 6	T1-13.20
PROBLEM SOLVING/ CASE STUDIES			
7	Problems on pulse code modulation and delta modulation	CO 1	T1-5.8 to 5.9
8	Problems on sampling, quantization	CO 1	T1-5.5 to 5.8
14	Problems on frequency shift keying	CO 1	T1-6.8 to 6.9
17	Problems on phase shift keying	CO 1	T1-6.2 to 6.3
24	Problems on line coding formats	CO 1	R2-7.1 to 7.2
31	Problems on the entropy of the source	CO 7	T1-13.1 to 13.3
35	Problems on source coding schemes	CO 2	T1-13.5 to 13.6
36	Problems on Huffman coding schemes	CO 2	T1-13.6 to 13.7
38	Problems on mutual information	CO 2	T1-13.1 to 13.3
43	Problems on linear block codes	CO 3	T1-13.13
47	Problems on hamming codes	CO 3	T1-13.16 to 13.18
49	Problems on syndrome decoding	CO 3	T1-13.14
51	Problems on cyclic codes	CO 3	T1-13.16 to 13.18
55	Problems on convolutional codes	CO 3	T1-13.19
56	Problems on tree diagram, trellis diagram.	CO 3	T1-13.20
DISCUSSION ON DEFINITION AND TERMINOLOGY			
57	Definitions on pulse digital modulation	CO 1	T1-5.1 to 5.3
58	Definitions on digital modulation techniques	CO 2	T1-6.1 to 6.3
59	Definitions on base band transmission and pulse shaping	CO 3	R2-7.1 to 7.2
60	Definitions on information theory and source coding	CO 4	T1-13.1 to 13.3
61	Definitions on linear block codes and convolution codes	CO 5	T1-13.11

DISCUSSION ON QUESTION BANK			
62	Pulse digital modulation	CO 1	T1-5.1 to 5.3
63	Digital modulation techniques	CO 2	T1-6.1 to 6.3
64	Base band transmission and pulse shaping	CO 5	R2-7.1 to 7.2
65	Information theory and source coding	CO 6	T1-13.1 to 13.3
66	Linear block codes and convolution codes	CO 6	T1-13.11

Course Coordinator **HOD,ECE**
Dr.S.China Venkateswarlu, 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	Electronics and Communication Engineering				
Course Title	Electronic Measurements and Instrumentation				
Course Code	AECB32				
Program	B.Tech				
Semester	V				
Course Type	Professional Elective-I				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr.Mohd.Khadir, Assistant Prfoessor,ECE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB03	II	Electrical Circuits
B.Tech	AECB06	III	Electronic Devices and Circuits

II COURSE OVERVIEW:

The purpose of this course is to design, realization and use of Electronic Systems for the measurement of electrical and non-electrical quantities. It gives an emphasis on analog and digital instruments, oscilloscopes, signal generators, signal analyzers, AC / DC bridges and transducers. The knowledge of measurements and instrumentation is used to test and analyze the performance of measuring instruments in the field of science, engineering and technology.

III COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB03	II	Electrical Circuits
B.Tech	AECB06	III	Electronic Devices and Circuits

IV MARKS DISTRIBUTION:

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

V CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

VI EVALUATION METHODOLOGY:

Each theory 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 sessional examinations or the marks scored in the make-up examination conducted.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE units and each unit carries equal weight age in terms of marks distribution. The question paper pattern is as follows. Two full questions witheitheror choice will be drawn from each unit. Each question carries 14 marks. There could be a maximum of three 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
8%	Remember
33%	Understand
42 %	Apply
17%	Analyze
0%	Create

Continuous Internal Assessment (CIA):
For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table-5. 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. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Internal Examination.

Quiz/Alternative Assessment Tool (AAT):
Two Quiz exams shall be online examination consisting of 20 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in the testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quizzes for every course.
In order to encourage innovative methods while delivering a course, the faculty members have been encouraged to use the Alternative Assessment Tool (AAT) in place of two quizzes. This AAT enables faculty to design own assessment patterns during the CIA. However, the usage of AAT is completely optional. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning centre. The AAT may include seminars, assignments, term paper, open ended experiments, microprojects, five minutes video, MOOCs etc.

VII COURSE OBJECTIVES:

The students will try to learn:

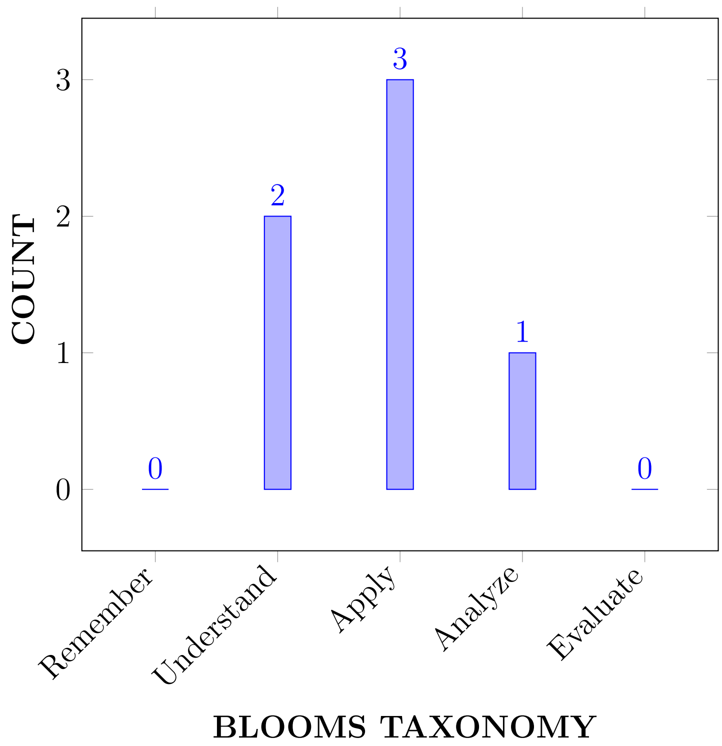
I	The performance characteristics and working principle of analog and digital instruments for measuring electrical quantities.
II	The analysis of various signals by using oscilloscopes and signal analyzers which have built in signal generators
III	The measurement of unknown resistive and reactive components by using various AC and DC bridge circuits.
IV	The construction and working of transducers for the conversion of physical quantities into electrical quantities

VIII COURSE OUTCOMES:

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

CO 1	**Illustrate** the fundamentals and working principle of analog and digital instruments for measuring of electrical parameters.	Understand
CO 2	**Demonstrate** the building blocks and functionality of oscilloscopes to display and measure the parameters of the signals.	Understand
CO 3	**Utilize** the signal generators to produce various signals for design and test the signal applications.	Apply
CO 4	**Analyze** the relative amplitude of the signal and its harmonic components in frequency domain by using Signal Analyzers	Analyze
CO 5	**Identify** appropriate bridge circuits tfor the measurement of unknown electrical parameters.	Apply
CO 6	**Select** the suitable transducers for measuring electrical and non-electrical parameters to resolve the real-world problem.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



IX PROGRAM OUTCOMES:

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

X HOW PROGRAM OUTCOMES ARE ASSESSED:

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

XI HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on the practical experience of ASIC prototype designs, Virtual Instrumentation and SOC designs	3	SEE/ CIE / AAT
PSO 3	Build the Embedded hardware design and software programming skills for entry level job positions to meet the requirements of employers.	3	AAT

3 = High; 2 = Medium; 1 = Low

XII 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	✓	✓	✓	-	-	-	-	-	-	✓	-	-	-	-	✓

XIII 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	**Examine** the schematics of measuring systems and performance characteristics **(knowledge)** of an instrument using the **principles of science and mathematics** for the solution of **complex engineering problems.**	3
	PO 2	**Formulate and analyze (Problem analysis) complex Engineering** problems for measurement of electrical parameters **using first principles of mathematics** and **Engineering sciences**	4
	PO 3	**Understand** the customer needs, use creativity and manage design process in **realization of measuring** instruments for measuring analog and digital values and **evaluate outcomes.**	3
	PO 10	**Effective presentation and speaking style** on building blocks of an instrument and **write subject matter effectively** on working principle of D' Arsonvalmovement.	2
	PSO 2	**Illustrate** the concept analog and digital meters to measure voltage, current and resistance by using virtual instrumentation.	1
CO2	PO 1	**Understand** different blocks present in Oscilloscopes **(knowledge)** and combine all the blocks to get the appropriate output an **engineering specialization to the solution of complex engineering problems.**	3
	PO 2	**Identify, Formulate and analyze (Problem analysis)complex engineering problems** for the measurement using principles of electrostatic deflection sensitivity in Oscilloscopes using **review research literature and mathematics and Engineering sciences.**	6
	PO 3	**Understand customer needs, manage the design** various Oscilloscopes for in realization of measuring signal parameters and **evaluate outcomes of the circuit.**	4
	PO 10	**Effective presentation and speaking style** on building blocks of Oscilloscopes and **write subject matter effectively** on working functionality of Digital Oscilloscopes.	2
	PSO 2	**Develop** the model of oscilloscopes to **analyze** the real time signals.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 3	PO 1	**Understand** concept of multi-function signal generators **analyze** the different blocks present in generator **an engineering specialization to the solution of complex engineering problems.**	3
	PO 2	**Review research literature, conclusions** using first principles of engineering sciences sciences Describe the working of multi-function signal generators **(Complex problem analysis).**	4
	PO 3	**Develop** signal generator circuit **based on customer needs for designg** of multi-function signal generators and **evaluate outcomes of the design.**	3
	PO 10	**Effective presentation and speaking style** on working of AF, RFSignal Generator and **write subject matter effectively** on working functionality of different blocks present in Signal Generators.	2
	PSO 2	**Develop the model** of signal generators to perform the real time signals.	2
CO4	PO 1	**Understand(knowledge)** the concepts of analyzers such as spectrum and wave analyzers and **analyze** the blocks of wave analyzers an engineering specialization to **the solution of complex engineering problems.**	3
	PO 2	**Compare** the working functionality of two analyzers **by formulate, review research literature**	3
	PO 10	**Effective presentation and speaking style** on concept of wave analyzer and **write subject matter effectively** on on analysis of various signal analyzers.	2
	PSO 2	**Develop** the model of signal analyzers to**examine** the real time signals with the harmonic components.	2
CO5	PO 1	**Understand (knowledge)** the concept of bridges in electronic measuring instruments **an engineering specialization to the solution of complex engineering problems**	3
	PO 2	**Identify, formulate and Analyze** AC and DC bridge circuits and **compare them by its applications using first principles of mathematics and Engineering sciences.**	4
	PO 3	**Understand customer needs, manage the design** AC and DC bridge circuits **on requirement and evaluate outcomes of the circuit.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 10	**Effective presentation and speaking style** on concept of AC and DC bridges and **write subject matter effectively** on measurement of unknown parameter using bridges.	2
	PSO2	**Understand** the performance of a bridge using practical experience to **analyze Virtual Instrumentation**	2
CO 6	PO 1	**Apply (understand) the knowledge of engineering fundamentals to** define transducer and Understand the concepts of different types of Transducers **(Engineering knowledge)**	3
	PO 2	**Identify, formulate, review research literature** using first principles of engineering sciences illustrate Transducers and classify them according to their application) **(complex engineering problems) .**	5
	PO 3	**Develop (Design/development of solutions)** an transducers like strain gauges, LVDT **(in the design of system components to establish innovative solutions**)to measure different electrical and non-electrical parameters.	4
	PO 10	**Effective presentation and speaking style** on working principles of all various types of Transducers and **write subject matter effectively** to measure different electrical and non-electrical parameters using all active and passive Transducers	2
	PSO 3	**Understand** the concepts of measuring instrument systems to measure different electrical parameters using **embedded hardware design**.	2

Note:For Key Competencies refer Annexure - I

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

XV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	40	30	-	-	-	-	-	-	40	-		-	50	-
CO 2	100	60	40	-	-	-	-	-	-	40	-	-	-	100	-
CO 3	100	40	30	-	-	-	-	-	-	40	-	-	-	100	-
CO 4	100	30	-	-		-	-	-	-	40	-		-	100	-
CO 5	100	40	30	-	-	-	-	-	-	40	-	-	-	100	-
CO 6	100	50	40	-	-	-	-	-	-	40	-		-	-	66.7

XVI COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	1	0	0	0	0	0	0	2	0	0	0	2	0
CO 2	3	2	2	0	0	0	0	0	0	2	0	0	0	3	0
CO 3	3	2	1	0	0	0	0	0	0	2	0	0	0	3	0
CO 4	3	2	0	0	0	0	0	0	0	2	0	0	0	3	0
CO 5	3	1	1	0	0	0	0	0	0	2	0	0	0	3	0
CO 6	3	2	2	0	0	0	0	0	0	2	0	0	0	0	3
TOTAL	18	11	8	0	0	0	0	0	0	12	0	0	0	14	3
AVERAGE	3	1.8	1.4	0	0	0	0	0	0	2	0	0	0	2.8	3

XVII 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	-	-	-	-	-

XVIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIX SYLLABUS:

MODULE I	**INTRODUCTION TO MEASURING INSTRUMENTS**
	Block schematics of measuring systems, performance characteristics, Static characteristics: Accuracy, resolution, precision, gross error, types of errors, Dynamic characteristics : Repeatability, reproducibility, fidelity, lag; Analog measuring instruments: D' Arsonval movement, DC voltmeters and ammeter, AC voltmeters and current meters, ohmmeters, multimeters, meter protection, extension of range, digital voltmeters: Ramp type, staircase, dual slope integrating type, successive approximation type, specifications of instruments.
MODULE II	**OSCILLOSCOPE**
	Oscilloscopes: CRT, block schematic of CRO, time base circuits, delay lines, high frequency CRO considerations, applications, specifications, special purpose oscilloscopes: Dual trace, dual beam CROs, sampling oscilloscopes, storage oscilloscopes, digital storage CROs, Lissajous figures, frequency measurement, phase measurement, CRO probes.
MODULE III	**SIGNAL GENERATOR AND SIGNAL ANALYZERS**
	Signal Generators: AF and RF signal generators, sine and square wave generators, function generators arbitrary waveform generator, sweep frequency generators, video signal generators, and specifications. Signal Analyzers: AF, HF wave analyzers, heterodyne wave analyzers, harmonic distortion, spectrum analyzers, power analyzers
MODULE IV	**AC AND DC BRIDGES**
	Measurements using DC and AC bridges: Wheat stone bridge, Kelvin bridge, AC bridges, Maxwell, Hay, Schering, Wien, Anderson bridges, Wagner & ground connection.
MODULE V	**TRANSDUCERS**
	Transducers: Classification, strain gauges, force and displacement, transducers, resistance thermometers, hotwire anemometers, LVDT, thermocouples, synchros; Piezoelectric transducers, variable capacitance transducers; Magneto strictive transducers, measurement of physical parameters: Flow measurement, displacement meters, liquid level measurement, measurement of humidity and moisture, velocity, force, pressure, high pressure, vacuum level, temperature measurements.

TEXTBOOKS

1. A.K.Sawhney,"Electrical and electronics measurements and instrumentation", 19th Edition,2011.
2. H.S.Kalsi, "Electronic Instrumentation", TMH, 2nd Edition,2004.

3. K. Lal Kishore, "Electronic Measurements and Instrumentation", Pearson Education,2nd Edition,2010

REFERENCE BOOKS:

1. David A. Bell, "Electronic Instrumentation and Measurements", Oxford University Press, 1st Edition, 2007
2. A.D. Helbincs, W.D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", PHI, 56th Edition, 2003.

WEB REFERENCES:

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

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index?route=course/details course id=356

XX COURSE PLAN

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		W 1
CONTENT DELIVERY (THEORY)			
2	Block schematics of measuring systems, performance characteristics	CO 1	T1:1.1, 1.2. T2:1.2-1.7 R2:2.10
3	Static and Dynamic characteristics, types of errors	CO 1	T1:1.2.,T2:1.2-1.7 R2:2.10
4	D' Arsonval movement	CO 1	T1: 2.2., T2:2.3-2.7 R2:3.3
5	DC voltmeters	CO 1	T1: 4.2,4.3. ,T2:4.3-4.7
6	DC ammeters	CO 1	T1: 3.2,3.3. T2:3.3-3.4
7	AC voltmeters	CO 1	T1: 4.7-4.17, T2:4.7-4.17
8	AC current meters (Ammeters)	CO 1	T1: 3.5, 3.6.,T2:3.5-3.7
9	Ohmmeters ,Multimeters, meter protection, extension of range	CO 1	T1: 4.4,4.6,T2:4.7-4.17
10	Digital voltmeters, Ramp type, staircase	CO 1	T1:5.1-5.10, R2:5.1
11	Digital voltmeters dual slope integrating type, successive approximation type, specifications of instruments.	CO 1	T1:5.1-5.10, R2:5.3
12	Oscilloscopes: CRT, block schematic of CRO	CO 2	T1:7.1-7.13,R2:4.1-4.3
13	Time base circuits, delay lines	CO 2	T1:7.1-7.13,R2:4.1-4.3

S.No	Topics to be covered	CO's	Reference
14	high frequency CRO considerations, applications, specifications	CO 2	T1:7.1-7.13,R2:4.1-4.3
15	special purpose oscilloscopes: Dual trace, dual beam CROs	CO 2	T1:7.14-7.18,R2:4.7-4.13
16	sampling oscilloscopes, storage oscilloscopes	CO 2	T1:7.19-7.28,R2:4.7-4.13
17	Digital Storage CROs	CO 2	T1:7.19-7.28,R2:4.7-4.13
18	Lissajous figures, frequency measurement, phase measurement	CO 2	T1:7.19-7.28,R2:4.7-4.13
19	CRO probes	CO 3	T1:7.19-7.28,R2:4.7-4.13
20	Signal Generators: standard signal generators	CO 3	T1:8.1-8.2,R2:6.1-6.13
21	AF sine and square wave generators	CO 3	T1:8.1-8.18,R2:6.1-6.13
22	function generators, arbitrary waveform generator	CO 3	T1:8.1-8.18,R2:6.1-6.13
23	sweep frequency generators, video signal generators	CO 3	T1:8.1-8.18,R2:6.1-6.13
24	Signal Analyzers: AF, HF wave analyzers	CO 4	T1:9.1-9.8, R2:7.1-7.6
25	heterodyne wave analyzers, harmonic distortion wave analyzers	CO 4	T1:9.1-9.8, R2:7.1-7.6
26	spectrum analyzers, power analyzers	CO 4	T1:9.1-9.8, R2:7.1-7.6
27	Measurements using DC bridges: Wheat stone bridge	CO 5	T1:11.2 R2:10.4
28	Measurements using DC bridges: Kelvin bridge	CO 5	T1:11.3 R2:10.5
29	AC bridges: Maxwell bridge, Hay bridge	CO 5	T1:11.11-11.12 R2:10.8
30	AC bridges: Schering bridge, Wien bridge	CO 5	T1:11.13-11.14 R2:10.9-10.10
31	AC bridges: Anderson bridge	CO 5	T1:11.18,R2:10.13
32	Wagner & ground connection	CO 5	T1:11.15,R2:10.16
33	Transducers: Classification	CO 6	T1:13.1,R2:12.1
34	strain gauges	CO 6	T1:13.6,R2:12.6
35	resistance thermometers	CO 6	T1:13.7,R2:12.7
36	hotwire anemometers, thermocouples	CO 6	T1:13.8,R2:12.9
37	LVDT	CO 6	T1:13.11,R2:12.10
38	Piezoelectric transducers	CO 6	T1:13.15,R2:12.17
39	Magneto strictive transducers	CO 6	T1:13.16,R2:12.18

S.No	Topics to be covered	CO's	Reference
40	measurement of physical parameters: force and displacement	CO 6	T1:13.23-13.27, R2:12.24-12.28
41	measurement of physical parameters: Pressure, vacuum level, temperature measurements	CO 6	T1:13.23-13.27, R2:12.24-12.28
42	Problem solving on Voltmeters and ammeters	CO 1	T1: 4.2-4.13.
43	Problem solving on series and shunt ohmmeters, digital multimeters	CO 1	T1: 4.2-4.13.R2:4.13
44	Problem solving on electrostatic deflection sensitivity, Velocity of electron beam	CO 2	T1:7.1-7.13,R2:4.1-4.3
45	Problem solving on frequency and phase measurement	CO 2	T1:7.1-7.13,R2:4.1-4.3
46	Problem solving on minimum detectable signal of spectrum analyzer	CO 4	T1:9.1-9.8, R2:7.1-7.6
47	Problem solving on whetstone bridge	CO 5	T1:11.2 R2:10.4
48	Problem solving on Kelvin bridge	CO 5	T1:11.3 R2:10.5
49	Problem solving on wien bridge	CO 5	T1:11.11-11.12 R2:10.8
50	Problem solving on Maxwell bridge	CO 5	T1:11.13-11.14 R2:10.9-10.10
51	Problem solving on Schering bridge	CO 5	T1:11.18,R2:10.13
52	Problem solving on Anderson bridge	CO 5	T1:11.2 R2:10.4
53	Problem solving on hay's bridge	CO 5	T1:11.3 R2:10.5
54	Problem solving on strain gauges	CO 6	T1:13.6,R2:12.6
55	Problem solving on LVDT	CO 6	T1:13.11,R2:12.10
56	Problem solving on Thermistor	CO 6	T1:13.15,R2:12.17
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Module-I: Introduction to Measuring Instruments	CO 1	T1:1.1-19,2.1-2.8,3.1-3.8,4.1-4.25,5.1-5.10
58	Module-II: Oscilloscopes	CO 2	T1:7.1-7.32
59	Module-III: Signal Generators and Wave Analyzers	CO 3,4	T1:8.1-8.10,9.1-9.6
60	Module-IV: AC and DC Bridges	CO 5	T1:11.1.-11.18
61	Module-V: Transducers	CO 6	T1:13.1-13.25
DISCUSSION OF QUESTION BANK			
62	Module-I: Introduction to Measuring Instruments	CO 1	T1:1.1-19,2.1-2.8,3.1-3.8,4.1-4.25,5.1-5.10
63	Module-II: Oscilloscopes	CO 2	T1:7.1-7.32

S.No	Topics to be covered	CO's	Reference
64	Module-III: Signal Generators and Wave Analyzers	CO 3,4	T1:8.1-8.10,9.1-9.6
65	Module-IV: AC and DC Bridges	CO 5	T1:11.1.-11.18
66	Module-V: Transducers	CO 6	T1:13.1-13.25

Course Coordinator
Mr.Mohd.Khadir, Assistant Prfoessor

HOD,ECE

ANNEXURE - I

KEY COMPETENCIES 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**

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

Department	**Electronics and Communication Engineering**				
Course Title	**Digital Design Through Verilog**				
Course Code	AECB44				
Program	B.Tech				
Semester	V				
Course Type	Professional Elective				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms. S. Swathi, Assistant Professor				

I COURSE OVERVIEW:

This course introduces the hardware description language for design and development of digital integrated circuits and field programmable devices. Provides hardware description language elements, synthesizable register transfer logic models in gate level, dataflow, behavioral, switch level modeling of combinational and sequential circuits. Allows to use computer aided design tools at the levels of system design, logic design and IC design.

II COURSE PRE-REQUISITES:

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

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Digital Design Through Verilog	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	✓	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). 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.

Percentage of Cognitive Level	**Blooms Taxonomy Level**
0%	Remember
20%	Understand
60 %	Apply
20 %	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).

Table 2: Assessment pattern for CIA

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

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 3.

Table 3: Assessment pattern for AAT

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

VI COURSE OBJECTIVES:

The students will try to learn:

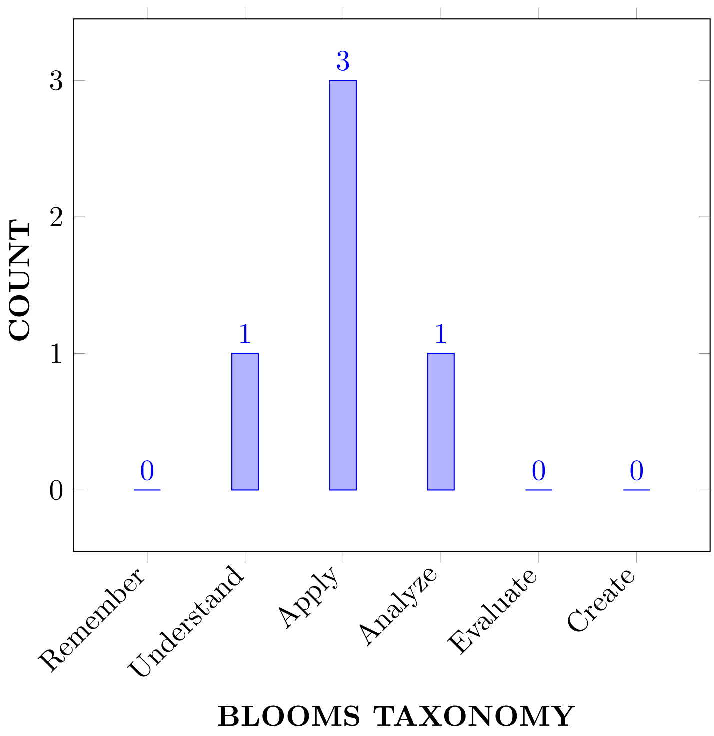
I	The fundamental principles of the verilog hardware descriptive language and its constructs used in synthesizable register transfer level (RTL) design implementation of digital logic systems.
II	The concepts of gate level, behavioral, dataflow and switch level modeling of fundamental digital logic circuits using verilog hardware description language.
III	The exposure to various stages of a typical state of the art CAD VLSI tool for simulation, synthesis, place and route, layout and power and clock routing modules.
IV	The analytical skills needed to model finite state machines using field programmable gate arrays, fault-tolerant high-speed computer arithmetic circuits, built-in self-test circuit (BIST).

VII COURSE OUTCOMES:

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

CO 1	**Describe** the basic language elements and data flow modelling constructs to implement the combinational and sequential circuits in Verilog.	Understand
CO 2	**Utilize** the basic logic gate primitives and user defined primitives for implementing digital circuits in gate level modelling.	Apply
CO 3	**Illustrate** the significance of structured procedures in behavioral modeling using blocking and nonblocking procedural assignments.	Understand
CO 4	**Make use of** loop and conditional statements to describe the digital circuits in behavioral modeling.	Apply
CO 5	**Identify** the methods to specify delays on switch primitives for designing modules with time delays in switch level modeling.	Apply
CO 6	**Distinguish** the synchronous and asynchronous sequential state machines for synthesizing the sequential circuits.	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 modeling to complex engineering activities with an understanding of the limitations.
PO 6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		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
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 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	SEE / CIE

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on the practical experience of ASIC prototype designs, Virtual Instrumentation and SOC designs.	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 OUT COMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	**PO 1**	**Recall** the basic constructs and conventions in verilog and these constructs provide the necessary framework for verilog HDL by applying the **own Engineering discipline, Science principles and methodology**.	2
	PO 10	Describe the basic language elements and data flow modelling by **giving effective presentations and take clear instructions** to implement the combinational and sequential circuits in verilog.	2

COURSE OUT COMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 2	PO 1	**Explain** the logic value set and strengths to model the functionality of real hardware supported by verilog HDL and data types such as nets, registers, vectors, numbers, simulation time, arrays, parameters, memories, and strings in verilog model actual data storage by applying the **mathematical principles, Scientific principles and methodology**	2
	PO 3	**Understand the customer needs, use creativity and manage design process** to model the complex digital circuits by using basic logic gate primitives and user defined primitives provided in verilog with the help of **modern engineering tools**.	4
	PO 4	Understand the **complex engineering problems** Use appropriate logic gate primitives and user defined primitives in the **design** of experiments for **analysis and interpretation of data, and synthesis of the information** to provide valid conclusions.	5
	PO 5	Select and apply appropriate logic gate primitives and user defined primitives to model the complex digital circuits by making use of **modern engineering tools**.	1
	PO 10	**Describe** the basic logic gate primitives and user defined primitives by **giving effective presentations and take clear instructions** to implement the digital circuits in gate level modelling.	2
	PSO 2	Using the basic logic gate primitives and user defined primitives can design a **prototype of ASIC**, such as PLDs, memory and processors.	1
CO 3	PO 1	Define the syntax of blocking and non blocking procedural constructs to build the digital circuits in behavioral modeling with **the knowledge of mathematics, science and engineering fundamentals**.	2
	PO 2	Understand the given **problem statement and formulate** the (complex) engineering problems of digital circuits, **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** based on the functionality of the data translation, validate the output of the circuit in reaching substantiated conclusions by the **interpretation of results**.	7

COURSE OUT COMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 3	**PO 4**	**Use** appropriate procedural constructs in the **design** of combinational and sequential logic circuits in behavioral modeling for **analysis** and **interpretation** of data, and synthesis of the information to provide valid conclusions.	4
	PO 5	Select and apply appropriate procedural constructs in behavioral modeling to model the complex digital circuits by making use of **modern engineering tools**.	1
	PO 10	Describe the significance of procedural constructs in behavioral modelling by **giving effective presentations and take clear instructions** to implement the digital circuits in verilog	2
	PSO 2	Using the loop, case and conditional statements can design a **prototype of ASIC**, such as PLDs, memory and processors.	1
CO 4	**PO 1**	Define the syntax of loop, case and conditional statements used to build the digital circuits in behavioral modeling with **the knowledge of mathematics, science and engineering fundamentals**.	2
	PO 2	Demonstrate the significance of loop, case and conditional statements in behavioral modeling and develop the verilog description for the hardware from the provided **information and data, develop solutions** based on the functionality of the data translation, validate the output of the circuit in reaching substantiated conclusions by the **interpretation of results**.	4
	PO 3	**Understand the customer needs, use creativity and manage design process** to model the complex digital circuits making use of loop, case and conditional statements provided in verilog with the help of modern engineering tools in the design of **system components to establish innovative solutions** in digital system design.	4
	PO 5	Select either loop or conditional statements and delays to model the **complex** digital circuits.	1
	PO 10	Describe the basic syntax of loop and conditional statements by **giving effective presentations and take clear instructions** to implement the digital circuits in behavioral modelling.	2
	PSO 2	Using the loop, case and conditional statements can design a **prototype of ASIC**, such as PLDs, memory and processors.	1

COURSE OUT COMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 5	**PO 1**	Define the types of delays on basic transistor switch and CMOS switch for implementing digital circuits in switch level modeling **using knowledge of mathematics, science and engineering fundamentals.**	2
	PO 2	Demonstrate the methods to specify delays on basic MOS switches and bidirectional pass switches and develop the verilog description with delays for the hardware in switch level modeling to **identify, formulate** and state a problem.	3
	PO 3	Design solutions for complex Engineering problems and design system components using digital system by **innovative solution and implementing them with modern tools** such as Xilinx and Vivado.	2
	PO 5	Select and apply appropriate basic transistor and MOS switches to model the complex digital circuits by making use of **modern engineering tools**.	1
	PO 10	Describe the basic switch primitives and delays by **giving effective presentations and take clear instructions** for designing the modules in switch level modelling.	2
	PSO 2	Using the basic transistor and MOS switches can design a **prototype of ASIC**, such as PLDs, memory and processors.	1
CO 6	**PO 2**	Demonstrate the methods to synthesize asynchronous and synchronous circuits and compare the verilog description to **identify, formulate and state a problem**.	3
	PO 4	Understand the **complex engineering problems**, use appropriate verilog description in the synthesis of asynchronous and synchronous sequential circuits for **analysis, interpretation of data, and synthesis of the information** to provide valid conclusions.	5
	PO 5	Select and apply appropriate design style to model the complex synchronous and asynchronous sequential circuits by making use of **modern engineering tools**	1
	PO 10	Describe the basic synchronous and asynchronous sequential machines by **giving effective presentations and take clear instructions** for synthesizing the sequential circuits.	2
	PSO 2	Using the synthesis of synchronous and asynchronous sequential machines can design a **prototype of ASIC**, such as PLDs, memory and processors.	1

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	2	-	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 2	2	-	4	5	1	-	-	-	-	2	-	-	-	1	-
CO 3	2	7	-	4	1	-	-	-	-	2	-	-	-	1	-
CO 4	2	4	4	-	1	-	-	-	-	2	-	-	-	1	-
CO 5	2	3	2	-	1	-	-	-	-	2	-	-	-	1	-
CO 6	-	3	-	5	1	-	-	-	-	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
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	66.7	-	-	-	-	-	-	-	-	40	-	-	-	-	-
CO 2	66.7	-	40	45.5	100	-	-	-	-	40	-	-	-	50	-
CO 3	66.7	70	-	36.4	100	-	-	-	-	40	-	-	-	50	-
CO 4	66.7	40	40	-	100	-	-	-	-	40	-	-	-	50	-
CO 5	66.7	30	20	-	100	-	-	-	-	40	-	-	-	50	-
CO 6	-	30	-	36.4	100	-	-	-	-	40	-	-	-	50	-

XV COURSE ARTICULATION MATRIX PO / PSO MAPPING:

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	-	2	2	3	-	-	-	-	1	-	-	-	2	-
CO 3	3	3	-	1	3	-	-	-	-	1	-	-	-	2	-
CO 4	3	2	2	-	3	-	-	-	-	1	-	-	-	2	-
CO 5	3	1	1	-	3	-	-	-	-	1	-	-	-	2	-
CO 6	-	1	-	1	3	-	-	-	-	1	-	-	-	2	-
TOTAL	**27**	**7**	**5**	**4**	**15**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**10**	**0**
AVERAGE	**3**	**1.75**	**1.67**	**1.33**	**3**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**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	**INTRODUCTION TO VERILOG HDL**
	History of HDL, Verilog HDL, Language Elements : Comments, Identifiers, Keywords, Value Set, Data Types, Memory Element, Constant, Parameter, Operators Dataflow Modeling: Continuous Assignment, Implicit Continuous Assignment, Delays, Design examples using data flow modeling.
MODULE II	**GATE LEVEL MODELING**
	Multiple-Input Gates, Gate Delays, Design Examples, User-Defined Primitives: Combinational User Defined Primitives, Sequential User-Defined Primitives.
MODULE III	**BEHAVIORAL MODELING**
	Procedural Constructs, Procedural Assignments, Conditional Statements, Case Statement Design examples using behavioral modeling. Loop Statements: For Loop, While Loop, Repeat Loop, Forever Loop, Block Statements4 Procedural Continuous Assignment, Design examples using behavioral modeling.
MODULE IV	**SWITCH LEVEL MODELLING**
	Basic Transistor Switches, CMOS Switch, Bi – directional Gates, Time Delays with Switch Primitives, Instantiations with Strengths and Delays, Strength Contention with Trireg Nets.
MODULE V	**SEQUENTIAL LOGIC**
	Analysis of Synchronous Sequential Machines, Synthesis of Synchronous Sequential Machines, Analysis of Asynchronous Sequential Machines, Synthesis of Asynchronous Sequential Machines

TEXTBOOKS

1. Joseph Cavanagh, "Verilog HDL: Digital Design and Modeling", CRC Press, 1 st Edition, 2007.
2. Michael D. Ciletti, "Advanced Digital Design with Verilog HDL", PHI, 2005.
3. Joseph Cavanagh, "Digital Design and Verilog HDL Fundamentals", CRC Press, 1 st Edition, 2008

REFERENCE BOOKS:

1. Stephen Brown and Zvonko Vranesic, "Fundamentals of Digital Logic design with Verilog Design", TMH, 2nd Edition, 2010.

2. Sunggu Lee "Advanced Digital Logic Design using Verilog, State Machine & Synthesis for FPGA", Cengage Learning, 2012.

3. Samir Palnitkar, "Verilog HDL", Pearson Education, 2nd Edition, 2009.

4. T. R. Padmanabhan and B. Bala Tripura Sundari, "Design through Verilog HDL", Wiley, 2009.

5. Zainalabdien Navabi, "Verilog Digital System Design", TMH, 2nd Edition, 2009.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108/108/108108111/

COURSE WEB PAGE:

https://lms.iare.ac.in/index?route=course/details&course_id=184

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=184
CONTENT DELIVERY (THEORY)			
2	Introduction to verilog HDL	C0 1	T1:1
3	Overview of digital design with verilog HDL.	C0 1	T1:2.1-2.2
4	Hierarchical modeling concepts	C0 1	T1: 2.3-2.10
5	Lexical conventions	C0 1	T1: 3.2 – 3.14
6	Data types	C0 1	T1: 4.1 – 4.4
7	Modules and ports	C0 1	T1: 4.5
8	Gate-level modeling	C0 2	T1: 4.6 – 4.7
9	Gate delays	C0 2	T1: 5.2
10	Dataflow modeling	C0 1	T1: 5.3- 5.5
11	Continuous dataflow modeling assignments	C0 1	T1: 5.6
12	Operator types	C0 1	T1: 6.2 – 6.5
13	Dataflow modeling examples	C0 1	T1: 6.6
14	Gate-level modeling examples	C0 2	T1: 7.1 – 7.5
15	Behavioral modeling	C0 3	T1: 7.6
16	Structured procedures	C0 3	T1: 7.7 – 7.9
17	Procedural assignments	C0 3	T1: 7.10
18	Timing controls	C0 3	T1: 7.11
19	Conditional statements	C0 4	T1: 7.12
20	Multi way branching	C0 4	T1: 8.2 – 8.8
21	Loops	C0 4	T1 : 8.9 – 8.11
22	Sequential and parallel blocks	C0 4	T1: 10.2 – 10.7

S.No	Topics to be covered	CO's	Reference
23	Generate blocks	C0 4	T1: 11.2 – 11.4
24	Tasks and functions	C0 3	T2: 5.1
25	Port connection rules	C0 3	T2: 5.2
26	Combinational user defined primitives	C0 4	T2: 5.3
27	Sequential user-defined primitives	C0 4	T2: 5.4
28	Behavioral modeling examples	C0 4	T1:1
29	Switch-level modeling	C0 5	T1:2.1-2.2
30	Switch-modeling elements	C0 5	T1: 2.3-2.10
31	Delay specification on switches	C0 5	T1: 3.2 – 3.14
32	Switch-level modeling examples	C0 5	T1: 4.1 – 4.4
33	Guidelines for UDP design	C0 6	T1: 4.5
34	Sequential logic	C0 6	T1: 4.6 – 4.7
35	Mealy machine	C0 6	T1: 5.2
36	Moore machine	C0 6	T1: 5.3- 5.5
37	Linear feedback shift register (LFSR)	C0 6	T1: 5.6
38	Synthesis of synchronous sequential machines	C0 6	T1: 6.2 – 6.5
39	Synthesis of asynchronous sequential machines	C0 6	T1: 6.6
40	Synchronous sequential machines examples	C0 6	T1: 7.1 – 7.5
41	Asynchronous sequential machines examples	C0 6	T1: 7.6
PROBLEM SOLVING			
42	8 to 1 multiplexer in dataflow modeling	C0 1	T1: 7.10
43	2 to 4 priority encoder dataflow modeling.	C0 1	T1: 7.11
44	1 to 8 de multiplexer using gate level modeling	C0 2	T1: 7.12
45	D flip flop using NAND gates in gate level modeling	C0 2	T1: 8.2 – 8.8
46	BCD adder module using gate level modeling	C0 2	T1 : 8.9 – 8.11
47	Full adder using 2 half adders in gate level modeling	C0 2	T1: 10.2 – 10.7
48	8 to 3 encoder using gate level modeling.	C0 2	T1: 11.2 – 11.4
49	4-bit binary to gray code converter using gate level modeling.	C0 2	T2: 5.1
50	8-bit up-down counter using behavioral modeling	C0 3	T2: 5.2
51	3 to 8 decoder using behavioral modeling	C0 3	T2: 5.3
52	8 to 1 multiplexer using case statement.	C0 4	T2: 5.4
53	4-bit universal shift register in behavioral modeling using case statement.	C0 4	T1:1
54	16-to-1 multiplexer using function	C0 5	T1:2.1-2.2
55	Left/Right shifter.	C0 5	T1: 2.3-2.10
56	101 Moore detectors and also obtain its test bench.	C0 6	T1: 3.2 – 3.14
DISCUSSION ON DEFINITIONS AND TERMINOLOGY			

S.No	Topics to be covered	CO's	Reference
57	Introduction to verilog HDL.	C0 1	T1: 4.5
58	Gate level modeling	C0 2	T1: 4.6 – 4.7
59	Behavioral modeling	C0 3	T1: 5.2
60	Switch level modelling	C0 5	T1: 5.3- 5.5
61	Sequential logic	C0 6	T1: 5.6
DISCUSSION ON TUTORIAL QUESTION BANK			
62	Introduction to verilog HDL.	C0 1	T1: 6.6
63	Gate level modeling	C0 2	T1: 7.1 – 7.5
64	Behavioral modeling	C0 3	T1: 7.6
65	Switch level modelling	C0 5	T1: 7.7 – 7.9
66	Sequential logic	C0 6	T1: 7.10

Course Coordinator **HOD,ECE**
Mrs. S. Swathi, 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.9 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**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Computer Architecture**				
Course Code	ACSB32				
Program	B.Tech				
Semester	V				
Course Type	Open Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr A KARTHIK, Assistant Professor				

I COURSE PRE-REQUISITES:

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

II COURSE OVERVIEW:
This course intended to provide the structure, internal working and implementation of a computer system. The fundamentals of various functional units of computer, computer instructions, addressing modes, computer arithmetic and logic unit, registers, data transfer, memory and input output system. It focuses on analysis of computer performance and functioning in modern computers.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Computer Architecture	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
70%	Understand
10%	Apply
20%	Analyze
0%	Evaluate
0%	Create

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

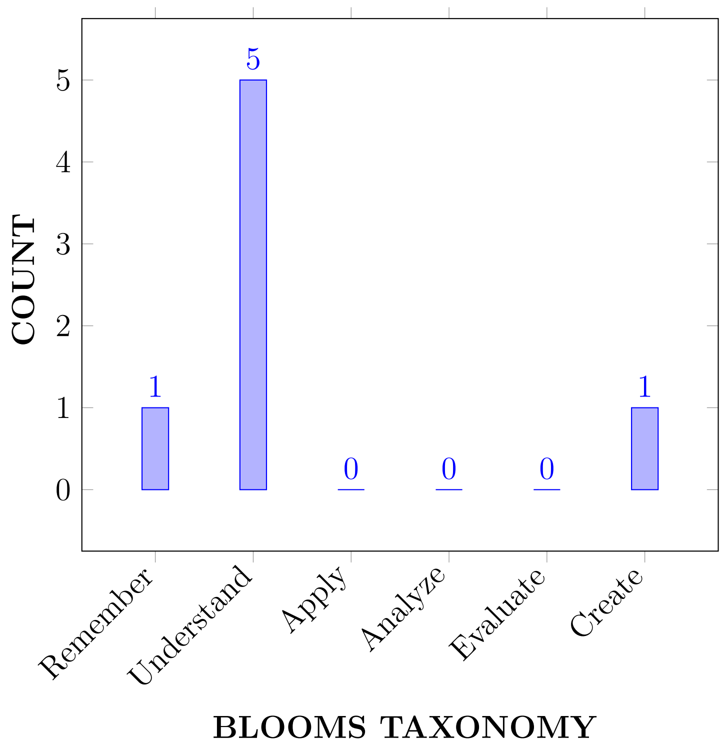
I	The basic concepts of the various functional units and characteristics of computer systems.
II	The concepts of central processing unit design and perform basic operations with signed and unsigned integers in decimal and binary number systems.
III	The function of each element of a memory hierarchy and compare the different methods for computer input and output.

VII COURSE OUTCOMES:

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

CO 1	**Explain** the structure, characteristics of computer systems and the various functional units for understanding the components of computers.	Understand
CO 2	**Demonstrate** the computer languages, machine, symbolic and assembly levels for understanding execution of program.	Understand
CO 3	**Recall** the number system their representations and conversion for the usage of instructions in digital computers.	Remember
CO 4	**Demonstrate** the register transfer language, represent memory and Arithmetic/ Logic/ Shift operations for implementation of micro operations.	Understand
CO 5	**Illustrate** the basics of hardwired and micro-programmed control of the CPU which generates the control signals to fetch and execute instructions.	Understand
CO 6	**Compare** different types of addressing modes for specifying the location of an operand.	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		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 / 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 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 / QUIZ / AAT

3 = High; 2 = Medium; 1 = Low

X 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 digital signal processing applications	2	Research papers /Project
PSO 2	**Focus** on the Application Specific Integrated Circuits (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
	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 OUT COMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 1	Understand the structure and characteristics of computer system (knowledge) for understanding components function of computer by applying the principles of science to engineering problems	1
	PO 10	Communicate effectively on **complex Engineering** activities with the Engineering community and with society at large.	1
CO 2	PO 1	Understand the concept (knowledge) of computer languages for execution of program.	2
	PO 10	Communicate effectively on **complex Engineering** activities with the Engineering community and with society at large.	1
CO 3	PO 1	Illustrate the arithmetic formulate (knowledge) of instructions used in digital computers by applying the principles of mathematics and science for solving complex engineering problems.	2
	PO 2	Understand the given arithmetic functions and formulate to the organization of computer using principles of mathematics and engineering science	3
	PO 10	Communicate effectively on **complex Engineering** activities with the Engineering community and with society at large.	1
	PSO1	Illustrate the concept of number system for obtaining of digital data to build the embedded system	1
CO 4	PO 1	Apply (knowledge) the register transfer language, bus and memory transfer characteristics for implement the micro operations by analyzing complex engineering problems using the principles of mathematics, engineering science.	2
	PO 2	Understand the register transfer language bus and memory transfer problem statement and finding the solution implementation of micro operations by analyzing complex engineering problems	2
	PO 10	Communicate effectively on **complex Engineering** activities with the Engineering community and with society at large.	1
	PSO1	Understanding the register transfer language for developing the processor in embedded technology	1

CO 5	PO 1	Illustrate characteristics of hardwired and micro-programmed control of the CPU for solving complex engineering problems generates control signals by applying mathematics, science and engineering fundamentals.	3
	PO 2	Analyze execute instruction problem statements control signals using mathematics principles.	1
	PO 10	Communicate effectively on **complex Engineering** activities with the Engineering community and with society at large.	1
CO 6	PO 1	Discuss (Understand) different types of addressing modes (knowledge) for specifying the location of an operand.	2
	PO 10	Communicate effectively on **complex Engineering** activities with the Engineering community and with society at large.	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	8	2	2	2
CO 1	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 3	2	3	-	-	-	-	-	-	-	1	-	-	1	-	-
CO 4	2	2	-	-	-	-	-	-	-	1	-	-	1	-	-
CO 5	3	1	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 6	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	33.3	-	-	-	-	-	-	-	-	20	-	-	-	-	-
CO 2	66.6	-	-	-	-	-	-	-	-	20	-	-	-	-	-
CO 3	66.6	30.0	-	-	-	-	-	-	-	20	-	-	100	-	-
CO 4	66.6	20.0	-	-	-	-	-	-	-	20	-	-	100	-	-
CO 5	100	10.0	-	-	-	-	-	-	-	20	-	-	-	-	-
CO 6	66.6	-	-	-	-	-	-	-	-	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≤ C≤ 5% – No correlation
2 - 40 % <C < 60% –Moderate
1-5 <C≤ 40% – Low/ Slight
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 3	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	1	-	-	2	-	-
CO 5	3	1	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	1	-	-	2	-	-
TOTAL	**15**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**6**	**-**	**-**	**4**	**-**	**-**
AVERAGE	**2.5**	**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
X	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVIII SYLLABUS:

MODULE I	**INTRODUCTION TO COMPUTER ORGANIZATION**
	Basic computer organization, CPU organization, memory subsystem organization and interfacing, input or output subsystem organization and interfacing, simple computer levels of programming languages, assembly language instructions, and a simple instruction set architecture.
MODULE II	**ORGANIZATION OF A COMPUTER**
	Register transfer: Register transfer language, register transfer, bus and memory transfers, arithmetic micro operations, logic micro operations, and shift micro operations; Control memory.

MODULE III	**CPU AND COMPUTER ARITHMETIC**
	CPU design: Instruction cycle, data representation, memory reference instructions, input- output, and interrupt, addressing modes, data transfer and manipulation, program control. Computer arithmetic: Addition and subtraction, floating point arithmetic operations, decimal arithmetic unit.
MODULE IV	**INPUT-OUTPUT ORGANIZATION**
	Input or output organization: Input or output Interface, asynchronous data transfer, modes of transfer, priority interrupt, direct memory access.
MODULE V	**MEMORY ORGANIZATION**
	Memory organization: Memory hierarchy, main memory, auxiliary memory, associative memory, cache memory, virtual memory; Pipeline: Parallel processing, Instruction pipeline

TEXTBOOKS

1. M. Morris Mano, "Computer Systems Architecture", Pearson, 3rd Edition, 2015
2. Patterson, Hennessy, "Computer Organization and Design: The Hardware/Software Interface", Morgan Kaufmann, 5th Edition, 2013.

REFERENCE BOOKS:

1. John. P. Hayes, "Computer System Architecture", McGraw-Hill, 3rd Edition, 1998.
2. Carl Hamacher, Zvonko G Vranesic, Safwat G Zaky, "Computer Organization", McGraw- Hill, 5 th Edition, 2002.
3. William Stallings, "Computer Organization and Architecture", Pearson Edition, 8th Edition,2010

COURSE WEB PAGE:

https://lms.iare.ac.in/index ?route=course/details& course id=137

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_137
CONTENT DELIVERY (THEORY)			
2	Introduction to Computer Organization	CO 1	T1-3.1-3.2
3	Basic Computer Organization and Architecture	CO 1	T1-3.3-3.4
4	CPU Organization	CO 1	T1-3.3-3.4
5	Memory subsystem organization and Interfacing	CO 1	T1-3.5

6	Input or output subsystem organization and Interfacing	CO 1	T1-4.2
9	Simple computer levels of programming languages	CO2	T1-4.4
10	Assembly language instructions	CO 2	T1-.5.1,4.5.2
11	A simple instruction set architecture	CO 2	T1-4.6
12	Register transfer language	CO 3	T1-4.7
13	Register transfer	CO 3	T1-4.10
15	Bus and memory transfers	CO 3	T1-4.10.6
16	Arithmetic micro operations	CO 3	T1-4.11
18	CPU and Computer Arithmetic	CO 3	T1-4.2
19	Instruction Cycle	CO 3	T1-5.1.1
20	Data Representation	CO 4	T1-5.1.1
21	Memory Reference Instructions	CO 4	T1-5.1.1
22	Input- Output, and Interrupt	CO 3	T1-5.2
23	Addressing Modes	CO 3	T1-5.3
25	Data transfer and Manipulation	CO 4	T1-5.3.2
26	Program Control	CO 4	T1-5.3.3,5.4
27	Computer Arithmetic	CO 4	T1-5.4.2
28	Addition and Subtraction	CO 4	T1-5.5
29	Floating point Arithmetic Operations	CO 7	T1-5.11
30	Multiplication Algorithm	CO 3	T1-5.11
32	Decimal Arithmetic unit	CO 6	T1-5.11
33	Input or Output Organization	CO 3	T1-5.11
34	Input or output Interface	CO 5	T1-7.1,7.2
37	Asynchronous data transfer	CO 5	T1-7.3,7.4
39	Modes of transfer	CO 5	T1-7.6,7.7
40	Priority interrupt	CO 5	T1-7.7.2
41	Direct memory access	CO 5	T1-7.8
42	Memory Organization	CO 5	T1-7.8.1,8.2
43	Memory hierarchy	CO 5	T1-7.10,11
44	Pipeline: Parallel processing	CO 5	T1-7.10.2-3
45	Instruction pipeline	CO 5	T1-7.10.3
46	I/O Processor	CO 6	R3-P184
47	Characteristics of Multiprocessors	CO6	R3-P185
48	Serial Communication	CO 6	R3-P191
49	RAM and its Organization	CO 6	R3-P190
50	Reduced Instruction Set Computer	CO 6	R3-P191
PROBLEM SOLVING/ CASE STUDIES			
7	Problems on Multiplication Algorithms	CO 1	T1-3.1-3.2
8	Problems on Restoring Division	CO 1	T1-3.3-3.4
14	Problems on Non- Restoring Division	CO 2	T1-4.6
17	Problems on BCD Addition	CO 2	T1-4.7
24	Problems on BCD Subtraction	CO 2	T1-5.1.1

31	Problems on BCD Multiplication	CO 2	T1-4.6
35	Problems on computation of rms delay	CO 2	T1-5.3.2
36	Problems on total power in the carrier	CO 2	T1-5.1.1
DISCUSSION ON DEFINITION AND TERMINOLOGY			
51	Introduction too Computer Organization	CO 1	T1-3.1-3.24
52	Organization of a Computer	CO 2	T1-4.1 to 4.9
53	CPU and Computer Arithmetic	CO 3	T1-5.1 to 5.16
54	Input-Output Organization	CO 5	T1-7.1 to 7.17
55	Memory Organization	CO 6	R3
DISCUSSION ON QUESTION BANK			
56	Introduction too Computer Organization	CO 1	T1-3.1-3.24
57	Organization of a Computer	CO 2	T1-4.1 to 4.9
58	CPU and Computer Arithmetic	CO3	T1-5.1 to 5.16
59	Input-Output Organization	CO 5	T1-7.1 to 7.14
60	Memory Organization	CO 6	R3

Signature of Course Coordinator **HOD,ECE**

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	**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

ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE DESCRIPTION

Course Title	**LINEAR AND DIGITAL IC APPLICATIONS LABORATORY**				
Course Code	AECB21				
Program	B.Tech				
Semester	V	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Chief Coordinator	Ms M Sreevani, Assistant Professor				

I COURSE OVERVIEW:

Linear and digital IC applications lab enables to learn design, testing and describing of circuit performance with digital and analog integrated circuits. It focuses on applications of special ICs and apply the techniques for the design of 741 ICs, applications of 555 timers, data converters and digital IC's for combination and sequential circuits design. This course provides practical hands-on experiments to analyze characteristics of commercially available digital integrated circuits.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
B.Tech	AECB19	V	Linear and Digital IC Applications	3

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Linear and Digital IC Applications 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.

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

VI HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		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 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.	3	Lab Experiments / CIE / SEE
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Lab Experiments / CIE / SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.	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.	3	Lab Experiments / CIE / SEE

3 = High; 2 = Medium; 1 = Low

VII HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on the Application Specific Integrated Circuit (ASIC) Prototype designs, Virtual Instrumentation and System on Chip (SOC) designs.	1	Lab Experiments / CIE / SEE

3 = High; 2 = Medium; 1 = Low

VIII COURSE OBJECTIVES:

The students will try to perform:

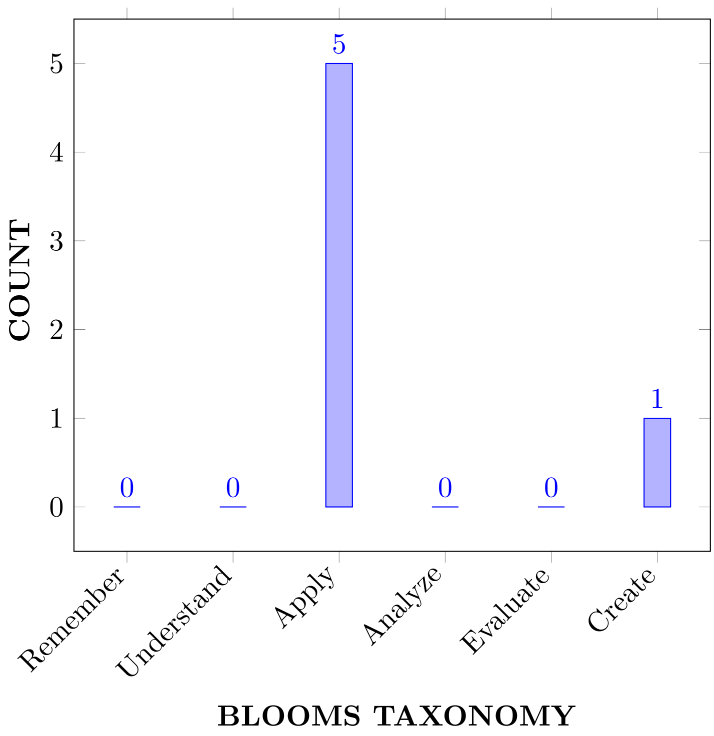
I	The experiments on design of Linear and Digital Integrated circuits using operational amplifier and digital ICs.
II	The design and implementation of analog circuits and gain the hands-on experience on the various building blocks of digital circuits.
III	The IC based real-time applications in the fields of communication systems and home-based automation systems.

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	**Design** linear Integrated circuits to perform mathematical operations and voltage gain calculations using IC741.	Create
CO 2	**Plot** the frequency response of second order active filters using IC 741	Apply
CO 3	**Determine** the frequency of oscillations of multi-vibrators using IC741 and IC555 timer.	Apply
CO 4	**Obtain** the capture range and lock-in range of phase locked loop circuit using IC565.	Apply
CO 5	**Construct** the low and high voltage regulators to find the percentage of regulation using IC723.	Apply
CO 6	**Implement** combinational and sequential circuits using digital ICs to verify their functionality.	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 matched.
CO 1	PO 1	**(Recall)** the basic function of transistor , importance of differential amplifier and the characteristics by applying the **own engineering discipline, science principles and methodology.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of improving dc, ac characteristics of an operational, **translate the information** into the model from the **provided information and data, develop solutions** as compensation techniques ,**validate** the frequency response , stability of the circuit by the **interpretation of results.**	7
	PO 4	**Analyze and interpret** the design of linear Integrated circuits to perform mathematical operations and voltage gain calculations.	2
	PO5	**Create, select and apply appropriate techniques** to design the linear Integrated circuits to perform mathematical operations and voltage gain calculations.	3
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects to design linear integrated circuits .	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies matched.
CO 2	PO 1	**Explain** the importance of feedback and realize linear and non linear circuits using op-amp and the application of that model using **own engineering discipline, scientific principles and methodology.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of applications of op-amp, **translate the information** into the model using IC741 from the provided **information and data, develop solutions**based on the functionality of the circuit,**validate** the output of the circuit in reaching substantiated conclusions by the **interpretation of results.**	7
	PO 4	**Analyze and interpret** the frequency response of active filter circuits to calculate different time constants.	2
	PO5	**Create, select and apply appropriate techniques** to find the frequency response of active filter circuits to calculate different time constants.	3
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects by Analyzing the frequency selective circuits.	2
	PSO 2	**Speaks fluently** about the importance of feeback and applications of operational amplifier**(Subject matter)**.	2
CO 3	PO 1	**Explain** the importance of IC 555 timer,voltage regulators and realize multivibrator circuits using IC 555 and the application of that model using **own engineering discipline, scientific principles and methodology.**	2
	PO 2	**Interpret**frequency of oscillations, pulse width and able to change these parameters based on **information and data collection , model translation and validate using experimental design.**	4
	PO 4	**Analyze and interpret** the frequency of oscillations of multi-vibrators using IC741 and IC555 timer circuits.	2
	PO5	**Create, select and apply appropriate techniques** to calculate the frequency of oscillations of multi-vibrators using IC741 and IC555 timer circuits.	3
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects to calculate the frequency of oscillations of multi-vibrators using IC741 and IC555 timer circuits.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies matched.
	PSO 2	**Apply** data converters in the field of application specific integrated circuit (ASIC) prototype designs and system on chip (SOC) designs.	1
CO 4	PO 1	**Demonstrate** different data converters for converting analog data to digital data and vice versa **applying basic knowledge of science and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of data converters, **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** based on the functionality of the data translation, **validate** the data converters in reaching substantiated conclusions by the **interpretation of results**.	7
	PO 4	**Analyze ans interpret** the capture range and lock-in range of phase locked loop circuit using IC565.	2
	PO5	**Create, select and apply appropriate techniques** to find the capture range and lock-in range of phase locked loop circuit using IC565.	3
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects to find the capture range and lock-in range of phase locked loop circuit using IC565.	2
	PSO 2	**Apply** data converters in the field of application specific integrated circuit (ASIC) prototype designs and system on chip (SOC) designs.	1
CO 5	PO 1	**Build** digital logical design using digital ICs with the **knowledge of mathematics, science and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of digital system design , **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** digital design using equipment, **validate** the design in reaching substantiated conclusions by the **interpretation of results**.	7
	PO 4	**Analyze and interpret** the low and high voltage regulators to find the percentage of regulation using IC723.	2
	PO5	**Create, select and apply appropriate techniques** to design the low and high voltage regulators to find the percentage of regulation using IC723.	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies matched.
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects to design the low and high voltage regulators to find the percentage of regulation using IC723.	3
CO 6	PO 1	**Build** digital logical design using digital ICs with the **knowledge of mathematics, science and engineering fundamentals.**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of digital system design , **translate the information** into the model and prototype systems from the provided **information and data, develop solutions** digital design using equipment, **validate** the design in reaching substantiated conclusions by the **interpretation of results**.	7
	PO5	**Create, select and apply appropriate techniques** to verify the functionality of digital logic circuits.	3
	PO9	To improve the performance of team effectively in the classroom periods, in the hands-on labs and in the design projects to verify the functionality of digital logic circuits.	3
	PSO 2	**Design**, various digital circuits in application secific integrated circuit (ASIC) and system on chip (SOC) designs.	1

XI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 1, PO 2	SEE Exams	PO 1, PO 2, PO 5	Seminars	PO1, PO12	Assignments	-
Laboratory Practices	PO 2, PO 3, PO 5	Student Viva		Mini Project	-	Certification	
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-	-	-

XII ASSESSMENT METHODOLOGY INDIRECT:

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

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

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

XIV SYLLABUS:

Week-1	**INVERTING, NON-INVERTING AND DIFFERENTIAL AMPLIFIERS**
	To construct and test the performance of an Inverting, Non-inverting amplifier and Differential amplifier using IC 741.
Week-2	**INTEGRATOR AND DIFFERENTIATOR**
	To construct and test the performance of an Integrator and Differentiator using IC 741.
Week-3	**SECOND ORDER ACTIVE LOWPASS, HIGHPASS AND BANDPASS FILTERS**
	To design and verify the operation of the Active low pass and High pass using IC 741.
Week-4	**SECOND ORDER ACTIVE BAND PASS AND BANDREJECT FILTERS**
	To design and verify the operation of the Band pass and Band reject filters using IC 741.
Week-5	**ASTABLE MULTIVIBRATORS USING 555**
	To design and construct an astablemultivibrator using IC 555.
Week-6	**MONOSTABLE MULTIVIBRATORS 555**
	To design and construct Monostable multivibrators using IC 555.
Week-7	**SCHMITT TRIGGER USING 555**
	To design and construct Schmitt trigger using NE555 Timer
Week-8	**PLL USING IC 565**
	Verifying characteristics of PLL.
Week-9	**INSTRUMENTATION AMPLIFIER**
	To design and verify the operation of instrumentation amplifier using IC 741.
Week-10	**DIGITAL TO ANALOG CONVERTER**
	To design and verify the operation of R-2R and Inverted R-2R DAC Converter using IC 741.
Week-11	**IC 723**
	To design and implement voltage regulator using IC 723.
Week-12	**RTL LOGIC**
	Verify Functionality of NOR and NAND gate using RTL Logic.
Week-13	**DTL LOGIC**
	Verify Functionality of NOR and NAND gate using DTL Logic

TEXTBOOKS

1. D. Roy Chowdhury, "Linear Integrated Circuits", New age international (p) Ltd, 2nd Edition,2003
2. Ramakanth A. Gayakwad, "Op-Amps & linear ICs", PHI, 3rdEdition,2003.
3. John F. Wakerly, "Digital Design Principles and Practices", Prentice Hall, 3rdEdition,2005.

REFERENCE BOOKS:

1. Salivahanan, "Linear Integrated Circuits and Applications", TMH, 1st Edition, 2008

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	To find voltage gain of inverting, Non-inverting and Differential Amplifiers using IC 741.	CO 1	T1:11.1-11.5
2	To find the frequency response of integrator and differentiator for different inputs using IC741.	CO 1	T1:11.1-11.5
3	To find the frequency response of second order Active Lowpass, High-pass And Bandpass Filters using IC 741.	CO 2	T1:4.8 , T1:7.2
4	To find the frequency response of Second Order Active Band Pass and Band-reject Filters using IC 741.	CO 2	T1:4.8 , T1:7.2
5	To find the frequency of oscillations of Astable Multivibrators Using 555timer.	CO 3	T2:10.4 , R2:7.2
6	To find the frequency of oscillations of Monostable Multivibrators Using 555timer.	CO 3	T2:10.4 , R1:7.2
7	To find the hysteresis voltage of Schmitt Trigger Using 555 timer.	CO 7	T2:10.4 , R1:7.2
8	To find the capture range and lock-in range of PLL Using IC 565.	CO 4	T1:8.2-8.5
9	To find the voltage gain of Instrumentation Amplifier using IC 741.	CO 1	T1:11.1-11.5
10	To find the different analog outputs using Digital to Analog Converter.	CO 5	T1:10.1 , T1:10.2
11	To find the voltage regulation of small voltage regulator using IC 723.	CO 4	T1:11.1-11.5
12	To verify the truth tables of RTL Logic using NAND and NOR implementations.	CO 6	T3:3.12 , R1:12.7
13	To verify the truth tables of DTL Logic using NAND and NOR implementations.	CO 6	T3:3.12 , R1:12.7

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design an automatic Street Light using 555 timer and LDR.
2	Design an analog Temperature Sensor detector using IC 741.
3	Design an Electronic Eye controlled security system using LDR.
4	Design PWM Based DC Fan Controller using IC 555 timer.
5	Design an automatic Washroom Light Switch using IC741.

Signature of Course Coordinator **HOD, ECE**

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

ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE DESCRIPTION

Course Title	**DIGITAL COMMUNICATIONS LABORATORY**				
Course Code	AECB22				
Program	B.Tech				
Semester	V	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Mr K Chaitanya, Assistant Professor				

I COURSE OVERVIEW:

This lab course gives the hands on experience in elements of digital communication systems. The design of various coding techniques, pulse analog and digital modulations to analyse signal to noise ratio, bit error rate, power and bandwidth for digital communication systems. This lab is useful in the digital signal processors in secured communication systems, multimedia communications and data storage applications.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB20	V	Digital Communications
B.Tech	AECB12	IV	Analog Communications

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Digital Communications 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 forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

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

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

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

1. **Experiment Based**

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

2. **Programming Based**

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

VI COURSE OBJECTIVES:

The students will try to learn:

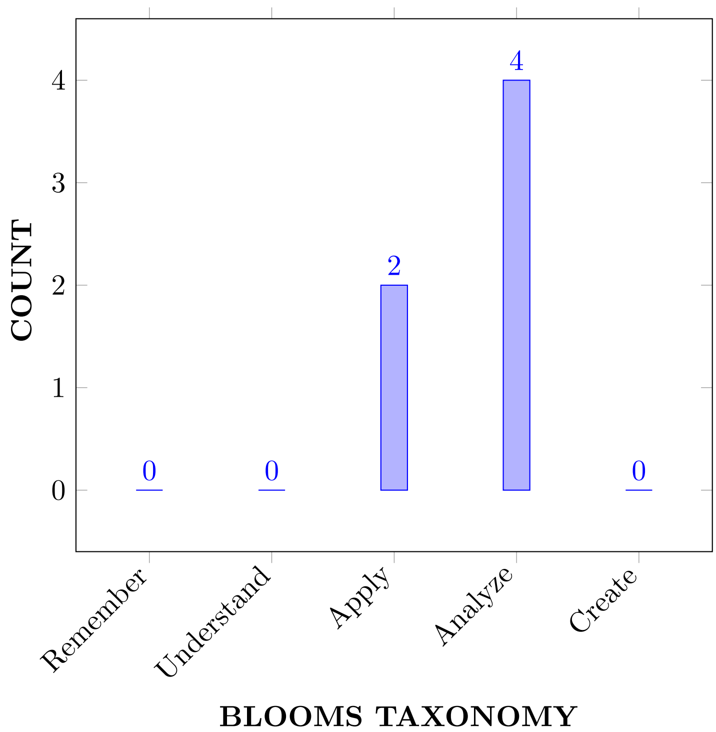
I	The Elements of digital communication systems to convert continuous time signals into discrete time signals.
II	The pulse analog modulation techniques, generation and detection of digital modulation techniques.
III	The time and frequency domain analysis of the signals in communication system by using MATLAB tools.

VII COURSE OUTCOMES:

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

CO 1	**Examine** sampling theorem for processing of different signals such as low pass signals, band-limited signals and bandpass signals. .	Analyze
CO 2	**Classify** the pulse modulation and demodulation methods for encoded data in analog to digital conversion.	Analyze
CO 3	**Apply** the concept of pulse code modulation and demodulation for the equivalent sequence of binary code word data.	Analyze
CO 4	**Categorize** the digital modulation techniques used for transfer a digital bit stream over an analog channel at a high frequency.	Analyze
CO 5	**Determine** bit rate in delta modulation and demodulation process for the no. of bits per sample are transmitted.	Apply
CO 6	**Develop** frequency domain description of different digital modulation techniques for spectral characteristics analysis.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Lab Experiments/CIE/SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	1	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 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 3	Make use of High Frequency Structure Simulator (HFSS) for modeling and evaluating the Patch and Smart Antennas for Wired and Wireless Communication Applications.	1	Lab Exercises/CIE/SEE

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 2	OIdentify **(Problem analysis)** sampling rate and sampling time interval in analog to digital signal conversion using **principles of mathematics, natural sciences, and engineering sciences**	2

	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
CO 2	PO 2	Identify **(Problem analysis)**pulse modulation techniques and convert analog signal into discrete signals **using principles of mathematics, natural sciences, and engineering sciences.**	2
	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
CO 3	PO 5	Create, select, and **apply** appropriate techniques to modelling the pulse code modulation and demodulation using serial to parallel and parallel to serial data transmission **(Modern Tool Usage)** to complex Engineering activities with an understanding of the limitations in PCM.	2
	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
CO 4	PO 2	Identify **(Problem analysis)** digital modulation techniques with reference to o and 1 as binary input and to reduce ambiguity using **principles of mathematics, natural sciences, and engineering sciences**	2
	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
	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
CO 5	PO 2	Identify **(Problem analysis)** the bit rate of delta modulation and demodulation with reference to o and 1 as binary input using **principles of mathematics, natural sciences, and engineering sciences**	2
	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

	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
	PSO 3	**Make use of High Frequency Structure Simulator (HFSS)** to design DPSK for Wired and Wireless Communication Applications.	1
CO 6	PO 2	Identify **(Problem analysis)** spectrum analysis for different modulations **using principles of mathematics, natural sciences, and engineering sciences.**	2
	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

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

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

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	PO 2, PO 5, PO 9, PSO 3	SEE Exams	PO 2, PO 5, PO 9, PSO 3	Seminars	-
Laboratory Practices	PO 2, PO 5, PO 9, PSO 3	Student Viva	PO 2, PO 5, PO 9, PSO 3	Certification	-
Assignments	-				

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**SAMPLING THEOREM – VERIFICATION**
	Verification of sampling theorem for under, perfect, over sampling cases.
WEEK II	**PULSE AMPLITUDE MODULATION AND DEMODULATION**
	Generation of Pulse Amplitude modulation and demodulation using hardware and matlab.
WEEK III	**PULSE WIDTH MODULATION AND DEMODULATION**
	Generation of Pulse width modulation and demodulation using hardware and matlab.
WEEK IV	**PULSE POSITION MODULATION AND DEMODULATION**
	Generation of pulse position modulation and demodulation using hardware and matlab.
WEEK V	**PULSE CODE MODULATION AND DEMODULATION**
	Generation of pulse code modulation and demodulation using hardware and understanding the concept analog to digital conversion.
WEEK VI	**DIFFERENTIAL PULSE CODE MODULATION AND DEMODULATION**
	Generation of differential pulse code modulation and demodulation using hardware.
WEEK VII	**DELTA MODULATION AND DEMODULATION**
	Generation of delta modulation and demodulation using hardware.
WEEK VIII	**FREQUENCY SHIFT KEYING**
	Generation of Frequency shift keying modulation and demodulation using hardware.
WEEK IX	**PHASE SHIFT KEYING**
	Generation of Phase shift keying modulation and demodulation using hardware.
WEEK X	**DIFFERENTIAL PHASE SHIFT KEYING**
	Generation of Differential Phase shift keying modulation and demodulation using hardware
WEEK XI	**AMPLITUDE SHIFT KEYING**
	Generation of Amplitude Shift Key modulation and demodulation using hardware.
WEEK XII	**QUADRATURE PHASE SHIFT KEYING**
	Generation of QPSK modulation and demodulation using hardware
WEEK XIII	**MATLAB for QPSK and SIMULINK for DPSK.**
	Understand frequency domain description of Quadrature Phase Shift Keying and Differential Phase shift keying.
WEEK XIV	**STUDY OF THE SPECTRAL CHARACTERISTICS OF AMPLITUDE MODULATION**
	Understand frequency domain description of Amplitude Modulation.

TEXTBOOKS

1. 1. Herbert Taub, Donald L. Schilling , "Principles of Communication Systems", TMH, 3^{rd} edition,2008

2. 2. K. Sam Shanmugam, "Digital and Analog Communication Systems", John Wiley and Sons, 2^{nd} Edition, 2005.

REFERENCE BOOKS:

1. John Proakis, "Digital Communications", TMH, 2^{nd} Edition 1983.

2. B.P.Lathi, "Modern Analog and Digital Communication", Oxford reprint, 3^{rd} Edition, 2004.

3. Singh, Sapre, "Communication Systems Analog and Digital", TMH, 2^{nd} Edition, 2004.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Verification of sampling theorem for under, perfect, over sampling cases.	CO 1	T1: 2.3
2	Generation of Pulse Amplitude modulation and demodulation using hardware and matlab.	CO 2	T1: 3.1
3	Generation of Pulse width modulation and demodulation using hardware and matlab.	CO 3	T1: 3.11
4	Generation of pulse position modulation and demodulation using hardware and matlab.	CO 4	T1: 4.8
5	Generation of pulse code modulation and demodulation using hardware and understanding the concept analog to digital conversion.	CO 5	T2: 2.8
6	Generation of differential pulse code modulation and demodulation using hardware.	CO 6	T2: 3.5
7	Generation of delta modulation and demodulation using hardware.	CO 7	T2: 4.6
8	Generation of Frequency shift keying modulation and demodulation using hardware.	CO 8	R1: 2.1
9	Generation of Phase shift keying modulation and demodulation using hardware.	CO 9	R1: 2.8
10	Generation of Differential Phase shift keying modulation and demodulation using hardware.	CO 10	R1: 3.1
11	Generation of Amplitude Shift Key modulation and demodulation using hardware.	CO 11	R2:2.1
12	Generation of QPSK modulation and demodulation using hardwarer	CO 12	R2:2.6
13	Understand frequency domain description of Quadrature Phase Shift Keying and Differential Phase shift keying	CO 12	R2:3.2
14	Understand frequency domain description of Amplitude Modulation	CO 11	R2:4.1

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design a sampling circuit with 5 V p-p amplitude and 100 Hz sine wave and remove aliasing effect..
2	Design PAM transmission of voice signal with $W = 3KHz$. Calculate transmission bandwidth if $f_s = 8KHz$ and $\tau = 8KHz$.
3	Design adaptive delta modulator and find the maximum amplitude of a 1 KHz sinusoidal signal input to a delta modulator that will prevent slope overload, when the sampling rate is 10,000 samples/sec and the step size is $\triangle = 0.1$.
4	Design a PCM circuit with IC CD4016, LM324, 7493, 7400 and Feed 2Vpp, 100Hz unipolar sine wave as the analog input (Set dc level at 2V to obtain a signal that varies between +1V and +3V). Make sure that the input peak voltage never exceeds the peak DAC output.
5	Design differential phase shift keying modulator using XOR gate with bit stream 11011100101. Draw the encoded sequence and the transmitted phase sequence.

Signature of Course Coordinator **HOD,ECE**
Mr. K Chaitanya, Assistant Professor

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

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Digital Signal Processing**				
Course Code	AECB23				
Program	B.Tech				
Semester	SIX				
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms.S Sushma, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHSB11	III	Mathematical Transform Techniques
B.Tech	AECB14	IV	Signals and systems

II COURSE OVERVIEW:

This course provides the design of discrete-time systems and analytical tools to analyze the discrete signals and systems. It focuses on the classification of discrete-time signals and systems, linear time-invariant systems, discrete fourier transform, fast fourier transform algorithms, digital filter design and multi rate signal processing. Digital signal processing applications are used in speech processing, image processing, audio and video data compression, communication systems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Digital Signal Processing	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
✓	Open Ended Experiments	✓	Tech talk	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
0%	Remember
36 %	Understand
54 %	Apply
10 %	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).

Table 2: Assessment pattern for CIA

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

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 3.

Table 3: Assessment pattern for AAT

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

VI COURSE OBJECTIVES:

The students will try to learn:

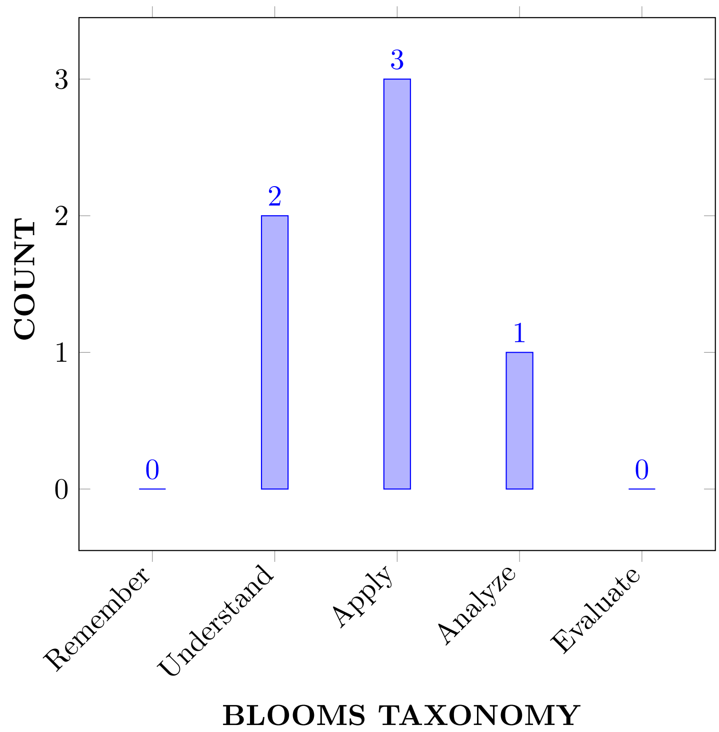
I	The classification and analysis of discrete time signals and systems in time and frequency domain.
II	The design and realization structures of finite and infinite impulse response filters and multi rate filters.
III	The implementation of digital filter algorithms using MATLAB tool..

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** the concept of discrete time signals and systems for analysing the response of LTI system in time domain and frequency domain.	Understand
CO 2	**Construct** the Decimation-in-time fast fourier transform and decimation-in-frequency fast fourier transform for reducing computational complexity of DFT..	Apply
CO 3	**Implement** the digital filters and their realization structures using various transformation technique.	Apply
CO 4	**Analyze** the performance characteristics of digital filters to meet expected system specifications using MATLAB..	Analyze
CO 5	**Interpret** the efficient implementation of sample rate conversion of digital signals to interface the digital systems with different sampling rates.	Understand
CO 6	**Identify** the errors in analog to digital conversion for tolerating finite word length effects.	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/ 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 / Projects

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	AAT / Projects
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	SEE / CIE
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/ 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.	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	**Explain(knowledge)** the classification and properties of discrete time signals and systems to analyze the response of linear time invariant systems(complex) in time and frequency domain by applying the fundamental concepts of **mathematical principles and engineering and science.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Understand** the given **problem statement and formulate (complex)** to analyze the response of LTI system in the time domain and frequency domain from provided **information and data**.	6
	PO 10	**Demonstrate** the ability to communicate effectively on discrte signals and systems.	1
CO 2	PO 1	**Apply the knowledge of mathematics, science, engineering fundamentals** to solve the fast fourier transform of discrete signals.	3
	PO 2	Formulate and analyze **(problem analysis) complex engineering problems** for fast fourier transform of discrete sigals using first principles of **mathematics and engineering sciencesto analyze** spectral characteristics of given signal and **validate the results** of decimation in time fast fourier transform and decimation in frequency fast fourier transform with discrete fourier transform in reaching substantiated conclusions by the **interpretation of results.**	7
	PO 3	**Understand the customer needs, use creativity and manage design process** to apply fast fourier transform algorithms for the given signal to **evaluate outcomes.**	5
	PO 10	**Demonstrate** the ability to communicate effectively on discrte fourier transform.	1
	PSO 1	**Develop** the capability to **analyze and apply FFT** on discrete signals and applications by its **mathematical models.**	1
CO 3	PO 1	**Apply the knowledge of mathematics, science, engineering fundamentals** to understand finite impulse response and infinite impulse filters.	3
	PO 2	**Understand the given problem statement and formulate** the design (complex) digital filters from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results.**	7
	PO 3	**Design** IIR and FIR filters for determining magnitude and phase response **by applying the principles of mathematics, science to the solutions of complex engineering problems and design system components.**	6
	PO 4	**Design** FIR and IIR filters from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results.**	5
	PO 10	**Demonstrate** the ability to communicate effectively on digital filters.	1
	PSO 1	**Apply** filter transformation methods to convert digital filters from analog filters	1
CO 4	PO 1	**Simulate** the FIR and IIR filters using MATLAB tool to analyze **performance parameters the knowledge of mathematics, science, engineering fundamentals.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	**Understand** the given **problem statement and formulate** the design (complex) digital filters from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results by simulating in MATLAB.**	7
	PO 3	**Develop** the MATLAB program to design IIR and FIR filters for determining magnitude and phase response by applying the principles of **mathematics, science to the solutions of complex engineering problems and design system components.**	6
	PO 4	**Apply (knowledge)** MATLAB code for designing digital filers and properties corresponding context of the engineering knowledge to given signal for spectral analysis of given signal.	5
	PO 5	**Analyze** the performance parameters of IIR and FIR filters using MATLAB to meet system specifications including prediction and modeling to **complex engineering** activities with an understanding of the limitations.	1
	PO 10	**Demonstrate** the ability to communicate effectively on MATLAB programs.	1
	PSO 1	**Understand** the analog and digital filters and apply transformation formulas to convert digital filters in MATLAB tool.	1
CO 5	PO 1	**Understand** the concept of multi rate signal processing which by applying the fundamental concepts of mathematical principles and **engineering and science**	3
	PO 2	**Illustrate** multi rate signal processing which are **important for design solutions for complex engineering problems.**	5
	PO 10	**Demonstrate** the ability to communicate effectively on multi rate signal processing	1
CO 6	PO 1	**Understand (knowledge)** concept of finite word length effects which by applying the fundamental concepts of mathematical principles and **engineering and science of mathematical principles.**	3
	PO 2	**Identify** the finite word length effects **while implementing signal processing techniques(analyze complex engineering problems) on digital signal processor(engineering sciences).**	5
	PO 10	**Demonstrate** the ability to communicate effectively on multi rate signal processing	1

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	6	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	7	5	-	-	-	-	-	-	1	-	-	1	-	-
CO 3	3	7	6	5	-	-	-	-	-	1	-	-	1	-	-
CO 4	3	7	6	5	1	-	-	-	-	1	-	-	1	-	-
CO 5	3	5	-	-	-	-	-	-	-	1	-	-	1	-	-
CO 6	3	5	-	-	-	-	-	-	-	1	-	-	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	**10**	**10**	**11**	**1**	**5**	**3**	**3**	**12**	**5**	**12**	**8**	**2**	**2**	**2**
CO 1	100	60	-	-	-	-	-	-	-	20	-	-	-	-	-
CO 2	100	70	50	-	-	-	-	-	-	20	-	-	50	-	-
CO 3	100	70	6 0	45	-	-	-	-	-	20	-	-	50	-	-
CO 4	100	70	60	45	100	-	-	-	-	20	-		50	-	-
CO 5	100	50	-	-	-	-	-	-	-	20	-	-	50	-	-
CO 6	100	50	-	-	-	-	-	-	-	20	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	3	-	-	-	-	-	-	-	1	-	-	-	-	
CO 2	3	3	-	-	-	-	-	-	-	1	-	-	2	-	-
CO 3	3	3	1	-	-	-	-	-	-	1	-	-	2	-	-
CO 4	3	3	2	1	3	-	-	-	-	1	-	-	2	-	-
CO 5	3	2	2	2	-	-	-	-	-	1	-	-	2	-	-
CO 6	3	2	-	-	-	-	-	-	-	1	-	-	-	-	-
TOTAL	**18**	**14**	**5**	**3**	**3**	-	-	-	-	**6**	-	-	**8**	-	-
AVERAGE	**3**	**2.67**	**1.66**	**1.5**	**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	-
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	REVIEW OF DISCRETE TIME SIGNALS AND SYSTEMS:
	Discrete time signal definition; Signal classification; Elementary signals; Transformation of elementary signals; Concept of digital frequency; Discrete time system definition; System classification; Linear time invariant (LTI) system; Properties of the LTI system; Time domain analysis of discrete time systems; Impulse response; The convolution sum; Methods of evaluating the convolution sum; Filtering using overlap-save and overlap-add method; Realization of digital filters: Concept of IIR and FIR filters; Realization structures for IIR and FIR filters using direct form-I and direct form-II, cascade, lattice and parallel.
MODULE II	DISCRETE FOURIER TRANSFORM AND EFFICIENT COMPUTATION:
	Introduction to discrete time Fourier transform (DTFT); Discrete Fourier transform (DFT) definition; Properties of DFT; Linear and circular convolution using DFT; Fast-Fourier-Transform (FFT): Direct computation of DFT; Need for efficient computation of the DFT (FFT algorithms); Radix-2 FFT algorithm for the computation of DFT and IDFT using decimation-in-time and decimation-in-frequency algorithms; General Radix-N FFT.
MODULE III	STRUCUTRE OF IIR FILTERS:
	Analog filters: Butterworth filters; Chebyshev type-1 and type-2 filters; Analog transformation of prototype LPF to HPF/BPF/BSF. Transformation of analog filters into equivalent digital filters using impulse invariant method and bilinear transform method; Matlab programs of IIR filters.
MODULE IV	SYMMETRIC AND ANTISYMMETRIC FIR FILTERS
	Design of linear phase FIR filters windowing and frequency sampling methods; Equiripple linear phase FIR filters; Parks-McClellan algorithm and remez algorithm; Least-mean-square error filter design; Design of FIR differentiators; Matlab programs of FIR filters; Comparison of FIR and IIR.

MODULE V	APPLICATIONS OF DSP:
	Multirate signal processing; Decimation; Interpolation; Polyphase structures for decimation and interpolation filters; Structures for rational sampling rate conversion; Applications of multirate signal processing for design of phase shifters, interfacing of digital systems with different sampling rates, sub band coding of speech signals. Analysis of finite word length effects: Representation of numbers; ADC quantization noise, coefficient quantization error, product quantization error, truncation and rounding errors; Limit cycle due to product round-off error; Round-off noise power; Limit cycle oscillations due to overflow in digital filters; Principle of scaling; Dead band effects.

TEXTBOOKS

1. John G. Proakis, Dimitris G. Manolakis, Digital signal processing, Principles, Algorithms and Applications, Prentice Hall, 4th Edition, 2007
2. Sanjit K Mitra, Digital signal processing, A computer base approach, McGraw-Hill Higher Education, 4th Edition, 2011.
3. Emmanuel C, Ifeacher, Barrie. W. Jervis, DSP-A Practical Approach, Pearson Education, 2nd Edition, 2002.
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1. Li tan, Digital signal processing: fundamentals and applications, Elsevier Science and. Technology Books, 2nd Edition, 2008.
2. Robert J.schilling, Sandra. L.harris, Fundamentals of Digital signal processing using Matlab, Thomson Engineering, 2nd Edition, 2005.
3. Salivahanan, Vallavaraj, Gnanapriya, Digital signal processing‖, McGraw-Hill Higher Education, 2nd Edition, 2009.

WEB REFERENCES:

1.https://lms.iare.ac.in/index?route=course/details&course_id=128
2. https://nptel.ac.in/courses/117/102/117102060/

COURSE WEB PAGE:

https://lms.iare.ac.in/index?route=course/details&course_id=128

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 DSP	CO 1	T1:2.1-2.2
3	Discrete time signal definition; Elementary signals; Signal classification	CO 1	T1:2.1-2.2
4	Transformation of elementary signals;	CO 1	T1:2.1-2.2
5	Discrete time system definition; System classification;	CO 1	T1:2.3-2.4

7	Linear time invariant (LTI) system; Properties of the LTI system;Impulse response;	CO 1	T1:2.3-2.4
8	Time domain analysis of discrete time systems;	CO 1	T1: 2.3.3
10	The convolution sum; Methods of evaluating the convolution sum;	CO 2	T1: 2.3.4
12	Filtering using overlap-save method	CO 1	T1: 2.3.4
13	Filtering using overlap-add method	CO 1	T1: 2.3.4
15	Realization of digital filters: Concept of IIR and FIR filters;	CO 3	T1: 9.2-9.3
16	Realization structures for IIR and FIR filters using direct form-I and direct form-II.	CO 3	T1: 9.2-9.3
17	Realization structures for IIR and FIR filters using cascade, lattice and parallel.	CO 3	T1: 7.1
20	Introduction to DTFT,DFT	CO 2	T1: 7.3
21	Properties of DFT	CO 2	T1: 7.3
22	Linear and circular convolution using DFT	CO 2	T1: 8.1
23	Fast-Fourier-transform (FFT): Direct computation of DFT	CO 2	T1: 8.1
24	DIT FFT Algorithm	CO 2	T1: 8.2
26	DIF FFT Algorithm	CO 2	T1: 10.3
27	IDFT using decimation-in-time and decimation-in-frequency algorithms; General Radix-N FFT.	CO 2	T1: 10.3
28	Introduction to digital filters	CO 3	T1: 10.3
29	Analog filters: Butterworth filters	CO 3	T1: 10.3
31	Design Chebyshev type-1 and type-2 filters;	CO 3	T1: 10.3
33	Analog transformation of prototype LPF to HPF/BPF/BSF.	CO 3	T1: 10.2
34	Transformation of analog filters into equivalent digital filters using impulse invariant method	CO 3	T1: 10.2
35	Bilinear transform method	CO 3	T1: 10.2
38	Matlab programs of IIR filters.	CO 4	T1: 10.2
39	Linear phase FIR filters	CO 3	T1: 10.2
40	Symmetric and asymmetric FIR filters	CO 3	T1: 10.2
41	Design of linear phase FIR filters using windowing method	CO 3	T1: 10.2
44	Design of linear phase FIR filters using Frequency sampling method	CO 3	T1: 10.2
46	Equiripple linear phase FIR filters	CO 3	T1: 10.2
47	Parks-McClellan algorithm and remez algorithm;	CO 3	T3:6.6
48	Least-mean-square error filter design	CO 3	T1: 11.1-11.3
49	Design of FIR differentiators	CO 3	T1: 11.1-11.3
50	Matlab programs of FIR filters; Comparison of FIR and IIR.	CO 4	T1: 11.6
51	Multirate signal processing; Decimation; Interpolation	CO 5	T1: 11.6

52	Polyphase structures for decimation and interpolation filters	CO 5	T1: 11.6
53	Structures for rational sampling rate conversion	CO 5	T1: 11.6
54	Applications of multirate signal processing for design of phase shifters	CO 5	T1: 11.6
55	Interfacing of digital systems with different sampling rates Sub band coding of speech signals	CO 5	T1: 11.6
56	Analysis of finite word length effects: Representation of numbers; ADC quantization noise	CO 6	T1: 11.7
57	coefficient quantization error, product quantization error, truncation and rounding errors	CO 6	T1: 11.7
58	Limit cycle due to product round-off error; Round-off noise power	CO 6	T1: 11.7
61	Limit cycle oscillations due to overflow in digital filters; Principle of scaling; Dead band effects.	CO 6	T1: 11.7
PROBLEM SOLVING/ CASE STUDIES			
9	Operation on signals, System characteristics	CO 1	T2:1.12
11	Time domain analysis of discrete time systems	CO 1	T1:1.2
13	Linear convolution and circular convolution	CO 1	T1:3.2
14	Overlap add method,Overlap save method	CO 1	T1:3.2
18	Realization structures of digital filters direct form I and II	CO 3	T1: 9.2-9.3
19	Realization structures of digital filters cascade and paralle form	CO 3	T1: 9.2-9.3
25	DFT Properties problems	CO 2	T1: 8.1
30	DIT FFT	CO 2	T1: 8.1
32	DIF FFT	CO 2	T1: 8.1
36	IIR Filters-butterworth filters	CO 3	T1: 10.3
38	IIR Filters- Chebyshev type-1 filters	CO 36	T1: 10.3
42	Impulse invariant method and bilinear transformation	CO 3	T1: 10.3
45	FIR filters -windowing method	CO 3	T1: 10.2
47	FIR filters -frequency sampling method	CO 3	T1: 10.2
59	Finite word length effects	CO 6	T1: 9.4-9.5, T1:9.6
DISCUSSION OF DEFINITION AND TERMINOLOGY			
61	System characteristics, impulse response	CO 1	T2:1.12
62	DFT and FFT	CO 2	T1: 7.2, T1: 8.1
63	IIR and FIR filters	CO 3	T1: 10.2, T1: 10.3
64	Multi rate signal processing	CO 5	T1: 11.6
65	Finite word length effects	CO 6	T1: 9.4-9.5, T1:9.6
DISCUSSION OF QUESTION BANK			
66	System characteristics,Time domain analysis,convolution sum	CO1, CO2	T1:1.12
67	Realization structures	CO 3	T1: 9.2-9.3

68	DFT and FFT	CO 2	T1: 8.1
69	IIR and FIR filters	CO 3	T1: 10.3, T1: 10.2
70	Multirate signal processing	CO 5, CO6	T1: 9.4-9.5,

Signature of Course Coordinator **HOD,ECE**
Ms. S Sushma, 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**

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**

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:

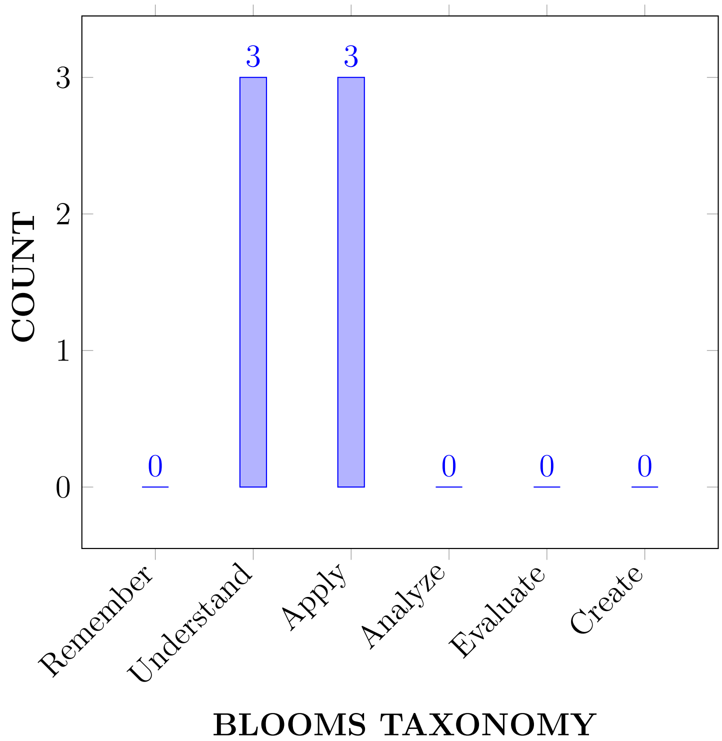
I	The signal descriptions along with functional architecture and hardware interfacing skills using microprocessors and micro controllers.
II	The instruction set and logic to build assembly language programs for arithmetic, logic and automated electronic systems.
III	The essential concepts of development 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

ELECTRONICS AND COMMUNICATIONENGINEERING
COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Radar systems and processing**				
Course Code	AECB50				
Program	B.Tech				
Semester	VI				
Course Type	Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms P. Annapurna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEC003	III	Probability Theory and Stochastic Processes
B.Tech	AEC005	IV	Analog Communications

II COURSE OVERVIEW:

This course introduces the Transmission of electromagnetic and radio waves to detect the range and velocity of targets. It covers the digital techniques that allow complicated signal processing in moving target indicator radar, pulse Doppler radars and digital data processing to perform automatic detection and tracking. It focuses on several ranging applications such as electronic warfare, navigation systems, missile terminal guidance and landing systems of air and space vehicles.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Radar Systems and Processing	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
50 %	Understand
40 %	Apply
10 %	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:

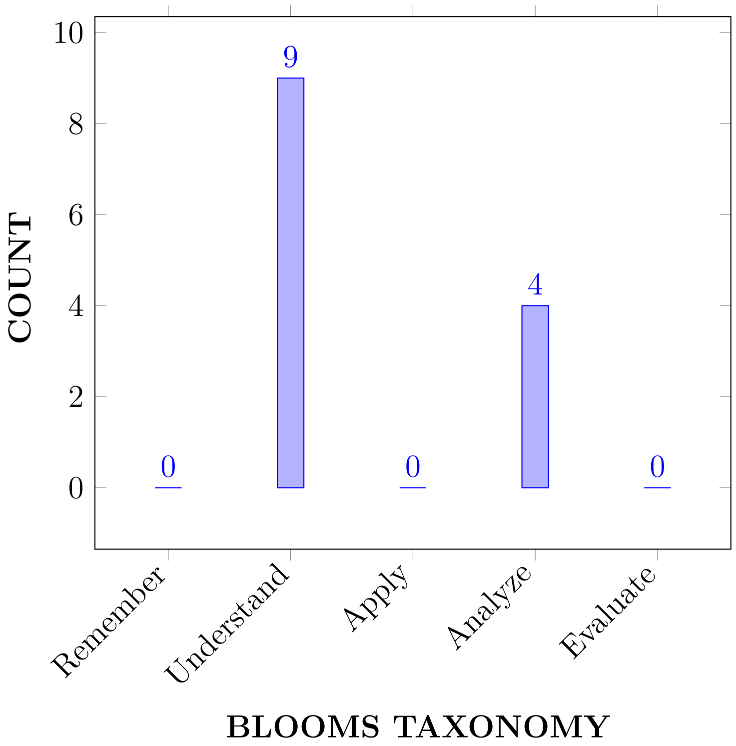
I	The principle and operation of radar systems and radar range equation for communication.
II	The use of Doppler frequency shift to detect moving target in stationary clutter , continuous wave radar system in altimeter applications.
III	The types of radar receivers, transmitter systems and effect of noise on radar signal detection.

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the principle and operation of Radar using Radar Range Equation to calculate transmitted power.	Understand
CO 2	**Analyze** the principle of FM-CW radar and use it in FM- CW altimeter to measure range and Doppler frequency of the target	Analyze
CO 3	**Illustrate** the concept of blind speeds, range gated Doppler filters and moving target indicator with Pulse Doppler radar for detection of moving targets.	Understand
CO 4	**Choose** the appropriate matched filters in Radars receivers to maximize signal to noise ratio	Apply
CO 5	**Describe** Radar displays and duplexers for transmission and display the data on the screen	Understand
CO 6	**Examine** the detection techniques of target echo signal reflected back to the radar antenna for obtaining the location and distance of the reflecting object.	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.	2	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	CIE/Quiz/AAT
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
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 SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
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.	1	-

3 = High; 2 = Medium; 1 = Low

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

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

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

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	**Demonstrate** the basic principle of radar System with the help of Block diagram (knowledge) **using the principles of science** and **mathematics** for **engineering problems**.	3
	PO 10	**Communicate effectively** on the factors affecting the radar performance using radar range equation to calculate Transmitter power.	2
CO 2	PO 1	**Understand** the principle of frequency modulated –continuous wave radar using the **principles of science** and **mathematics** for **engineering problems**.	2
	PO 2	**Analyze** the concept and apply it for altimeter applications **Use research-based knowledge and of data to provide valid conclusions.**	2
	PO 10	**Communicate effectively** the concept using effective presentations	2
CO 3	PO 1	understand the principle of moving target indicator radar and Pulse Doppler radar **using the principles of science and mathematics for engineering problems**	2
	PO 4	Differentiate the two radars for moving target indication and clutter rejection **Design solutions for complex engineering problems for the public safety environmental considerations**	1
	PO 10	**Communicate effectively** the concept of moving target indicator using effective presentations	2
CO 4	PO 1	Understand the concept of matched filters in Radars receivers **using the principles of science and mathematics for engineering problems)**	2
	PO 4	Explain the concept of matched filters in Radars receivers **Identify, formulate, review research using first principles of engineering sciences.**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 10	**Communicate effectively** the concept of matched filters in Radars receivers	2
	PSO 3	**Analyze** the concept to measure received signal power using High frequency structure simulator **Use research-based knowledge and of data to provide valid conclusions.**	2
CO 5	PO 1	**Understand** (knowledge) the concepts display devices and duplexers by **applying the principles of mathematics, science to the solutions of complex engineering problems**	3
	PO 3	**Desin** display devices and receviers usin complex engineering solutions to meet specified needs with appropriate consideration for the public health and safety	1
	PO 10	**Communicate effectively** the concept of display devices and duplexers using effective presentations	2
	PSO 3	**Analyze** the concept of display devices and duplexers for **wireless communication applications**	2
CO 6	PO 1	**(Understand)** the concept of target echo signal reflected back to the radar antenna **using the principles of science and mathematics for engineering problems)**..	2
	PO 2	**Adentify, formulate, review research** target echo signal for obtaining the location and distance of the reflecting object	2
	PO 4	**Use research-based knowledge analysis and interpretation of data**of target echo signal for obtaining the location and distance of the reflecting object	2
	PO 10	**Communicate effectively** the concept of antennas using effective presentations	1
	PSO 3	Make use of High frequency structure simulator (HFSS) for evaluating the antennas for wired and wireless communication applications	2

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

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

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	-	-	-	-	-	-	-	-	-	30		-	-	-
CO 2	66.7	20	-	-	-	-	-	-	-	-	40	-	-	-	-
CO 3	66.7	-	10	-	-	-	-	-	-	-	30	-	-	-	-
CO 4	66.7	-	-	27.3	-	-	-	-	-	-	30		-	-	100
CO 5	100	-	10	-	-	-	-	-	-	-	30	-	-	-	100
CO 6	66.7	20	-	18.2	-	-	-	-	-	-	40		-	-	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	2	2	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 3	2	-	-	1	-	-	-	-	-	1	-	-	-	-	-
CO 4	2	-	-	3	-	-	-	-	-	1	-		-	-	3
CO 5	3	-	1	-	-	-	-	-	-	1	-	-	-	-	3
CO 6	2	2	-	2	-	-	-	-	-	1	-		-	-	3
TOTAL	14	4	1	6	**0**	**0**	**0**	**0**	**0**	6	**0**	**0**	**0**	**0**	9
AVERAGE	2.11	2.0	1.0	2.0	**0**	**0**	**0**	**0**	**0**	1.0	**0**	**0**	**0**	**0**	3

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction to Radar - Radar frequency bands and Applications; Radar Range equation; Pulse Radar: Block diagram and Operation; Maximum unambiguous range; Radar wave forms; Prediction of Target range; Minimum detectable signal; Receiver noise, Receiver Bandwidth, SNR; Probability of False alarm, Probability of Target Detection, Integration of echo pulses- SNR improvement; Radar Cross Section (RCS) of targets; RCS fluctuation models, transmitter power, PRF and Range ambiguities; system losses.
MODULE II	**CW AND FREQUENCY MODULATED RADAR**
	Moving Targets and Doppler Frequency; CW Radar: Introduction, Block Diagram, Isolation between transmitter and receiver, Non-zero IF receiver, Receiver bandwidth requirements, Applications; Frequency Modulated CW radar: Range and Doppler measurement, Mathematical Analysis, Block Diagram and characteristics, FM-CW altimeter, multiple frequency CW radar, Ambiguity Diagram and its application, Concept of pulse compression, Pulse Compression Radars: FM and Phase Coded Radars.
MODULE III	**MOVING TARGET INDICATION AND PULSE DOPPLER RADAR**
	Moving target indication (MTI) on A scope, butterfly effect, MTI using delay line canceller (DLC), Doppler measurement using Pulse radar, MTI radar (with power amplifier transmitter), MTI radar (with power oscillator transmitter), filter characteristics of DLC, blind speeds, double DLCs, Blind speeds, Staggered PRFs. Range gated doppler filters, MTI radar parameters, moving target detector; MTI radar performance: Parameter Definitions, limitations to MTI performance, non-coherent MTI. Pulse doppler radar; MTI radar versus Pulse Doppler radar
MODULE IV	**TRACKING RADAR AND RADAR DETECTION IN NOISE**
	Search and Tracking radars, track while scan (TWS) radar, Angle/Bearing Tracking: Sequential Lobing, Conical scan, Monopulse methods; Monopulse Tracking: Amplitude comparison (1D, 2D), Phase comparison, Bearing errors (without mathematical treatment), Glint Noise and Frequency Agility, Tracking in range, Acquisition, Comparison of trackers, Tracking with Surveillance Radar. Matched Filter (MF) receiver, MF response characteristics; Correlation Receiver, Efficiency of non matched filters, Matched filter with non-white noise, Automatic Detection of radar signals: Tapped Delay Line (TDL) detection, CFAR receiver, Radar Clutter: Land and Sea clutter (without mathematical treatment).

MODULE V	RADAR TRANSMITTERS AND RECEIVERS
	Advantages and Disadvantages of Magnetron Oscillator, Klystron Amplifier, Traveling wave tube (TWT) Amplifier, Hybrid Linear-Beam Amplifier and Crossed-Field Amplifiers, Solid State Sources and Amplifiers, Methods for employing solid-state transmitters. Receiver Noise Figure (NF) - Noise Temperature; Measurement of NF, NF of Mixers, Basics of Radar Displays and Duplexers; Phased array antennas: Current and Radiation pattern, Beam steering and effects, Basics of Antenna feeds and Phase shifters

TEXTBOOKS

1. Merrill I Skolnik, "Introduction to Radar Systems", TMH Special Indian Edition, 2nd Edition, 2007.

REFERENCE BOOKS:

1. Merrill I Skolnik , "Radar Handbook", McGraw-Hill Professional Publishing, 3nd Edition, 2008

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	-	W1
	CONTENT DELIVERY (THEORY)		
2	Radar frequency bands and Applications; Radar Range equation	CO 1	T1: 1.1-1.3
3	Pulse Radar: Block diagram and Operation; Maximum unambiguous range	CO 1	T1: 1.4-1.6
4	Receiver Bandwidth, SNR; Probability of False alarm	CO 2	T1:2.1-2.2
5	Probability of Target Detection, Integration of echo pulses- SNR improvement	CO 2	T1:2.3-2.4
6	Radar Cross Section (RCS) of targets	CO 1	T1:2.7-2.12
7	RCS fluctuation models, transmitter power, PRF and Range ambiguities; system losses	CO 1	T1:2.7-2.12
8	system losses	CO 1	T1:2.7-2.12
9	Moving Targets and Doppler Frequency	CO 4	T1:3.1-3.2
10	CW Radar: Introduction, Block Diagram, Isolation between transmitter and receiver, Non-zero IF receiver,	CO 4	T1:3.3-3.4
11	Non-zero IF receiver	CO 4	T1:3.5-3.6
12	Frequency Modulated CW radar: Range and Doppler measurement, Mathematical Analysis,	CO 4	T1:3.7-3.8
13	Block Diagram and characteristics, FM-CW altimeter	CO 4	T1:3.6-3.7
14	multiple frequency CW radar	CO 4	T1:3.8-3.9

15	Moving target indication (MTI) on A scope	CO 5	T1:4.1-4.4
16	butterfly effect, MTI using delay line canceller (DLC) Doppler measurement using Pulse radar, MTI radar .	CO 5	T1:4.5-4.8
17	Doppler measurement using Pulse radar, MTI radar .	CO 5	T1:4.9-4.10
18	Range gated doppler filters, MTI radar parameters	CO 6	T1:5.1-5.3
19	moving target detector; MTI radar performance: Parameter Definitions,	CO 6	T1:4.1-4.10
19	limitations to MTI performance	CO 6	T1:4.1-4.10
20	Search and Tracking radars, track while scan (TWS) radar, Angle/Bearing Tracking: Sequential Lobing	CO 6	T1:5.1-5.2
21	Conical scan, Monopulse methods; Monopulse Tracking	CO 6	T1:5.3-5.4
22	Amplitude comparison, Phase comparison, Bearing errors	CO 6	T1:5.5-5.6
23	Glint Noise and Frequency Agility, Tracking in range, Acquisition,	CO 6	T1:5.7-5.8
24	Comparison of trackers	CO 6	T1:5.8-5.10
25	Tracking with Surveillance Radar	CO 6	T1:5.9-5.10
26	MF response characteristics; Correlation Receiver	CO 3	T1:10.1- 10.3
27	Efficiency of non matched filters,	CO 3	T1:10.4- 10.5
28	Matched filter with non-white noise	CO 6	T1:10.6- 10.7
29	Automatic Detection of radar signals	CO 6	T1:10.8- 10.9
30	Tapped Delay Line (TDL) detection, CFAR receiver	CO 6	T1: 10.8 T1: 13.1-13.2
31	Radar Clutter: Land and Sea clutter	CO 5	T1: 10.8 T1: 13.3-13.4
32	Advantages and Disadvantages of Magnetron Oscillator	CO 5	T1:6.1-6.3
33	Klystron Amplifier, Traveling wave tube (TWT) Amplifier	CO 5	T1:6.4-6.6
34	SHybrid Linear-Beam Amplifier	CO 5	T1:6.1-6.6
35	Crossed-Field Amplifiers	CO 5	T1:6.1-6.6
36	Receiver Noise Figure (NF)	CO 5	T1:9.1-9.5 T1: 8.1-8.3
37	NF of Mixers	CO 6	T1:9.1-9.5
38	Basics of Radar Displays and Duplexers	CO 4	T1:9.1-9.5
39	Phased array antennas: Current and Radiation pattern	CO 4	T1:9.1-9.3 T1: 8.1-8.3
40	Beam steering and effects	CO 4	T1:9.4-9.5 T1: 8.3-8.4
41	Basics of Antenna feeds and Phase shifters	CO 5	T1:9.6-9.7 T1: 8.5-8.8

PROBLEM SOLVING/ CASE STUDIES			
42	Radar Range equation	CO 2	T1-4.3.1-4.3.1
43	Maximum unambiguous range	CO 2	R4- 6.8-6.9 R4- 6.14- 6.15
44	Pulse Radar	CO 2	T1-4.4- 4.5
45	Cut off frequency of rectangular waveguide	CO 3	T1 -4.6
46	CW Radar	CO 4	T1-10.1.1-10.1.2
47	FM-CW Radar	CO 4	T1-7.1-7.3
48	Doppler measurement using Pulse radar	CO 4	T1-8.1-8.3
49	MTI Radar	CO 5	R4-7.2
50	delay line canceller (DLC)	CO 5	R4- 7.13
51	Tracking radars	CO 5	T1-8.5-8.6
52	Klystron Amplifier	CO 5	T1-8.6-8.7
53	Receiver Noise Figure (NF)	CO 6	T1-9.1-9.3
54	Crossed-Field Amplifiers	CO 5	T1–11.4
55	Phased array antennas	CO 5	T1–11.5
56	Antenna feeds and Phase shifters	CO 6	T1-11.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Introduction	CO 2	T1-4.3.1-4.3.1
58	CW and frequency modulated radar	CO 5	R4- 7.13
59	Moving Target Indication and Pulse Doppler radar	CO 6	T1-9.1-9.3
60	Tracking radar and radar detection in noise	CO 6	T1-9.4-9.6
61	Radar Transmitters and Receivers	CO 6	T1–11.5
DISCUSSION OF QUESTION BANK			
62	Introduction lines	CO 2	T1-4.3.1-4.3.1
63	CW and frequency modulated radar	CO 5	R4- 7.13
64	Moving Target Indication and Pulse Doppler radar	CO 6	T1-9.1-9.3
65	Tracking radar and radar detection in noise	CO 6	T1-9.4-9.6
66	Radar Transmitters and Receivers	CO 6	T1–11.5

Signature of Course Coordinator **HOD,ECE**
Ms P.Annapurna Assistant Professor

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

COURSE DESCRIPTION

Department	**ELECTRONICS AND COMMUNICATION ENGINEERING**
Course Title	**WIRELESS COMMUNICATIONS AND NETWORKS**
Course Code	AECB42
Program	B.Tech
Semester	VI
Course Type	Professional Elective
Regulation	R-18

	Theory			Practical	
Course Structure	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. A Prashanth, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEC005	IV	Analog Communications
B.Tech	AEC009	V	Digital Communications

II COURSE OVERVIEW:

This course is intended to provide an overview of transmitting information from one point to another without using any connection like wires, cables or any physical medium. It covers the fundamentals of cellular communications, radio propagation, equalization, diversity and wireless networks.It focuse on performance analysis and design of a wireless communication system such as mobile telephone, satellite communication, TV and radio transmissions.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Wireless Communications and Networks	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
70%	Understand
10%	Apply
20%	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:

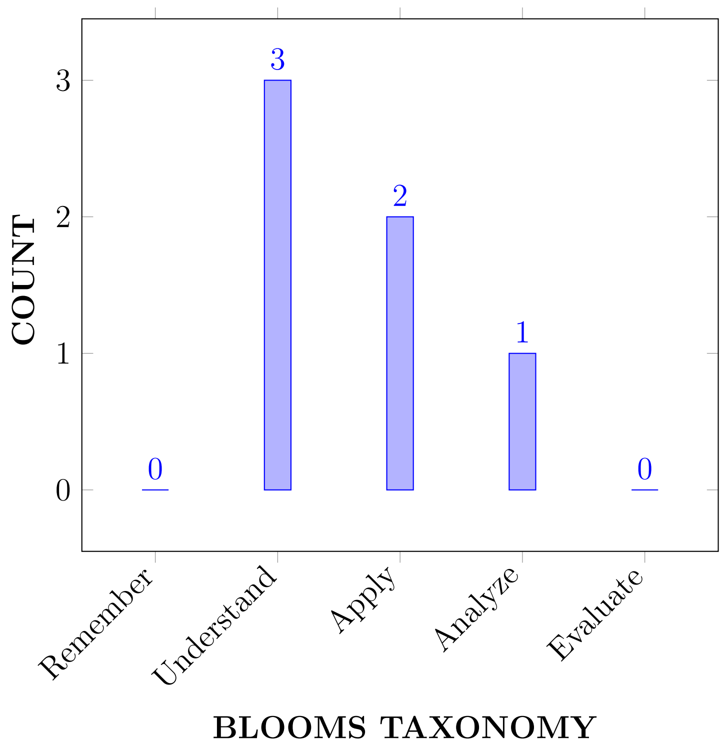
I	The concepts of frequency reuse, handoff, multipath channels and multiple access techniques used in wireless communication systems.
II	The process of fading mechanism, types of equalizers and diversity techniques.
III	The wireless network standards together with network protocols.

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the functioning of a cellular system for implementing technical challenges.	Understand
CO 2	**Summarize** the propagation mechanisms and radio wave propagation to know the behavior of radio waves..	Understand
CO 3	**Apply** the channel path loss models for the reduction in power density (attenuation) of an electromagnetic wave.	Apply
CO 4	**Identify** the multiple access schemes and techniques for providing multiple users on a single channel.	Apply
CO 5	**Analyze** the process of equalization and diversity schemes carried out in mobile devices for reduced distortion of received signals.	Analyze
CO 6	**Classify** the types of wireless local area networks and networking standards for implementing the network of computing devices.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations

Program Outcomes	
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
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PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
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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.
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PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	**Build** embedded software and digital circuit development platform for robotics, embedded systems and digital signal processing applications	–	—
PSO 2	**Focus** on the Application Specific Integrated Circuits (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.	2	Research papers /Project

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 cell structure and handoff (knowledge) for understanding wireless system by applying the principles of **science to engineering problems.**	1
CO 2	PO 1	Understand the concept **(knowledge)** of channel capacity and co-channel interference for **considering design** parameters.	2
	PO 2	**Finding** the channel interfernce and **review** the fading operations by analyzing **complex engineering problems**	3
	PO 4	**Knowledge** of the channel interfernce **characteristics** and **ability to apply modeling techniques** of fading operations by analyzing **engineering problems**	5
	PSO 3	Illustrate the concept of channel capacity for **wireless communication.**	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 3	PO 1	Illustrate the radio wave propagation **(knowledge)** used in propagation mechanisms by applying the **principles of mathematics** and **science for solving complex engineering problems.**	2
	PO 2	Understand the radio wave propagation and **formulate** to the propagation mechanisms using principles of **mathematics and engineering science.**	3
	PSO 3	Illustrate the concept of radio wave propagation for **wireless communication.**	1
CO 4	PO 1	Analyze (knowledge) the channel path loss models and transmission operations by **analyzing complex engineering problems** using the principles of **mathematics, engineering science.**	2
	PO 2	Understand the channel path loss models p**roblem statement** and finding the **solution implementation** of fading operations by analyzing **complex engineering problems**	3
CO 5	PO 1	Identify parameters of mobile multipath channels for**solvingcomplex engineeringproblemsgenerates by applyingmathematics, scienceandengineering fundamentals.**	3
CO 6	PO 1	Discuss (Understand) different types of multiple access **(knowledge)** for specifying multiple users over a single channel.	2
	PO 2	Identify the parameters of multiple access schemes **problem statements** using **mathematics principles.**	2
	PSO 3	Illustrate the concept of channel capacity for **wireless communication.**	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	1	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	2	3	-	5	-	-	-	-	-	-	-	-	-	-	1
CO 3	2	3	-	-	-	-	-	-	-	-	-	-	-	-	1
CO 4	2	3	-	5		-	-	-	-	-	-		-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	2	-	-	-	-	-	-	-	-	-		-	-	1

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	33.3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 2	66.6	30.0	-	45.5	-	-	-	-	-	-	-	-	-	-	50
CO 3	66.6	30.0	-	-	-	-	-	-	-	-	-	-	-	-	50
CO 4	66.6	30.0	-	45.5		-	-	-	-	-	-		-	-	-
CO 5	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	66.6	30.0	-	-		-	-	-	-	-	-		-	-	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	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	1	-	2	-	-	-	-	-	-	-	-	-	-	2
CO 3	2	1	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 4	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	1	-	-	-	-	-	-	-	-	-	-	-	-	2
TOTAL	12	4	-	2	-	-	-	-	-	-	-	-	-	-	6
AVERAGE	1.2	1	-	2	-	-	-	-	-	-	-	-	-	-	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
X	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVIII SYLLABUS:

MODULE I	**THE CELLULAR CONCEPT SYSTEM DESIGN FUNDAMENTALS**
	Introduction, frequency reuse, channel assignment strategies, handoff strategies; Prioritizing handoffs, practical handoff considerations, interference and system capacity; Co-channel interference and system capacity, channel planning for wireless systems, adjacent channel interference, power control for reducing interference, trunking and grade of service, improving coverage and capacity in cellular systems; Cellsplitting, sectoring.
MODULE II	**MOBILE RADIO PROPAGATION**
	Large-Scale Path Loss: Introduction to radio wave propagation, free space propagation model, relating power to electric field, the three basic propagation mechanisms; Reflection: Reflection from dielectrics, Brewster angle, reflection from prefect conductors, ground reflection (Two-Ray) mode; Diffraction Fresnel zone geometry, knife-edge diffraction model, multiple knife-edge diffraction, scattering, outdoor propagation models; Longley-Ryce model, Okumura Model, HataModel, PCS extension to hata Model, Walfisch and Bertoni model, wideband PCS microcell model, indoor propagation models-partition losses (Same Floor), partition losses between floors, log-distance path loss model, ericsson multiple breakpointmodel, attenuation factor model, signal penetration into buildings, ray tracing and site specific modeling.
MODULE III	**CELLULAR SYSTEM DESIGN FUNDAMENTALS**
	Small-scale fading and multipath: Small scale multipath propagation; Factors influencing small scale fading, Doppler shift, impulse response model of a multipath channel; Relationship between bandwidth and received power, small; Scale multipath measurements; Direct RF pulse system, spread spectrum sliding correlator channel sounding, frequency domain channels sounding, parameters of mobile multipath channels; Time dispersion parameters. Coherence Bandwidth, Doppler spread and coherence time, types of small - Scale fading; Fading effects due to multipath time delay spread, flat fading, frequency selective fading, fading effects due to Doppler Spread-Fast fading, slow fading, statistical models for multipath fading channels; Clarkes model for flatfading, spectral shape due to Doppler spread in Clarkes model, simulation of Clarke and Gans Fading model, level crossing and fading statistics, two-ray Rayleigh fading model.
MODULE IV	**EQUALIZATION AND DIVERSITY**
	Introduction, fundamentals of equalization, training a generic adaptive equalizer, equalizers in a communication receiver, linear equalizers, non-linear equalization; Decision feedback equalization (DFE), maximum likelihood sequence estimation (MLSE) equalizer, algorithms for adaptive equalization; Zero forcing algorithm, least mean square algorithm, recursive least squares algorithm; Diversity techniques; Derivation of selection diversity improvement, derivation of maximal ratio combining improvement, practical space diversity consideration; Selection diversity, feedback or scanning diversity, maximal ratio combining, equal gain combining, polarization diversity, frequencydiversity, time diversity, RAKE receiver.

MODULE V	**WIRELESS NETWORKS**
	Introduction to wireless networks, advantages and disadvantages of wireless local area networks, WLAN topologies, WLAN standard IEEE 802.11, IEEE 802.11 medium access control, comparison of IEEE802.11 a,b,g and n standards, IEEE 802.16 and its enhancements, wireless PANs, Hipper LAN, WLL.

TEXTBOOKS

1. Theodore.S. Rapport, —Wireless Communications‖, Pearson Education, 2nd Edition, 2010.
2. UpenDalal, "Wireless communication", oxford University press.
3. KavehPahlvan, Prashant Krishnamurthy, "Principle of wireless networks", A United Approach‖, Pearson Education, 2004.
4. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005.

REFERENCE BOOKS:

1. P.Nicopolitidis, M.S. Obaidat, G.I.Papadimitria, A.S. Pomportsis,"Wireless Networks" John Wiley and sons, 1st Edition, 2003.
2. Vijay K Garg,"Wireless Communications and Networks", Morgan Kaufmann Publishers an Imprint of Elsevier, USA 2009 (Indian Reprint).
3. Mark Ciampa Jorge Olenewa, "wireless communication and Networking", IE, 2009.
4. X.Wang, H.V.Poor ,Wireless communication system, Pearson Education, 2004.
5. JochenSchiller,"Mobile Communication", Pearson Education, 2nd Edition, 2003.

WEB REFERENCES:

1. https://lms.iare.ac.in/index ?route=course/details& course id_137

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	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO)and CO-PO Mapping	-	
	CONTENT DELIVERY (THEORY)		
2	Frequency reuse and channel assignment strategies.	CO 1	T1-3.1-3.2
3	Handoff strategies: Prioritizing handoffs, practical handoff considerations.	CO 1	T1-3.3-3.4
4	Co-channel interference and system capacity	CO 1	T1-3.3-3.4
5	Trunking and grade of service	CO 1	T1-3.5

6	Improving coverage and capacity in cellular systems: Cell splitting, sectoring.	CO 1	T1-4.2
9	Introduction to radio wave propagation	CO2	T1-4.4
10	Free space propagation model and relating power to electric field	CO 2	T1-.5.1,4.5.2
11	Reflection: Reflection from dielectrics	CO 2	T1-4.6
12	Diffraction Fresnel zone geometry and knife-edge diffraction	CO 3	T1-4.7
13	Scattering and outdoor propagation models	CO 3	T1-4.10
15	Longley-Ryce model and okumura Model,	CO 3	T1-4.10.6
16	Indoor propagation models-partition losses (Same Floor) and partition losses between floors	CO 3	T1-4.11
18	Ericsson multiple break point model and attenuation factor model,	CO 3	T1-4.2
19	Small-scale fading and multipath	CO 3	T1-5.1.1
20	Factors influencing small scale fading	CO 3	T1-5.1.1
21	Relationship between bandwidth and received power	CO3	T1-5.1.1
22	Spread spectrum sliding correlator channel sounding and parameters of mobile multipath channels	CO 4	T1-5.2
23	Coherence bandwidth and doppler spread and coherence time, types of small - Scale fading.	CO 4	T1-5.3
25	Fading effects due to multipath time delay spread	CO 3	T1-5.3.2
26	Slow fading, statistical models for multipath fading channels	CO 3	T1-5.3.3,5.4
27	Clarkes model for flat fading	CO 4	T1-5.4.2
28	Simulation of clarke and gans fading model	CO 3	T1-5.5
29	Level crossing and fading statistics, two-ray Rayleigh fading model.	CO 3	T1-5.11
30	Small scale multipath measurements	CO 3	T1-5.11
32	Fading effects due to Doppler Spread-Fast fading	CO 3	T1-5.11
33	Two-ray Rayleigh fading model		T1-5.11
34	Fundamentals of equalization	CO 5	T1-7.1,7.2
37	Training a generic adaptive equalizer	CO 5	T1-7.3,7.4
39	Non-linear equalization	CO5	T1-7.6,7.7
40	Decision feedback equalization (DFE) and maximum likelihood sequence estimation equalizer (MLSE)	CO 5	T1-7.7.2
41	Algorithms for adaptive equalization	CO 5	T1-7.8
42	Derivation of selection diversity improvement	CO 5	T1-7.8.1,8.2
43	Derivation of maximal ratio combining improvement, practical space diversity consideration	CO 5	T1-7.10,11
44	Diversity techniques	CO 5	T1-7.10.2-3
45	Polarization diversity and RAKE receiver.	CO 5	T1-7.10.3

46	Introduction to wireless networks	CO 6	R3-P184
47	WLAN topologies and WLAN standard IEEE 802.11	CO6	R3-P185
48	Comparison of IEEE802.11 a,b,g and n standards	CO 6	R3-P191
49	IEEE 802.16 and its enhancements	CO 6	R3-P190
50	Wireless PANs, Hipper LAN, WLL.	CO 6	R3-P191
PROBLEM SOLVING/ CASE STUDIES			
7	Problems on grade of service	CO 1	T1-3.1-3.2
8	Problems on probability of cell system	CO 1	T1-3.3-3.4
14	Problems on effective aperture	CO 2	T1-4.6
17	Problems on diffraction loss	CO 3	T1-4.7
24	Problems on received power	CO 4	T1-5.1.1
31	Problems on Brewster angle	CO 4	T1-4.6
35	Problems on computation of rms delay	CO 4	T1-5.3.2
36	Problems on total power in the carrier	CO 4	T1-5.1.1
DISCUSSION ON DEFINITION AND TERMINOLOGY			
51	Interference in communication	CO 1	T1-3.1-3.24
52	Cluster in a cellular system	CO2	T1-4.1 to 4.9
53	Knife edge diffraction	CO3	T1-5.1 to 5.16
54	Topology	CO 5	T1-7.1 to 7.17
55	Significance of Equalization	CO 6	R3
DISCUSSION ON QUESTION BANK			
56	The cellular concept system design fundamentals	CO 1	T1-3.1-3.24
57	Mobile radio propagation	CO 2	T1-4.1 to 4.9
58	Cellular system design fundamentals	CO3	T1-5.1 to 5.16
59	Equalization and diversity	CO5	T1-7.1 to 7.14
60	Wireless networks	CO 6	R3

Signature of Course Coordinator **HOD,ECE**

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

COURSE DESCRIPTION

Department	**Electronnics and Communication Engineering**				
Course Title	**Cellular and Mobile Communications**				
Course Code	AECB39				
Program	B.Tech				
Semester	VI				
Course Type	Professional Elective-III				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr B.Santhosh Kumar, Assistant Professor				

I COURSE OVERVIEW:

The cellular mobile communication allows the users to communicate with others in different locations without the use of any physical connection. It covers the operation, performance criteria, handoff mechanism and channel assignments of the cellular system. The applications include Wi-Fi, Bluetooth, cell phones and wireless power transfer.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEC005	IV	Analog Communications
B.Tech	AEC009	V	Digital Communications

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Cellular and Mobile Communications	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
✓	Open Ended Experiments	✓	Techtalk	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
30%	Apply
0%	Analyze
0%	Evaluate
0%	Create

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

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

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

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

Alternative Assessment Tool (AAT)
This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes,

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

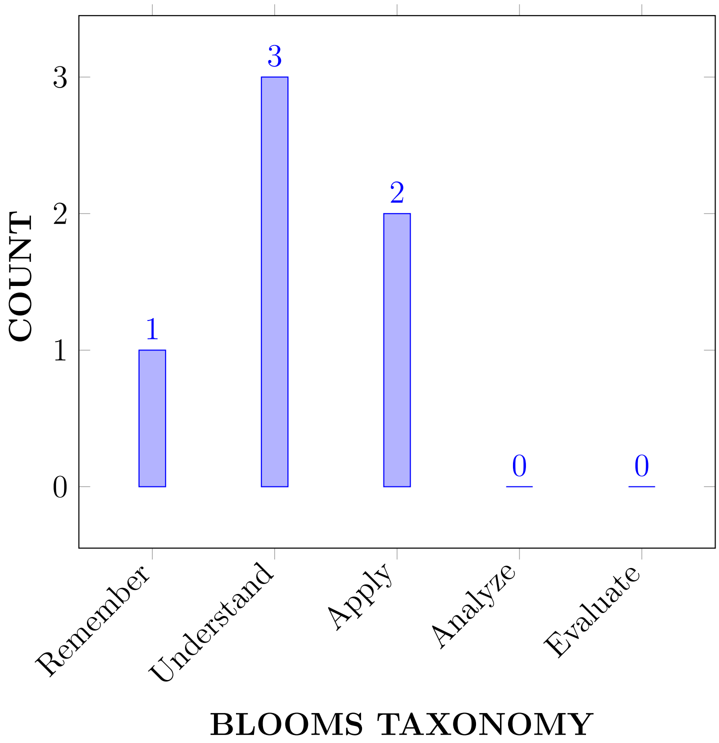
I	The cellular mobile system, cell coverage, cell site and mobile antennas system for interference reduction.
II	The wireless system standard applications for the Global System for Mobile Communications, Code Division Multiple Access and Time Division Multiple Access technologies.
III	The advanced intelligent network for wireless communications and future public land mobile telecommunications.

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the cellular mobile system design concepts to improve the Signal to noise ratio and cell coverage	Understand
CO 2	**Utilize** the omni directional and directional antennas to improve the channel capacity and interference reduction for improving the design parameters.	Apply
CO 3	**Find** the Co-channel and non co-channel interferences and their parameters to improve the system capacity.	Remember
CO 4	**Illustrate** the importance of Handoff for preventing loss of interruption of services to a caller.	Understand
CO 5	**Make use of** the Numbering and grouping, setup access and paging channels for low traffic in the mobile and land originating calls.	Apply
CO 6	**Infer** the Intelligent cell concept and advanced intelligent networkfor advanced land mobile telecommunication 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.

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	1	CIE/Quiz/AAT

3 = High; 2 = Medium; 1 = Low

X 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 digital signal processing applications	–	–
PSO 2	**Focus** on the Application specific Integrated circuits (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	Research papers /Project

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	PO1	**Identify** the basic mobile telephone Systems by applying the **mathematics, science and engineering fundamentals** to solve the limitations of the conventional system.	3
	P02	**Understand** the cellular mobile system design concepts (**problem statement**) and **implementation** (solution development) of the information and general description and **interpretation** of the problem.	4

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 2	PO1	**Understand** the concept of frequency reuse channels, deduce the co-channel interference reduction factor.	3
	PO3	**Outline** the concept of frequency channels and desired C/I in an omni directional antenna system.	2
CO 3	PO1	**Remember** concepts of cell coverage for signal and traffic.	2
	PO2	**Compare** the co-channel and non co-channel interferences, antenna system and their parameters.	5
	PSO3	**Understand** impairments due to multipath fading channel and be able simulate standard stochastic channel models for various environments.	2
CO 4	PO1	**Illustrate** the concepts of signal reflects in flat and hilly terrain and phase difference between direct and reflected paths.	2
CO 5	PO1	**Interpret** current and proposed cellular technologies	2
	PO3	**Analyze** various methodologies to improve the channel capacity and reduce the interferences	2
	PSO3	**Interpret** current and proposed cellular technologies	2
CO 6	PO1	**Utilize** the advanced wireless technologies for future wireless networks .	3
	PO2	**Illustrate** the concepts of signal reflects in flat and hilly terrain and phase difference between direct and reflected paths.	5
	PSO3	**Able** to work in advanced research wireless and mobile cellular networks.	1

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	3	10	10	11	1	5	3	3	12	5	12	8	2	2	2
CO 1	100	40	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	100	-	20	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	67	50	-	-	-	-	-	-	-	-	-	-	-	-	100
CO 4	67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	67	-	20	-	-	-	-	-	-	-	-	-	-	-	100
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	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	3
CO 4	3	-	-	-	-	-	-	-	-	-	-		-	-	-
CO 5	3	-	1	-	-	-	-	-	-	-	-	-	-	-	3
CO 6	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2
TOTAL	18	5	2	-	-	-	-	-	-	-	-	-	-	-	8
AVERAGE	3	1.66	1	-	-	-	-	-	-	-	-	-	-	-	2.66

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	**CELLULAR MOBILE RADIO SYSTEMS**
	Introduction to cellular mobile System, performance criteria, uniqueness of mobile radio environment, operation of cellular systems, hexagonal shaped cells, analog and digital Cellular systems, General description of the problem, concept of frequency channels, Co-channel Interference Reduction Factor, desired C/I from a normal case in a omni directional Antenna system, Cell splitting, consideration of the components of Cellular system.
MODULE II	**INTERFERENCE AND CELL COVERAGE FOR SIGNAL AND TRAFFIC**
	Introduction to Co-Channel Interference, real time Co-Channel interference, Co-Channel measurement, design of Antenna system, Antenna parameters and their effects, diversity receiver, non-cochannel interference-different types, Signal reflections in flat and hilly terrain, effect of human made structures, phase difference between direct and reflected paths, constant standard deviation, straight line path loss slope, general formula for mobile propagation over water and flat open area, near and long distance propagation antenna height gain, form of point to point model.
MODULE III	**CELL SITE AND MOBILE ANTENNAS**
	Sum and difference patterns and their synthesis, omni directional antennas, directional antennas for interference reduction, space diversity antennas, umbrella pattern antennas, minimum separation of cell site antennas, high gain antennas, Numbering and grouping, setup access and paging channels channel assignments to cell sites and mobile units, channel sharing and borrowing, sectorization, overlaid cells, non-fixed channel assignment, Handoff, dropped calls and cell splitting, types of handoff, handoff invitation, delaying handoff, forced handoff, mobile assigned handoff. Intersystem handoff, cell splitting, micro cells, vehicle locating methods, dropped call rates and their evaluation.
MODULE IV	**WIRELESS SYSTEMS AND STANDARDS**
	Second generation and Third generation Wireless Networks and Standards, WLL, Bluetooth, GSM, IS95, DECT, GSM architecture, GSM channels, multiplex access scheme, TDMA, CDMA.
MODULE V	**INTELLIGENT NETWORK FOR WIRELESS COMMUNICATIONS**

	Intelligent cell concept, advanced intelligent network, SS7 network and ISDN for AIN, AIN for mobile communication, asynchronous transfer mode technology, future public land mobile telecommunication system, wireless information superhighway

TEXTBOOKS

1. W.C.Y. Lee, "Mobile Cellular Telecommunications", Tata McGraw-Hill, 2nd Edition, 2006.
2. Gordon L. Stuber, "Principles of Mobile Communications", Springer International, 2nd Edition, 2007.
3. Yi-Bing Lin and Imrich chlantae, "Wireless and Mobile Network Architecture", John Wiley, 1st Edition, 2006.

REFERENCE BOOKS:

1. Theodore. S. Rapport, "Wireless Communications", 3rd Edition, Pearson Education, 2003.
2. Lee, "Wireless and Mobile Communications", McGraw Hill, 3rd Edition, 2006.
3. Jon W. Mark and Weihua Zhqung, "Wireless Communication and Networking", PHI, 1st Edition, 2005.
4. R. Blake, "Wireless Communication Technology", Thompson Asia Pvt. Ltd., 1st Edition 2004.

COURSE WEB PAGE:

https://lms.iare.ac.in/index ?route=course/details course id 127

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_127
CONTENT DELIVERY (THEORY)			
2	Introduction, Frequency Reuse.	CO 1	T1-3.2-3.3
3	Channel Assignment Strategies, Handoff Strategies.	CO 1	T1-3.3-3.4
4	Prioritizing Handoffs, Practical Handoff Considerations	CO 2	T1-3.3-3.4
5	Interference and system capacity -Co channels Interference and system capacity	CO 2	T1-3.5
6	Channel planning for Wireless Systems.	CO 1	T1-4.2

7	Trunking and Grade of Service	CO2	T1-4.4
8	Brewster Angle, Reflection from prefect conductors	CO 2	T1-4.2
9	Reflection: Reflection from dielectrics	CO 1	T1-4.6
10	The Three Basic Propagation Mechanisms, Reflection-Reflection from Dielectrics	CO 3	T1-4.7
11	Scattering and outdoor propagation models	CO 2	T1-4.10
12	Longley-Ryce model and okumura Model,	CO 1	T1-4.10.6
13	Indoor propagation models-partition losses (Same Floor) and partition losses between floors	CO 3	T1-4.11
14	Ericsson multiple break point model and attenuation factor model,	CO 3	T1-4.2
15	Small-scale fading and multipath	CO 2	T1-5.1.1
16	Factors influencing small scale fading	CO2	T1-5.1.1
17	Relationship between bandwidth and received power	CO 2	T1-5.1.1
18	Spread spectrum sliding correlator channel sounding and parameters of mobile multipath channels	CO 4	T1-5.2
19	Coherence bandwidth and doppler spread and coherence time, types of small - Scale fading.	CO 4	T1-5.3
20	Fading effects due to multipath time delay spread	CO 2	T1-5.3.2
21	Slow fading, statistical models for multipath fading channels	CO 3	T1-5.3.3,5.4
21	Clarkes model for flat fading	CO 3	T1-5.4.2
22	Ground Reflection (Two-Ray) Model, Diffraction-Fresnel Zone Geometry	CO 5	T1-5.5
23	Level crossing and fading statistics, two-ray Rayleigh fading model.	CO 5	T1-5.11
24	Small scale multipath measurements	CO 3	T1-5.11
25	Fading effects due to Doppler Spread-Fast fading	CO 6	T1-5.11
26	Two-ray Rayleigh fading model	CO 3	T1-5.11
27	Fundamentals of equalization	CO 4	T1-7.1,7.2
28	Training a generic adaptive equalizer	CO 4	T1-7.3,7.4
29	Non-linear equalization	CO 4	T1-7.6,7.7
30	Decision feedback equalization (DFE) and maximum likelihood sequence estimation equalizer (MLSE)	CO 4	T1-7.7.2
31	Algorithms for adaptive equalization	CO 5	T1-7.8

32	Derivation of selection diversity improvement	CO 4	T1-7.8.1,8.2
33	Derivation of maximal ratio combining improvement, practical space diversity consideration	CO 5	T1-7.10,11
34	Diversity techniques	CO 4	T1-7.10.2-3
35	Polarization diversity and RAKE receiver.	CO 4	T1-7.10.3
36	Introduction to wireless networks	CO 5	R3-P184
37	WLAN topologies and WLAN standard IEEE 802.11	CO 4	R3-P185
38	Comparison of IEEE802.11 a,b,g and n standards	CO 4	R3-P191
39	IEEE 802.16 and its enhancements	CO 4	R3-P190
40	Wireless PANs, Hipper LAN, WLL.	CO 5	R3-P191
PROBLEM SOLVING/ CASE STUDIES			
41	Problems on Signal reflections in flat and hilly terrain	CO 2	T1-3.1-3.2
42	Problems on probability of cell system	CO 3	T1-3.3-3.4
43	Problems on effective aperture	CO 4	T1-4.6
44	Problems on diffraction loss	CO 3	T1-4.7
45	Problems on received power	CO 4	T1-5.1.1
46	Problems on grade of service	CO 6	T1-4.6
47	Problems on phase difference between direct and reflected paths	CO 4	T1-5.3.2
48	Problems on path loss slope	CO 5	T1-5.1.1
DISCUSSION ON DEFINITION AND TERMINOLOGY			
49	The cellular concept system design fundamentals	CO 1	T1-3.1-3.24
50	Mobile radio propagation	CO 3	T1-4.1 to 4.9
51	Cellular system design fundamentals	CO 5	T1-5.1 to 5.16
52	Equalization and diversity	CO 4	T1-7.1 to 7.17
53	Asynchronous transfer mode technology	CO 3	R3 7.4-7.8
DISCUSSION ON QUESTION BANK			
54	The cellular concept system design fundamentals	CO 2	T1-3.1-3.24
55	Mobile radio propagation	CO 3	T1-4.1 to 4.9
56	Channel sharing, borrowing, sectorization and overlaid cells	CO 5	T1-5.1 to 5.16
57	WLL, Bluetooth, GSM, IS95, DECT	CO 4	T1-7.1 to 7.14
58	Wireless networks and standards	CO 5	R3-8.6-8.9
59	SS7 network and ISDN for AIN, AIN for mobile communication	CO 6	T2-9.9 to 9.12

60	Intelligent cell concept, advanced intelligent network	CO 6	T2-9.3 to 9.7

Course Coordinator **HOD,ECE**
Mr B.Santhosh 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**

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.

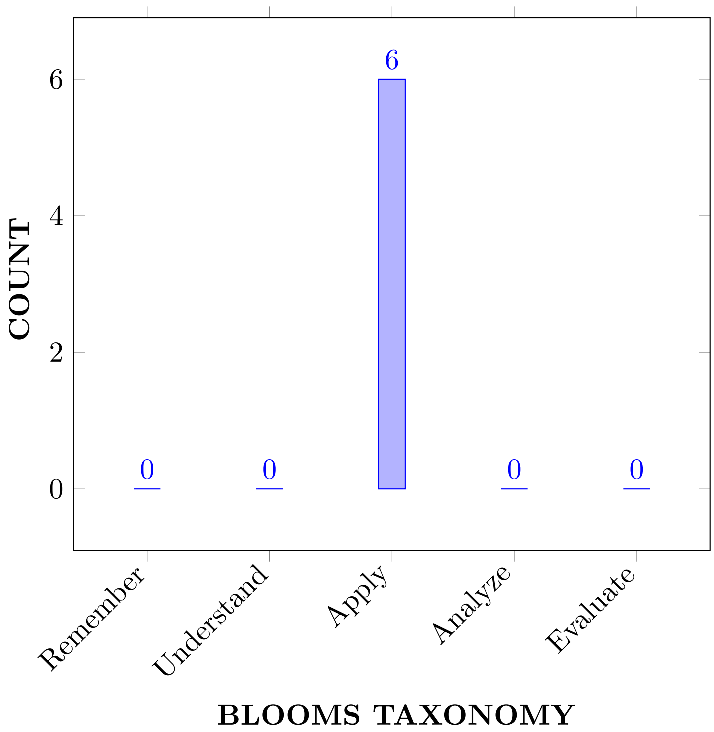
VII COURSE OUTCOMES:

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

ELECTRONICS AND COMMUNICATION ENGINEERING

COURSE DESCRIPTION

Course Title	**DIGITAL SIGNAL PROCESSING LABORATORY**				
Course Code	AECB25				
Program	B.Tech				
Semester	VI	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	2	1
Course Coordinator	Dr.S.China Venkateswarlu, Professor				

I COURSE OVERVIEW:

This course is concerned with the implementation of digital signal processing algorithms using different computational platforms such as MATLAB and DSP tools that give core knowledge to develop the real time applications in the area of DSP. It focuses on the convolution, discrete Fourier transform, fast Fourier transform algorithms, digital filter design and multi rate signal processing. Digital signal processing applications are used in speech processing, image processing, audio and video data compression, communication systems.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB17	IV	Signals and systems laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Digital signal processig 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:

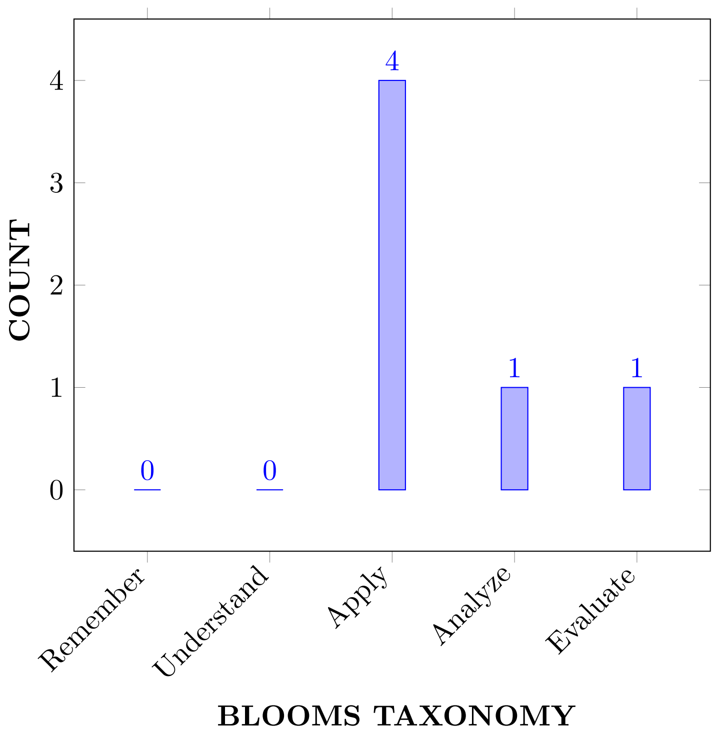
I	The behavior of discrete time signals and systems in time and frequency domain.
II	The analysis of IIR, FIR digital filters and multi rate signal processing systems.
III	The implementation of real time digital signal processing algorithms using MATLAB tool and TI TMSC67XX target board.

VII COURSE OUTCOMES:

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

CO 1	**Apply** discrte Fourier transform for spectral analysis of discrete signals.	Apply
CO 2	**Apply** fast Fourier transform algorithms for reducing computational complexity of discrete Fourier transform.	Apply
CO 3	**Compare** IIR digital filter and FIR Digital filters using different methods.	Evaluate
CO 4	**Analyze** the Goertzel algorithm for the generation and detection of dual-tone multi-frequency (DTMF) signaling.	Analyze
CO 5	**Apply** multi-rate signal processing methods such as decimation and interpolation for interfacing the digital systems with different sampling rates.	Apply
CO 6	**Apply** the digital signal processing algorithms for designing real time embedded signal processing applications.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	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	3	Lab Exercises/ CIE/ SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Exercises/ CIE/ SEE
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	1	Lab Exercises/ Projects
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	Lab Exercises/ Projects

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.	2	Lab Exercises/ CIE/ SEE

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	PO 2	Understand the given **problem statement and formulate** to analyze the response of LTI system in the time domain and frequency domain from provided **information and data.**	3
	PO 5	**Apply**the concept of convolution for finding the response of LTI system using MATLAB tool.	1
	PO 10	**Demonstrate** the ability to communicate effectively in Design and implementation for spectral analysis of discrete signals and make effective Interpretation. .	1
CO 2	PO 2	Understand the given **problem statement and formulate**the design (complex) engineering problems of spectral characteristics of discrete time signals from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results.**	4
	PO 5	Select MATLAB tool for analyzing the discrete signals and systems in frequency domain to meet system specifications including **prediction and modeling to complex engineering activities** with an understanding of the limitations.	1
	PO 10	**Demonstrate** the ability to communicate effectively in Design and implementation for reducing computational complexity of discrete Fourier transform and make effective Interpretation.	1
	PSO 1	Develop the capability to (**analyze and apply** DFT and their properties on discrete signals in applications by its **mathematical models**	1
CO 3	PO 2	Understand the given (**problem statement and formulate**)(complex) convolution sum by using overlap add and overlap save method from provided **information and data**in reaching substantiated conclusions by the **interpretation of results.**	4
	PO 5	Apply overlap add method and overlap save methods for filtering of long duration of sequences using MATLAB to meet system specifications including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	1
	PO 10	**Demonstrate** the ability to communicate effectively in Design and implementation using different methods and make effective Interpretation.	1
CO 4	PO 2	Formulate and analyze **(Problem analysis) complex Engineering problems** for fast Fourier transform of discrete signals using first principles of **mathematics and Engineering sciences.**	3

	PO 5	Apply fast Fourier transform algorithms for reducing computational complexity using MATLAB to meet system specifications including prediction and modeling to **complex engineering activities** with an understanding of the limitations.	1
	PO 10	**Demonstrate** the ability to communicate effectively in Design and implementation for the generation and detection of dual-tone multi-frequency (DTMF) signaling and make effective Interpretation.	1
	PSO 1	Develop the capability to analyze the spectral characteristics by applying fast Fourier transform(FFT) algorithms on discrete signals and systems applications by its **mathematical models.**	1
CO 5	PO 2	Understand the given **problem statement and formulate** for designing the (complex) infinite impulse response(IIR)digital filters from the provided **information and data** in reaching substantiated conclusions by the **interpretation of results.**	4
	PO 3	Design infinite impulse response(IIR) digital filters using Butterworth and chebyshev for determining magnitude and phase response by applying the principles of **mathematics, science to the solutions of complex engineering problems and design system components.**	3
	PO 5	Analyze the performance parameters of IIR filters using chebyshev in MATLAB to meet system specifications including **prediction and modeling to complex engineering activities** with an understanding of the limitations.	1
	PO 10	**Demonstrate** the ability to communicate effectively in Design and implementation for interfacing the digital systems with different sampling rates and make effective Interpretation.	1
CO 6	PO 2	Understand the given **problem statement and formulate**for designing the (complex) engineering problems of FIR filters from the provided **information and data**in reaching substantiated conclusions by the **interpretation of results.**	4
	PO 3	Design FIR filters using windows and frequency sampling methods using **principles of mathematics and engineering sciences.**	2
	PO 5	Analyze the performance parameters of FIR filters using chebyshev in MATLAB to meet system specifications including **prediction and modeling to complex engineering activities** with an understanding of the limitations.	1
	PO 10	**Demonstrate** the ability to communicate effectively in Design and implementation for designing real time embedded signal processing applications and make effective Interpretation.	1

	PSO 1	Develop the capability to **analyze and apply** windows and frequency sampling methods for designing of FIR filters by its **mathematical models.**	2

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

COURSE OUTCOMES	PROGRAM OUTCOMES				PSO'S
	PO 2	PO 3	PO 5	PO 10	PSO 1
CO 1	3			1	
CO 2	4		1	1	1
CO 3	4		1	1	
CO 4	3		1	1	1
CO 5	4	3	1	1	
CO 6	4	2	1	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	**LINEAR CONVOLUTION VS CIRCULAR CONVOLUTION**
	Generation of linear convolution without using built in function and the function conv in MATLAB Generation of circular convolution without using built in function in MATLAB.
WEEK II	**DFT AND IDFT**
	Compute the Discrete Fourier Transform and IDFT with and without fft and ifft in MATLAB.

WEEK III	**OVERLAPADD AND OVERLAP-SAVE METHODS**
	Implementation of Linear convolution using DFT (Overlapadd and Overlap-Save methods).
WEEK IV	**DIT-FFT ALGORITHM**
	Implementation of Decimation-in-time radix-2 FFT algorithm.
WEEK V	**DIF-FFT ALGORITHM**
	Implementation of Decimation-in-frequency radix-2 FFT algorithm.
WEEK VI	**IIR DIGITAL FILTERUSING BUTTERWORTH METHOD AND BILINEAR TRANSFORMATION**
	Implementation of IIR digital filter using Butterworth method and bilinear transformation.
WEEK VII	**IIR Digital Filter Using Chebyshev (Type I And II) Method**
	Implementation of IIR digital filter using Chebyshev (Type I and II) method.
WEEK VIII	**FIR DIGITAL FILTER USING WINDOWS**
	Implementation of FIR digital filter using window (Rectangular, Hamming, Hanning, Bartlett) methods.
WEEK IX	**FIR DIGITAL FILTER USING FREQUENCY SAMPLING METHOD**
	Implementation of FIR digital filter using frequency sampling method.
WEEK X	**OPTIMUM EQUIRIPPLE FIR DIGITAL FILTER**
	Implementation of optimum equiripple FIR digital filter using window methods.
WEEK XI	**DTMF TONE GENERATION AND DETECTION**
	DTMF Tone Generation and Detection Using Goertzel Algorithm.
WEEK XII	**SAMPLING RATE CONVERSION**
	Implementation of sampling rate conversion by decimation, interpolation and a rational factor using MATLAB.
WEEK XIII	**SINE WAVE GENERATION**
	a) Implementation of DFT b) Sine wave generation using lookup table with values generated from MATLAB.
WEEK XIV	**IIR AND FIR FILTERS USING DSP KITS**
	IIR and FIR Filter Implementation using DSP Kits.

TEXTBOOKS

1. John G. Proakis, Dimitris G. Manolakis, Digital signal processing, Principles, Algorithms and Applications, Prentice Hall, 4th Edition, 2007 .
2. Sanjit K Mitra, Digital signal processing, A computer base approach, McGraw-Hill Higher Education, 4th Edition, 2011.
3. Emmanuel C, Ifeacher, Barrie. W. Jervis, DSP-A Practical Approach, Pearson Education, 2nd Edition, 2002.
4. A.V. Oppenheim, R.W. Schaffer, Discrete Time Signal Processing, PHI, 2nd Edition, 2006.

REFERENCE BOOKS:

1. RobertJ.schilling,Sandra.L.harris, "Fundamentals of Digital Signal Processing using MATlab" , Thomson Engineering, 2nd Edition,2005.
2. Vinay K. Ingle , John G. Proakis, "Digital Signal Processing Using MATlab", Cengage 4th Edition, 2009.

3. DSK Donald Reay, Rulph Chassaing, "Digital Signal Processing and Applications with the TMS 320C6713 and TMS 320C6416" Wiley 2^{nd} Edition.

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	Linear convolution vs circular convolution	CO 1	T1: 2.3.3
2	DFT and IDFT	CO 1	T1: 7.2
3	Overlap-add and overlap-save methods	CO 1	T1: 2.3.4
4	DIT-FFT algorithm	CO 2	T1: 8.1
5	DIT-FFT algorithm	CO 2	T1: 8.2
6	IIR digital filter using Butterworth method and bilinear transformation	CO 3	T1: 10.3
7	IIR digital filter using Chebyshev (Type I and II) method	CO 3	T1: 10.3
8	FIR digital filter using windows	CO 4	T1: 10.2
9	FIR digital filter using frequency sampling method	CO 4	T1: 10.3
10	Optimum equiripple FIR digital filter	CO 4	T1: 10.4
11	DTMF tone generation and detection	CO 5	T3:6.6
12	Sampling rate conversion	CO 5	T1: 11.6
13	Sine wave generation	CO 5	T1:2.1-2.2
14	IIR and FIR filters using DSP kits	CO 6	T1: 10.3

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design an audio application such as to plot a time and frequency display of microphone plus a cosine using DSP chip .
2	Develop compressors and expanders to decrease and increase the dynamic range of audio signals in computer music.
3	Converting CD DATA TO DVD DATA.
4	Design Vocoders (voice coder) to reduce the bandwidth requirements of normal voice signal using analysis-synthesis sections.
5	Noise removal: Add noise above 3 KHz and then remove interference suppression using 400 Hz tone.

Signature of Course Coordinator **HOD,ECE**
Dr.S.China Venkateeswarlu, Professor of ECE

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

Department	**ELECTRONICS AND COMMUNICATION ENGINEERING**				
Course Title	**VLSI Design**				
Course Code	AECB27				
Program	B.Tech				
Semester	VII ECE				
Course Type	Core				
Regulation	IARE-R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	-	-	-
Course Coordinator	Ms K.S.Indrani, Assistant Professor, ECE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB07	III	Digital System Design
B.Tech	AECB19	V	Integrated Circuits Applications

II COURSE OVERVIEW:

This course introduces the students the fabrication techniques of design and implementation of very large scale (VLSI) circuits. Specific topics include: CMOS logic, MOSFET theory, design rules & layout procedures and logic and circuit simulations. The course further gives information on data path subsystems, PLD's performance parameters and testing approaches for the circuits.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
VLSI design	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two 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
15 %	Apply
35%	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:

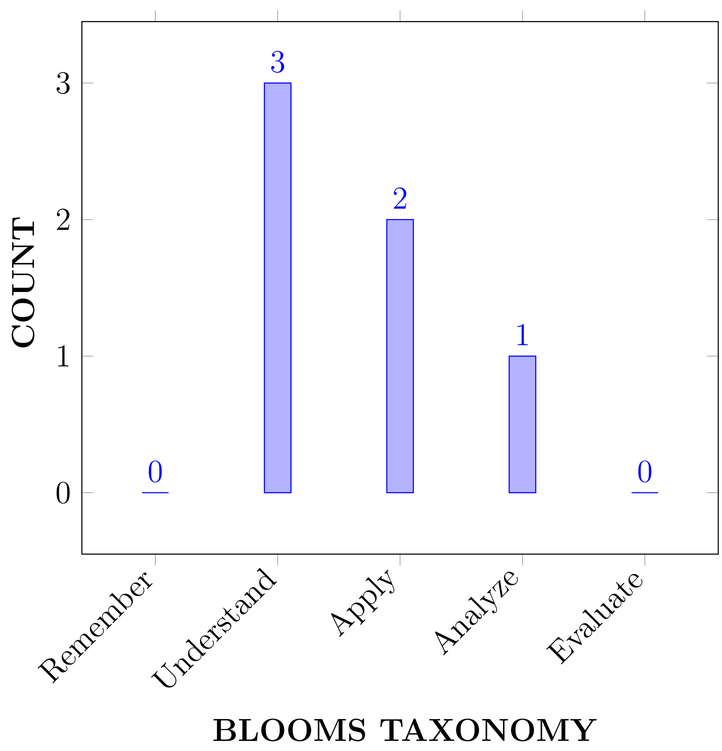
I	The aspects of hierarchical VLSI design from the metal oxide semiconductor transistor up to the system level, fabrication and testing.
II	The subsystem design incorporating into a VLSI chip with contemporary techniques for achieving high-speed, low-power and low area overhead.
III	Advanced modern tools such as vivado and cadence for front end and back end for chip design through a practical approach.

VII COURSE OUTCOMES:

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

CO 1	**Summarize** the MOSFET fabrication process , electrical properties,scaling for analyzing reliability issues and understanding latest trends in VLSI .	Understand
CO 2	**Develop** the stick diagrams, layouts of MOS circuits using lambda, absolute and Euler physical design rules.	Apply
CO 3	**Describe** inverters, complex gates and dynamic CMOS circuits interms of power consumption, distortion and speed of operation	Understand
CO 4	**Explain** data path subsystems and array subsystemsusing stick diagrams and layouts.	Apply
CO 5	**Outline** the role of Programmable logic devices for realization of complex boolean functions.	Understand
CO 6	**Examine** the test strategies, implementation approach on full custom and semi custom design for speed, cost, reconfiguration and reliability parameters.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

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

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.	3	SEE, CIE, AAT

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
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	Relate the fabrication process **(knowledge)** ,occurrence of latch up by applying the principles of **mathematics, science and engineering fundamentals**	3
	PO 2	Formulate and analyze **(problem analysis) complex Engineering problems for** MOSFET scaling and its effect using the first principles of **mathematics and engineering sciences**	3
	PO 10	Describe the effects of scaling on MOS circuits for area, delay, power with **clarity**	1
CO 2	PO 1	**Build** the stick diagrams, layouts of MOS circuits **(knowledge)** by following design rules with **mathematics, science and engineering fundamentals**	3
	PO 2	Understand the given **problem statement** and **formulate** the circuit design, **translate the information** into the model using stick diagram and layout **validate** the output of the circuit in reaching substantiated conclusions by the **interpretation of results.**	5
	PO 4	**Design** layout of transistors from stick diagram **using experimental design and analyze** the characteristics of circuit	2
	PO 10	Explain the stick diagrams, layouts of MOS circuits using lambda, absolute and Euler physical design rules with **clarity**	1

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PSO 2	Design any type of ASIC ,SOC designs using cadence tools and analyze the speed, area and delay with the knowledge of layout.	2
CO 3	PO 1	Examine the conditions mathematically for improved performance of inverters, static and dynamic gates regarding symmetry of transfer characteristics, rise, fall times **(knowledge)** by applying the field effect transistor **fundamentals** with support from other engineering disciplines, **mathematics, and scientific methodologies**	2
	PO 2	Understand the given **problem statement and formulate** conditions for improved performance of inverters, static and dynamic gates from the given **information and data** in reaching substantiated conclusions by the **interpretation of results**	4
	PO 4	**Design** the circuit using various CMOS logics **using experimental design and analyze** the features of circuit in terms of area ,delay	2
	PO 10	Describe inverters, complex gates and dynamic CMOS circuits for power consumption, distortion and speed of operation with **clarity**	1
CO 4	PO 1	**Describe** data path subsystems **(knowledge)** consisting of shifters, adders, multipliers, ALUs, parity generators, counters and comparators with the support of **VLSI engineering tools such as stick diagrams and layouts, mathematics, science and engineering fundamentals**	3
	PO 2	Formulate and analyze **(problem analysis) complex Engineering problems** for data path subsystems consisting of shifters, adders, multipliers, ALUs, parity generators, counters and comparators using first principles of **mathematics and engineering sciences**	5
	PO 4	**Design** various data path subsystems using **research-based knowledge and research methods** including design of experiments.	2
	PO 10	Explain data path subsystems containing arithmetic logic units, parity generators, comparators and memories using stick diagrams and layouts. with **clarity**	1
	PSO 2	Focus on the data path subsystems and array subsystems these type of system are prototype for ASIC and SOC designs	2
CO 5	PO 1	**Design** the boolean functions with the **(knowledge)** of programmable logic devices, choose appropriate logic device with the **engineering fundamentals**	3

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems , **translate the information** into the model using boolean function from the provided **information and data**based on the functionality of the circuit,**validate** the output of the circuit in reaching substantiated conclusions by the **interpretation of results** with help of CPLD and FPGA devices.	7
	PO 3	**Design solutions** using programmable logic devices with **innovative solution** and implementing them using modern tools such as cadence software, verilog and VHDLtools.	3
	PO 4	Examine any logic function using **design of experiments, analysis and interpretation of data** with cadence or verilog tools	2
	PO 10	Describe implementation approaches on boolean functions on FPGA with**clarity**	1
CO 6	PO 1	Discuss importance of full custom and semi custom designs with **(knowledge) using** scientific principles and methodology **of VLSI design**	2
	PO 2	Understand the given **problem statement** and **formulate** the (complex) engineering problems of VLSI systems, **translate the information** into the model using cadence software **develop solutions**based on the functionality of the circuit,**validate** the output of the circuit by applying various testing methods and **interpret the results.**	7
	PO 3	**Design solutions for complex engineering problems and design system components** using full custom or semi custom designs **innovative solution** and implementing them using modern tools and verify the results using testing methods	3
	PO 4	Examine sequential and combinational logic circuits with **design of experiments, analysis and interpretation of data** using various test procedures.	2
	PO 10	Prepare for Tech talks and concept video presentations keeping in view of latest trends in technology with **clarity.**	1
	PSO 2	**Focus on testing of application specific integrated circuit (ASIC) prototype designs, virtual instrumentation designs and system on chip (SOC) designs** appropriate for entry level job positions in front end or back end to meet the requirements of employers.	2

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

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

COURSE OUTCOMES	PO's / NO. OF VITAL FEATURES												PSO'S		
	PO 1	PO 2	PO 3	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	3	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	5	-	2	-	-	-	-	-	1	-	-	-	-	-
CO 3	3	4	-	2	-	-	-	-	-	1	-	-	-	-	-
CO 4	3	5	2	2		-	-	-	-	1	-	-	-	2	-
CO 5	3	7	3	2	-	-	-	-	-	1	-	-	-	-	-
CO 6	2	7	3	2	-	-	-	-	-	1	-	-	-	2	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	100	30	-	-	-	-	-	-	-	20	-	-	-	-	-
CO 2	66	50	-	18	-	-	-	-	-	20	-	-	-	-	-
CO 3	100	40	-	18	-	-	-	-	-	20	-	-	-	-	-
CO 4	100	50	20	18	-	-	-	-	-	20	-	-	-	100	-
CO 5	100	70	30	18	-	-	-	-	-	20	-	-	-	-	-
CO 6	66	70	30	18	-	-	-	-	-	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	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	2	-	1	-	-	-	-	-	1	-	-	-	-	-
CO 3	3	1	-	1	-	-	-	-	-	1	-	-	-	-	-
CO 4	3	2	1	1	-	-	-	-	-	1	-	-	-	3	-
CO 5	3	2	1	1	-	-	-	-	-	1	-	-	-	-	-
CO 6	3	3	1	1	-	-	-	-	-	1	-	-	-	3	-
TOTAL	18	11	3	5	-	-	-	-	-	6	-	-	-	6	-

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AVERAGE	3	1.8	1	1	-	-	-	-	-	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	**MOSFETS**
	Introduction to IC Technology: MOS; PMOS; NMOS, CMOS and BiCMOS, Fabrication Flow; Basic electrical Properties of MOS and BiCMOS Circuits: Ids-Vds relationships in saturation and ohmic regions, MOS transistor threshold Voltage, gm, gds, Figure of merit, Pass transistor; NMOS Inverter; Various pull ups; CMOS Inverter analysis and design; Bi-CMOS Inverters; Latchup.
MODULE II	**VLSI DESIGN STYLES**
	VLSI Design Flow; MOS Layers; Stick Diagrams; Physical layout design rules: Absolute and lambda based CMOS design rules for wires, contacts and transistors, Euler's rule for physical design with examples; Transistors Layout Diagrams for NMOS and CMOS Inverters; Scaling of MOS circuits; Trends and projections in VLSI design and technology; CMOS nanotechnology
MODULE III	**BASIC CIRCUIT CONCEPTS AND GATE LEVEL DESIGN**
	Sheet Resistance and area capacitance of layers; Inverter Time delays; Driving large capacitive loads; Propagation Delays; Wiring capacitances; Fan-in and Fan-out; Choice of layers; VLSI Interconnects; Reliability issues in CMOS VLSI; Latching; Electro-migration. Gate Level Design: Complex gates, Switch logic; Transmission gates; Other forms of CMOS logic such as Pseudo –nMOS; Dynamic CMOS; Clocked CMOS; CMOS domino; n-p CMOS.

MODULE IV	**DATA PATH SUBSYSTEMS**
	Data Path Sub Systems: Sub system design; Barrel shifters; Ripple carry, Carry Look Ahead, Carry select Adders, Manchester carry chain ; ALUs; Multipliers; Parity generators; Comparators; Zero/one detectors; Asynchronous and Synchronous Counters; Array Subsystems: SRAM, DRAM, ROM, Floating gate concepts and Flash Memories, Serial access Memories.
MODULE V	**LOGIC DESIGN AND TESTING STRATEGIES**
	Programmable Logic Devices: Design Approach – PROM, PLA and PAL; FPGAs; CPLDs; FPGA building block architectures; FPGA interconnect routing procedures; Speed and area tradeoff; Implementation strategies: Full custom and semi custom design; CMOS Testing; Built-in Self –Test Strategies

TEXTBOOKS

1. A. Pucknell, Kamran Eshraghian, "BASIC VLSI Design," Third Edition, Prentice Hall of India, 2007. ISBN: 978-81-203-0986-9

2. R. Jacob Baker, Harry W.LI., David E.Boyee, "CMOS Circuit Design, Layout and Simulation," Wiley-IEEE Press, USA, 2005. ISBN: 978-0-470-88132-3

3. Jan Rabaey, Anantha Chandrakasan, B.Nikolic, "Digital Integrated Circuits: A Design Perspective," Second Edition, Phi Learning, 2009. ISBN: 97881203225789

REFERENCE BOOKS:

1. N. Weste, K. Eshraghian, "Principles of CMOS VLSI Design", Second Edition, Addision Wesley, 1993. ISBN: 978-81-317-1942-8

2. M.J. Smith, "Application Specific Integrated Circuits", Addisson Wesley, First edition, 1997. ISBN-13: 978-0321602756

3. John P. Uyemura, "CMOS Logic Circuit Design," Springer, USA, 2007. ISBN: 0-7923-8452-0 Yuan S W, "Foundations of fluid Mechanics", Prentice-Hall, 2nd Edition, 1987.

WEB REFERENCES:

1. https://https://lms.iare.ac.in/index?route=course/details &course_id=361

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 Overview, Elaboration of Objectives and Outcomes.		https://lms.iare.ac.in/index?route=course/details&course_id=361
CONTENT DELIVERY (THEORY)			
2	Importance of IC technology and basics of MOSFETs	CO1	T1-1.1-1.3,1.4
3	NMOS, PMOS and CMOS fabrication Flow and twintub	CO1	T1-1.7,1.8
4	Process flow of BiCMOS- Latch up problem in CMOS	CO1	R1-2.1-2.2
5	Different Current - voltage characteristics of a MOSFET, Threshold voltage concept in MOSFETs.	CO 1	T1-2.2
5	Effect of transconductance, output conductance and figure of merit on performance characterstics of MOS.	CO 1	T1-2.12
6	PASS transistors , NMOS inverter design and impedance ratios of Nmos inverter.	CO 3	R1-4.7
7	Alternative forms of Pull –up's, CMOS inverter design and properties	CO 3	R1-2.5.3
8	Various forms of Bi-CMOS inverters	CO 3	T1-2.6
9	Processing steps of VLSI Design	CO 1	T1-3.1, 3.2.
10	Introduction to Stick Diagrams; Physical design rules	CO 2	T1-3.4,3.5
11	Introduction to Lambda based design rules	CO 2	T1-3.3
12	Double metal MOS process rules, 2µm design rules, Contact cuts	CO 2	T1-3.4,3.5
13	Euler's rule for physical design	CO 2	T1-3.3
14	Scaling in MOS circuits	CO 1	R1-4.8
15	Model and effects of scaling	CO 1	R1-4.8
16	VLSI Interconnects, Reliability issues in CMOS VLSI	CO 1	R1-4.5
17	Trends and projections in VLSI design and technology, CMOS Nano technology	CO 1	R1-4.7
18	Sheet Resistance and area capacitance of MOS layers	CO 3	T1-2.13,
19	Inverter Time delays, Driving large capacitive loads	CO 3	T1-6.3

20	Propagation Delays, Wiring capacitances; Fan-in and Fan-out	CO1	T1-6.2
21	Gate level design: complex gates, Switch logic-	CO 3	T1-4.11
22	Transmission gates ,Other forms of CMOS logic such as Pseudo –nMOS	CO 3	T1-4.10, 4.11
23	Architecture Dynamic CMOS,clocked CMOS	CO 3	R1-6.3.7
24	Architecture of CMOS domino; n-p CMOS	CO 3	R1-6.3.2
25	Design Approach – PROM, PLA and PAL	CO 5	T3 -7.7
26	Internal block description of FPGA	CO 5	T3
27	Internal block description of CPLD	CO 5	T3
28	Different types FPGA interconnect routing procedures; Performance tradeoff	CO4	R1-6.3.4
29	implementation strategies: full custom	CO 6	R1-6.6.7
30	implementation strategies: semi custom design	CO 6	R1-8.1,8.2
31	Comparison of FPGA and CPLD	CO 5	T3
32	Comparison of Full custom and semi custom designs	CO 6	R1-6.6.7
33	Design modules in subsystems ,basics of shifters	CO 4	R1-6.3.4
34	Architecture of Ripple carry, Carry Look Ahead, Carry select Adders	CO 4	R1-6.6.7
35	Architecture of Manchester carry chain ,ALUs.	CO 4	R1-8.1,8.2
36	Architectures of Multipliers	CO 4	R1-8.9
37	Architectures of Parity generators; Comparators; Zero/one detectors;	CO 4	R1-8.4
38	Design of Asynchronous and Synchronous Counters	CO 4	R1-8.3,8.5
39	Memory operation of SRAM, DRAM, ROM	CO 4	R1-9.1,9.2, 9.3
40	Memory operation of Floating gate concepts and Flash Memories.CMOS Testing and BIST	CO 6	T3-7.2,7.3
PROBLEM SOLVING/ CASE STUDIES			
41	Finding drain current, drain to source resistance, transconductance	CO 1	R1-2.5.3
42	Finding electrical properties of MOS based on different parameters	CO 1	T1-2.6
43	Finding the shift in characteristics based on impedance ratio and beta ratios	CO 1	T1-2.10
44	Design of stick diagrams	CO 2	T1-3.1, 3.2.
45	Design of Layout of MOS transistor	CO 2	T1-3.4,3.5
46	Design using Euler's physical design	CO 2	T1-3.3
47	Calculation of resistance and capacitance of layers	CO 3	T1-1.1-1.3,1.4

48	Calculation of Delay with respect to circuit	CO 3	T1-1.7,1.8
49	Design of complex gate and transmission gate designs	CO 3	T1-2.5,2.9
50	Design of shifter circuits	CO 4	R1-8.1,8.2
51	Design of adders	CO 4	R1-8.9
52	Design of multipliers	CO 4	R1-8.4
53	Look up tables and FPGA design	CO 5	R1-6.3.2
54	Design of PROM	CO 5	R1-6.3.4
55	Design of PLA,PAL	CO 5	R1-6.6.7
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	MOS transistor fundamental and basic electrical properties	CO 1	T1-1.1-1.3,1.4
57	Stick diagram ,layout, scaling of MOS circuits	CO 2	T1-3.1, 3.2
58	Delay of MOS circuits, gate level circuit design	CO 3	T1-4.6
59	Adders, multipliers, memory units	CO 4	R1-8.1,8.2
60	Architectures of Programmable logical devices and testing	CO 5, CO 6	R1-6.3.2
DISCUSSION OF QUESTION BANK			
61	MOS transistor fundamental and basic electrical properties	CO 1	T1
62	VLSI design styles, Stick diagram ,layout, scaling of MOS circuits	CO 2	T1
63	Basic circuit concepts and gate level design	CO 3	R1
64	Data path subsystems	CO 4	R2
65	Programmable logical devices	CO 5	R1

Signature of Course Coordinator **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**
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**

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

ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE DESCRIPTION

Course Title	**MICROWAVE AND SATELLITE ENGINEERING**				
Course Code	AECB28				
Program	B.Tech				
Semester	VII	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Ms P Annapurna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEC007	IV	Electromagnetic Theory and Transmission Lines
B.Tech	AEC011	V	Antennas and Propagation

II COURSE OVERVIEW:

This course allows students to study and analyze microwave systems at high frequencies, typically in the MHz and GHz range where lumped elements (e.g., resistors, capacitors, inductors) are no longer appropriate. It introduces passive and active microwave devices that constitute wireless communication systems between the antenna and the signal processor. It deals withthe concepts of satellite communication andits principles to design of global satellite systems for communication.The main applications are cellular communications, high-speed digital and analog circuits, wireless networks and radar.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Microwave and satellite engineering	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

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

Percentage of Cognitive Level	Blooms Taxonomy Level
16 %	Remember
49 %	Understand
33 %	Apply
0 %	Analyze

Continuous Internal Assessment (CIA):

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

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

Continuous Internal Examination (CIE):

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

Quiz - Online Examination

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

Alternative Assessment Tool (AAT)

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

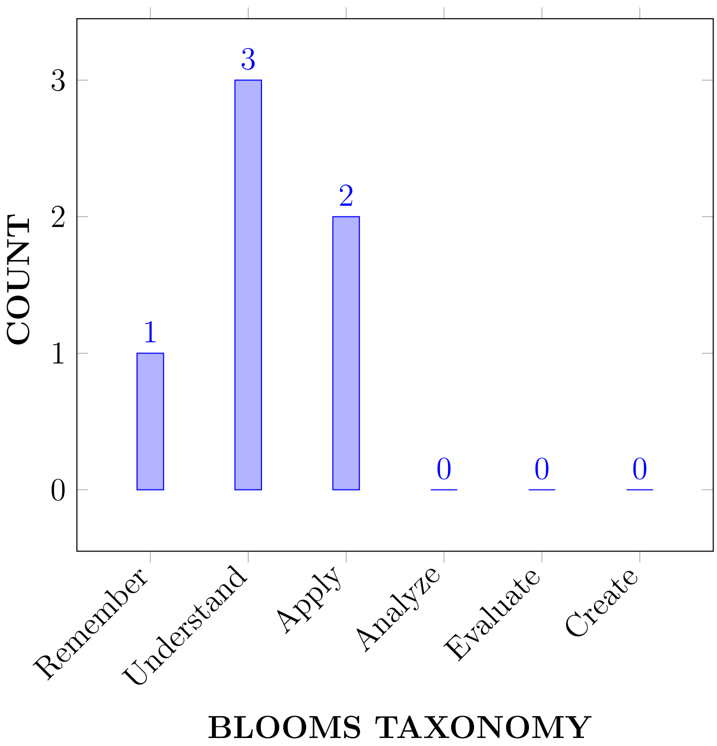
I	The concepts of wave guide components and electromagnetic wave propagation for microwave communication using Maxwell's equations.
II	The generation of microwave signals to measure different parameters using microwave test bench.
III	TheConcept of Satellite communication and understand placement of communication satellite in Geostationary-Earth-Orbit.

VII COURSE OUTCOMES:

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

CO 1	**Recall** the concepts of transmission lines and waveguides to derive the field components of wave equationsin rectangular modes.	Remember
CO 2	**Illustrate** the principle of waveguide components which are used to couple microwave power from the waveguide system to make the relation between input and output power .	Understand
CO 3	**Apply** the concept of S-Matrix to measure output power in microwave junctions and directional couplers	Apply
CO 4	**Demonstrate** the operation of microwave tubes, solid state devices for the generation and transmission of the microwave frequencies.	Understand.
CO 5	**Describe**the satellite subsystem to control the altitude and position of a complete space vehicle / satellite	Understand
CO 6	**Identify** an appropriate modulation, multiplexing and multiple access schemes for a satellite communication link to improve the link performance.	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, QUIZ
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, QUIZ
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, QUIZ
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	SEE/ CIE, AAT, QUIZ

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 3	Make use of High Frequency Structure Simulator(HFSS)for modeling and evaluating patch and smart antennas for wire and wireless communication applications	3	-

3 = High; 2 = Medium; 1 = Low

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

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

CO 4	✓	✓	-	✓	-	-	-	-	-	✓	-		-	-	-
CO 5	✓	✓	-	-	-	-	-	-	-	✓	-	-	-	-	-
CO 6	✓	✓	-	-	-	-	-	-	-	✓	-		-	-	✓

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

Course Outcomes (COs)	**POs / PSOs**	**Justification for mapping (Students will be able to)**	**No. of key competencies**
CO1	PO 1	**Recall** the concepts of transmission lines and waveguides (knowledge) to derive the field components of wave equations i.e TE,TM and TEM by **applying the principles of science to complex engineering problems**	2
	PO 10	**Communicate effectively on** the concepts of transmission lines and waveguides (knowledge) to derive the field components of wave equations i.e TE,TM and TEM modes	1
CO2	PO 1	**Recall** the concepts of power dividers and couplers (knowledge) and obtain the expressions by **applying the principles of mathematics, engineering science for complex engineering problems.**	2
	PO 2	**Formulate and analyze (Problem analysis) complex Engineering problems** for Determining the s-parameters on power dividers **using first principles of mathematics and Engineering sciences**	2
	PO 4	**Analyze** the microwave components to evaluate the s-parameters on power dividers and couplers (knowledge) methods including **design of experiments, analysis of complex problems**	2
	PO 10	**Communicate effectively on** the concepts of measuring different wave guide parameters	2
CO3	PO 1	**Understand** the performance characteristics of a Reflex klystron and two-cavity (knowledge) for calculating the input and output power and efficiency by **applying the principles of mathematics, science to the solutions of complex engineering problems.**	2
	PO 2	**Formulate and analyze (Problem analysis)** complex Engineering problems to evaluate the performance of microwave sources using **first principles of mathematics and Engineering sciences**	2
	PO4	**Analyze** the microwave power sources (knowledge) including **design of experiments, analysis of complex problems**	2

	PO 10	**Communicate effectively on** the concepts of micrwave power for Determining the s-parameters on power dividers	3
CO4	PO 1	Extend the concept of limitations of conventional tubes to microwave tubes for analyzing the microwave solid state devices (Knowledge) by **applying the principles of mathematics, engineering science for complex engineering problems.**	2
	PSO 3	Apply the concept of microwave tubes to develop klystron amplifierand oscillator which are used in microwave engineering lab for amplifying microwave signals by **applying the principles of of science to complex engineering problems.**	2
	PO 10	**Communicate effectively on** the concepts of detection, generation and amplification of solid state microwave devices.	2
CO5	PO 1	Interpret the operating principle of satellite subsystems **applying mathematics, engineering fundamentals for complex engineering problems.**	2
	PSO 3	**Understand the different types of sub systems by applying mathematics, engineering fundamentals for complex engineering** problems.	2
	PO 10	**Communicate effectively on** the concepts of satellite subsystems .	2
CO6	PO 1	identify different types of modulation, multiplexing and multiple access schemes **applying mathematics and engineering science for engineering problems.**	2
	PO 10	**Communicate effectively on** the concepts of modulation, multiplexing and multiple access schemes	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	-	-	-	-	-	-	-		2	-		-	-	-
CO 2	3	3	-	-	-	-	-	-	-	2	-	-	-	-	-
CO 3	2	4	-	4	-	-	-	-	-	3	-	-	-	-	-
CO 4	2	4	-	4	-	-	-	-	-	2	-		-	-	2
CO 5	2	3	-	-	-	-	-	-	-	3	-	-	-	-	2
CO 6	2	3	-	-	-	-	-	-	-	3	-		-	-	-

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	-	-	-	-	-	-	-	-	20	-		-	-	-
CO 2	100	30	-	-	-	-	-	-	-	20	-	-	-	-	-
CO 3	66.6	40	-	36.4	-	-	-	-	-	30	-	-	-	-	-
CO 4	66.6	40	-	36.4	-	-	-	-	-	20	-		-	-	100
CO 5	66.6	30	-	-	-	-	-	-	-	30	-	-		-	100
CO 6	66.6	30	-	-	-	-	-	-	-	30	-		-	-	-

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	1	-	-	-	-	-	-	-	-	1	-		-	-	-
CO 2	3	1	-	-	-	-	-	-	-	1-	-	-	-	-	-
CO 3	3	2	-	1	-	-	-	-	-	1	-	-	-	-	-
CO 4	3	2	-	1	-	-	-	-	-	1	-	-	-	-	3
CO 5	3	1	-	-	-	-	-	-	-	1	-	-	-	-	3
CO 6	3	1	-	-	-	-	-	-	-	1	-		-	-	-
TOTAL	16	7	**0**	2	**0**	**0**	**0**	**0**	**0**	6	**0**	**0**	**0**	**0**	6
AVERAGE	2.3	1.4	**0**	1.0	**0**	**0**	**0**	**0**	**0**	2.0	**0**	**0**	**0**	**0**	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
X	Assessment of Mini Projects by Experts		

XVIII SYLLABUS:

MODULE I	**MICROWAVE TRANSMISSION LINES**
	Introduction, Microwave Spectrum and Bands, Applications of Microwaves. Rectangular Waveguides – Solution of Wave Equations in Rectangular Coordinates, TE/TM mode analysis, Expressions for Fields, Characteristic Equation and Cut-off Frequencies Waveguide Multiport Junctions – E plane and H plane Tees, Magic Tee. Directional Couplers – 2 Hole, Bethe Hole types, Illustrative Problems.
MODULE II	**MICROWAVE TUBES**
	Microwave Tubes – O Type and M Type Classifications, O-type Tubes : 2 Cavity Klystrons – Structure, Reentrant Cavities, Velocity Modulation Process and Applegate Diagram, Bunching Process,Reflex Klystrons – Structure, Velocity Modulation and Applegate Diagram, Mathematical Theory of Bunching, Power Output, Efficiency,Helix TWTs: Significance, Types and Characteristics of Slow Wave Structures; Structure of TWT and Amplification Process. M-Type Tubes: Introduction, Cross-field Effects, Magnetrons – Different Types, Cylindrical Traveling Wave Magnetron – Hull Cut-off and Hartree Conditions, Modes of Resonance and PI-Mode Operation..
MODULE III	**MICROWAVE SOLID STATE DEVICES MICROWAVE MEASUREMENTS**
	Liquid propellant rockets, classification and components, thrust chamber, feed systems, propellant tanks, turbo-pumps, types of valves and applications, design considerations. Different bipropellant systems like cryogenics and their characteristics, pogo and slosh engine gimbal systems and thrusters for control; Spacecraft propulsion and control systems design problems.
MODULE IV	**ORBITAL MECHANICS, LAUNCHERS AND SATELLITE SUBSYSTEMS**
	Basic Concepts of Satellite Communications, Orbital Mechanics and Launchers: Orbital Mechanics, Look Angle determination, Orbital Perturbations, Orbit determination, Launches and Launch vehicles, Orbital Effects in Communication Systems Performance.Satellite Subsystems: Attitude and Orbit Control System, Telemetry, Tracking, Command and Monitoring, Power Systems, Communication Subsystems, Satellite Antennas.

MODULE V	SATELLITE LINK DESIGN AND MULTIPLE ACCESS
	Satellite Link Design: Basic Transmission Theory, System Noise Temperature and G/T Ratio, Design of Down Links, Up Link Design, Design Of Satellite Links For Specified C/N. Multiple Access: Frequency Division Multiple Access (FDMA), Intermediation, Calculation of C/N, Time Division Multiple Access (TDMA), Frame Structure, Examples, Satellite Switched TDMA Onboard Processing, DAMA, Code Division Multiple Access (CDMA), Spread Spectrum Transmission and Reception.

TEXTBOOKS

1. Microwave and radar engineering by Kulakrni
2. SamuelY.Liao,“MicrowaveDevicesandCircuits”,Pearson,3rdEdition,2003.
3. Dennisroddy,“SatelliteCommunications”,4thEdition,2004.
4. Pratt.Bostian,Allnutt,“SatelliteCommunications”,WileyIndia,2ndEdition,2006.

REFERENCE BOOKS:

1. Microwave engineering by R.E.Collins.
2. MRichharia,“SatelliteCommunicationSystems”,R.E.CollinMacMillan,2ndEdition,2005

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	-	W1
	CONTENT DELIVERY (THEORY)		
2	Introduction to microwave spectrum and bands and Applications of microwaves	CO 1	T1-1.0-1.4
3	rectangular waveguides-TEmodes, expressions for fields, characteristic equation and cutoff frequencies	CO 1	T1-4.1.1-4.1.3
4	rectangular waveguides-TM modes, expressions for fields, characteristic equation and cutoff frequencies	CO 1	T1-4.1.1-4.1.3
5	filter characteristics, dominant and degenerate modes, sketches of TE and TM mode fields in the cross-section	CO 1	T1-4.1.6-4.1.7
6	mode characteristics, phase and group velocities & wavelengths and impedance relations	CO 1	T1-4.1.8-4.1.11
7	power transmission and power losses in rectangular guide, related problems	CO 1	T1-4.1.12
8	resonant cavities, mode characteristics, and coupling coefficients	CO 1	T1-6.3.1-6.3.1
9	coupling mechanisms, waveguide discontinuities, various attenuators, and phase shifters	CO 1	R1- 6.8-6.9 R1-6.14- 6.15

10	waveguide multiport junctions such as E-Plane, H-plane tees, magic tee, hybrid ring.	CO 2	T1-5.4- 5.5
11	waveguide multiport junctions such as E-Plane, H-plane tees, magic tee, hybrid ring.	CO 2	T1-5.4- 5.5
12	waveguide multiport junctions such as E-Plane, H-plane tees, magic tee, hybrid ring.	CO 2	T1-5.4- 5.5
10	Faraday rotation of ferrite components such as gyrator, isolator, and circulators	CO 2	T1 -5.6
13	waveguide multiport junctions such as E-Plane, H-plane tees, magic tee, hybrid ring.	CO 2	T1-5.4- 5.5
14	Limitations and Losses of conventional tubes at Microwave frequencies over microwave tubes and categorize the different types of microwave tubes.	CO 3	T1 - 6.1
15	two cavity klystrons structure Reentrant cavities, velocity modulation process and Applegate diagram	CO 3	T1 - 6.2- 6.3
16	reflex klystron operation-structure, Applegate diagram and principle of working, mathematical theory of bunching, power output, efficiency	CO 3	T1 - 6.4.1
17	oscillating modes and o/p characteristics, effect of repeller voltage on power o/p	CO 3	T1 - 6.4.2-6.4.3
18	the significance, types and characteristics of slow wave structures, structure of TWT and Amplification process(qualitative treatment),gain considerations.	CO 3	T1-7.5
16	classification of magnetrons and cross field Effects	CO 3	T1-7.6
19	eight-cavity cylindrical travelling wave magnetron Hull cut-off and Hartree conditions	CO 4	T1-7.1.1-7.1.2
20	RWH Theory, characteristics, and operation of GUNN diode	CO 4	T1-7.3-7.3
21	avalanche transit time devices, basic modes of operation	CO 4	T1-8.1-8.3
22	microwave bench setup different blocks and their features precautions	CO 4	T1-9.1-9.2
23	Measurement of VSWR	CO 4	T1-9.1-9.2
24	Measurement of Power	CO 4	T1-9.1-9.2
25	Measurement of Attenuation	CO 4	T1-9.1-9.2
26	Understand the various types of microwave parameter measurement techniques	CO 4	R1 -7.5-7.9
27	Basic Concepts of Satellite Communications, Orbital Mechanics and Launchers: Orbital Mechanics, Look Angle determination	CO 5	T3-2.1-2.2
28	Orbital Perturbations, Orbit determination, Launches and Launch vehicles, Orbital Effects in Communication Systems Performance	CO 5	T3-2.3-2.3
29	Satellite Subsystems: Attitude and Orbit Control System, Telemetry.	CO 5	T3-2.4-2.4

30	Tracking, Command and Monitoring, Power Systems,	CO 6	T3-2.5-2.8
31	Communication Subsystems, Satellite Antennas..	CO 6	T3-2.5-2.8
32	Satellite Link Design: Basic Transmission Theory	CO 6	T3-3.1-3.2
33	System Noise Temperature and G/T Ratio	CO 6	T3-3.1-3.2
34	Design of Down Links, Up Link Design	CO 6	T3-3.4-3.5
35	Design Of Satellite Links For Specified C/N	CO6	T3-3.4-3.5
36	Multiple Access: Frequency Division Multiple Access (FDMA), I	CO 6	T3-3.6-3.9
37	Intermediation, Calculation of C/N	CO 6	T3-3.6-3.9
38	Time Division Multiple Access (TDMA)	CO 6	T3-4.1-4.3
39	Time Division Multiple Access (TDMA)	CO 6	T3-4.1-4.3
40	DAMA, Code Division Multiple Access (CDMA)	CO 6	T3-4.3-4.5
41	Spread Spectrum Transmission and Reception.	CO 6	T3-4.3-4.5
PROBLEM SOLVING/ CASE STUDIES			
42	Phase velocity, group velocity, wavelength and impedance relations	CO 2	T1-4.3.1-4.3.1
43	Field components of TM waves for rectangular waveguide	CO 2	R4- 6.8-6.9 R4- 6.14- 6.15
44	Field components of TE waves for rectangular waveguide	CO 2	T1-4.4- 4.5
45	Cut off frequency of rectangular waveguide	CO 3	T1 -4.6
46	Waveguide multiport junctions- E plane Tee Junction	CO 4	T1-10.1.1-10.1.2
47	Waveguide multiport junctions- H plane Tee Junction	CO 4	T1-7.1-7.3
48	Waveguide multiport junctions- E-H plane Tee Junction	CO 4	T1-8.1-8.3
49	Ferrites: Faraday rotation principle	CO 5	R4-7.2
50	Output power in Klystron	CO 5	R4- 7.13
51	Output power in Reflex Klystron	CO 5	T1-8.5-8.6
52	Helix Traveling Wave tube: Slow wave structures	CO 5	T1-8.6-8.7
53	Microwave cross field tubes (M type)- Magnetrons	CO 6	T1-9.1-9.3
54	Microwave measurements	CO 6	T1–11.4
55	TDMA,FDMA,CDMA	CO 6	T1–11.5
56	Spread spectrum	CO 6	T1-11.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
57	Microwave Transmission lines	CO 1	T1-4.3.1-4.3.1
58	Microwave tubes	CO 3	R4- 7.13
59	Microwave solid-state devices and Microwave measurements	CO 4	T1-9.1-9.3
60	Orbital mechanics, Launchers and satellite sub systems	CO 5	T1-9.4-9.6
61	Satellite link devices and multiple access	CO 6	T1–11.5

DISCUSSION OF QUESTION BANK			
62	Microwave Transmission lines	CO 1	T1-4.3.1-4.3.1
63	Microwave tubes	CO 3	R4- 7.13
64	Microwave solid-state devices and Microwave measurements	CO 4	T1-9.1-9.3
65	Orbital mechanics, Launchers and satellite sub systems	CO 5	T1-9.4-9.6
66	Satellite link devices and multiple access	CO 6	T1–11.5

Signature of Course Coordinator **HOD,ECE**
Ms P Annapurna, Assistant Professor

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

COURSE DESCRIPTION

Department	**Electronics and Communication Engineering**				
Course Title	**Embedded Systems**				
Course Code	AECB58				
Program	B. Tech				
Semester	VII				
Course Type	Open Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mrs. P. Ganga Bhavani, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
B.Tech	ACSB32	V	Computer Architecture	4
B.Tech	AECB24	VI	Microprocessors and Microcontrollers	4

II COURSE OVERVIEW:

This course allows students to learn the fundamentals of embedded system hardware and firmware design. It focusses on embedded system design process, embedded C, interfacing modules, software development tools for debugging and testing of embedded applications, ARM and SHARC processor architectures and memory organization. It provides hands-on experience on implementation of embedded application prototype design using embedded C.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Embedded Systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
✓	Open Ended Experiments	✓	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
42 %	Apply
8 %	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 Videos	Assignment	Tech-talk	Seminar	Open Ended Experiment
20%	30%	30%	10%	10%

VI COURSE OBJECTIVES:

The students will try to learn:

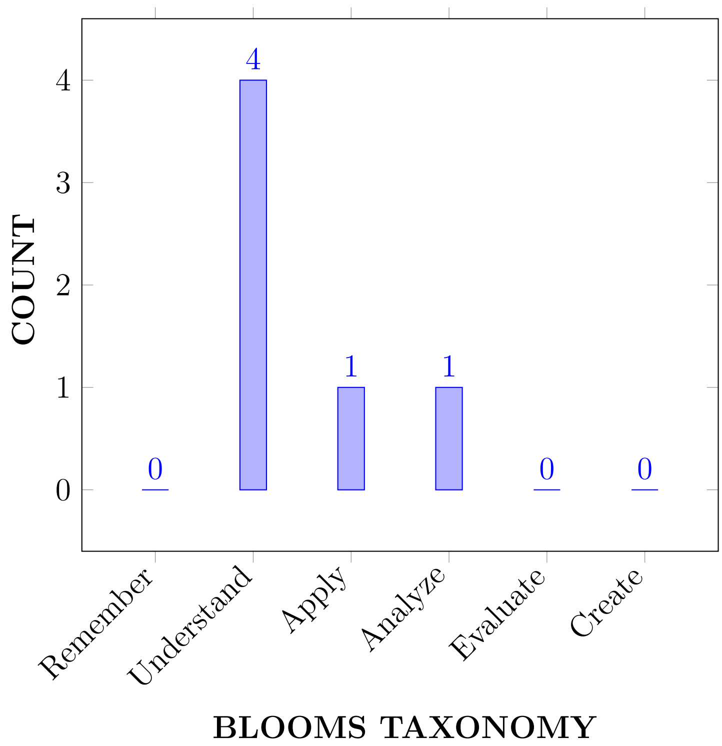
I	The fundamental concepts of embedded computing, embedded C, RTOS and embedded software tools for implementing embedded systems.
II	Embedded software development tools for debugging and testing of embedded applications, architectures of ARM and SHARC processors.
III	Interfacing with external environments using sensors, actuators and communication in distributed embedded systems.

VII COURSE OUTCOMES:

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

CO 1	**Summarize** the concepts of Embedded Systems and formalisms for system design with examples.	Understand
CO 2	**Analyze** the Embedded Systems programming in C with Keil Integrated Development Environment (IDE).	Analyze
CO 3	**Demonstrate** the principles of RTOS and the methods used for saving memory and power in real time environments.	Understand
CO 4	**Make use of** embedded software development tools for debugging and testing of embedded applications.	Apply
CO 5	**Illustrate** the architecture, memory organization and instruction level parallelism of ARM and SHARC processors used in Embedded Systems.	Understand
CO 6	**Interpret** the concepts of Internet of Things used in the embedded systems 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.	2	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.	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	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

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 / Projects

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 2	Focus on the Application Specific Integrated Circuit (ASIC) Prototype designs, Virtual Instrumentation and System on Chip (SOC) designs.	2	Seminars / Projects

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	Illustrate the concepts (knowledge) of embedded systems using their architectures by using mathematics, science, engineering fundamentals to the solution of complex engineering problems.	3
	PO 10	Describe the concepts of Embedded Systems and formalisms by giving effective presentations and take clear instructions for system design with examples.	1
	PSO1	Build Embedded Software and Digital Circuit Development platform for Robotics, Embedded Systems and Signal Processing Applications.	2
CO2	PO 1	Apply the integration of sensors, actuators and on-chip peripherals of microcontroller architectures for prototype design by applying engineering fundamentals.	1
	PO 2	Understand the given the embedded application problem statement and finding the solution implementation of prototype embedded system design by analyzing complex engineering problems.	6
	PO 3	Design solutions for complex Engineering problems and design system components of embedded applications that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO2	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information of the basic embedded modules using different electronic circuits to provide valid conclusions.	6
	PO 5	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information of the basic embedded modules using different electronic circuits to provide valid conclusions.	1
	PO 10	Use Keil Integrated Development Environment by giving effective presentations and take clear instructions for analyzing the Embedded Systems programming in C.	1
CO3	PO 1	Demonstrate (knowledge) the principles of RTOS such as interrupt latency and context switching in hard real time environments by applying the knowledge of science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
	PO 10	Describe the principles of RTOS and the methods used for saving memory and power giving effective presentations and take clear instructions Use Keil Integrated Development Environment by giving effective presentations and take clear instructions in real time environments.	1
	PSO1	Formulate and Evaluate the embedded applications in the field of Intelligent Embedded and Semiconductor technologies.	2
CO4	PO 1	Make use of embedded software development tools (knowledge) for debugging and testing of embedded applications to the solution of complex engineering problems using mathematics, science, engineering fundamentals.	3
	PO 2	Understand the given the embedded application problem statement and finding the solution implementation of embedded applications using tools by analyzing complex engineering problems.	5
	PO 3	Design solutions for complex Engineering problems and design system components of embedded applications that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	5
	PO 4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information of the embedded software development tools to provide valid conclusions.	6

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 4	PO 5	Create, select, and apply appropriate techniques, resources, and modern Engineering tools including prediction and modelling the embedded circuits using Keil integrated development environment tool to complex Engineering activities with an understanding of the limitations.	1
	PO 10	Use embedded software development tools by giving effective presentations and take clear instructions for debugging and testing of embedded applications.	1
CO5	PO 1	Understand (knowledge) the architecture, memory management and application development using ARM and SHARC processors by applying engineering fundamentals.	1
	PO 10	Explain the architecture, memory organization and instruction level parallelism of ARM and SHARC processors by giving effective presentations and taking clear instructions.	1
	PSO2	Focus on the Application Specific Integrated Circuit (ASIC) Prototype designs, Virtual Instrumentation and System on Chip (SOC) designs.	1
CO6	PO 1	Model a embedded application prototype using embedded C by applying engineering fundamentals.	1
	PO 2	Understand the problem statement of embedded prototype design in global engineering applications in complex problem analysis using mathematics.	5
	PO 3	Design solutions of embedded applications in global engineering applications for complex Engineering problems that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.	6
	PO 10	Describe the concepts of Internet of Things used in embedded systems applications by giving effective presentations and taking clear instructions.	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	8	2	2	2
CO 1	3	-	-	-	-	-	-	-	-	1	-	-	2	-	-
CO 2	1	6	6	6	1	-	-	-	-	1	-	-	-	-	-
CO 3	1	-	-	-	-	-	-	-	-	1	-	-	2	-	-
CO 4	3	5	5	6	1	-	-	-	-	1	-	-	-	-	-
CO 5	1	-	-	-	-	-	-	-	-	1	-	-	-	1	-
CO 6	1	5	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	100	-	-	-	-	-	-	-	-	20	-	-	100	-	-
CO 2	33.3	60	60	54.5	100	-	-	-	-	20	-	-	-	-	-
CO 3	33.3	-	-	-	-	-	-	-	-	20	-	-	100	-	-
CO 4	100	50	50	54.5	100	-	-	-	-	20	-	-	-	-	-
CO 5	33.3	-	-	-	-	-	-	-	-	20	-	-	-	50	-
CO 6	33.3	50	60	-	-	-	-	-	-	20	-	-	-	-	-

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

1 -5 $<C\leq 40\%$ – Low/ Slight

2 - 40 % $<C < 60\%$ –Moderate

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	1	-	-	3	-	-
CO 2	1	3	3	3	3	-	-	-	-	1	-	-	-	-	-
CO 3	1	-	-	-	-	-	-	-	-	1	-	-	3	-	-
CO 4	3	2	2	2	3	-	-	-	-	1	-	-	-	-	-
CO 5	1	-	-	-	-	-	-	-	-	1	-	-	-	2	-
CO 6	1	2	3	-	-	-	-	-	-	1	-	-	-	-	-
TOTAL	10	7	8	5	6	-	-	-	-	6	-	-	6	2	0
AVERAGE	1.66	1.16	1.33	0.83	1	-	-	-	-	1	-	-	1	0.33	0

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

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	**EMBEDDED COMPUTING**
	Definition of embedded system, embedded systems vs. general computing systems, history of embedded systems, complex systems and microprocessor, classification, major application areas, the embedded system design process, characteristics and quality attributes of embedded systems, formalisms for system design, design examples.
MODULE II	**INTRODUCTION TO EMBEDDED C AND APPLICATIONS**
	C looping structures, register allocation, function calls, pointer aliasing, structure arrangement, bit fields, unaligned data and endianness, inline functions and inline assembly, portability issues; Embedded systems programming in C, binding and running embedded C program in Keil IDE, dissecting the program, building the hardware; Basic techniques for reading and writing from I/O port pins, switch bounce; Applications: Switch bounce, LED interfacing, interfacing with keyboards, displays, D/A and A/D conversions, multiple interrupts, serial data communication using embedded C interfacing.
MODULE III	**RTOS FUNDAMENTALS AND PROGRAMMING**
	Operating system basics, types of operating systems, tasks and task states, process and threads, multiprocessing and multitasking, how to choose an RTOS ,task scheduling, semaphores and queues, hard real-time scheduling considerations, saving memory and power. Task communication: Shared memory, message passing, remote procedure call and sockets; Task synchronization: Task communication synchronization issues, task synchronization techniques, device drivers.
MODULE IV	**EMBEDDED SOFTWARE DEVELOPMENT TOOLS**
	Host and target machines, linker/locators for embedded software, getting embedded software into the target system; Debugging techniques: Testing on host machine, using laboratory tools, an example system.
MODULE V	**MODULE V INTRODUCTION TO ADVANCED PROCESSOR**
	Introduction to advanced architectures: ARM and SHARC, processor and memory organization and instruction level parallelism; Networked embedded systems: Bus protocols, I2C bus and CAN bus; Internet-Enabled systems, design example-Elevator controller.

TEXTBOOKS

1. Shibu K.V, “Introduction to Embedded Systems”, Tata McGraw Hill Education Private Limited, 2nd Edition, 2009.
2. Raj Kamal, “Embedded Systems: Architecture, Programming and Design”, Tata McGraw-Hill Education, 2nd Edition, 2011.
3. Andrew Sloss, Dominic Symes, Wright, “ARM System Developer’s Guide Designing and Optimizing System Software”, 1st Edition, 2004.

REFERENCE BOOKS:

1. Wayne Wolf, — Computers as Components, Principles of Embedded Computing Systems Design, Elsevier, 2 nd Edition, 2009
2. Dr. K. V. K. K. Prasad, — Embedded / Real-Time Systems: Concepts, Design & Programming, dreamtech publishers, 1 st Edition, 2003.
3. Frank Vahid, Tony Givargis, —Embedded System Design‖, John Wiley & Sons, 3 rd Edition, 2006
4. Lyla B Das, “Embedded Systems” , Pearson Education, 1st Edition, 2012.
5. David E. Simon, “An Embedded Software Primer”, Addison-Wesley, 1st Edition, 1999.
6. Michael J.Pont, “Embedded C”, Pearson Education, 2nd Edition, 2008.

WEB REFERENCES:

1. https://lms.iare.ac.in/index?route=course/detailscourseid = 228

COURSE WEB PAGE:

1. https://lms.iare.ac.in/index?route=course/playercourseid = 228sectionid = 729lessonid = 7135

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&courseid=228
CONTENT DELIVERY (THEORY)			
2	Definition of embedded system, embedded systems vs. general computing systems.	CO 1	T1-1.1
3	History of Embedded systems	CO 1	T1-1.

4	Complex systems and microprocessor, classification,major application areas.	CO 1	T1-1.3
5	The embedded system design process	CO 1	T2-1.4
6	Characteristics and quality attributes of embedded systems	CO 1	T2-1.5
7	Formalisms for system design, design examples.	CO1	R2-1.2
10	Introduction to embedded C,C looping structures.	CO 2	T3-1.3
11	Register allocation, Function calls, and pointer aliasing.	CO 2	T3-2.4
12	Structure arrangement, Bit fields, unaligned data and endianness.	CO 2	T3-2.5
13	Inline functions and inline assembly, portability issues.	CO 2	T3-2.6
14	Embedded systems programming in C, binding and running embedded C program in Keil IDE	CO 2	T3-2.7
15	Embedded C program in Keil IDE, dissecting the program, building the hardware	CO 2	T3-2.8
16	Basic techniques for reading and writing from I/O port pins, switch bounce	CO 2	T3-2.9
17	Applications: Switch bounce, LED interfacing.	CO 2	R2-3.1
18	Interfacing with keyboards, displays	CO 2	R2-3.2
19	D/A and A/D conversions, multiple interrupts.	CO 2	R2-3.3
20	Serial data communication using embedded C interfacing.	CO 2	R2-3.4
28	RTOS Fundamentals, Operating system basics, types of operating systems	CO 3	R2-3.5
29	Tasks and task states, process and threads	CO 3	R2-3.6
30	Multiprocessing and multitasking, how to choose an RTOS	CO 3	R3-3.7
31	Task scheduling, semaphores and queues	CO 3	R3-3.8
32	Hard real-time scheduling considerations, saving memory and power.	CO 3	R3-4.1
33	Task communication: Shared memory, message passing	CO 3	R3-4.1
34	Remote procedure call and sockets	CO 3	R3-4.2
35	Task synchronization: Task communication synchronization issues	CO 3	R3-4.2
36	Task synchronization techniques, device drivers.	CO 3	R3-4.3
37	Host and target machines	CO 4	R3-4.3
38	Linker for embedded software	CO 4	R3-4.4
39	Locators for embedded software	CO 4	R3-4.4
40	Getting embedded software into the target system	CO 4	R3-4.5
41	Debugging techniques: Testing on host machine	CO 4	R3-4.5
44	Debugging techniques using laboratory tools, an example system.	CO 4	R3-4.5
47	Introduction to advanced architectures: ARM	CO 5	T2-8.1
48	Introduction to advanced architectures: SHARC	CO 5	T2-8.1
49	Processor and memory organization	CO 5	T2-8.2
50	Instruction level parallelism	CO 5	T2-8.2
51	Networked embedded systems: Bus protocols	CO 6	T2-8.3
52	Networked embedded systems: I2C bus and CAN bus	CO 6	T2-8.3

53	Internet-Enabled systems	CO 6	T2-8.4
54	Design example-Elevator controller.	CO 6	T2-8.4
PROBLEM SOLVING/ CASE STUDIES			
8	BMW 850i brake and stability control system	CO 1	T2-1.4
9	Design example of model train controller	CO 1	T3-2.7
21	Embedded C program for Switch bounce	CO 2	R2-3.2
22	Embedded C program for LED interface	CO 2	R3-4.5
23	Embedded C program for Interfacing with keyboards	CO 2	T2-8.2
24	Embedded C program for Interfacing with displays	CO 2	T2-1.4
25	Embedded C program for 7 Segment Display Interfacing	CO 2	T3-2.7
26	Embedded C program for ADC Interfacing with 8051 microcontroller	CO 2	R2-3.2
27	Embedded C program for DAC Interfacing with 8051 microcontroller	CO 2	R3-4.5
45	Design of Digital camera	CO 4	T2-8.2
46	Design of Microwave oven	CO 4	T2-1.4
55	Design of Elevator controller	CO 6	T3-2.7
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Embedded computing	CO 1	T1-1.3
57	Introduction to embedded c and applications	CO 2	T3-2.4
58	RTOS fundamentals and programming	CO 3	R3-4.2
59	Embedded software development tools	CO 4	R3-4.4
60	Introduction to advanced processors	CO 5, CO 6	T2-8.3
DISCUSSION OF QUESTION BANK			
61	Embedded computing	CO 1	T1-1.3
62	Introduction to embedded c and applications	CO 2	T3-2.4
63	RTOS fundamentals and programming	CO 3	R3-4.2
64	Embedded software development tools	CO 4	R3-4.4
65	Introduction to advanced processors	CO 5, CO 6	T2-8.3

Course Coordinator **HOD,ECE**
Mrs. P. Ganga Bhavani, Assistant Professor

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

COURSE DESCRIPTION

Department	**ELECTRONICS AND COMMUNICATION ENGINEERING**				
Course Title	**DIGITAL IMAGE PROCESSING**				
Course Code	AECB35				
Program	B.Tech				
Semester	VI				
Course Type	PROFESSIONAL ELECTIVE - II				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
Course Coordinator	Dr. B. Surekha Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AEC003	III	Probability Theory and Stochastic Process
UG	AEC009	V	Digital Communications

II COURSE OVERVIEW:

The course is intended to provide image processing fundamentals, representation, sampling, quantization, image acquisition and imaging geometry. Transform techniques including two dimensional Fourier transforms, Walsh, Hotelling, Haar and Slant transforms. Analyze image processing filters and techniques for the applications of enhancement, segmentation and compression.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Image Processing	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
70%	Understand
20%	Apply
0 %	Analyze

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

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

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

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

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

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

VI COURSE OBJECTIVES:

The students will try to learn:

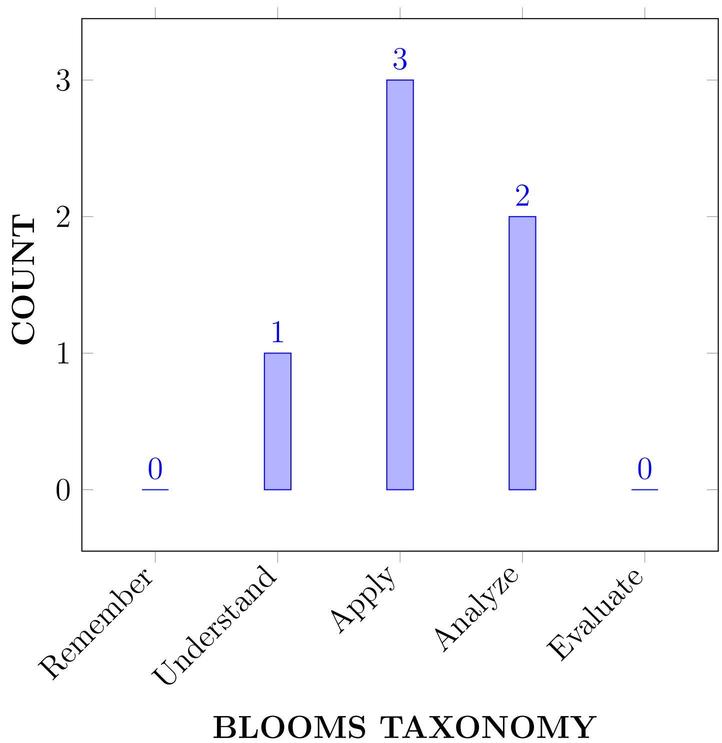
I	The fundamental concepts of digital image processing methods and techniques.
II	The image enhancement, image segmentation and compression techniques in spatial and frequency domains.
III	The algorithms to solve image processing problems to meet design specifications of various applications of image processing in industry, medicine and defense.
IV	Fundamentals of image representation and processing in MATLAB.

VII COURSE OUTCOMES:

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

CO 1	**Interpret** the principles and terminology of digital image processing for describing the features of image.	Understand
CO 2	**Make use of** image transform techniques for analyzing images in transformation domain for image pre-processing.	Apply
CO 3	**Construct** image intensity transformation and filtering techniques for image enhancement in the spatial and frequency domain.	Apply
CO 4	**Analyze** the image restoration in the spatial and frequency domains to deal with noise models for removing degradation from given image.	Analyze
CO 5	**Apply** region-based morphological operations and edge-based image segmentation techniques for detection of objects in images to remove the imperfections in the structure of the image.	Apply
CO 6	**Compare** the lossy and lossless compression models for achieving image compression.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	SEE/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	SEE/CIE, Quiz/AAT
PO 3	**Design/Development of Solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations	1	SEE/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	SEE /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	TECH TALK/ CONCEPT VIDEOS
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.		

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

PROGRAM SPECIFIC OUTCOMES		Strength	Proficiency Assessed by
PSO 1	Build the Embedded software and digital circuit development platform for robotics, embedded systems and signal processing applications.	2	SEE, PROJECTS

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	Illustrate the principles of the Digital Image Processing terminology **(knowledge)** for understanding image and its representation, pixel, intensity, gray level, relationship between the pixels by applying the principles of **engineering science to complex engineering problems**	2
	PO 10	**Effective presentation and Speaking Style** on sampling and quantization and **write Subject Matter Effectively** the difference between analog and digital images.	4
CO 2	PO 1	**Develop a image with various** image transform properties types and its types using **Scientific principles and methodology fundamental mathematics.**	3
	PO 2	**Formulate and analyze (Problem analysis) complex Engineering problems** for image transforms using **first principles of mathematics and Engineering sciences.**	5
	PO 10	**Effective presentation and Speaking Style** on properties of transforms and **write Subject Matter Effectively** on types of transforms.	4
	PSO 1	**Design of experiments** on image transforms **with project development and execution process** of **modern** tools such as MATLAB with image processing tool box, python, CV2.	2
CO 3	PO 1	**Illustrate the principles of an image find by using engineering** techniques for image enhancement by using **mathematical methods.**	2
	PO 2	**Illustrate** the filter processing **model translation** for spatial domain and **formulate** the time domain filter.	2
	PO 3	**Develop** a histogram techniques **complex engineering problem with appropriate considerations** and environmental considerations for image enhancement.	5

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO 4	**Demonstrate** the **Use** image enhancement **analyze and interpretation and Ability to apply quantitative methods** in frequency domain processing technique to **provide valid** digital image.	7
	PO 10	**Effective presentation and Speaking Style** on histogram processing **Write Subject Matter Effectively** on manipulation technique of an digital image.	4
	PO 12	**Recognize the need for** the image segmentation in different image applications and **ability to improve** the enhancement algorithms in the broadest context of **technological advancements.**	6
	PSO 1	**Design of experiments with project development and execution** modern tools such as MATLAB with image processing tool box, python, CV2.	6
CO 4	PO 1	Distinguish the image restoration in the spatial and frequency domains **(knowledge)** to remove the noise present the image by applying the principles of **(mathematics, engineering science for complex engineering problems.**	2
	PO 2	Formulate and analyze **(Problem analysis) complex Engineering problems** for image restoration using first principles of **mathematics and Engineering sciences**	5
	PO 3	**(Develop** spatial and frequency domain techniques **complex engineering problem with appropriate considerations** and **environmental considerations** for image restoration.	4
	PO 4	Understand the image restoration in the spatial and frequency domains **(knowledge)** methods **including design of experiments, analysis of complex problems.**	4
	PO 10	**Effective presentation and Speaking Style and write** on degradation models and noise sources for image restoration of digital images	3
	PSO 1	**Design of experiments with project development and execution** image restoration with modern tools such as MATLAB with image processing tool box, python, CV2.	2
CO 5	PO 1	**Interpret** Image Segmentation and formulate representation techniques to apply **Mathematical principles fundamental mathematics.**	3
	PO 2	**Apply Problem statement** the segmentation techniques for edge linking and boundaries by using **principles of mathematics and formulate** segmentation techniques.	3
	PO 10	**Effective presentation and Speaking Style and write on** image segmentation techniques.	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** for image Segmentation technique, and **broadest context of technological change in digital image and advanced engineering concepts.**	6
	PSO1	**Design of experiments with project development and execution** image segmentation with modern tools such as MATLAB with image processing tool box, python, CV2.	2
CO6	PO 1	**Understand the** various source coding techniques and Interpret Image Compression standards using **engineering science and mathematical models.**	3
	PO 2	**Identify and analyze** fidelity criteria, image compression models **implement** using **engineering science, design system components** for source Encoder and decoder, error free compression and **model translation** using **principal of mathematics.**	5
	PO 10	**Present effectively** and **Clarity** source encoder and **write effectively subject matter** on decoder techniques.	4
	PO 12	**Recognize the ability** of image restoration algorithms for **life-long learning in the broadest context of** image processing.	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	3	5	-	-	-	-	-	-	-	2	-	-	2	-	-
CO 3	2	2	5	7	-	-	-	-	-	2	-	6	2	-	-
CO 4	2	5	5	4	-	-	-	-	-	2	-	-	2	-	-
CO 5	3	3	-	-	-	-	-	-	-	2	-	6	2	-	-
CO 6	3	5	-	-	-	-	-	-	-	2	-	4	-	-	-

XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	66.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	0.0	0.0	0.0
CO 2	100	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	100	0.0	0.0
CO 3	66.6	20.0	50.0	63.6	0.0	0.0	0.0	0.0	0.0	40.0	0.0	50.0	100	0.0	0.0
CO 4	66.6	50.0	50.0	36.3	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	100	0.0	0.0

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 5	100	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	50.0	100	0.0	0.0
CO 6	100	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	33.3	0.0	0.0	0.0

XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

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

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

COURSE OUTCOMES	PROGRAM OUTCOMES												PSO'S		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-
CO 2	3	2	-	-	-	-	-	-	-	1	-	-	3	-	-
CO 3	3	1	2	3	-	-	-	-	-	1	-	2	3	-	-
CO 4	3	2	2	1	-	-	-	-	-	1	-	-	3	-	-
CO 5	3	1	-	-	-	-	-	-	-	1	-	2	3	-	-
CO 6	3	2	-	-	-	-	-	-	-	1	-	1	-	-	-
TOTAL	18	8	4	4	-	-	-	-	-	6	-	5	12	-	-
AVERAGE	3	1.6	2	2	-	-	-	-	-	1	-	1.6	3	-	-

XVI ASSESSMENT METHODOLOGY-DIRECT:

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

XVII ASSESSMENT METHODOLOGY-INDIRECT:

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

XVIII SYLLABUS:

MODULE I	**INTRODUCTION**
	Digital image fundamentals and image transforms digital image fundamentals, sampling and quantization, relationship between pixels; Image transforms: 2-D FFT, properties, Walsh transform, Hadamard transform, discrete cosine transform, Haar transform, Slant transform, Hoteling transform.

MODULE II	**IMAGE ENHANCEMENT**
	Introduction, image enhancement in spatial domain, enhancement through point processing, types of point processing, histogram manipulation, linear and non-linear gray level transformation, local or neighborhood operation, median filter processing; Spatial domain high pass filtering, filtering in frequency domain, obtaining frequency domain filters from spatial filters, generating filters directly in the frequency domain, low pass (smoothing) and high pass (sharpening) filters in frequency domain.
MODULE III	**IMAGE RESTORATION**
	Image restoration degradation model, algebraic approach to restoration. Inverse filtering, least mean square filters, constrained least square restoration, interactive restoration.
MODULE IV	**IMAGE SEGMENTATION**
	Image segmentation detection of discontinuities, edge linking and boundary detection, threshold, region oriented segmentation morphological image processing dilation and erosion, structuring element decomposition, the Strel function, erosion; Combining dilation and erosion: Opening and closing the hit and miss transformation.
MODULE V	**IMAGE COMPRESSION**
	Image compression: Redundancies and their removal methods, fidelity criteria, image compression models, source encoder and decoder, error free compression, lossy compression, JPEG 2000 standard.

TEXT BOOKS

1. R.C. Gonzalez & R.E. Woods, —Digital Image Processing‖, Addison Wesley/ Pearson education, 2nd Education, 2002.

2. S. Jayaraman, S. Esakkirajan, T. Veerakumar, “Digital Image Processing”, TMH, 3rd Edition, 2010.

REFERENCE BOOKS:

1. A.K.Jain, —Fundamentals of Digital Image Processing, PHI. 3RD Edition, 2003.

2. Rafael C. Gonzalez, Richard E Woods and Steven, —Digital Image Processing using MATLAB‖L. Edition, PEA, 2004.

3. William K. Pratt, John, —Digital Image Processing‖, Wilely, 3rd Edition, 2004.

4. Somka, Hlavac, Boyle, “Digital Image Processing and Computer Vision”, Cengage Learning, 1st Edition, 2008.

5. Adrain Low, “Introductory Computer vision Imaging Techniques and Solutions”, Tata McGraw-Hill, 2nd Edition, 2008.

6. John C. Russ, J. Christian Russ, “Introduction to Image Processing & Analysis”, CRC Press, 1st Edition, 2010.

WEB REFERENCES:

1. https://nptel.ac.in/courses/117105135

COURSE WEB PAGE:

1. https://akanksha.iare.ac.in/index?route=course/details&course_id=129

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 Image Processing	CO 1	T1:1.4-1.5
2	Digital Image Fundamentals	CO 1	T1:1.4-1.5
3	Analyze sampling and quantization	CO 1	T1:2.4-2.5
4	Relationship between pixels	CO 1	T1:2.4-2.5
5	Introduction to Image transforms	CO 1	T1:2.4-2.5
6	2D-FFT and properties	CO 2	T1:2.6-2.6.8; R2: 5.8-5.10
7	Properties of 2D FFT	CO 2	T1:2.6-2.6.8; R2: 5.8-5.10
8	Haar transform, Slant transform	CO 2	T1:3.1-3.6
9	Hoteling transform, Walsh transform	CO 2	T1:3.1-3.6
10	Hoteling transform, Walsh transform	CO 2	T1:3.1-3.6
11	Discrete cosine transform, Hadamard transform	CO 2	T1:3.1-3.6
12	Introduction to image enhancement	CO 3	T1:3.1-3.6
13	Image enhancement in spatial domain	CO 3	T1:3.1-3.6
14	Understand enhancement through point processing	CO 3	T1:3.1-3.8
15	Types of point processing	CO 3	T1:3.1-3.8
16	Histogram manipulation	CO 3	T1:3.1-3.8

17	Understand median filter processing	CO 3	T1:3.1-3.8; R2: 7.4-7.5
18	Spatial domain high pass filtering	CO 3	T1:3.1-3.8; R2: 7.4-7.5
19	Histogram equalization	CO 3	T1:3.1-3.8; R2: 7.4-7.5
20	Apply the Histogram processing technique for image enhancement	CO 3	T1:3.1-3.8; R2: 7.4-7.5
21	Understand filtering in frequency domain	CO 4	T1:4.1-4.6
22	Obtaining frequency domain filters from spatial filters	CO 4	T1:4.1-4.6
23	Generating filters directly in the frequency domain	CO 4	T1:4.1-4.6
24	Low pass (smoothing) filter in frequency domain.	CO 4	T1:4.1-4.6
25	High pass (sharpening) filter in frequency domain	CO 4	T1:4.1-4.6
26	Introduction to Image segmentation	CO 5	T1:10.1-10.6
27	Detection of discontinuities	CO 5	T1:10.1-10.6
28	Edge linking and boundary detection	CO 5	T1:10.1-10.6
29	Threshold techniques for image segmentation	CO 5	T1:10.1-10.6
30	Understand region oriented segmentation	CO 5	T1:10.1-10.6 ; T1:9.1-9.6
31	Morphological image processing, dilation and erosion	CO 5	T1:10.1-10.6; T1:9.1-9.6
32	Understand structuring element decomposition, the Strel function, erosion;	CO 5	T1:9.1-9.6
33	Combining dilation and erosion: Opening and closing	CO 5	T1:9.1-9.6
34	The hit and miss transformation	CO 5	T1:9.1-9.6
35	Introduction to Image compression	CO61	T1:8.1-8.3 ; R2: 7.4-7.5

36	Redundancies and their removal methods	CO 6	T1:8.1-8.3; R2: 7.4-7.5
37	Fidelity criteria, image compression models	CO 6	T1:8.1-8.3; R2: 7.4-7.5
38	Understand source encoder and decoder	CO 6	T1-8.1-8.1.7
39	Error free compression	CO 6	T1-8.1-8.1.7
40	Lossy compression & JPEG 2000 standard	CO 6	T1-8.1-8.1.7
	PROBLEM SOLVING/ CASE STUDIES		
1	Problem solving on 2-D FFT and it's properties	CO 2	T1:2.6-2.6.8; R2: 5.8-5.10
2	Problem solving on Walsh transform, Hadamard transform	CO 3	T1:3.1-3.6
3	Problem solving on Haar Transform	CO 2	T1:3.1-3.6
4	Problem solving on Slant, Hoteling and discrete cosine transform	CO 2	T1:3.1-3.6
5	Problem solving on image enhancement in spatial domain and point processing	CO 3	T1:3.1-3.6
6	Problem solving on histogram manipulation and equalization	CO 3	T1:3.1-3.8
7	Problem solving on gray-level transformation and median filter processing	CO 3	T1:3.1-3.8
8	Problem solving on image enhancement using filtering methods	CO 3	T1:4.1-4.6
9	Problem solving on image enhancement using filtering methods	CO 3	T1:4.1-4.6
10	Problem solving on image restoration using filtering techniques	CO 4	T1:4.1-4.6
11	Problem solving on image segmentation using edge linking and boundary detection	CO 5	T1:10.1-10.6
12	Problem solving on image segmentation using region orientation morphological processing	CO 5	T1:10.1-10.6
13	Problem solving on image segmentation using dilation and erosion	CO5	T1:10.1-10.6
14	Problem solving on image compression using removal of redundancies	CO 6	T1:8.1-8.3; R2: 7.4-7.5
15	Problem solving on image compression using JPEG 2000 standard	CO 6	T1:8.1-8.3; R2: 7.4-7.5

DISCUSSION OF DEFINITION AND TERMINOLOGY			
1	Definitions and terminologies on Introduction to Digital image processing	CO 1	T1:1.4-1.5
2	Definitions and terminologies on image enhancement	CO 3	T1:3.1-3.8
3	Definitions and terminologies on image restoration	CO 4	T1:4.1-4.6
4	Definitions and terminologies on image segmentation	CO 5	T1:10.1-10.6
5	Definitions and terminologies on image compression	CO 6	T1:8.1-8.3; R2: 7.4-7.5
DISCUSSION OF QUESTION BANK			
1	Discussion on question bank of introduction to digital image processing	CO 2	T1:1.4-1.5
2	Discussion on question bank of image enhancement	CO 3	T1:3.1-3.8
3	Discussion on question bank of image restoration	CO 4	T1:3.1-3.8; R2: 7.4-7.5
4	Discussion on question bank of image segmentation	CO 5	T1:10.1-10.6
5	Discussion on question bank of image compression	CO 6	T1:8.1-8.3; R2: 7.4-7.5

Signature of Course Coordinator **HOD,ECE**
Dr. B. Surekha Reddy, Assistant Professor

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

ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE DESCRIPTION

Course Title	ANTENNAS AND MICROWAVE ENGINEERING LABORATORY				
Course Code	AECB30				
Program	B.Tech				
Semester	IV	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Dr.V.Kishen Ajay Kumar, Associate Professor				

I COURSE OVERVIEW:

This course deals with the measurements of the signals at micro frequency range. This course introduces students to the broad area of RF microwave engineering. It involves measurement of frequency, wave length, VSWR, impedance and scattering parameters of various micro wave devices like circulator, directional coupler, and magic-tee. Microwave devices support larger bandwidth and hence higher data rates are transmitted. There are a wide variety of applications for microwaves like outdoor broadcasting transmissions and long distance telephone calls.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEC011	V	Antennas and Propagation
B.Tech	AEC015	VI	Microwave Engineering

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Microwave Engineering Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

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

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

	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 experiments on microwave test equipment to make measurements of microwave parameters and devices.
II	The measurement of S-Parameters of microwave components to gain the practical hands on experience on the microwave test bench.

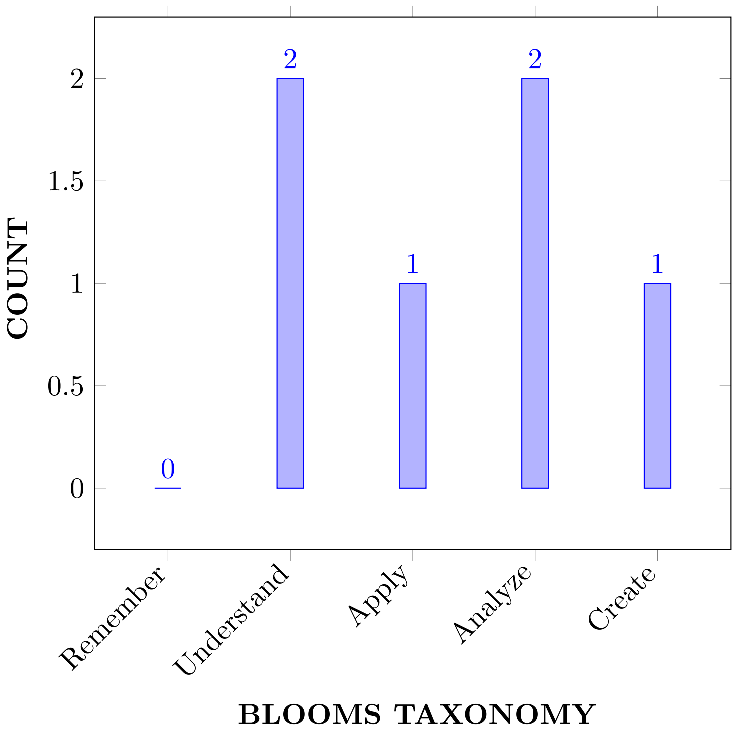
III	The simulation to plot the radiation pattern for an antenna using High Frequency Software Simulator.

VII COURSE OUTCOMES:

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

CO 1	**Summarize** the Waveguide components and their specifications using microwave test bench set-up. .	Understand
CO 2	**Sketch** the characteristics of Reflex klystron. to obtain the electronic tuning range using Klystron bench set up.	Apply
CO 3	**Analyze** the characteristics of Directional coupler, circulator and magic tee using microwave test bench setup.	Analyze
CO 4	**Distinguish** the low and high Voltage Standing Wave Ratio of unknown load load to find out the reflection coefficient using slotted line section.	Analyze
CO 5	**Identify** fundamental parameters of the antenna to measure far-field radiation pattern using High Frequency Structure Simulator	Understand
CO 6	**Design** various antennas to find out the antenna parameters using test setup and High Frequency Structure Simulator.	Create

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

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

3 = High; 2 = Medium; 1 = Low

X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
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.	1	Lab Exercises

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 2	**Identify** the Waveguide components and their specifications using microwave test bench set-up, **analyze** complex **engineering problems** from the element, and find out **conclusions** from the radiating components using the **principles of mathematics** and **natural sciences.**	6
	PO 5	**Summarize** the Waveguide components and their specifications using microwave test bench set-up by **applying modern Engineering and IT tools.**	2
CO 2	PO 2	**Identify the characteristics of Reflex klystron and Gunn diode, formulate the modes using Klystron bench set up, apply the principles of mathematics, natural sciences, and engineering sciences .**	5
	PO 3	**Examine (Design) the characteristics** of reflex klystron and find out its tuning range using design solutions for **complex engineering problems** that meet the specified needs with appropriate consideration.	2
	PO 9	**Use research-based knowledge** and **research methods** including **design of experiments** to **analyze** the characteristics of reflex klystron and Gunn diode and **interpretation of data, function effectively** as an **individual**, and as **a member** to obtain the readings	8
CO 3	PO 2	**Identify** the characteristics of Directional coupler, circulator and magic tee using microwave test bench setup, **analyze** the **complex design considerations** using **principles of mathematics** and **evaluate the appropriate solution**	6
	PO 3	**Understand** the characteristics of Directional coupler, circulator and magic tee using various system components and identify solutions that meet the specified needs for the **societal and environmental considerations**.	2
CO 4	PO 2	**Understand the (Problem analysis)** concept of microwave junction and S-Parameters using review research literature, and analyze **complex engineering problems** reaching substantiated conclusions using **first principles engineering sciences**	2

	PO 3	**Obtain** the S-parameters for different microwave components to measure coupling factor, insertion and isolation using microwave test bench to meet the specified needs with appropriate consideration.	1
CO 5	PO 2	**Understand the (Problem analysis)** concept of VSWR and reflection coefficient using review research literature, and analyze complex engineering problems reaching substantiated conclusions **using first principles engineering sciences** .	2
	PO 3	**Measure** low VSWR to find out reflection coefficient and SWR using microwave test bench using design solutions for complex engineering problems that meet the specified needs with appropriate consideration .	1
	PO 5	**Analyze** the polar pattern of different Microwave antennas to find out gain, beam width and level of the first side lobe using 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
	PO 9	**(Team work)Individual and team work: Function effectively as an individual, and as a member** to obtain the readings .	6
	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
CO 6	PO 2	**Analyze** the radiation pattern of dipole antenna to find out the antenna parameters using **test setup** and **High Frequency Software Simulator**	5
	PO 3	**Obtain** the radiation pattern of various antennas to find out the antenna parameters using High Frequency Software Simulator for **complex engineering problems** that meet the specified needs with appropriate consideration.	2
	PO 5	**Analyze** the radiation pattern of microstrip feed antenna to find out the antenna parameters using **modern Engineering and IT tools** such as High Frequency Software Simulator.	2
	PO 9	**(Team work) Individual and team work:** Function effectively as an **individual**, and as a **member** to **obtain** the readings.	8
	PSO 3	**Make use** of High frequency structure simulator (HFSS) to **analyze** the radiation pattern of various antennas to find out the antenna parameters .	2

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

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

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

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	-	60	-	-	20	-	-	-	-	-	-		-	-	-
CO 2	-	50	-	-	-	-	-	-	66.7	-	-	-	-	-	-
CO 3	-	60	20	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	-	20	50	-	-	-	-	-	-	-	-		-	-	-
CO 5	-	20	50	-	50	-	-	-	50	20	-	-	-	-	-
CO 6	-	50	50	-	50	-	-	-	66.7	-	-		-	-	100

XV COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

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

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

XVI ASSESSMENT METHODOLOGY DIRECT:

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

XVII ASSESSMENT METHODOLOGY INDIRECT:

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

XVIII SYLLABUS:

Week-1	**STUDY OF MICROWAVE COMPLONENTS**
	To study the different wave guide components in the microwave bench setup.
Week-2	**MODE CHARACTERISTICS OF REFLEX KLYSTRON**
	To study the characteristics of Reflex Klystron oscillator, finding the mode numbers and efficiencies of different modes.
Week-3	**GUNN DIODE CHARACTERISTICS**
	To study the characteristics of Gunn diode oscillator. .
Week-4	**DIRECTIONAL COUPLER CHARACTERISTICS**
	To measure coupling factor, insertion loss, isolation and directivity of a Directional coupler.
Week-5	**MEASUREMENT OF VSWR**
	To measure the low and high VSWRs of matched terminals.
Week-6	**CIRCULATOR CHARACTERISTICS**
	To measure the isolation and insertion loss of a three port circulator
Week-7	**MEASURMENT OF SCATTERING PARAMETERS OF MAGIC TEE**
	To find the scattering parameters of a four port Magic Tee.
Week-8	**INTRODUCTION TO HFSS**
	Introduction To HFSS Tool.
Week-9	**MONOPOLE ANTENNA DESIGN**
	To find the gain of Monopole Antenna.
Week-10	**DIPOLE ANTENNA DESIGN**
	To draw the Radiation Pattern of Dipole Antenna Design.
Week-11	**MICROSTRIP FEED ANTENNA DESIGN**
	To find the gain and radiation pattern of Microstrip Feed Antenna Design.
Week-12	**PROBE FEED PATCH ANTENNA DESIGN**
	To draw the 3D polar plot of Probe Feed Patch Antenna Design.

Week-13	**MEASUREMENT OF PHASE SHIFT**
	To measure the Phase shift between two components in the microwave bench set up.
Week-14	**MICROSTRIP LINE DESIGN**
	To find the gain of Microstrip Line Design

REFERENCE BOOKS

1. Samuel Y. Liao, ―Microwave Devices and Circuits‖, Pearson, 3 rd Edition, 2003.
2. . Herbert J. Reich, J.G. Skalnik, P.F. Ordung and H.L. Krauss, ―Microwave Principles‖ ,CBS Publishers and Distributors, New Delhi, 1st Edition, 2004.
3. . F.E. Terman, ―Electronic and Radio Engineering‖, Tata McGraw-Hill Publications, 4 th Edition, 1955.

WEB REFERENCES:

1. http://www.ee.iitkgp.ac.in
2. http://www.citchennai.edu.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
1	Study of Microwave Components.	CO 1	R1
2	Mode characteristics of reflex klystron	CO 2	R1,R2
3	Gunn diode characteristics.	CO 3	R1,R2
4	Directional coupler characteristics	CO 3	R1,R2
5	Measurement of VSWR	CO 3	R1,R2
6	Circulator characteristics	CO 3	R1,R2
7	Measurement of scattering parameters of magic tee	CO 3	R1,R2
8	Introduction to HFSS	CO 5	R1,R3
9	Monopole antenna design	CO 6	R1,R3
10	Dipole antenna design	CO 5	R1,R3
11	Microstrip feed antenna design.	CO 5	T1–17.1 to 17.6
12	Probe feed patch antenna design	CO 6	R1,R3
13	Slot coupled patch antenna.	CO 4	R1,R2
14	Microstrip line design.	CO 5	R1,R2

XX EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design microwave components such as: Directional couplers, circulators and Hybrid junctions using Simulation software.
2	Design antenna arrays such as: Binomial, Chebyshev using Simulation
3	RF based Wireless Chatting.
4	RF Communication based Data Encryption and Decryption Wirelessly.
5	Electronic eye with Security System using RF with Message Broad Casting.
6	Secret code Enabled Secure communication using RF Communication.
7	Unique office communication system using RF.

Signature of Course Coordinator **HOD,ECE**
Dr.V.Kishen Ajay Kumar, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE DESCRIPTION

Course Title	**VLSI DESIGN LABORATORY**				
Course Code	AECB29				
Program	B.Tech				
Semester	VII	ECE			
Course Type	core				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	1.5
Course Coordinator	Ms M Saritha, Assistant Professor				

I COURSE OVERVIEW:

The art of VLSI circuit design is dynamic with advances in process technology and innovations in the electronic design automation (EDA) industry. The objective of this laboratory course is to demonstrate the various stages in VLSI design flow using cadence software. Hands on training on logic and circuit simulations of MOSFETS, ring oscillators, multiplexers, analog amplifiers etc are included. The course also covers physical layout of complex logic gates for chip design.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEC002	III	Digital System Design
B.Tech	AEC008	v	Integrated Circuits Applications

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
VLSI Design 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:

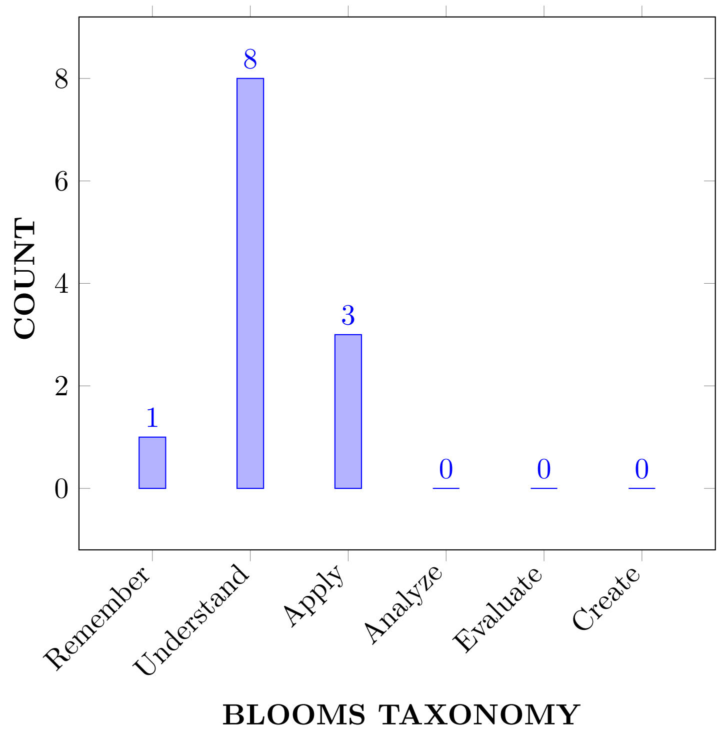
I	Modern tools for functional level to physical layout with verification at intermediate stages in the VLSI design flow in top-down approach.
II	Design and simulations of analog, digital and mixed circuits for optimum values of area over head, power and time delay.
III	The Chip design through a practical approach using advanced modern tools such as vivado and cadence for front end and back end.

VII COURSE OUTCOMES:

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

CO 1	**Calculate** the static, dynamic and noise margin parameters of CMOS inverter using the output and transfer characteristics of MOSFETst. .	Apply
CO 2	**Build** the Ring oscillator for assessment of frequency and phase noise margin parameters.	Apply
CO 3	**Analyze** complex gates, switch logic and transmission gates for performance optimization of distortion, power consumption and circuit delays.	analyze
CO 4	**Build** 4 X 1 multiplexer using 2 X 1 multiplexer basic building block and circuit symbols with necessary inter connections.	Apply
CO 5	**Examine** the conditions for optimum performance of lathes and registers with the knowledge of digital system design.	Analyze
CO 6	**Calculate** bandwidth, gain, and common mode rejection ratio parameters for Differential, MOSFET and casode amplifiers.	Apply
CO 7	**Build** the stick diagrams, layouts of MOS circuits using design rule checks (DRC) and verifications.	Apply
CO 8	**Construct** simulation, synthesis and design verification of data path sub systems using the key elements of VLSI design flow.	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.	3	Lab Experiments / CIE / SEE
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	Lab Experiments / CIE / SEE
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations	3	Lab Experiments / CIE / SEE
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Lab Experiments and Discussions
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	Discussions
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	Research paper analysis / Short term courses

3 = High; 2 = Medium; 1 = Low

IX HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PSO 2	Focus on the Application Specific Integrated Circuit (ASIC) Prototype designs, Virtual Instrumentation and System on Chip (SOC) designs.	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	Identify the conditions practically for improved performance of inverters regarding symmetry of transfer characteristics, rise and fall times (knowledge) by applying the field effect transistor fundamentals with support from other engineering disciplines, **mathematics, and scientific methodologies.**	2
	PO 2	Understand the given **problem statement and formulate** conditions for improved performance of inverter from the provided information and data in reaching substantiated conclusions by the **interpretation of results** in the Laboratory.	4
CO 2	PO 1	Identify the conditions practically for improved performance of ring oscillators regarding frequency and phase noise margin parameters **(knowledge)** by applying the oscillation **fundamentals** with support from other engineering disciplines, **mathematics, and scientific methodologies**.	2
CO 3	PO 1	Illustrate complex gates, switch logic and transmission gates **(knowledge)** for performance optimization of distortion, power consumption and circuit delays through simulation by applying the principles of **mathematics.**	1
	PO 2	Understand the given logic gates **problem statement** and finding the **solution implementation** for performance optimization by **analyzing complex engineering problems**.	3
CO 4	PO 1	Design multiplexers **(knowledge)** consisting of transmission gates and pass gates with the support of **VLSI engineering tools such as stick diagrams and layouts.**	1
	PO 2	Formulate and analyze **(Problem analysis) complex Engineering problems** for multiplexers textbf(knowledge) consisting of transmission gates and pass gates using first principles of **mathematics and Engineering sciences.**	5
CO 5	PO 1	Design latches **(knowledge)** consisting of multiplexers with the support of VLSI engineering tools such as stick diagrams and layouts.	1
	PO 2	Formulate and analyze **(Problem analysis)** complex Engineering problems for latches **(knowledge)** consisting of multiplexers using first principles of **mathematics and Engineering sciences.**	5

CO 6	PO 1	Identify the conditions practically for improved performance of Differential, MOSFET and casode amplifiers regarding bandwidth, gain, and common mode rejection ratio parameters (knowledge) by applying the oscillation fundamentals with support from other engineering disciplines, **mathematics, and scientific methodologies.**	2
CO 7	PO 1	Build the stick diagrams, layouts of MOS circuits (knowledge) by following design rules with **engineering sciences.**	1
	PO 5	Develop layouts of MOS circuits using **modern Engineering and IT tools** to reduce area overhead.	1
	PO 9	Focus on working as a **member or leader** in developing the layouts for MOS circuits and perform analysis by **individual and team work.**	2
	PSO 2	Build stick diagrams and layouts of MOS circuits by **experimentation** and Understanding the **performance parameters** of Application Specific Integrated Circuit (ASIC) System on Chip (SOC) designs.	2
CO 8	PO 1	Develop data path subsystems (knowledge) consisting of shifters, adders, multipliers, ALUs, parity generators, counters and comparators with the support of **VLSI engineering tools such as stick diagrams and layouts.**	1
	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	3
	PO 12	Recognize the need and have sufficient preparation in field of VLSI design to enhance skill and additional efforts for **future advancement and lifelong learning.**	2
	PSO 2	Build data path sub systems using the key elements of VLSI design flow with minimum hardware and delay by experimentation and Understanding the performance parameters of Application Specific Integrated Circuit (ASIC) and System on Chip (SOC) designs.	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 5	PO 10	
CO 1	2			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		
CO 7	2		2	3

XII ASSESSMENT METHODOLOGY DIRECT:

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

XIII ASSESSMENT METHODOLOGY INDIRECT:

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

XIV SYLLABUS:

WEEK I	**MOSFET**
	To plot the (i) Output characteristics (ii) Transfer characterisctics of an N-channel and P-channel MOSFET.
WEEK II	**CMOS INVERTER**
	To design and plot the static (VTC) and dynamic charateristics of a digital CMOS inverter.
WEEK III	**RING OSCILLATOR**
	To design and plot the output characteristics of a 3-inverter ring oscillator.
WEEK IV	**LOGIC GATES**
	To design and plot the dynamic characteristics of 2-input NAND, NOR, XOR and XNOR logic gates using CMOS technology.
WEEK V	**4X1 MULTIPLEXER**
	To design and plot the characteristics of a 4X1 ditial multiplexer using pass transistor logic.
WEEK VI	**LATCHES**
	To design and plot the characteristics of a positive and negative latch based on multiplexers.

WEEK VII	**REGISTERS**
	To design and plot the characteristics of a master-slave positive and negative edge triggered registers based on multiplexers.
WEEK VIII	**DIFFERENTIAL AMPLIFIER**
	Design and simulation of simple 5 transistor differential amplifier, Measure the values of Gain, ICMR and CMRR.
WEEK IX	**NMOS INVERTER AND CMOS INVERTER**
	To design the layout of NMOS and CMOS inverter.
WEEK X	**LAYOUT OF 2-INPUT NAND, NOR GATES**
	To design the layout of 2-input NAND, NOR gates.
WEEK XI	**COMMON SOURCE AMPLIFIER**
	Analysis of Frequency response of Common source amplifier.
WEEK XII	**COMMON DRAIN AMPLIFIER**
	Analysis of Frequency response of Common drain Amplifier.
WEEK XIII	**SINGLE STAGE CASCODE AMPLIFIER**
	Design and Simulation of Single Stage Cascode Amplifier.
WEEK XIV	**BASIC CURRENT MIRROR, CASCODE CURRENT MIRROR AMPLIFIER**
	Design and Simulation of Basic Current Mirror, Cascode Current Mirror Amplifier.

TEXT BOOKS:

1. Razavi, Design of Analog CMOS Integrated Circuits, Tata McGraw Hill Publications,2002.
2. Allen Holberg, CMOS Analog Circuit Design, Oxford Publications, 2002.
3. Baker, Li, Boyce, CMOS Mixed Circuit Design, Wiley Publications, 2002.

REFERENCE BOOKS:

1. Mohammad Rashid, "Electronic Devices and Circuits", Cengage learning, 1st Edition, 2014.
2. David A. Bell, "Electronic Devices and Circuits", Oxford University Press, 5th Edition, 2009.

Web References:

1. http://ee.usc.edu/ redekopp/ee209/virtuoso/setup/USCVLSI-VirtuosoTutorial.pdf

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	To plot the (i) Output characteristics (ii) Transfer characterisctics of an N-channel and P-channel MOSFET.	CO 1	T1: 3.1
2	To design and plot the static (VTC) and dynamic characteristics of a digital CMOS inverter.	CO 1	T1: 3.11
3	To design and plot the output characteristics of a 3-inverter ring oscillator.	CO 2	T1: 4.8

4	To design and plot the dynamic characteristics of 2-input NAND, NOR, XOR and XNOR logic gates using CMOS technology.	CO 3	T1: 4.8
5	To design and plot the characteristics of a 4X1 ditial multiplexer using pass transistor logic.	CO 4	T1: 5.5
6	To design and plot the characteristics of a positive and negative latch based on multiplexers.	CO 5	T1: 5.6
7	To design and plot the characteristics of a master-slave positive and negative edge triggered registers based on multiplexers.	CO 5	T1: 8.3
8	Design and simulation of simple 5 transistor differential amplifier, Measure the values of Gain, ICMR and CMRR.	CO 5	T1: 8.3
9	To design the layout of NMOS and CMOS inverter.	CO 7	T1: 9.2
10	To design the layout of 2-input NAND, NOR gates.	CO 7	T1: 9.3
11	Analysis of Frequency response of Common source amplifier.	CO 6	T1: 10.6
12	Analysis of Frequency response of Common drain Amplifier.	CO 6	T1: 10.7
13	Design and Simulation of Single Stage Cascode Amplifier.	CO 6	T1:10.7
14	Design and Simulation of Basic Current Mirroe, Cascode Current Mirror Amplifier	CO 6	T1:10.7

XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design and plot the static (VTC) and dynamic characteristics of a digital nMOS inverter with different forms of pull up loads.
2	Design and plot the static (VTC) and dynamic characteristics of a digital Bi CMOS inverter.
3	To design and plot the dynamic characteristics of Non-inverting Boolean Functions using CMOS Technology.
4	To design and plot the characteristics of a 8X1 digital multiplexer usng pass transistor logic.
5	To design the layout of 3-input NAND, NOR gates.

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HOD,ECE