

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous) Dundigal, Hyderabad - 500 043

ELECTRONICS AND COMMUNICATION ENGINEERING

Course Title	PROBABILITY TH	EORY AND STOC	CHASTIC PROCE	SSES					
Course Code	A30405	\$30405							
Regulation	R13 – JNTUH	R13 – JNTUH							
Course Stars stars	Lectures	Tutorials	Practicals	Credits					
Course Structure	5	-	-	4					
Course Coordinator	Ms. Mary Swarnalatha, Associate Professor, Department of ECE								
Team of Instructors	Mr. G. Anil Reddy, A	ssistant Professor, D	Department of ECE						

COURSE DESCRIPTION FORM

I. COURSE OVERVIEW:

The course addresses the concepts, principles and techniques of sets and probability and random variable and random process. The course teaches the fundamentals of probability applying the concepts of mean and variance and development techniques. This course forms the basis for the study of advanced subjects like signals and systems. Students will learn probability concepts and difference between random variable and random process and estimation of power spectral density.

PREREQUISITE(S):

Level	Credits	Periods/ Week	Prerequisites
UG	4	5	M1, M2

II. MARKS DISTRIBUTION:

Sessional Marks	University End Exam marks	Total marks
 Midterm Test There shall be two midterm examinations. Each midterm examination consists of essay paper, objective paper and assignment. The essay paper is for 10 marks of 60 minutes duration and shall contain 4 questions. The student has to answer 2 questions, each carrying 5 marks. The objective paper is for 10 marks of 20 minutes duration. It consists of 10 multiple choice and 10 fill-in-the blank questions, the student has to answer all the questions and each carries half mark. First midterm examination shall be conducted for the first two and half units of syllabus and second midterm examination shall be conducted for the remaining portion. Five marks are earmarked for assignments. There shall be two assignments in every theory course. Assignments are usually issued at the time of commencement of the semester. These are of problem solving in nature with critical thinking. Marks shall be awarded considering the average of two midterm tests in each course. 	75	100

III. EVALUATION SCHEME:

S. No	Component	Duration	Marks
1.	I Mid Examination	80 minutes	20
2.	I Assignment	-	5
3.	II Mid Examination	80 minutes	20
4.	II Assignment	-	5
5.	External Examination	3 hours	75

4. COURSE OBJECTIVES:

- 1. To provide mathematical background and sufficient experience so that the student can read, write, and understand sentences in the language of probability theory, as well as solve probabilistic problems in signal processing and Communication Engineering.
- 2. To introduce students to the basic methodology of randomness in nature and to apply it to problems
- 3. To understand basic concepts of probability theory, random variables, multiple random variables, Conditional probability, joint distribution stastical independence between random variables and expectation including mean square estimation.
- 4. To understand the difference between time averages and statistical averages.
- 5. Analysis of random process and application to the various fields.
- 6. To teach students how to apply sums and integrals to compute probabilities, means, and expectations.

V. COURSE OUTCOMES:

At the end of the course the students are able to:

- 1. Understand probabilities and able to solve using an appropriate sample space.
- 2. Compute various operations like expectations from probability density functions (pdfs) and probability distribution functions
- 3. Perform Likelihood ratio tests from pdfs for statistical engineering problems.
- 4. Mean and covariance functions for simple random variables.
- 5. Understand Auto-correlation and cross correlation properties between two random variables.
- 6. Explain the concept of random process, differentiate between stochastic and ergodic processes.
- 7. Explain the concept of power spectral density and power density spectrum of a random process.
- 8. Apply the principles of a random process in system concepts.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

	Program Outcomes	Level	Proficiency assessed by
PO1	An ability to apply knowledge of basic sciences, mathematical skills, engineering and technology to solve complex electronics and communication engineering problems (Fundamental Engineering Analysis Skills).	Н	Assignments, Tutorials
PO2	An ability to identify, formulate and analyze engineering problems using knowledge of Basic Mathematics and Engineering Sciences. (Engineering Problem Solving Skills)	Н	Hands on Practice Sessions
PO3	An ability to provide solution and to design Electronics and Communication Systems as per social needs (Social Awareness)	Н	Lab Sessions
PO4	An ability to investigate the problems in Electronics and Communication field and develop suitable solutions (Creative Skills)	Н	Hands on Practice
PO5	An ability to use latest hardware and software tools to solve complex engineering problems (Software and Hardware Interface).	Н	Design Exercises

	Program Outcomes	Level	Proficiency assessed by
PO6	An ability to apply knowledge of contemporary issues like health, Safety and legal which influences engineering design (Social Awareness).	S	Hands on Practice
PO7	An ability to have awareness on society and environment for sustainable solutions to Electronics & Communication Engineering problems (Social awareness).	S	Lab session
PO8	An ability to demonstrate understanding of professional and ethical responsibilities (Engineering impact assessment skills).	Ν	Presentation
PO9	An ability to work efficiently as an individual and in multidisciplinary teams (Team Work).	S	Design Exercises
PO10	An ability to communicate effectively and efficiently both in verbal and written form (Communication Skills).	Ν	Document Preparation, Presentation
PO11	An ability to develop confidence to pursue higher education and for life-long learning (Continuing education awareness)	S	Seminars, Discussions
PO12	An ability to design, implement and manage the electronic projects for real world applications with optimum financial resources (Practical engineering analysis skills).	Н	Exercises

N - None	S - Supportive	H - Highly Related

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

	PROGRAM SPECIFIC OUTCOMES	LEVEL	PROFICIENCY ASSESSED BY
PSO 1	Professional Skills: An ability to understand the basic concepts in Electronics & 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.	Н	Lectures and Assignments
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.	S	Tutorials
N - 1	None S - Supportive	H – Highly Re	lated

VIII. SYLLABUS:

UNIT I

PROBABILITY and RANDOM VARIABLE:

Probability introduced through Sets and PROBABILITY: Relative Frequency Experiments and Sample Spaces, Discrete and Continuous Sample Spaces, Events, Probability Definitions and Axioms, Mathematical Model of Experiments, Probability as a Relative Frequency, Joint Probability, Conditional Probability, Total Probability, Bayes' Theorem, and Independent Events.

RANDOM VARIABLE: Definition of a Random Variable, Conditions for a Function to be a Random Variable, Discrete and Continuous, Mixed Random Variable.

UNIT II

Distribution and Density functions and OPERATION ON ONE RANDOM VARIABLE – **EXPECTATIONS**: Distribution and Density functions: Distribution and Density functions and Properties, Binomial, Poisson, Uniform, Gaussian, Exponential, Rayleigh, Conditional Distribution, Methods of defining Conditioning Event, Conditional Density, Properties.

OPERATION ON ONE RANDOM VARIABLE – EXPECTATIONS: Introduction, Expected Value of a Random Variable, Function of a Random Variable, Moments about the Origin, Central Moments, Variance and Skew, Chebychev's Inequality, Characteristic Function, Moment Generating Function, Transformations of a Random Variable: Monotonic Transformations for a Continuous Random Variable, Nonmonotonic Transformations of Continuous Random Variable, Transformation of a Discrete Random Variable.

UNIT III

MULTIPLE RANDOM VARIABLES and OPERATIONS:

MULTIPLE RANDOM VARIABLES: Vector Random Variables, Joint Distribution Function, Properties of Joint Distribution, Marginal Distribution Functions, Conditional Distribution and Density – Point Conditioning, Conditional Distribution and Density – Interval conditioning, Statistical Independence, Sum of Two Random Variables, Sum of Several Random Variables, Central Limit Theorem, (Proof not expected). Unequal Distribution, Equal Distributions.

OPERATIONS ON MULTIPLE RANDOM VARIABLES: Expected Value of a Function of Random Variables: Joint Moments about the Origin, Joint Central Moments, Joint Characteristic Functions, Jointly Gaussian Random Variables: Two Random Variables case, N Random Variable case, Properties, Transformations of Multiple Random Variables, Linear Transformations of Gaussian Random Variables.

UNIT IV

STOCHASTIC PROCESSES – TEMPORAL CHARACTERISTICS: The Random Process Concept, Classification of Processes, Deterministic and Nondeterministic Processes, Distribution and Density Functions, concept of Stationary and Statistical Independence. First-Order Stationary Processes, Second-Order and Wide-Sense Stationary, (N-Order) and Strict-Sense Stationary, Time Averages and Ergodicity, Mean-Ergodic Processes, Correlation-Ergodic Processes, Autocorrelation Function and Its Properties, Cross-Correlation Function and Its Properties, Covariance Functions, Gaussian Random Processes, Poisson Random Process.

UNIT V

STOCHASTIC PROCESSES – SPECTRAL CHARACTERISTICS: The Power Spectrum: Properties, Relationship between Power Spectrum and Autocorrelation Function, The Cross-Power Density Spectrum, Properties, Relationship between Cross-Power Spectrum and Cross-Correlation Function. Spectral Characteristics of System Response: Power Density Spectrum of Response, Cross-Power Density Spectrums of Input and Output of a linear system

TEXT BOOKS:

- 1. Probability, Random Variables & Random Signal Principles Peyton Z. Peebles, TMH, 4th Edition, 2001.
- 2 Probability and random process- Scott Miler, Donald Childers, 2 Ed, Elsevier, 2012

REFERENCES:

- 1. Probability, Random Variables and Stochastic Processes Athanasius Papoulis and S. Unnikrishna Pillai, PHI, 4th Edition, 2002.
- 2. Theory of probability and stochastic processes Pradeep kumar gosh, university press
- 3. Probability and Random Processes with Application to Signal Processing Henry Stark and John W. Woods, Pearson Education, 3rd Edition.
- 4. Probability Methods of Signal and System Analysis. George R. Cooper, Clave D. MC Gillem, Oxford, 3rd Edition, 1999.
- 5. Statistical Theory of Communication S.P. Eugene Xavier, New Age Publications, 2003.

IX. COURSE PLAN:

At the end of the course, the students are able to achieve the following course learning outcomes. Subject: PTSP

Branch& Year: ECE-II Semester: I Academic Year: 2015-201

Lecture			
No	Learning Objective	Topics to be covered	Reference
L1	To know basic concepts of	Probability and Random variables : Introduction	T1
	Probability and random variables		
L2	To know the basics about sets and	Probability introduced through Sets and	T1
	relative frequency	relative frequency: Experiments and Sample	
		Spaces, Discrete and Continuous Sample	
		Spaces	
L3	Introduction about events and probability	Events, Probability Definitions and Axioms,	TI
		Mathematical Model of Experiments and	
T 4	To low one the components of isint and	Probability as a Relative Frequency	TT 1
L4	for know the concepts of joint and	Joint Probability, Conditional Probability	11
τ.5	Introduction to total probability and	Total Probability Rayes' Theorem	Т1
LS	haves theorem, the concept of	Independent Events	11
	independent events	independent Events	
L6	Problems on events and probability	Problems	T1
L7	Problems on conditional and joint	Problem	T1.T2
	probability		
L8	Problems on baye's theorem	Problems	T1,T2
L9	To know the basic concepts and	Random Variable,: definition, Conditions and	T1
	definition of random variable	its types	
L10	To know Conditions for a Function to be	Conditions for a Function to be a Random	T1
	a Random Variable	Variable	
L11	Introduction to distribution and density	distribution and Density functions, properties	T1
	functions To know the concept of		
	density function and properties		
L12	Understanding the problems on density	Problems on density and distribution functions	TI
T 10	and distribution functions	Din amial Distribution	TT 1
LIS	distribution Boisson distribution	Binomial Distribution	11
	uniform distribution		
T 14	To know the concept of Gaussian and	Gaussian and Exponential Distribution	T1
1/14	Exponential distribution	Gaussian and Exponential Distribution	11
L15	To know the concept of Rayleigh and	Rayleigh Distribution, Conditional	T1
	conditional distribution	Distribution	
L16	Introduction to methods of conditional	Methods of defining Conditional Event	T1
	event		
L17	Introduction to conditional density and	Conditional Density, properties	T1
	properties		
L18	To know the concept of moments about	Moments about the Origin, Central Moments	T1
T 10	origin and central moments	V. 1 01	
L19	To know the concepts of variance and	Variance and Skew	TI
T 20	SKew	Chabyahay'a Inaquality. Characteristic	T1
L20	characteristic function	Euler S Inequality, Characteristic	11
I 21	To know the concepts of moment	Moment Generating Function	T1
1.21	generating function	Woment Generating Function	11
L22	Problems and characteristic and moment	Problems	T1
	generating functions. conditional density		
	and variance and skew		
L23	To know the concepts of transformation	Transformations of a Random Variable:	T1
	of a random variable	Monotonic Transformations for a Continuous	

L24 To know the concepts of non monotonic Non monotonic Transformations of Continuous random variable T1 L25 Problems on monotonic and non monotonic transformation of a Discrete Random Variable. T1 L26 Problems on monotonic transformation Problems T1 L26 To know the concepts of multiple mandom Variables and Operations: T1 T1 L27 To know the concepts of point monotonic transformation T1 T1 distribution properties Marginal Distribution functions and conditional distribution and Density – Point Conditioning distribution functions and conditional distribution and Density – Point Conditioning distribution functions and conditional distribution and Density – Point Conditioning distribution and bey reveal Random Variables, Sum of Several Random Variables. T1 L30 Problems on conditional distribution and density function. Central Limit Theorem, (Proof not expected). T1 L31 Understand the concept of operation on multiple random variables T1 Distribution, Equal Distributions T1 L32 Problems on central limit theorem Problems T1 T1 L33 To understand the concept of operation on multiple random variables. Two Random Variables and Or Multiple Random Variables. Two Random Variables and theorem T1 T1			Random Variable	
Line transformations of continuous random variable Random Variable, Transformation of a Discrete Random Variable T1 L25 Problems on monotonic and non monotonic transformation T0 L26 To know the concepts of multiple random variables and operations Wettor Random Variables, Joint Distribution Function T1 L27 To know the concept of marginal distribution properties Marginal Distribution Functions, Conditional distribution functions and conditional distribution T1 L29 To know the concept of statistical statistical Independence, Sum of Two Random Variables, Sum of Several Random Variables, Sum of Several Random Variables T1 L30 Problems on conditional distribution and density function Problems T1 L31 Understand the concept of operation on multiple random variables T1 T1 L31 To understand the concept of operation on multiple random variables T1 T1 L33 To understand the concept of operation on multiple random variables T1 T1 L34 To know the concepts of joint darasteristic functions T1 T1 L34 To know the concept of operation on multiple random variables T1 T1 L34 To know the concept of joint darasteristic functions T1 T1 <th>L.24</th> <th>To know the concepts of non monotonic</th> <th>Non monotonic Transformations of Continuous</th> <th>T1</th>	L.24	To know the concepts of non monotonic	Non monotonic Transformations of Continuous	T1
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126 To know the concepts of multiple random variables and operations Tit 127 To know the concepts of joint distribution properties Tit 128 To know the concept of marginal distribution properties Properties of Joint Distribution functions and conditional distribution functions and conditional distribution Tit 129 To know the concept of the concept of Statistical Independence, Sum of Everal Random Variables, Sum of Several Random Tit 130 Problems on conditional distribution and density function Problems Tit 131 Understand the concept of central limit theorem Central Limit Theorem, (Proof not expected). Tit 132 Problems on central limit theorem Problems Tit 133 To understand the concept of operation on multiple random variables Operations On Multiple Random Variables: Tit Tit 134 To know the concepts of joint central moments to understand the concept of joint characteristic functions Operations of Multiple Random Variables: Two Random Variables: Joint Moments about the Origin Tit 135 To understand the concept of joint central moments to understand the concept of and central instribution of Gaussian Random Variables Tit 1434 To know the concepts of joint central andom Variables case, N Ran	L25	Problems on monotonic and non	Problems	T1
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1.32 Onload the concept of central number of the concent of the c	L31	Understand the concept of central limit	Central Limit Theorem (Proof not expected)	T1
L32Problems on central limit theoremProblemsT1L33To understand the concept of operation on multiple random variablesOperations On Multiple Random Variables: Expected Value of a Function of Random Variables: Joint Moments about the OriginT1L34To know the concepts of joint central moments to understand the concept of joint characteristic functionsJoint Central Moments Joint Characteristic FunctionsT1L35To understand the concepts of jointly Gaussian Random Variables: Two Random Variables case, N Random Variables caseJointly Gaussian Random Variables: Two Random Variables case, N Random variablesT1L36To understand the properties and transformation of Gaussian random variablesProperties, Transformations of Multiple VariablesT1L37To understand the concepts of linear transformation of Gaussian random variablesLinear Transformations of Gaussian Random VariablesT1L38Problems on joint central moments Problems on joint characteristic functions and jointly Gaussian random variablesProblemsT1L39Problems on linear transformation of Gaussian random variablesProblemsT1L40Understand the concept of The Random Process Concept,T1T1L41Classification of Processes, Deterministic Attionary Processes, Second- Stationary and Statistical IndependenceT1L42Understand the concept of Distribution and Density Functions, concept of Stationary and Statistical IndependenceT1L43Understand the concept of First-Order Stationary and Statistical Independen	1.51	theorem	Unequal Distribution, Equal Distributions	11
L32 From the concept of operation on multiple random variables T1 L33 To understand the concept of operation on multiple random variables Operations On Multiple Random Variables: T1 L34 To know the concepts of joint central moments to understand the concept of joint characteristic functions Joint Central Moments Joint Characteristic T1 L35 To understand the concepts of jointly Gaussian Random Variables: Two Random Variables: Two Random Variables case, N Random Variables case T1 L36 To understand the properties and transformation of multiple random variables Properties, Transformations of Multiple T1 Random Variables To understand the concepts of linear transformation of Gaussian random variables Linear Transformations of Gaussian Random T1 L36 To understand the concepts of linear transformations of Gaussian Random Variables T1 L37 To understand the concepts of linear transformation of Gaussian random variables Linear Transformations of Gaussian Random T1 L38 Problems on joint central moments problems on joint characteristic functions and jointly Gaussian random variables Problems T1 L39 Problems on linear transformation of Gaussian random variables Problems T1 L40 Understand the concept of The Random Processes Concept P1 T1 T1	L32	Problems on central limit theorem	Problems	T1
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and jointly Gaussian random variablesProblems on linear transformation of Gaussian random variables jointly Gaussian random variables jointly Gaussian random variablesProblemsT1L40Understand the concept of The Random Process Concept,The Random Process ConceptT1L41Classification of Processes, Deterministic and Nondeterministic ProcessesClassification of Processes, Deterministic and Nondeterministic ProcessesT1L42Understand the concept of and Density Functions, concept of Stationary and Statistical IndependenceDistribution Stationary Processes, Second- Order and Wide-Sense Stationary, (N-Order) and Strict-Sense StationaryT1		Problems on joint characteristic functions		
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Process Concept, Image: Classification of Processes, Deterministic and Nondeterministic Processes, Deterministic and Nondeterministic Processes T1 L41 Classification of Processes, Deterministic and Nondeterministic Processes Nondeterministic Processes T1 L42 Understand the concept of Distribution and Density Functions, concept of Stationary and Statistical Independence Distribution and Density Functions, concept of Stationary and Statistical Independence T1 L43 Understand the concept of First-Order Stationary Processes, Second- Order and Wide-Sense Stationary, (N-Order) and Wide-Sense Stationary, (N-Order) T1	L40	Understand the concept of The Random	The Random Process Concept	T1
L41 Classification of Processes, Deterministic Classification of Processes, Deterministic and Nondeterministic Processes T1 and Nondeterministic Processes Nondeterministic Processes T1 L42 Understand the concept of Distribution and Density Functions, concept of Stationary and Statistical Independence T1 L43 Understand the concept of First-Order Stationary Processes, Second- Order and Wide-Sense Stationary, (N-Order) and Strict-Sense Stationary, (N-Order) T1		Process Concept,		
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L42 Orderstand the concept of Distribution and Density Functions, concept of Stationary and Statistical Independence T1 L43 Understand the concept of First-Order Stationary Processes, Second- Order and Wide-Sense Stationary, (N-Order) and Strict-Sense Stationary T1	T 42	and Nondeterministic Processes	Nondeterministic Processes	T 1
Image: Stationary and Statistical Independence Stationarity and Statistical Independence L43 Understand the concept of First-Order Stationary Processes, Second- Order and Order and Wide-Sense Stationary, (N-Order) Wide-Sense Stationary, (N-Order) and Strict-Sense Stationary	L42	Understand the concept of Distribution	Distribution and Density Functions, concept of	11
L43 Understand the concept of First-Order First-Order Stationary Processes, Second- T1 Stationary Processes, Second- Order and Wide-Sense Stationary, (N-Order) and Order and Wide-Sense Stationary, (N-Order) T1		Stationary and Statistical Indonandance	stationarity and statistical independence	
Stationary Processes, Second- Order and Order and Wide-Sense Stationary, (N-Order) Wide-Sense Stationary, (N-Order) and Strict-Sense Stationary	I /12	Understand the concept of First Order	First-Order Stationary Processes Second	T1
Wide-Sense Stationary. (N-Order) and and Strict-Sense Stationary	143	Stationary Processes Second-Order and	Order and Wide-Sense Stationary (N-Order)	11
TO DESCRIPTION AND A DESCRIPT		Wide-Sense Stationary (N-Order) and	and Strict-Sense Stationary	

	Strict-Sense Stationary		
L44	Understand the concept of Time	Time Averages and Ergodicity, Mean-Ergodic	T1
	Averages and Ergodicity, Mean-Ergodic	Processes, Correlation-Ergodic Processes	
	Processes, Correlation-Ergodic Processes	_	
L45	Understand the concept of	Autocorrelation Function and Its Properties	T1
	Autocorrelation Function and Its	-	
	Properties		
L46	Understand the concept of Cross-	Cross-Correlation Function and Its Properties	T1
	Correlation Function and Its Properties	-	
L47	Understand the concept of Covariance	Covariance Functions	T1
	Functions		
L48	Understand the concept of Linear system	Linear system response of mean and mean	T1
	response of mean and mean square value	square value	
L49	Understand the concept of Gaussian	Gaussian Random Processes	T1
	Random Processes, Poisson Random		
	Process		
L50	Understand the concept of Poisson	Poisson Random Process	T1
	Random Process		
L51	Problems on first and second order	Problems	T1
	stationary process		
L52	Problems on wss and sss and time	Problems	T1
	averages and ergodicty		
L53	Problems on auto-correlation and cross-	Problems	T1
	correlation		
L54	To understand the concept of power	The Power Spectrum: Properties	T1
	spectrum		
L55-56	Understand the relationship between	Relationship between Power Spectrum and	T1
	power spectrum and acf	Autocorrelation Function	
L57	Understand the concept of cross-pdf	The Cross-Power Density Spectrum, Properties	T1
L58	Understand the relationship between	Relationship between Cross-Power Spectrum	T1
	cross-pdf and ccf	and Cross-Correlation Function	
L59	Understand the concept of spectral	Spectral Characteristics of System Response:	T1
	characteristics and system response	Power Density	
L60	Understand the concept of spectrum	Power Spectrum of Response	
	response		
L61-62	Understand the concept of cross-pdf of	Cross-Power Density Spectrums of Input and	T1
	I/O linear system	Output of a Linear System	
L63	Probems on power spectrum and cross-ps	Problems	T1
	and pds		
L64	Problems on cross-pdf and ccf	Problems	T1

X. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course	Course Program Outcomes														
Objectives	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
Ι	Н	Н				S					S		Н	S	
II	S	Н				Н					S		Н	S	
III		Н				Н					Н		Н	S	
IV	Н	S				S					Н		S	Н	
V						S					Н		S	Н	
VI		Н				S					Н		S	Н	

S - Supportive

H - Highly Related

Course Outcomes	Program Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02	PS03
1	Н	S		S		S					S		Н	S	
2	Н			S		S					Н		Н	S	
3				S							U		S		
4	S	Η		Н		Н					S		S		
5	Н	S		Н		Н					Н		S	S	
6	Н			S		S					S		Н	S	
7	S			Н		S					Н		Н	S	
8	S	Η		Н		Н					S		S	S	

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

S - Supportive

H - Highly Related

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HOD, ELECTRONICS AND COMMUNICATION ENGINEERING