INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

ELECTRONICS AND COMMUNICATION ENGINEERING

COURSE DESCRIPTOR

Course Title	**PROBABILTY THOERY AND STOCHASTIC PROCESS**				
Course Code	**AECB08**				
Programme	B.Tech				
Semester	III	ECE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. M V Krishna Rao, Professor, ECE				
Course Faculty	Mrs. G Ajitha, Assistant Professor, ECE Mr. N Nagaraju, Assistant Professor, ECE				

I. COURSE OVERVIEW:

The course addresses the principles of probability theory and random variables. The course also introduces the concepts of random processes and sample functions, which are nothing but the noise signals that appear in a communication channel. The course also introduces the concepts such as Information, entropy of random sources and various coding techniques based on information theory. This course (along with the Signals and Systems course) forms the basis for the next level courses: Analog communication (AC), Digital communication (DC) and Digital Signal Processing (DSP), Radar Systems (RS) and Digital Image Processing (DIP). Students will learn the basics of probability functions (PDF and CDF), Moments, Random Variable Transformations, Temporal and Spectral properties of Random processes, Types of Random Processes, LTI system driven by Random Process, Input and output correlations, and Input and output Power spectral densities..

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHSB11	II	Mathematical Transform Techniques	4

III. MARKS DISTRIBUTION:

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

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V. EVALUATION METHODOLOGY:

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

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

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

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

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

Table 1: Assessment pattern for CIA

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

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	Lectures, Assignments
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	3	Lab related exercises
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including	2	Term Paper

Program Outcomes (POs)		Strength	Proficiency assessed by
	design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.		

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	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.	1	Seminar
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	Lab related exercises
PSO 3	**Successful Career and Entrepreneurship:** An understanding of social-awareness & 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

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Understand the random experiments, sample space and event probabilities.
II	Study the random variables, density and distribution functions, moments and transformation of random variables.
III	Understand the concept of random process and sample functions (signals)
IV	Explore the temporal and spectral characteristics of random processes

IX. COURSE OUTCOMES

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Appreciate the concept of the random experiments, event probabilities, random variables and their description, functions of random variables	CLO 1	Describe the basic concepts of the random experiments, event probabilities, joint and conditional probabilities- bayes theorem
		CLO 2	Learn and understand the concept of random variables, continuous and discrete variables, the probability density functions (pdfs), probability distribution functions (pdfs), different random variables and their properties
		CLO 3	Learn and understand the functions of a random variable, standard and central moments, and their physical significance
CO 2	Learn and understand the Single Random Variable Transformation- Multiple Random Variables	CLO 4	Understand the characteristic and moment generating functions; understand and apply the transformations on continuous and discrete random variables - expectations
		CLO 5	Learn and understanding of vector random variables, joint, marginal and conditional distribution functions, joint, marginal and conditional density functions.
		CLO 6	Learn and understand the conditional distribution and density functions: point and interval conditioning
		CLO 7	State and explain the central limit theorem : sum of several random variables
CO 3	Understand the Operations multiple random variables and their expectations	CLO 8	Learn and understanding of functions of vector random variables, joint standard and central moments, joint characteristic and moment generating functions
		CLO 9	Learn and understanding of jointly gaussian random variables; and transformations of multiple random variables
CO 4	Understand the concept of random processes and their time domain description	CLO 10	Learn and understanding of random process, sample functions and time domain characteristics: stationary, independence and ergodicity
		CLO 11	Contrasting of correlation and covariance functions, gaussian and poisson random processes
CO 5	Explore the spectral characteristics of random processes, and filtered random processes	CLO 12	Distinguish between auto- and cross- power density spectra, properties, relationship between correlation functions and power density spectra
		CLO 13	Understand and discuss the linear time invariant (lti) systems driven by random process, input-output spectral relations, white and colored noises

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AECB08.01	CLO 1	Describe the basic concepts of the random experiments, event probabilities, joint and conditional probabilities- bayes theorem	PO 1, PSO 1	3
AECB08.02	CLO 2	Learn and understand the concept of random variables, continuous and discrete variables, the probability density functions (pdfs), probability distribution functions (pdfs), different random variables and their properties	PO 1, PSO 1	3
AECB08.03	CLO 3	Learn and understand the functions of a random variable, standard and central moments, and their physical significance	PO 1, PO 2	3
AECB08.04	CLO 4	Understand the characteristic and moment generating functions; understand and apply the transformations on continuous and discrete random variables - expectations	PO 1, PO 2, PSO 2	3
AECB08.05	CLO 5	Learn and understanding of vector random variables, joint, marginal and conditional distribution functions, joint, marginal and conditional density functions.	PO 1, PSO 1	3
AECB08.06	CLO 6	Learn and understand the conditional distribution and density functions: point and interval conditioning	PO 1, PSO 1	3
AECB08.07	CLO 7	State and explain the central limit theorem : sum of several random variables	PO 4	2
AECB08.08	CLO 8	Learn and understanding of functions of vector random variables, joint standard and central moments, joint characteristic functions	PO 1, PSO 2	3
AECB08.09	CLO 9	Learn and understanding of jointly gaussian random variables; and transformations of multiple random variables	PO 1, PO 2	3
AECB08.10	CLO 10	Learn and understanding of random process, sample functions and time domain characteristics: stationary, independence and ergodicity	PO 1, PO 2	3
AECB08.11	CLO 11	Contrasting of correlation and covariance functions, gaussian and poisson random processes	PO 2, PSO 2	3

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AECB08.12	CLO 12	Distinguish between auto- and cross- power density spectra, properties, relationship between correlation functions and power density spectra	PO 2, PSO 1	2
AECB08.13	CLO 13	Understand and discuss the linear time invariant (lti) systems driven by random process, input-output spectral relations, white and colored noises	PO 2, PO 3, PSO 2	2

3 = High; 2 = Medium; 1 = Low

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

Course Outcomes (COs)	Program Outcomes (POs)				
	PO 1	PO 2	PO 4	PSO 1	PSO 2
CO 1	3	3		3	3
CO 2	3		2	3	
CO 3	3	3		1	3
CO 4	3	3		1	2
CO 5		2	2	2	2

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

(CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3												3		
CLO 2	3												3		
CLO 3	3	3													
CLO 4	3	3												3	
CLO 5	3												3		
CLO 6	3												3		
CLO 7				2											
CLO 8	3													3	
CLO 9	3	3													
CLO 10	3	3													

(CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 11		3												2	
CLO 12		2											2		
CLO 13		2		2										2	

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XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO4, PSO1, PSO2	SEE Exams	PO1, PO2, PO4, PSO1, PSO2	Assignments	PO1, PO2, PO4	Seminars	PO1, PO2, PO4, PSO1, PSO2
Laboratory Practices	PO 2, PO 4	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1, PO2, PO4, PSO1						

XIV. ASSESSMENT METHODOLOGIES - INDIRECT

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

XV. 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 and Ergodicity, 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.

TEXT BOOKS:

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

REFERENCE BOOKS:

1. Random Processes for Engineers-Bruce Hajck, Cambridge unipress, 2015
2. Probability, Random Variables and Stochastic Processes – Athanasios Papoulis and S. Unnikrishna Pillai, PHI, 4th Edition, 2002.
3. Probability, Statistics & Random Processes-K .Murugesan, P. Guruswamy, Anuradha Agencies, 3rd Edition, 2003.
4. Signals, Systems & Communications - B.P. Lathi, B.S. Publications, 2003.

XVI. COURSE PLAN:

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

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-3	Define random experiments, sample spaces, events, probability, axioms, joint, conditional and total probabilities, bay's theorem, independent events	CLO 1	T1:1.1-1.5
4	Random variables: definition, conditions for mapping function of a random variable, types of random variable,	CLO 2	T1:2.0-2.1
5-9	Distribution and density functions: definition and properties, binomial, poisson, uniform, gaussian, exponential, rayleigh random variables	CLO 2	T1:2.2-2.5
10	Methods of defining conditioning event, conditional distribution, conditional density and their properties,	CLO 2	T1:2.6
11-13	Expected value of a random variable, function of a random variable, standard and central moments, variance and skew, chebychev's inequality	CLO 3	T1:3.0-3.2
14	Characteristic function, moment generating function	CLO 4	T1:3.3
15-18	Monotonic and non-monotonic transformations of single random variables (continuous and discrete)	CLO 4	T1:3.4
19-22	Vector random variables, joint distribution function and its properties, marginal distribution functions, joint density function and its properties, marginal density functions,	CLO 5	T1:4.0-4.4
23-24	Conditional distribution and density – point conditioning, conditional distribution and density – interval conditioning, statistical independence,	CLO 6	T1:4.5
25-26	Sum of two and more random variables, central limit theorem: equal and unequal distribution.	CLO 7	T1:4.6-4.7
27-28	Expected value of a function of multiple random variables, correlation and covariance , correlation coefficient,	CLO 8	T1:5.0-5.1
29-31	Joint moments about the origin, joint central moments, joint characteristic function	CLO 8	T1:5.2
32-33	Jointly gaussian random variables: two random variables case and n random variable case, properties	CLO 9	T1:5.3
34-36	Transformations of multiple random variables, jacobian matrix, linear transformations of gaussian random variables	CLO 9	T1:5.4-5.5
37-40	Random process: definition and classification, distribution and density functions, stationarity and statistical independence.	CLO 10	T1:5.4-5.6

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
41-43	First- order, second- order , wide-sense stationarities (n-order) and strict-sense stationarity, time averages and ergodicity, mean-ergodic and correlation-ergodic processes	CLO 10	T1:6.1-6.2
42-44	Autocorrelation function and its properties, cross-correlation function and its properties, covariance functions, gaussian and poisson random processes.	CLO 10	T1:6.3
45-49	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.	CLO 11	T1:8.2
50-52	Power density spectrum: definition and properties, relationship between power density spectrum and autocorrelation function	CLO 12	T1:7.1-7.2
53-54	Cross power spectral density: definition and properties, relationship between cross-power spectrum and cross-correlation function	CLO 12	T1:7.3-7.4
55-57	System evaluation using random noise, spectral characteristics of system response: power density spectrum of response, cross-power density spectra of input and output,	CLO 13	T1:8.3-8.4
58-60	Noise bandwidth, white and colored noises	CLO 13	T1:8.5-8.7

XVII. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S NO	Description	Proposed Actions	Relevance with POs	Relevance with PSOs
1	Explore the pseudo random noise and its properties.	Two additional lecture hours	PO 2, PO 4	PSO 2
2	Study of pink noise	One additional lecture hour	PO 2, PO 4	PSO 2

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