

**MODULE - I**

**Chapter 1 : Basic Concepts in Probability 1-1 to 1-13**

**Syllabus :** Definitions of probability, joint, conditional, and total probability, Bayes’ theorem, independence of events, binary symmetric communication channel analysis using Bayes’ theorem.

**1.1 Basics of Probability ..... 1-1**

1.1.1 Mathematical Definition of Probability ..... 1-1

1.1.2 Axioms of Probability..... 1-3

1.1.2(A) Properties of Probability ..... 1-3

1.1.3 Conditional Probability ..... 1-4

1.1.3(A) Properties of Conditional Probability ..... 1-4

**1.2 Independent Events ..... 1-5**

**1.3 Partition of a Sample Space ..... 1-6**

1.3.1 Theorem of Total Probability ..... 1-7

1.3.2 Bay’s Theorem of Conditional Probability.... 1-7

**1.4 Binary Symmetric Communication Channel ..... 1-11**

**MODULE - II**

**Chapter 2 : Introduction to Random Variables**

**2-1 to 2-22**

**Syllabus :** Continuous, discrete, and mixed random variables, probability density function, probability distribution function, and probability mass function, properties of PDF and CDF. Special distributions - Binomial, Poisson, Uniform, Gaussian and Rayleigh Distributions Mean, variance and moments of random variables.

**2.1 Random Variable ..... 2-1**

2.1.1 Discrete Random Variable ..... 2-1

2.1.2 Continuous Random Variable ..... 2-2

2.1.3 Mixed Random Variable ..... 2-3

**2.2 Cumulative Distribution Function (CDF) 2-3**

2.2.1 Properties of Cumulative Distribution Function (CDF) of random Variable X ..... 2-3

**2.3 Mathematical Expectation ..... 2-9**

2.3.1 Variance ..... 2-10

2.3.2 Covariance ..... 2-10

2.3.3 Moments ..... 2-10

2.3.3(A) Raw Moments ..... 2-11

2.3.3(B) Central Moments ..... 2-11

**2.4 Moment Generating Function ..... 2-12**

2.4.1 Properties of Moment Generating Function ..... 2-12

**2.5 Special Probability Distribution ..... 2-12**

2.5.1 Binomial Distribution ..... 2-13

2.5.2 Poisson Distribution ..... 2-13

2.5.3 Normal Distribution / Gaussian Distribution ..... 2-18

2.5.4 Uniform Distribution ..... 2-21

2.5.5 Rayleigh Distribution ..... 2-22

**MODULE - III**

**Chapter 3 : Operations on One Random Variable**

**3-1 to 3-47**

**Syllabus** : Function of a random variable and their distribution and density functions. Expectation, variance, moments, and characteristic function of random variable. Transformation of a random variable, Markov and Chebyshev inequality, characteristic functions, moment theorem.

**3.1 Function of a Random Variable..... 3-1**

3.1.1 Function of a Discrete Random Variable ..... 3-1

3.1.2 The Random Variable X is Continuous but y is Discrete ..... 3-2

3.1.3 If Both X and Y are Continuous Random Variable..... 3-3

**3.2 Expectation of a Random Variable..... 3-5**

**3.3 Mean and Variance ..... 3-7**

**3.4 Type I : Mean and Variance of a Discrete Random Variable ..... 3-8**

3.4.1 Mean and Variance of a Continuous Random Variable..... 3-9

**3.5 Type II : Mean and Variance of a Function of a Discrete Random Variable..... 3-11**

3.5.1 Mean and Variance of a Function of a Continuous Random Variable.....3-12

**3.6 Properties of Variance ..... 3-13**

**3.7 Moments of Higher Order ..... 3-14**

**3.8 Moment Generating Function ..... 3-16**

**3.9 Characteristic Functions ..... 3-18**

3.9.1 Properties of Characteristic Functions .....3-19

**3.10 Joint Characteristic Function ..... 3-20**

3.10.1 Properties of Joint Characteristic Function ..... 3-20

3.10.2 Standard Distribution ..... 3-20

**3.11 Transformation of Random Variables .. 3-23**

3.11.1 Transformation of Single Random Variable ..... 3-23

3.11.1(A) Case I : The Random Variable X is Discrete ..... 3-23

3.11.1(B) Case II : The Random Variable X is Continuous But Y is Discrete ..... 3-24

3.11.1(C) Case III : X and Y Both Are Continuous Random Variables ..... 3-25

3.11.1(D) Case IV : The Random Variable X is Continuous and Y = g(x) is Not Monotonic 3-27

3.11.2 One Function of Two Random Variable ..... 3-29

3.11.3 Two Function of Two Random Variables ... 3-32

**3.12 Chebyshev's Inequality ..... 3-35**

**3.13 Markov's Inequality ..... 3-37**

**3.14 Characteristic Function of Random Variable ..... 3-38**

3.14.1 Properties of Characteristic Function (Moment Theorem) ..... 3-38

**3.15 Cumulant Generating Function ..... 3-39**

**3.16 Joint Characteristic Function ..... 3-40**

3.16.1 Properties of Joint Characteristic Function ..... 3-40

**3.17 Characteristic Function of Standard Distribution ..... 3-40**

3.17.1 Binomial Distribution ..... 3-40

3.17.2 Poisson Distribution .....3-40

3.17.3 Geometric Distribution .....3-41

3.17.4 Uniform Distribution .....3-41

3.17.5 Standard Normal Distribution .....3-41

3.17.6 Exponential Distribution .....3-42

**MODULE - IV**

**Chapter 4 : Multiple Random Variables and Convergence**  
4-1 to 4-27

**Syllabus :** Pairs of random variables, joint CDF and joint PDF. One function of two random variables; joint moments, covariance and correlation independent, uncorrelated and orthogonal random variables. Central limit theorem and its significance.

**4.1 Introduction to Pairs of Random Variables .....4-1**

4.1.1 Distribution Function of a Two Dimensional Random Variable (X, Y)..... 4-1

4.1.2 Probability Density Function (PDF) of a Two Dimensional Random Variable ..... 4-1

4.1.3 Properties of Joint Density Function ..... 4-2

**4.2 Marginal Distribution Function .....4-2**

4.2.1 Marginal Probability Density Function ..... 4-2

**4.3 Conditional Distribution Function.....4-6**

4.3.1 Conditional Density Function..... 4-7

4.3.2 Properties of Conditional Density Function ..... 4-7

4.3.3 Independence of Random Variables ..... 4-7

**4.4 One Function of Two Random Variables ..... 4-10**

**4.5 Joint Moments ..... 4-14**

**4.6 Covariance and Correlation ..... 4-15**

**4.7 Uncorrelated and Orthogonal Random Variables ..... 4-16**

**4.8 Central Limit Theorem and Its Significance..... 4-20**

4.8.1 Central Limit Theorem..... 4-20

4.8.2 Significance of Central Limit Theorem..... 4-21

**MODULE - V**

**Chapter 5 : Random Processes** 5-1 to 5-32

**Syllabus :** Definitions, statistics of stochastic processes, nth order distribution, second-order properties : mean and autocorrelation, Poisson process, normal processes, SSS, WSS. Mean and correlation ergodic processes, transmission of WSS through LTI system, introduction to Markov process.

**5.1 Introduction to Random Processes ..... 5-1**

5.1.1 Definition of Random / Stochastic Process...5-1

**5.2 Classification of Random Processes ..... 5-1**

5.2.1 First Order Statistics .....5-2

5.2.2 Second Order Statistics .....5-6

**5.3 Poisson Process ..... 5-9**

5.3.1 Mean and Variance of Poisson Process.....5-9

5.3.2 Autocorrelation, Autocovariance and Correlation Coefficient of Poisson Process..... 5-10

5.3.3 Joint Probability Density.....5-10

5.3.4 Properties of Poisson Process .....5-11

**5.4 Normal Process / Gaussian Process ..... 5-13**

5.4.1 Process Depending on Stationary  
Gaussian Process.....5-14

**5.5 Strict Sense Stationary (SSS) Process .... 5-15**

5.5.1 Order of Stationary Process .....5-15

**5.6 Wide Sense Stationary Process ..... 5-17**

**5.7 Introduction to Ergodic Process ..... 5-21**

5.7.1 Mean Ergodic Process.....5-22

5.7.2 Mean Ergodic Theorem .....5-22

5.7.3 Correlation Ergodic Process.....5-22

**5.8 Linear Time Invariant (LTI) System..... 5-25**

5.8.1 Types of Systems.....5-25

5.8.2 LTI System .....5-26

5.8.3 Transmission of WSS Through  
LTI System .....5-26

5.8.4 Properties of Systems .....5-26

**5.9 Introduction to Markov Process..... 5-27**

5.9.1 Classification of States of a Markov Chain.. 5-28

5.9.2 Chapman Kolmogorov Equation..... 5-28

**MODULE - VI**

**Chapter 6 : Introduction to Statistical Learning  
and Applications 6-1 to 6-12**

**Syllabus** : Regression and model building, Simple linear regression, Multiple linear regression, Least square estimation of the coefficients, Residual calculations.  
Applications of simple linear regression in prediction of new observations.

**6.1 Regression and Model Building..... 6-1**

6.1.1 Simple Linear Regression Model .....6-1

6.1.2 Multiple Regression Model.....6-3

6.1.3 Least Square Estimation of the  
Coefficients (Parameters).....6-3

**6.2 Applications of Simple Linear  
Regression ..... 6-9**

