	Discipline-Specific Core (DSC) Courses			Discipline-Specific Elective (DSE) Courses		GE
Sem.	**B.Sc. (Hons.)**	**B.A.(P)**	**B.Sc.(P)**	**B.Sc. (Hons.)**	**B.A.(P)/B.Sc.(P)**	
I	1. Descriptive Statistics 2. Introduction to Probability 3. Calculus	1. Descriptive Statistics and Probability Theory 2. Economic Statistics	1. Descriptive Statistics and Probabilty Theory			1a. Basic Statistics+ 1b. Time Series Analysis and Index Numbers
II	4. Theory of Probability Distributions 5. Applied Statistics* 6. Algebra for Statistics	3. Statistical Methods 4. Applications in Statistics	2. Statistical Methods			2a. Introductory Probability 2b. Applications in Statistics
III	7. Sample Surveys 8. Advanced Probability Distributions 9. Mathematical Analysis	5. Elements of Sampling Distributions* 6. Statistical Quality Control	3. Elements of Sampling Distributions*	1a. Optimization Techniques 1b. Psychological and Educational Statistics	1. Time series Analysis and Index Numbers*	3. Sampling Distributions
IV	10. Sampling Distributions 11.Total Quality Management 12. Time Series Analysis	7. Basics of Statistical Inference* 8. Introduction to Vital Statistics and Demography	4. Basics of Statistical Inference*	2a. Computer Programming in C 2b. Advanced Techniques of Sample Surveys 2c. Demography (Not for BA(P)) 2d. Introduction to Vital Statistics and Demography(for B.Sc.(P) only)+		4a. Basics of Statistical Inference 4b. Statistical Computing using R
V	13. Theory of Estimation 14. Linear Models 15. Stochastic Processes	9. Introduction to Design of Experiments 10. Statistical Simulation	5. Introduction to Design of Experiments	3a. Acturial Statistics 3b. Simulation Techniques in Statistics (Not for BA(P)) 3c. Environmental Statistics 3d. Regression Analysis (Not for B.Sc.(H))		5a. Introduction to Statistical Linear Models 5b. Statistical Techniques for Quality Control
VI	16. Testing of Hypothesis 17. Design of Experiments 18. Econometrics	11. Survey Sampling 12. Statistical Methods for Psychology and Education*	6. Survey Sampling	4a. Bio-statistics 4b. Order Statistics and its Applications 4c. Statistical Computing and Basic Data Mining* 4d. Research Methodolgy		6a. Survey Sampling and Design of Experiments 6b. Statistics in Actuaries
VII	19. Multivariate Analysis	13. Stochastic Processes & Queuing Theory	7. Stochastic Processes & Queuing Theory	5a. Financial Statistics 5b. Advanced Design of Experiments 5c. Advanced Theory of Biostatistics 5d. Research Methodology	5a. Linear Programming Techniques 5b. Introduction to Statistical Linear Models 5c. Statistical Methods in Psychology and Education 5d. Research Methodology	7a. Non-Parametric Methods 7b. Introduction to Bayesian Inference 7c. Elements of Stochastic Processes
VIII	20. Bayesian Inference	14. Fundamentals of Econometrics	8.Fundamentals of Econometrics	6a. Non-Parametric Testing 6b. Reliability Theory and Life Testing 6c. Generalized Linear Models 6d. Advanced Stochastic Processes	6a. Introduction to Non Parametric Methods 6b. Reliability Theory 6c. Multivariate Data Analysis 6d. Statistical Simulation	8a. Order Statistics 8b. Statistics in Finance 8c. Introduction to Reliability Theory

1. EC dated 10.10.2022 (Sem I)
2. EC dated 03.03.2023 (Sem II)
3. EC minutes dated 03.02.2023 (1264) (Sem III)
4. EC minutes dated 14.09.2023 (Sem IV, V and VI)
5. EC minutes dated 07.08.2024+*
6. AC minutes dated 27.12.2024 (1021) (Sem VII and VIII)

*; Only Name Change (In Sem II, III, IV and VI)

.+; Complete Syallbus change (Sem IV (DSE) and Sem I (GE))

UNIVERSITY OF DELHI

CNC-II/093/1(22)/2022-23/216
Dated: 10.10.2022

NOTIFICATION

Sub: Amendment to Ordinance V

[E.C Resolution No. 18-1/ (18-1-4) dated 18.08.2022]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester-I of the following departments under Faculty of Mathematical Sciences based on Under Graduate Curriculum Framework -2022 to be implemented from the Academic Year 2022-23.

Sem I EC dtd. 10.10.22

DEPARTMENT OF STATISTICS

B.Sc. (H) Statistics

Category-I

DISCIPLINE SPECIFIC CORE COURSE – 1: DESCRIPTIVE STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Descriptive Statistics	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- To tabulate statistical information given in descriptive form and to use graphical
- techniques to interpret
- To understand various measures of central tendency, dispersion, skewness and kurtosis. Moments and its properties.
- Familiarize with quantitative and qualitative data and available statistical tools to analyse them.
- Finding linear correlation between two variates using different measures and studying their properties. Least square method of fitting of curves, regression lines and their elementary properties.

Learning Outcomes:

The Learning Outcomes of this course are as follows:

- Understand concepts of sample vs. population and get acquainted with different types of data /scales. Distinguish between primary and secondary data. Tabulate and plot frequency distribution. Deals with numerical and graphical ways to describe and display data using histograms, stem and leaf plot and box plots.
- Calculate measures of central locations like mean, geometric mean, harmonic mean, median and mode and explain their properties
- Calculate measures of the spread: variance, standard deviation, range and inter-quartile range and explain their properties.
- Understand the meaning of probability and probabilistic experiment. Familiarize with the four approaches to probability theory and particularly, the axiomatic approach and use and manipulate the four axioms of probability comfortably to derive the results of other set operations

- Understand and exploit Addition and Multiplicative laws of probability
- understand the meaning of conditional probability, conditioning, and reduced sample space, compute joint and conditional probabilities. independence, total probability, Bayes' rule and applications.
- Understand the concept of a random variable, differentiate between independent and uncorrelated random variables, distinguish between discrete, continuous, random variables and be able to represent them using probability mass, probability density, and cumulative distribution functions, Univariate transformation and its application.
- Understand expectation and its properties, Compute variance and covariance in terms of expectation. Solve problems based on expectation and its properties.

SYLLABUS OF DSC-1

Theory

Unit – 1 **(09 hours)**

Data Visualization

Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Types of Data: Concepts of population and sample, quantitative and qualitative data, cross-sectional and time-series data, discrete and continuous data. Different types of scales: Nominal, ordinal, interval and ratio. Collection and Scrutiny of Data: Primary data. Secondary data – its major sources. Complete enumeration. Construction of tables with one or more factors of classification, frequency distributions and cumulative frequency distributions and their graphical representations (Histograms, frequency polygon), stem and leaf displays.

Unit – 2 **(15 hours)**

Data Summarization

Measures of Central Tendency: Mathematical and positional, partition values, Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, graphical representation of various measures of location and dispersion (Ogives, Histograms, Box Plot) Moments: Raw moments, Central moments, Absolute moments, Factorial moments, Sheppard's corrections, skewness and kurtosis, Types of frequency distributions.

Unit – 3 **(06 hours)**

Theory of Attributes

Theory of attributes: consistency and independence of data with special reference to attributes, Association of attributes: concept, Yules coefficient of Colligation and Coefficient of Colligation.

Unit – 4 **(15 hours)**

Correlation and Regression

Bivariate data: Definition, scatter diagram, Karl Pearson's coefficient of correlation. Spearman's rank correlation coefficient (Introductory with interpretation). Principle of least squares and

fitting of polynomials and exponential curves, lines of regression, properties of regression coefficients, angle between two regression lines, and residual variance.

Practical – 30 Hours

List of Practicals:

1. Graphical representation of data- frequency polygon, histogram and ogive.
2. Practical based on arithmetic mean and to find missing frequencies given arithmetic mean.
3. Practical based on median and partition vales using formulae and to find them graphically also.
4. Practical based on mode by using formula, graphically, method of grouping.
5. Practical based on combined mean and combined variance.
6. Practical based on quartile deviation using formula and graphically.
7. Practical based on mean deviation and standard deviation.
8. Practical based on coefficient of variation.
9. Practical based on moments about origin and moments about any arbitrary point.
10. Practical on skewness based on mean, median, mode and standard deviation.
11. Practical based on central moments, skewness and kurtosis.
12. Practical based on fitting of polynomials.
13. Practical based on fitting of exponential curves, power curves.
14. Practical based on association and independence of attributes.
15. Practical based on fundamental set of class frequencies in attributes (find missing frequencies given fundamental set of class frequencies).
16. Practical based on Karl Pearson correlation coefficient.
17. Practical based on correlation coefficient for a bivariate frequency distribution.
18. Practical based on lines of regression, angle between lines and estimated values of variables.
19. Practical based on rank correlation with ties.
20. Practical based on rank correlation without ties.

Essential Readings

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I, 8th Ed. The World Press, Kolkata.
- Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th Edn., S. Chand and Sons. Delhi.
- Bernstein, S. and Bernstein, R. (2020). Schaums: Outline of Elements of Statistics I Descriptive Statistics and Probability. McGraw Hill.
- Heumann, C., Schomaker, M. and Shalabh (2016). Introduction to Statistics and Data Analysis with Exercises, Solutions and Applications in R. Springer.

Suggestive Readings

- Tukey, J.W. (1977). Exploratory Data Analysis, Addison-Wesley Pub. Co. N.Y.
- Myatt, G, J. and Johnson, W.P. (2014). Making sense of data: A practical guide to

exploratory data analysis and data mining. 2nd Edn, John Wiley & Sons, Inc. N. J.
- Agresti, A., Christine Franklin, C. and Klingenberg, B. (2017). Statistics: the art and science of learning from data. Pearson. Boston.
- Dudewicz, E. and Mishra, S. N. (1988). Modern Mathematical Statistics. Wiley.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 2: INTRODUCTION TO PROBABILITY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Probability	4	3	0	1	Class XII pass with Mathematics	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- Familiarize students with the mathematical basis of probability theory.
- Prepare students with important tools for statistical analyses at the undergraduate level.
- Promote understanding through real-world statistical applications.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Understand the meaning of probability and probabilistic experiment. Familiarize with the four approaches to probability theory and particularly, the axiomatic approach, use and manipulate the four axioms of probability comfortably to derive the results of other set operations.
- Understand and use addition and multiplicative laws of probability, understand the meaning of conditional probability, conditioning, and reduced sample space, compute joint and conditional probabilities. independence, total probability, Bayes' rule and applications.
- Understand the concept of a random variable, differentiate between independent and uncorrelated random variables, distinguish between discrete and continuous, random variables and be able to represent them using probability mass, probability density, and cumulative distribution functions. Acquaint with Univariate transformation and its application.
- Understand expectation and its properties, Compute variance and covariance in terms of expectation. Solve problems based on expectation and its properties.

SYLLABUS OF DSC - 2

Theory

Unit – 1 **(12 hours)**

Elements of Probability

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – Classical, Statistical. Limitations of Classical definition. Probability of union and intersection of events, Probability of occurrence of exactly m and at least m events out of n events, Examples based on classical approach and repeated trials, Kolmogorov's Axiomatic definition and problems based on it, Matching problems.

Unit – 2 **(09 hours)**

Laws of Probability

Conditional Probability, laws of addition and multiplication, theorem of total probability, Examples based on conditional probability and laws of addition and multiplication, independent events – Pairwise mutual independence, Bayes' theorem and its applications, Geometric probability.

Unit – 3 **(15 hours)**

Random variables

Distribution function and properties, Discrete random variables - p.m.f., discrete distribution function, Continuous random variables - p.d.f, illustrations and properties of random variables. Measures of central tendency, dispersion, skewness and kurtosis for continuous probability distributions, Examples based on random variables, Continuous distribution functions and their properties, Univariate transformation of random variables, Examples based on univariate transformations.

Unit – 4 **(09 hours)**

Mathematical Expectation

Expectation of random variable and its properties (addition and multiplication theorem of expectation), Variance and Covariance in terms of expectation and their properties, Examples based on Expectation and its properties.

Practical – 30 Hours

List of Practicals:

1. Problem based long run relative frequency to establish statistical definition of probability
2. Problem based on geometric probability.
3. Problem based on permutations and combinations when all objects are distinguishable.
4. Problem based on permutations and combinations when not all objects are different.
5. Computation of probability related to occurrence of exactly m and at least m events out of n events.

6. Computation of probabilities related to matching problems
7. Computation of conditional probabilities using addition and multiplication laws.
8. Problem related to application of Bayes Theorem.
9. Computation of distribution function of discrete and continuous random variables and calculations of probabilities of events thereof.
10. Graphical representation of probability function and distribution function of discrete/continuous arbitrary random variables.
11. Finding expectation, variance and covariances of discrete as well as continuous random variables
12. Finding expectation, variance and covariances of linear function of discrete as well as continuous random variables.
13. Constructing sample space for two-dimensional random variable.

Essential Readings

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I, 8th Ed. The World Press, Kolkata.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2017). An Outline of statistical theory, Vol. I, The World Press, Kolkata.
- Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th Edn., S. Chand and Sons. Delhi.
- Ross, S.M. (2002). A first course in Probability, 6th Ed., Pearson.
- Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia.

Suggestive Readings

- Chung, K.L. (2000). A Course in Probability Theory, 3rd Edn. Academic Press.
- Parzen, E. (1960). Modern probability theory and its applications. John Wiley.
- Feller, W. (1968) An introduction to probability theory and its applications. Vol. I, 3rd Edn. John Wiley & Sons Inc., New York.
- Blake, I. F. (1987). Introduction to Applied Probability. Krieger Publishing Co.

Note: **Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

DISCIPLINE SPECIFIC CORE COURSE – 3: CALCULUS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course	Credits	Credit distribution of the course	Eligibility	Pre-requisite

title & Code		Lecture	Tutorial	Practical/ Practice	criteria	of the course (if any)
Calculus	4	3	0	1	Class XII pass with Mathematics	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize students with the basic mathematical tools.
- It helps students to understand the other statistical concepts.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Understand to solve applied problems using differentiation and integration.
- Understand to solve applied problems under integral sign and changes of order of integration.

SYLLABUS OF DSC – 3

Theory

Unit – 1 **(15 hours)**

Differential Calculus

Review of limits, continuity and differentiability, partial differentiation and total differentiation. Indeterminate forms: L-Hospital's rule, Leibnitz rule for successive differentiation. Euler's theorem on homogeneous functions.

Unit – 2 **(15 hours)**

Integral Calculus

Review of integration and definite integral. Differentiation under integral sign, double integral, changes of order of integration. Beta and Gamma functions: Properties and relationship between them.

Unit – 3 **(15 hours)**

Differential Equations

Exact differential equations. Differential equations of first order and first degree. Higher Order Differential Equations: Linear differential equations of order n, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals. The Cauchy-Euler's equation of order n. Formation and solution of a partial differential equations. Equations easily integrable. Linear partial differential equations of first order. Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals.

Practical – 30 Hours

List of Practicals:

1) Verification of Euler's Theorem.
2) Applications of differentiation
    a. Calculate income and price elasticity of demand.
    b. Determination of price and quantity for which total revenue is maximum.

c. Find the level of output for which the average cost is minimum.
d. Solve profit maximization problems.
e. Evaluate first and second order partial derivatives of functions of the form $Z = f(x, y)$.
f. Examine a function of two variables for relative maxima and relative minima.
g. Find the nature of the commodities by using the concept of partial marginal demand functions.
h. Find four partial elasticities for a demand function of two variables.

3) Applications of Integration
a) Derive total cost function from given marginal cost function.
b) Derive total revenue function and demand function form a given marginal revenue function.
c) Calculate the maximum profit if marginal revenue and marginal cost are given.
d) Find the demand function when the price elasticity of demand is given.

4) Applications of Differential Equations
a) Application on growth and decay.
b) Application of the form $\frac{d^2y}{dx^2} = f(x)$ and $\frac{d^2y}{dx^2} = f(y)$ to physical problems.
c) Application on coordinate geometry.

5) Verify that the area under the curve is unity under the given p.d.f. and also calculate
a) Arithmetic Mean
b) Median
c) Mode
d) Standard Deviation

Essential Reading

- Prasad, G. (2017). Differential Calculus, 19th Ed. (Revised), Pothishala Pvt. Ltd., Allahabad.
- Prasad, G. (2017). Integral Calculus, 17th Ed. (Revised), Pothishala Pvt. Ltd., Allahabad.
- Ahsan, Z. (2004). Differential Equations and their Applications, 2nd Ed., PHI, Pvt. Ltd., New Delhi.
- Shanti Narayan and P K Mittal (2018). Differential Calculus. 15th Ed (Revised)., S Chand Publication, New Delhi
- Shanti Narayan and P K Mittal (2016). Integral Calculus. 11th Ed (Revised), S Chand Publication, New Delhi.
- Business Mathematics Theory and Applications, V. K. Kapoor (2012), Sultan Chand & Sons.

Suggestive Reading

- R. S. Soni (2000) Business Mathematics with applications in Business and Economics, 3rd ed., Pitamber Publishing Company (P) Ltd.
- Brahma Nand, B. S. Tyagi and B. D. Sharma, Integral Calculus, Kedar Nath Ram Nath.

Note: **Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

REVISED SYLLABI OF SEM 1
(w.e.f academic session 2023-2024 onwards)

B.Sc. (P)/B.A(P) with Statistics as Major

Category II

DISCIPLINE SPECIFIC CORE COURSE-1: DESCRIPTIVE STATISTICS AND PROBABILITY THEORY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Descriptive Statistics and probability theory	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives

Learning objectives include:

1. Introduction to Statistics.
2. Graphical representation of data.
3. Understanding the concept of Probability.

Learning outcomes

After completion of this course, students will develop a clear understanding of:

1. Apply the fundamental concepts of statistics.
2. Understand handling various types of data and their graphical representation.
3. Employ measures of location and dispersion.
4. Bivariate data. Significance of various coefficients of correlation.
5. Employ fitting of linear curve.

Use probability theory and its applications

SYLLABUS OF DSC-1

Theory

UNIT – I **(15 hours)**

Basic Statistics

Fundamentals of statistics. Diagrammatic representation of data. Measures of central tendency: location and positional. Partition values, Measures of Dispersion: range, quartile deviation, mean

deviation, standard deviation, coefficient of variation. Moments: raw and central, Measures of skewness and kurtosis.

UNIT – II **(15 hours)**

Correlation and Regression

Bivariate data: definition, scatter diagram. Correlation and regression: Karl Pearsons coefficient of correlation, Spearman's rank correlation coefficient, lines of regression, properties of regression coefficients, angle between two regression lines. Principle of least-square and fitting of linear curve.

UNIT – III **(15 hours)**

Probability

Probability: Introduction, Random experiment, sample point and sample space, event, algebra of events, Definition of Probability - classical, relative frequency and axiomatic approaches to probability, merits and demerits of these approaches (only general ideas to be given). Theorems on probability, conditional probability, independent events: pairwise and mutually independent. Bayes theorem and its applications.

Practical -30 Hours

List of Practicals:

1. Problems based on graphical representation of data. Histograms (equal class intervals and unequal class intervals), frequency polygon, ogive curve.
2. Problems based on mean using raw data, grouped data for change of origin and scale.
3. Problems based on arithmetic mean and to find missing frequencies given arithmetic mean.
4. Problems based on median and partition vales using formulae and to find them graphically
5. Problems based on mode by using formula, graphically, method of grouping.
6. Problems based on mean deviation and standard deviation.
7. Problems based on combined mean and variance.
8. Problems based on coefficient of variation.
9. Comparison of data using consistency approach.
10. Problems on skewness based on mean, median, mode and standard deviation.
11. Problems based on central moments.
12. Relationships between moments about origin and central moments.
13. Problems based on skewness and kurtosis.
14. Problems based on Karl Pearson correlation coefficient.
15. Problems based on Spearman's rank correlation with ties.
16. Problems based on Spearman's rank correlation without ties.
17. Problems based on lines of regression and estimated values of variables.
18. Problems on regression coefficients.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005). Fundamentals of Statistics, Vol. I, 8th Ed., World Press, Kolkatta.
- Gupta, S.C. and Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand and Sons.
- Hogg, R. V., McKean, J., and Craig, A. T. (2005). Introduction to mathematical statistics. Pearson Education.

- Freund, J.E. (2009). Mathematical Statistics with Applications, 7th Ed., Pearson Education.

SUGGESTIVE READINGS

- Mood, A.M., Graybill, F.A. and Boes, D.C. (2007). Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw Hill Publication
- Miller, Irwin and Miller, Marylees (2006): John E Freund's Mathematical Statistics with Applications, (7th ed.) Pearson Education, Asia.
- Nagar and Das (1997) Basic Statistics. 2nd ed., Oxford University Press

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE-2: ECONOMIC STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Economic Statistics	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives

The learning objectives include:

1. Introduce the concept of time series, its components, and their estimation.
2. Introduce the application of time series.
3. Introduce the concept, formulation, and application of index numbers.

Learning outcomes

After completing this course, students will develop a clear understanding of:

1. The concepts of time series and index numbers.
2. Formulate, solve, and analyse the use of time series and index numbers for real-world problems.

SYLLABUS DSC 2

Theory

UNIT - I **(15 hours)**

Components of Time Series

Introduction to Time Series, Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series, Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and exponential).

UNIT - II **(12 hours)**

Trend and Seasonality

Fitting of modified exponential, Gompertz and logistic curve, Moving average method, Measurement of seasonal variations by method of simple averages, ratio to trend method, and ratio to moving average method.

UNIT - III **(18 hours)**

Index Numbers

Introduction to Index numbers, Problems in the construction of index numbers, Construction of price and quantity index numbers: simple aggregate, weighted aggregate (Laspeyres, Paasche's, Drobish-Bowley, Marshall-Edgeworth's, Walsch and Fisher's Formula), simple and weighted average of price relatives, and chain base method, Criteria for a good index number, Errors in the measurement of price and quantity index numbers, Consumer price index number, its construction and uses, Uses and limitations of index numbers.

Practical - 30 Hours

List of Practicals:

Practical based on

1. Fitting of linear trend
2. Fitting of quadratic trend
3. Fitting of an exponential curve
4. Fitting of modified exponential curve by the method of
   a. Three selected points
   b. Partial sums
5. Fitting of Gompertz curve by the method of
   a. Three selected points
   b. Partial sums
6. Fitting of logistic curve by the method of three selected points
7. Fitting of trend by moving average method (for n even and odd)
8. Measurement of seasonal indices by
   a. Method of simple averages
   b. Ratio-to-trend method
   c. Ratio-to-moving-average method
9. Construction of price and quantity index numbers by simple aggregate method.
10. Construction of price and quantity index numbers by Laspeyres, Paasche's, Drobish-Bowley, Marshall-Edgeworth, Walsch and Fisher's Formula.
11. Construction of price and quantity index numbers by simple and weighted average of price relatives.
12. Construction of index number by Chain base method.
13. Construction of consumer price index number by
    a. Family budget method
    b. Aggregate expenditure method
14. Time Reversal Test and Factor Reversal Test

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Goon A M, Gupta M K and Dasgupta B (2018): Fundamentals of Statistics, Volume II, 9th Edition and 4th reprint.
- Gupta, S.C. and Kapoor, V.K. (2014). Fundamentals of Applied Statistics, 11th Ed., Sultan Chand.
- Croxton, Fredrick E, Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd edition, Prentice Hall of India Pvt. Ltd.

SUGGESTIVE READING

- Mukhopadhyay, P. (1999). Applied Statistics, New Central Book Agency, Calcutta.
- Allen R.G.D. (1975): Index Numbers in Theory and Practice, Macmillan

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

B.Sc. (P)/B.A(P) with Statistics as Non- Major

Category III

DISCIPLINE SPECIFIC CORE COURSE-1: DESCRIPTIVE STATISTICS AND PROBABILITY THEORY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Descriptive Statistics and probability theory	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives

Learning objectives include:

4. Introduction to Statistics.
5. Graphical representation of data.
6. Understanding the concept of Probability.

Learning outcomes

After completion of this course, students will develop a clear understanding of:

6. Apply the fundamental concepts of statistics.
7. Understand handling various types of data and their graphical representation.
8. Employ measures of location and dispersion.
9. Bivariate data. Significance of various coefficients of correlation.
10. Employ fitting of linear curve.
11. Use probability theory and its applications.

SYLLABUS OF DSC-1

Theory

UNIT – I **(15 hours)**

Basic Statistics

Fundamentals of statistics. Diagrammatic representation of data. Measures of central tendency: location and positional. Partition values, Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation. Moments: raw and central, Measures of skewness and kurtosis.

UNIT – II **(15 hours)**

Correlation and Regression

Bivariate data: definition, scatter diagram. Correlation and regression: Karl Pearsons coefficient of correlation, Spearman's rank correlation coefficient, lines of regression, properties of regression coefficients, angle between two regression lines. Principle of least-square and fitting of linear curve.

UNIT – III **(15 hours)**

Probability

Probability: Introduction, Random experiment, sample point and sample space, event, algebra of events, Definition of Probability - classical, relative frequency and axiomatic approaches to probability, merits and demerits of these approaches (only general ideas to be given). Theorems on probability, conditional probability, independent events: pairwise and mutually independent. Bayes theorem and its applications.

Practical -30 Hours

List of Practicals:

1. Problems based on graphical representation of data. Histograms (equal class intervals and unequal class intervals), frequency polygon, ogive curve.
2. Problems based on mean using raw data, grouped data for change of origin and scale.
3. Problems based on arithmetic mean and to find missing frequencies given arithmetic mean.
4. Problems based on median and partition vales using formulae and to find them graphically
5. Problems based on mode by using formula, graphically, method of grouping.
6. Problems based on mean deviation and standard deviation.
7. Problems based on combined mean and variance.

8. Problems based on coefficient of variation.
9. Comparison of data using consistency approach.
10. Problems on skewness based on mean, median, mode and standard deviation.
11. Problems based on central moments.
12. Relationships between moments about origin and central moments.
13. Problems based on skewness and kurtosis.
14. Problems based on Karl Pearson correlation coefficient.
15. Problems based on Spearman's rank correlation with ties.
16. Problems based on Spearman's rank correlation without ties.
17. Problems based on lines of regression and estimated values of variables.
18. Problems on regression coefficients.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005). Fundamentals of Statistics, Vol. I, 8th Ed., World Press, Kolkatta.
- Gupta, S.C. and Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand and Sons.
- Hogg, R. V., McKean, J., and Craig, A. T. (2005). Introduction to mathematical statistics. Pearson Education.
- Freund, J.E. (2009). Mathematical Statistics with Applications, 7th Ed., Pearson Education.

SUGGESTIVE READINGS

- Mood, A.M., Graybill, F.A. and Boes, D.C. (2007). Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw Hill Publication
- Miller, Irwin and Miller, Marylees (2006): John E Freund's Mathematical Statistics with Applications, (7th ed.) Pearson Education, Asia.
- Nagar and Das (1997) Basic Statistics. 2nd ed., Oxford University Press

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES: TIME SERIES ANALYSIS AND INDEX NUMBERS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Time Series Analysis and Index Numbers	4	3	0	1	Class XII pass with Mathematics	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- Introduce the concept of time series, its components, and their estimation.
- Introduce the application of time series.
- Introduce the concept, formulation, and application of index numbers.

Learning outcomes

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

- Understand the concepts of time series and index numbers.
- Formulate, solve, and analyze the use of time series and index numbers for real-world problems.

SYLLABUS OF GE

Theory

Unit - 1 **(15 hours)**

Components of Time Series

Introduction to Time Series, Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series, Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and exponential).

Unit - 2 **(15 hours)**

Trend and Seasonality

Fitting of modified exponential, Gompertz and logistic curve, Moving average method, Measurement of seasonal variations by method of simple averages, ratio to trend method, and ratio to moving average method.

Unit - 3 **(15 hours)**

Index Numbers

Introduction to Index numbers, Problems in the construction of index numbers, Construction of price and quantity index numbers: simple aggregate, weighted aggregate (Laspeyres, Paasche's, Drobish-Bowley, Marshall-Edgeworth's, Walsch and Fisher's Formula), simple and weighted average of price relatives, and chain base method, Criteria for a good index number, Errors in the measurement of price and quantity index numbers, Consumer price index number, its construction and uses, Uses and limitations of index numbers.

Practical – 30 Hours

List of Practicals:

a. Fitting of linear trend
b. Fitting of quadratic trend
c. Fitting of an exponential curve
d. Fitting of modified exponential curve by the method of
    - Three selected points
    - Partial sums
e. Fitting of Gompertz curve by the method of
    - Three selected points
    - Partial sums
f. Fitting of logistic curve by the method of three selected points
g. Fitting of trend by moving average method (for n even and odd)
h. Measurement of seasonal indices by
    - Method of simple averages
    - Ratio-to-trend method
    - Ratio-to-moving-average method
i. Construction of price and quantity index numbers by simple aggregate method.
4. Construction of price and quantity index numbers by Laspeyres, Paasche's, Drobish-Bowley, Marshall-Edgeworth, Walsch and Fisher's Formula.
5. Construction of price and quantity index numbers by simple and weighted average of price relatives.
6. Construction of index number by Chain base method.
7. Construction of consumer price index number by
    a. Family budget method
    b. Aggregate expenditure method

14. Time Reversal Test and Factor Reversal Test

Essential Readings

- Croxton, Fredrick E, Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd edition, Prentice Hall of India Pvt. Ltd.
- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II, 9th Ed., World Press, Kolkata.
- Gupta, S.C. and Kapoor, V.K. (2014). Applied Statistics, 11th Ed., Sultan Chand.

Suggestive Reading

- Allen R.G.D. (1975): Index Numbers in Theory and Practice, Macmillan
- Mukhopadhyay, P. (1999). Applied Statistics, New Central Book Agency, Calcutta.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

UNIVERSITY OF DELHI

CNC-II/093/1(40)/EC-1270/2024-25/156
Dated: 07.08.2024

NOTIFICATION

Sub: Amendment to Ordinance V

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

In pursuant of EC Resolution No. 5-13/ dated 27.07.2024, the following amendment is made based on Undergraduate Curriculum Framework 2022 implemented from the Academic Session 2022-2023:

(i) Addition of a paper titled "Introduction to Vital Statistics and Demography" for students of BSc (Programme) Mathematical Sciences under the Pool of DSEs in Semester-IV (Note: The paper is already running as a DSC paper of BA Prog. (Major) in Sem-IV). – **Annexure-1.**
(ii) Deletion of a Generic Elective paper titled "Introduction to Statistics" in Semester-1.
(iii) Revision of Generic Elective paper titled "Basic Statistics" in Semester-1 - **Annexure-2.**
(iv) Correction in the name/title of following papers:

Existing	**Proposed**
BSc (Hons.) –DSC4 Theory of Probability Distribution	BSc (Hons.) –DSC4 Theory of Probability Distributions
BSc (Hons.) –DSC50 Applied Statistics-I	BSc (Hons.) –DSC5 Applied Statistics
BA Prog./ BSc (Prog.) Mathematical Sciences-DSC3 Sampling Distributions	BA Prog./ BSc (Prog.) Mathematical Sciences-DSC3 Elements of Sampling Distributions
BA Prog./ BSc (Prog.) Mathematical Sciences-DSC4 Elements of Statistics Inference	BA Prog./ BSc (Prog.) Mathematical Sciences-DSC4 Basics of Statistical Inference
BSc. (Prog.) Mathematical Sciences-DSE-1 Index numbers and Time Series Analysis	BSc. (Prog.) Mathematical Sciences-DSE-1 Time Series Analysis and Index numbers
BSc (Hons.) - DSE – Semester-6 Statistical Computing and Data Mining	BSc (Hons.) - DSE – Semester-6 Statistical Computing and Basic Data Mining
BA (Prog.) - DSC-6 – Semester-6 Statistical Methods in Psychology and Education	BA (Prog.) - DSC-6 – Semester-6 Statistical Methods for Psychology and Education

REGISTRAR

Annexure-2

DEPARTMENT OF STATISTICS

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY DEPARTMENT OF STATISTICS CATEGORY-IV, SEMESTER-I

With effect from academic session 2024-2025

GENERIC ELECTIVES- 1A: BASIC STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Basic Statistics	4	3	0	1	Class XII pass with Mathematics	NIL	Statistics

Learning Objectives

The Learning Objectives of this course are as follows:

- Acquainting the students with descriptive data analysis.
- To introduce students to different measurement scales, qualitative and quantitative and discrete and continuous data.
- To help students to organise data into frequency distribution graphs, including bar graphs, histograms, polygons and ogives.
- Students should be able to understand the purpose for measuring central tendency, dispersion, skewness and kurtosis and should be able to compute them as well.
- Students should be able to understand theory of attributes, independence and association of attributes.

Learning outcomes

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

- Apply the concepts of statistical population and sample, variables and attributes.
- Present tabular and graphical representation of data based on variables.
- Measures of central tendency, Dispersion, Skewness and Kurtosis.
- Employ moments and their use in studying various characteristics of data.

- Employ correlation and regression analysis of bivariate data.
- Understand theory of attributes.

SYLLABUS OF GE -1a

Theory

Unit - 1 **(10 hours)**

Elementary Statistics

Concepts of a statistical population and sample from a population, quantitative and qualitative data, nominal, ordinal and time-series data, discrete and continuous data. Presentation of data by tables and by diagrams, frequency distributions for discrete and continuous data, graphical representation of a frequency distribution by histogram and frequency polygon, cumulative frequency distributions (inclusive and exclusive methods).

Unit – 2 **(18 hours)**

Descriptive Statistics

Measures of Central Tendency: Arithmetic mean, median, mode, geometric mean, harmonic mean, partition values. Measures of Dispersion: Range, quartile deviation, mean deviation, standard deviation, variance, coefficient of dispersion: coefficient of variation. Moments, Measure of skewness and kurtosis.

Unit – 3 **(07 hours)**

Theory of Attributes

Theory of Attributes: Consistency of data, independence of attributes, association of attributes, Yule's coefficient of association, coefficient of colligation.

Unit - 4 **(10 hours)**

Correlation and Regression

Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.

Practical – 30 Hours

List of Practicals:

1. Problems based on graphical representation of data.
2. Problems based on measures of central tendency using raw data, grouped data and for change of origin and scale.
3. Problems based on measures of dispersion using raw data, grouped data and for change of origin and scale.
4. Problems based on combined mean and variance and coefficient of variation.

5. Problems based on Moments using raw data, grouped data and for change of origin and scale.
6. Problems based on relationships between moments about origin and central moments.
7. Problems based on Skewness and kurtosis.
8. Problems based on Karl Pearson correlation coefficient (with/without change of scale and origin).
9. Problems based on Lines of regression, angle between two lines of regression
10. Problems based on Spearman rank correlation.
11. Fitting of polynomials and exponential curves.
12. Checking consistency of data.
13. Checking the independence of attributes
14. Measuring the association between the attributes

Essential Readings

- Goon, A. M., Gupta, M. K. and Dasgupta, B. (2003). An Outline of Statistical Theory (4th ed., Vol. I). World Press, Kolkata.
- Gupta, S. C. and Kapoor, V. K. (2021). Fundamentals of Mathematical Statistics (60^{th} ed.). Sultan Chand and Sons.
- Hogg, R. V., Craig, A. T. and Mckean, J. W. (2005). Introduction to Mathematical Statistics (6th ed.). Pearson Education.
- Mood, A.M. Graybill, F.A. and Boes, D.C. (2007). Introduction to the Theory of Statistics, 3rd Ed., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

Suggestive Reading

- Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

UNIVERSITY OF DELHI

CNC-II/093/1(23)/2022-23/451
Dated: 03.03.2023

NOTIFICATION

Sub: Amendment to Ordinance V

[E.C Resolution No. 38-1/ (38-1-4) dated 08.12.2022]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester-II of the following departments under Faculty of Mathematical Sciences based on Under Graduate Curriculum Framework -2022 to be implemented from the Academic Year 2022-23.

SEM II 03/03/23
EC dtd. ~~08/12/22~~

DEPARTMENT OF STATISTICS

B. Sc. (H) Statistics

Category-I

DISCIPLINE SPECIFIC CORE COURSE-4: THEORY OF PROBABILITY DISTRIBUTIONS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Theory of probabilit distributions	4	3	0	1	Class XII pass with Mathematics	Descriptive Statistics, Probability Theory, Calculus

Learning Objectives

The learning objectives of this course are as follows:

- Acquaint students with requisite tools for problem-solving available in statistical methodology.
- Prepare students to handle two/three-dimensional data and familiarize them with different measures of association as well as regression.
- Introduction to various discrete and continuous distributions and their properties.

Learning Outcomes

The learning outcomes of this course are as follows:

- Understand the role of expectation and its usefulness. Get familiar with different kind of generating functions and their strength and weaknesses
- Handle problems based on two-dimensional random variables using Jacobians and bivariate transformations.
- Understand and exploit various measures of correlation and regression for problem-solving.
- Familiarize with the concept of partial and multiple correlation coefficients and their properties
- Get acquainted with various discrete and continuous distributions their properties and interrelations and solve problems based on them.

SYLLABUS OF DSC-4

Theory

UNIT I **(09 Hours)**

Expectation

Mathematical Expectation: Conditional expectations and its properties. Bivariate transformations with illustrations. Moments, moment generating function and its properties. Cumulants, cumulant generating function and its properties. Characteristic function and its properties. Inversion theorem for continuous random variables (without proof) along with applications.

UNIT II **(12 Hours)**

Expectation (contd.)

Some inequalities involving expectation - Cauchy Schwartz Inequality, Jenson's inequality.

Two-dimensional random variables: Joint probability mass function/ Joint probability density function, marginal and conditional probability mass function/ probability density function, independence of random variables, examples based on joint/marginal/conditional pmf/pdf.

Conditional expectation and variance, Jacobian of transformation, Bivariate transformation of random variables, and Examples based on bivariate transformation.

UNIT III **(09 Hours)**

Correlation and Regression

Properties of various measures of correlation and regression using expectation, Correlation Ratio, Intra-class correlation, Partial and multiple correlations – definition, Yule's notation, the plane of regression, properties of residuals, multiple and partial correlation coefficients and their properties (derivation based on three variables), the relationship between multiple, partial and total correlations and examples based on them.

UNIT IV **(15 Hours)**

Probability Distributions

Discrete probability distribution – Binomial, Poisson- measures of central tendency, dispersion, skewness and kurtosis, recurrence relations based on moments, moment generating function, cumulant generating function, characteristic function, additive property, fitting of distribution, and examples based on application.

Continuous Probability distribution - Normal - measures of central tendency, dispersion, skewness and kurtosis, recurrence relations based on moments, moment generating function, cumulant generating function, characteristic function, additive property fitting of distribution and examples based on application, Uniform distribution – moments, mgf, mean deviation and examples based on bivariate transformations.

PRACTICAL – 30 Hours

List of Practicals:

1. Practical based on regression lines and properties of regression coefficients.
2. Practical based on Correlation ratio.
3. Practical based on Intra-class correlation.
4. Practical based on multiple correlation coefficient.
5. Practical based on partial correlation coefficient.

6. Practical based on planes of regression.
7. Word problems based on application s of Binomial distribution.
8. Practical based on fitting of Binomial distribution (when parameters are given).
9. Practical based on fitting of Binomial distribution (when parameters are not given).
10. Practical based on calculation of area under the normal curve.
11. Practical based on calculation of ordinates given area under the normal curve.
12. Practical based on fitting of the normal curve when parameters are not given.
13. Practical based on use of normal approximation to the binomial distribution.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS.

ESSENTIAL READINGS

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2016). *An Outline of Statistical Theory,* Vol. I, The World Press, Kolkata.
- Gupta, S. C. and Kapoor, V. K. (2020). *Fundamentals of Mathematical Statistics*, 12th Edn., S. Chand and Sons. Delhi.
- Hogg, R.V., Tanis, E.A. and Rao, J.M. (2009). *Probability and Statistical Inference*, 7th Ed., Pearson Education, New Delhi.
- Miller, I. and Miller, M. (2006). *John E. Freund's Mathematical Statistics with Applications*, 8th Ed., Pearson Education, Asia.
- Mukhopadhyay, P. (2016). *Mathematical Statistics.* Books And Allied, India.

SUGGESTED READINGS

- Mood, A.M. Graybill, F.A. and Boes, D.C. (2007). *Introduction to the Theory of Statistics*, 3rd Ed., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
- Rohatgi, V. K and Saleh M. E. (2015). *An Introduction to Probability and Statistics,* 3rd Edn. John Wiley & Sons, Inc., New Jersey.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

vide EC no (1270) 07.08.24 only name changed

DISCIPLINE SPECIFIC CORE COURSE-5: APPLIED STATISTICS I

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Applied Statistics	4	3	0	1	Class XII pass with Mathematics	Descriptive Statistics

Learning Objectives

The learning objectives of this course are as follows:

- This course will help students to know the applications of Statistics and learn and apply these concepts in real life situations.
- This course will give exposure to two applied fields of statistics viz. Vital Statistics and Index Numbers.
- They will be having hands on practice of working on the data related to above mentioned fields.
- This course will help them understand about the working of the Indian Official Statistical System.

Learning Outcomes:

The learning outcomes of this course are as follows:

- Understanding of the distinction between Vital Statistics and Demography.
- Knowledge of basic measures of Mortality, Fertility, and Population Growth.
- Ability to construct of Life Tables.
- Understanding of fundamental concepts of Index Numbers.
- Ability to construct Price and Quantity Index numbers, Consumer and Wholesale Price Index Numbers.
- Knowledge of Official Statistical System in India, Statistical offices at the Centre and States along with their functions.

SYLLABUS OF DSC-5

Theory

UNIT I **(18 Hours)**

Vital Statistics

Introduction, Sources of collecting vital statistics, Errors in census and registration data, Uses of Vital Statistics. Measurements of mortality: Crude death rate (CDR), Age specific death rate (ASDR), Standardized death rates and Infant mortality rate.

Life table: Assumptions, description and construction of Complete life table. Definition of Abridged life table.
Measurements of fertility: Crude birth rate (CBR), General fertility rate (GFR), Age specific fertility rate (ASFR), Total fertility rate (TFR).
Measurements of population growth: Crude rate of natural increase, Pearle's vital index, Gross reproduction rate (GRR) and Net reproduction rate (NRR).

UNIT 2 **(12 Hours)**

Index numbers

Introduction, Problems involved in the construction of index numbers, Constructions of index numbers of Prices and Quantities. Index numbers based on Average of Price Relatives, Criteria for a good Index numbers. Errors in the measurement of Price and Quantity Index Numbers, Consumer price index number, Concept of Wholesale price index number with interpretation. Uses and Limitation of Index numbers.

UNIT 3 **(15 Hours)**

Indian Official Statistics

Introduction, Present official statistical system in India, Statistical offices at the Centre, Statistical offices in the States, Methods of collection of official statistics on population, price (retail as well wholesale).

PRACTICAL -30 Hours

List of Practicals:

1. To calculate CDR and ASDR for a given set of data
2. To find Standardized death rate by Direct and Indirect method
3. To construct a complete life table
4. To fill in the missing entries in a life table
5. To calculate CBR and GFR for a given set of data
6. To calculate ASFR for a given set of data
7. To calculate TFR for a given set of data
8. To calculate Crude rate of Natural Increase and Pearle's Vital Index
9. To calculate GRR and NRR for a given set of data and compare them
10. To Construct price and quantity index numbers by Laspeyre's, Paasche's, Marshall-Edgeworth, Drobish -Bowley, Walsch and Fisher's Formula.
11. To test the goodness of an Index number using Time Reversible Test and Factor Reversible Test
12. To Construct price index numbers based on Average of Price Relatives
13. To Construct Chain base index numbers
14. Base shifting, Splicing and Deflating of Index Numbers
15. To construct Consumer price index number using Aggregate Expenditure method and Family Budget method and compare

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS.

ESSENTIAL READINGS:

- Croxton, Fredrick E, Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd edition, Prentice Hall of India Pvt. Ltd.

- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th edition, World Press Pvt. Ltd.
- Gupta, S.C., and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 4th edition (reprint 2010), Sultan Chand and Sons.
- Mukhopadhyay P. (2011): Applied Statistics, 2nd edition (revised reprint), Books and Allied Pvt. Ltd.

SUGGESTED READINGS

- Benjamin, B. (1968): Health and Vital Statistics. G. Allen and Unwin.
- Mudgett B.D. (1951): Index Numbers, John Wiley.
- Allen R.G.D. (1975): Index Numbers in Theory and Practice, Macmillan.
- Nagar A.L. & Das R. K. (1976): Basic Statistics.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE-SPECIFIC CORE COURSE-6: ALGEBRA FOR STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Algebra For Statistics	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives

- Algebra serves as a building block that will enable students to learn more advanced techniques that will help them to solve problems more quickly and easily.

Learning Outcomes:

The learning outcomes of this course are as follows:

- Understanding the fundamental concepts of matrices and determinants
- Understanding of partitioning of matrices, Echelon form
- Solving Linear equations
- Knowledge of Vector spaces and Subspaces, Orthonormal Basis
- Identifying rank of a Matrix
- Computing generalized inverse, characteristic roots and vectors, quadratic forms

SYLLABUS OF DSC-6

Theory

UNIT I **(09 Hours)**

Algebra of matrices

A review related to triangular, symmetric, and skew-symmetric matrices, singular, and non-singular matrices, and their properties.

Idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices, Trace of a matrix, unitary, involutory and nilpotent matrices. Adjoint and inverse of a matrix and related properties. Partitioning of matrices and simple properties.

UNIT II **(12 Hours)**

Determinants

A review related to properties and applications of determinants for 3^{rd} and higher orders. Alternant determinant, Circulant determinant, Jacobi's Theorem, the product of determinants. Use of determinants in solution to the system of linear equations, row reduction and echelon forms, the matrix equations AX=B, solution sets of linear equations, Applications of linear equations, inverse of a matrix.

UNIT III **(09 Hours)**

Vector spaces

Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, Gram Schmidt Orthogonalization Process. Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum, and the product of two matrices.

UNIT IV **(15 Hours)**

Generalized Inverse

Generalized inverse (concept, properties with illustrations). Characteristic roots and characteristic vector, Properties of characteristic roots and characteristic vector, Cayley Hamilton theorem and application, Spectral Decomposition. Quadratic forms, Derivatives of linear functions, and quadratic forms. Linear orthogonal transformation and their diagonalization.

PRACTICAL – 30 Hours

List of Practicals:

1. Inverse of a matrix by method of partitioning.
2. Every non-singular square matrix can be expressed as product of elementary matrices.
3. Generalised Inverse of a matrix and Symmetric Generalised Inverse of a matrix.
4. Find XGX ′ for any matrix X of order nxk; k< n, where G is generalized inverse of X′ X and study its properties.
5. Construction of Idempotent matrix and study its properties.
6. Construction of Orthogonal matrix and study its properties.
7. Characteristic roots and characteristic vectors and its properties

8. Cayley Hamilton Theorem and application.
9. Quadratic Form:
   (a) Reducing Quadratic Form into canonical form and find rank, index and signature of the form.
   (b) Identify the nature of Quadratic Form.
10. Construction of an orthonormal basis vector using Gram Schmidt Orthogonalization process.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS.

ESSENTIAL READINGS:

- Searle, S.R.: Matrix Algebra useful for Statistics, John Wiley & Sons, 1982.
- Krishnamurthy, V., Mainra, V.P. and Arora, J.L. (2015). An Introduction to Linear Algebra, East West Press Pvt. Ltd., New Delhi.
- Hadley, G.: Linear Algebra, Narosa Publishing House (Reprint), 2002.
- Gupta, S. C.: An Introduction to Matrices (Reprint), Sultan Chand & Sons, 2008.

SUGGESTED READINGS:

- Biswas, S. (1997). A Textbook of Matrix Algebra, New Age International.
- Singal, M.K. and Singal, Asha Rani: Algebra, R. Chand & Co., 2011.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

~~B.Sc.(Prog.)~~/B.A(Prog.) with Statistics as Major

Category-II

DISCIPLINE SPECIFIC CORE COURSE – 3: Statistical Methods

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Methods	4	3	0	1	Class XII pass with Mathematics	Descriptive Statistics

Course Objectives:

The learning objectives include:

- To know the difference between discrete and continuous random variables.
- To develop the thinking of students so that they can use the concepts of statistical probability distribution in real life.
- To understand the concept of random variables, probability distributions and expectation

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Concept of random variables.
- Basic concepts of discrete & continuous random variables.
- Distinguish between Moments generating functions & Cumulant generating functions
- Concept of joint, marginal and conditional probability distribution for two dimensional random variables and their independence.
- Discrete probability distributions with their properties.
- Continuous probability distributions with their properties.

SYLLABUS OF DSC

Theory

Unit – 1 **(15 hours)**

Random Variables

Random variables: Discrete and continuous random variables, pmf, pdf and cdf, illustrations of random variables and its properties, expectation of random variable and its properties. Variance, covariance and their properties with illustrations. Moments and cumulants, moment generating function with properties, cumulants generating function and characteristic function.

Unit – 2 **(08 hours)**

Bivariate Probability Distribution

Bivariate probability distributions, marginal and conditional distributions, independence of variates (only general idea to be given). Transformation in univariate and bivariate distributions.

Unit – 3 **(10 hours)**

Discrete Probability Distributions

Discrete probability distributions – Binomial, Poisson- measures of central tendency, dispersion, skewness and kurtosis, recurrence relations based on moments, moment generating function, cumulant generating function, characteristic function, additive property, fitting of distribution and examples.

Unit – 4 **(12 hours)**

Continuous Probability Distributions

Continuous Probability distribution - Normal - measures of central tendency, dispersion, skewness and kurtosis, recurrence relations based on moments, moment generating function, cumulant generating function, characteristic function, additive property and examples. Exponential distribution – moment generating function and lack of memory. Gamma distribution – moment generating function, cumulant generating function and additive property.

Practicals

List of Practicals: **(30 hours)**

(Practical to be performed on computer using Microsoft Excel/Electronic Spreadsheet/SPSS/Any Statistical Package

1. Problems based on expectations, variance and co-variances.
2. Fitting of binomial distributions for n and p = q = ½ and for n and p given.
3. Fitting of binomial distributions computing mean and variance.

4. Fitting of Poisson distributions for give n and λ and after estimating mean.
5. Fitting of suitable distribution.
6. Application problems based on Binomial distribution.
7. Application problems based on Poisson distribution.
8. Problems based on the Area property of Normal distribution.
9. Application problems based on Normal distribution.
10. Problems based on bivariate probability distributions.

Essential Readings

1. Goon, M., Gupta, M.K. and Dasgupta, B. (2003). *An outline of Statistical Theory*, Vol. I, 4th Ed., World Press, Kolkata.
2. Gupta, S.C. and Kapoor, V.K. (2020). *Fundamentals of Mathematical Statistics*, 12th Ed., Sultan Chand and Sons.
3. Hogg, R. V., McKean, J., and Craig, A. T. (2005). *Introduction to mathematical statistics*. Pearson Education.
4. Rohtagi, V.K. and Saleh, A.K. Md. E. (2009). *An Introduction to Probability and Statistics*, 2nd Ed., John Wiley and Sons.

Suggestive Readings

1. Ross, S.A. (2007). *Introduction to Probability Models*, 9 Ed., Academic Press
2. Mood, A.M., Graybill, F.A. and Boss, D.C. (2007). *Introduction to the Theory of Statistics*, 3rd Ed., Tata McGraw Hill Publication.

DISCIPLINE SPECIFIC CORE COURSE – 4: APPLICATIONS IN STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Applications i Statistics	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives:

- Acquaint students with the current official statistical system in India
- Familiarize students with important concepts of Demand Analysis
- Introduction to Utility and Production functions.

Learning Outcomes:

After taking this paper, the student should be able to:

- Understand the current and prevailing official statistical system in India, role of MoSPI, CSO, NSSO, and their important publication
- Understand the laws of demand and supply, Price and Income elasticity of demand.
- Differentiate between Partial and Cross Elasticities of Demand, Engel's law, Pareto's law, and different curves of concentration.
- Understand theory of utility function, Utility Curve, Marginal rate of substitution, Budget line, and Construction of Utility Curve.

SYLLABUS OF DSC

Theory

Unit I **(12 Hours)**

Indian Official Statistics

Present official statistical system in India, Methods of collection of official statistics and their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications.

Unit II **(12 Hours)**

Demand Analysis

Concept of differentiation and partial differential.

Introduction: Demand and Supply and its laws, Price Elasticity of Demand, Income elasticity of demand, Nature of commodities, Partial and Cross Elasticities of Demand, Types of data required for its estimation, computation of demand function from given price elasticity of demand, Engel's law and Engel Curves, Pareto's law of income distribution, Curves of concentration.

Unit III **(12 Hours)**

Utility Function

Introduction: Theory of Utility, Statistical decision making under Utilities, general definition of utility function, advantages and disadvantage of Utility function, Utility Curve, Basic axioms of Utility, example of utility function, Indifference curves and their properties, Marginal rate of substitution, Budget line, constrained utility maximization, Construction of Utility Curve.

Unit IV **(09 Hours)**

Production Function

Production function, Marginal productivity, Average productivity, Degree of production function, Linear homogeneous production function, Euler's theorem, Returns to scales, Isoquants, Isocost curves, Equilibrium of the firm, Marginal rate of technical substitution, Elasticity of substitution, Constant elasticity of substitution.

PRACTICAL - 30 Hours

List of Practical

1. Fitting of demand curve.
2. Calculate income elasticity of demand from given data.
3. Calculation of price elasticity of demand from the given data.
4. Estimation of constant demand function.
5. To fit Engel's curve and draw them.
6. Comparison of inequality in distribution of expenditure.
7. Fitting of Pareto distribution to given data.
8. Computation and plotting of Lorenz Curve and computation of concentration ratio.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS.

ESSENTIAL READINGS:

- Fundamentals of Statistics, Vol.2, Goon, A. M., Gupta, M. K. and Dasgupta, B. (2001). World Press.
- Business Mathematics with Applications, S.R. Arora and Dinesh Khattar, S.Chand & Company Ltd.
- Applied Statistics, Parimal Mukhopadhyay (2011), Books and Allied (P) Ltd.
- Business Mathematics Theory and Applications, V.K. Kapoor (2012), Sultan Chand & Sons.

SUGGESTED READINGS:

- Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.
- mospi.nic.in/nscr/iss.html.
- Business Mathematics with applications in Business and Economics, R.S. Soni, Pitambar Publishing Company (P) Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B.Sc(P)/B.A(P) with Statistics as Non-Major

Category-III

DISCIPLINE SPECIFIC CORE COURSE – 2: Statistical Methods

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Methods	4	3	0	1	Class XII pass with Mathematics	Descriptive Statistics

Course Objectives:

The learning objectives include:

- To know the difference between discrete and continuous random variables.
- To develop the thinking of students so that they can use the concepts of statistical probability distribution in real life.
- To understand the concept of random variables, probability distributions and expectation

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Concept of random variables.
- Basic concepts of discrete & continuous random variables.
- Distinguish between Moments generating functions & Cumulant generating functions
- Concept of joint, marginal and conditional probability distribution for two dimensional random variables and their independence.
- Discrete probability distributions with their properties.
- Continuous probability distributions with their properties.

SYLLABUS OF DSC

Theory

Unit – 1 **(15 hours)**

Random Variables

Random variables: Discrete and continuous random variables, pmf, pdf and cdf, illustrations of random variables and its properties, expectation of random variable and its properties. Variance, covariance and their properties with illustrations. Moments and cumulants, moment generating function with properties, cumulants generating function and characteristic function.

Unit – 2 **(8 hours)**

Bivariate Probability Distribution

Bivariate probability distributions, marginal and conditional distributions, independence of variates (only general idea to be given). Transformation in univariate and bivariate distributions.

Unit – 3 **(10 hours)**

Discrete Probability Distributions

Discrete probability distributions – Binomial, Poisson- measures of central tendency, dispersion, skewness and kurtosis, recurrence relations based on moments, moment generating function, cumulant generating function, characteristic function, additive property, fitting of distribution and examples.

Unit – 4 **(12 hours)**

Continuous Probability Distributions

Continuous Probability distribution - Normal - measures of central tendency, dispersion, skewness and kurtosis, recurrence relations based on moments, moment generating function, cumulant generating function, characteristic function, additive property and examples. Exponential distribution – moment generating function and lack of memory. Gamma distribution – moment generating function, cumulant generating function and additive property.

Practicals

List of Practicals: **(30 hours)**

(Practical to be performed on computer using Microsoft Excel/Electronic Spreadsheet/SPSS/Any Statistical Package

1. Problems based on expectations, variance and co-variances.
2. Fitting of binomial distributions for n and $p = q = ½$ and for n and p given.
3. Fitting of binomial distributions computing mean and variance.
4. Fitting of Poisson distributions for give n and λ and after estimating mean.
5. Fitting of suitable distribution.
6. Application problems based on Binomial distribution.
7. Application problems based on Poisson distribution.

8. Problems based on the Area property of Normal distribution.
9. Application problems based on Normal distribution.
10. Problems based on bivariate probability distributions.

Essential Readings

1. Goon, M., Gupta, M.K. and Dasgupta, B. (2003). *An outline of Statistical Theory*, Vol. I, 4th Ed., World Press, Kolkata.
2. Gupta, S.C. and Kapoor, V.K. (2020). *Fundamentals of Mathematical Statistics*, 12th Ed., Sultan Chand and Sons.
3. Hogg, R. V., McKean, J., and Craig, A. T. (2005). *Introduction to mathematical statistics*. Pearson Education.
4. Rohtagi, V.K. and Saleh, A.K. Md. E. (2009). *An Introduction to Probability and Statistics*, 2nd Ed., John Wiley and Sons.

Suggestive Readings

1. Ross, S.A. (2007). *Introduction to Probability Models*, 9 Ed., Academic Press
2. Mood, A.M., Graybill, F.A. and Boss, D.C. (2007). *Introduction to the Theory of Statistics*, 3rd Ed., Tata McGraw Hill Publication.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY DEPARTMENT OF STATISTICS CATEGORY-IV

GENERIC ELECTIVES : INTRODUCTORY PROBABILITY

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introductory Probability	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives :

- Acquaint students with the mathematical foundation of probability.
- familiarize students with important tools for statistical analyses at introductory level.
- Introduction to some common discrete and continuous distributions and their properties.

Learning Outcomes:

After taking this paper, the student should be able to:

- Understand the meaning of probability and probabilistic experiment. Various approaches to probability theory and in particular the axiomatic approach. Laws of probability, conditional probability, conditioning, and reduced sample space, compute joint and conditional probabilities. Bayes' rule and applications.
- Understand the concept of a random variable, expectation and its properties, Compute variance and covariance in terms of expectation. Moment generating function and its properties.
- Get familiar with some standard discrete and continuous distribution and the usefulness of Central limit Theorem in daily life.

SYLLABUS OF GE

Theory

UNIT-I **(12 Hours)**

Probability

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional

Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

UNIT II **(18 Hours)**

Random Variables

Random Variables: Discrete and continuous random variables, pmf, pdf, cdf. Illustrations of random variables and its properties. Expectation, variance, moments and moment generating function.

UNIT III **(15 Hours)**

Probability Distributions

Standard probability distributions: Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric, Uniform, Normal, Exponential, Beta, Gamma. De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.) (Only Statements)

PRACTICAL - 30 Hours

List of Practical:

1. Application problems based on addition law of probability.
2. Application problems based on conditional probability.
3. Application problems based on Bayes law.
4. Application problems based on Expectation of random variable.
5. Computing MGF and how it helps in finding moments.
6. Computing cdf for discrete and continuous random variables drawing its graph.
7. Fitting of binomial distributions for n and $p = q = ½$
8. Fitting of binomial distributions for n and p given.
9. Fitting of binomial distributions computing mean and variance.
10. Fitting of Poisson distributions for given value of lambda.
11. Fitting of Poisson distributions after computing mean.
12. Application problems based on binomial distribution.
13. Application problems based on Poisson distribution.
14. Problems based on area property of normal distribution.
15. To find the ordinate for a given area for normal distribution.
16. Application based problems using normal distribution.
17. Fitting of normal distribution when parameters are given.
18. Fitting of normal distribution when parameters are not given.
19. Computing probabilities using Microsoft Excel functions binomdist(), poisson(), normsdist(), normsinv(), normdist(), and norminv().
20. Computing Binomial probabilities for large n and small p using Microsoft Excel functions binomdist() and poisson().
21. Computing Binomial probabilities for large n and $p \in (0.4, 0.6)$ using Microsoft Excel functions binomdist() and normdist().

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS.

SUGGESTED READINGS:

1. Hogg, R.V., Tanis, E.A. and Rao, J.M. (2009). Probability and Statistical Inference, 7th Ed, Pearson Education, New Delhi.
2. Miller, I. and Miller, M. John E. Freund (2006). Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia.
3. Myer, P.L. (1970). Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

2B

GENERIC ELECTIVES: APPLICATIONS IN STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Applications in Statistics-II	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives:
- Acquaint students with the current official statistical system in India
- Familiarize students with important concepts of Demand Analysis
- Introduction to Utility and Production functions.

Learning Outcomes:

After taking this paper, the student should be able to:
- Understand the current and prevailing official statistical system in India, role of MoSPI, CSO, NSSO, and their important publication
- Understand the laws of demand and supply, Price and Income elasticity of demand.
- Differentiate between Partial and Cross Elasticities of Demand, Engel's law, Pareto's law, and different curves of concentration.
- Understand theory of utility function, Utility Curve, Marginal rate of substitution, Budget line, and Construction of Utility Curve.

SYLLABUS OF GE

Theory

Unit I **(09 Hours)**

Indian Official Statistics

Present official statistical system in India, Methods of collection of official statistics and their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications.

Unit II **(12 Hours)**

Demand Analysis

Concept of differentiation and partial differential.

Introduction: Demand and Supply and its laws, Price Elasticity of Demand, Income elasticity of demand, Nature of commodities, Partial and Cross Elasticities of Demand, Types of data required for its estimation, computation of demand function from given price elasticity of demand, Engel's law and Engel Curves, Pareto's law of income distribution, Curves of concentration.

Unit III **(12 Hours)**

Utility Function

Introduction: Theory of Utility, Statistical decision making under Utilities, general definition of utility function, advantages and disadvantage of Utility function, Utility Curve, Basic axioms of Utility, example of utility function, Indifference curves and their properties, Marginal rate of substitution, Budget line, constrained utility maximization, Construction of Utility Curve.

Unit IV **(12 Hours)**

Production Function

Production function, Marginal productivity, Average productivity, Degree of production function, Linear homogeneous production function, Euler's theorem, Returns to scales, Isoquants, Isocost curves, Equilibrium of the firm, Marginal rate of technical substitution, Elasticity of substitution, Constant elasticity of substitution.

PRACTICAL - 30 Hours

List of Practical

1. Fitting of demand curve.
2. Calculate income elasticity of demand from given data.
3. Calculation of price elasticity of demand from the given data.
4. Estimation of constant demand function.
5. To fit Engel's curve and draw them.
6. Comparison of inequality in distribution of expenditure.
7. Fitting of Pareto distribution to given data.
8. Computation and plotting of Lorenz Curve and computation of concentration ratio.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS.

ESSENTIAL READINGS:

- Fundamentals of Statistics, Vol.2, Goon, A. M., Gupta, M. K. and Dasgupta, B. (2001). World Press.
- Business Mathematics with Applications, S.R. Arora and Dinesh Khattar, S.Chand & Company Ltd.
- Applied Statistics, Parimal Mukhopadhyay (2011), Books and Allied (P) Ltd.
- Business Mathematics Theory and Applications, V.K. Kapoor (2012), Sultan Chand & Sons.

SUGGESTED READINGS:

- Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.
- mospi.nic.in/nscr/iss.html.
- Business Mathematics with applications in Business and Economics, R.S. Soni, Pitambar Publishing Company (P) Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

REGISTRAR

Appendix-65
Resolution No. 60 {60-1(60-1-7)}

EC(1264)-03.02.2023

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DEPARTMENT OF STATISTICS

Semester-III

DEPARTMENT OF STATISTICS
B. Sc. (H) Statistics
Category-I

DISCIPLINE SPECIFIC CORE COURSE-7: SAMPLE SURVEYS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Sample Surveys	4	3	0	1	Class XII with Mathematics	DSC-1 and 2

Learning Objectives:
The learning objectives of this course are to introduce:
- Tools and techniques for selecting a representative sample from a target population keeping in mind the objectives to be fulfilled.
- Obtain an estimator of the population parameter on the basis of the selected sample and study its properties.

Learning Outcomes:
After successful completion of this course, students should be able to:
- Understand the fundamental concepts of population and sample and the principles of sample survey
- Describe the value and methodologies for sample surveys versus other approaches to collecting information from populations.
- Determine the appropriate sample size and its allocation for nationwide sample surveys or for surveys to be conducted in a program area.
- Identify a proper sampling frame and select primary sample points.
- Apply steps involved in selecting a sample using Simple Random Sampling with or without replacement, Stratified Sampling, Systematic Sampling and Ratio and Regression Methods of Estimation

SYLLABUS OF DSC-7
Theory
UNIT I **(10 Hours)**
Basics of Survey Sampling
Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principles of sample survey, Steps involved in survey sampling.

UNIT II **(8 Hours)**
Simple Random Sampling
Simple random sampling (SRS) with and without replacement, their properties, procedures of selecting a simple random sample, estimation of population mean and total, sampling for proportions, determination of sample size, bivariate population.

UNIT III **(10 Hours)**

Stratified Random Sampling

Stratified Random Sampling: Estimation of population mean and total, Allocation of sample in different strata using equal, proportional, optimum and Neyman allocations, comparison with SRS, practical difficulties in adopting Neyman allocation, estimation of gain in precision due to stratification.

UNIT IV **(7 Hours)**

Systematic Random Sampling

Systematic Random Sampling: Estimation of population mean and total, comparison with SRS and stratified sampling in the presence of linear trend, Yates' correction, definition of circular systematic sampling.

UNIT V **(10 Hours)**

Ratio and Regression Method of Estimation

Ratio method of estimation, first approximation to ratio estimator and its bias, first approximation to variance of ratio estimator, estimator of variance of ratio estimator, comparison of ratio with SRS.

Regression method of estimation, first approximation to linear regression estimator and its bias, first approximation to variance of the linear regression estimator, estimator of variance of the linear regression estimator, comparison with SRS and ratio estimator.

Practical -30 Hours

List of Practicals :

1. To select SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and establish all properties relative to SRS.
3. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WOR and establish all properties relative to SRS.
4. Estimate mean, standard error and the sample size for SRSWOR.
5. Stratified Sampling: allocation of sample to strata by proportional. Compare the efficiencies of above method relative to SRS.
6. Stratified Sampling: allocation of sample to strata by Neyman's methods. Compare the efficiencies of above method relative to SRS.
7. Estimation of gain in precision in stratified sampling.
8. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend and using end's correction.
9. Ratio estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiency of ratio estimator relative to SRS.
10. Regression estimation: Calculate the population mean or total of the population.
11. Calculate mean squares. Compare the efficiency of regression estimator relative to SRS.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

• Goon A M, Gupta M K and Dasgupta B (2018): Fundamentals of Statistics, Volume II, 9th Edition and 4th reprint.

- Cochran, W.G. (2011): Sampling Techniques (3rd Ed.), Wiley Eastern John Wiley and Sons.
- Sukhatme, P. V., Sukhatme, B. V., Sukhatme, S., Asok, C.(1984). Sampling Theories of Survey with Application, IOWA State University Press and Indian Society of Agricultural Statistics.

SUGGESTIVE READINGS:

- Gupta, S.C. and Kapoor, V.K. (2007): Fundamentals of Applied Statistics, Sultan Chand and Sons.
- Singh, D. and Chaudhary, F. S. (2015): Theory and Analysis of Sample Survey Designs.
- Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
- Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE-8: ADVANCED PROBABILITY DISTRIBUTIONS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Probability Distributions	4	3	0	1	Class XII with Mathematics	DSC-4

Learning Objectives

The learning objectives of this course are as follows:

- The course introduces students to advanced discrete and continuous probability distributions, and their important characteristics.
- It will enable them to understand the applications of these distributions.

Learning Outcomes

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

- Understand important advanced discrete probability distributions and their properties.
- Understand and apply important advanced continuous probability distributions and their properties.
- Apply their understanding of these distributions in real-life problems related to different areas of statistics.

SYLLABUS OF DSC-8

Theory

UNIT I **(15 hours)**

Discrete Probability Distributions

Negative Binomial Distribution: Probability distribution, particular cases, moment generating function, cumulants, limiting case, derivation of moments from binomial distribution and recurrence relation for probabilities of negative binomial distribution. Examples and applications based on the distribution. Hypergeometric Distribution: Probability distribution, mean, variance, approximation to Binomial Distribution and recurrence relation. Examples and applications based on the distribution. Geometric Distribution: Probability distribution, lack of memory property, moments and moment generating function. Examples and applications based on the distribution. Multinomial Distribution: Probability distribution and practical application.

UNIT II **(15 hours)**

Continuous Probability Distributions

Rectangular or Uniform Distribution: Definition, probability distribution and cumulative probability distribution, moments, and moment generating function, characteristic function and mean deviation about mean. Examples and applications based on the distribution. Gamma Distribution: Definition and properties, probability distribution, mean, variance, moment generating function, cumulant generating function, additive property and limiting case. Examples and applications based on the distribution. Beta Distribution: Beta Distribution of the first kind: Definition, probability distribution and cumulative probability distribution, mean, variance and harmonic mean. Beta Distribution of the second kind: Definition, probability distribution, mean, variance and harmonic mean. Examples and applications based on the distributions.

UNIT III **(15 hours)**

Continuous Probability Distributions (contd.)

Exponential Distribution: Definition, probability distribution and cumulative probability distribution, moment generating function, mean, variance and lack of memory property. Examples and applications based on the distribution. Standard Laplace (Double Exponential) Distribution: Definition, probability distribution, characteristic function and moments. Two Parameter Laplace Distribution: Definition, probability distribution, characteristic function and moments. Examples and applications based on the distribution. Weibull Distribution: Probability distribution, moments and practical applications. Logistic Distributions: Probability distribution, moments and practical applications. Cauchy Distribution: Definition, probability distribution, characteristics function, additive property and moments. Examples and applications based on the distribution.

PRACTICAL – 30 Hours

List of Practicals:

Practicals based on:

1. Application of Negative Binomial Distribution.
2. Fitting of Negative Binomial Distribution.
3. Application of Hypergeometric Distribution
4. Fitting of Geometric Distribution.
5. Lack of memory property of Geometric Distribution
6. Applications of
   (a) Geometric Distribution.
   (b) Multinomial Distribution.
   (c) Rectangular Distribution
   (d) Gamma Distribution
   (e) Beta Distribution.

(f) Exponential Distribution.
(g) Weibull Distribution.
(h) Logistic Distribution.
(i) Cauchy Distribution.

7. Lack of memory property of Exponential Distribution.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS.

ESSENTIAL READINGS

- Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, Twelfth Edition, Sultan Chand and Sons, Delhi.
- Ross, Sheldon M. (2013): A First Course in Probability, Ninth Edition, Pearson.
- Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications, Eight Edition., Pearson Education, Asia.
- Mood, A.M. Graybill, F.A. and Boes, D.C. (2007). Introduction to the Theory of Statistics, Third Edition, (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

SUGGESTED READINGS

- Rohatgi, V. K and Saleh M. E. (2015). An Introduction to Probability and Statistics, Third Edition, John Wiley and Sons, Inc., New Jersey.
- Hogg, R.V., Tanis, E.A. and Rao, J.M. (2009). Probability and Statistical Inference, 7th Ed., Pearson Education, New Delhi.
- Ross, Sheldon M.(2009). Introduction to Probability and Statistics for Engineers and Scientists, Fourth Edition, Academic Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 9: MATHEMATICAL ANALYSIS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Mathematical Analysis	4	3	0	1	**Class XII with Mathematics**	---

Learning Objectives

The learning objectives include:

- To study Real Analysis, which deals with the analytical properties of real functions and sequences.
- To study Numerical Analysis, which is the study of algorithms that use numerical approximation for the problems of mathematical analysis.

Learning Outcomes:

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

- Understand the fundamental properties of real numbers and real-valued functions.
- Understand the Analytical properties of sequences.
- Apply Infinite series, their properties and different tests.
- Apply limits, continuity, differentiability, and mean value theorems.
- Use the fundamentals of numerical analysis, interpolation, numerical integration and difference equation.

SYLLABUS OF DSC-9

Theory

UNIT I **(10 hours)**

Set Theory and Sequences

Completeness: The Completeness property of R; Archimedean property in R; Neighbourhood and limit points: Neighbourhood, Open Set, Closed Set, Supremum and Infimum, Limit Point of a Set; Sequences: Definition of a Sequence, Convergent Sequence, Divergent Sequence, Oscillatory Sequence, Cauchy Sequence, Monotone Sequence.

UNIT II **(10 hours)**

Series

Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's n^{th} root test, Raabe's test. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only). Absolute convergence of series, Conditional convergence.

UNIT III **(10 hours)**

Limit and Continuity

Review of limit, continuity and differentiability, uniform Continuity and boundedness of a function. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with Lagrange's and Cauchy's form of remainder (without proof). Taylor's and Maclaurin's series expansions of sin(x), cos(x), log (1+x).

UNIT IV **(15 hours)**

Numerical Methods

Factorial, finite differences and interpolation. Operators, E and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Gauss and Stirling interpolation formulae. Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eights rule, Stirling's approximation to factorial n. Solution of difference equations of first order, Euler Maclaurin's summation formula.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

Practicals based on:

1. Formation of difference table, fitting of polynomial and missing terms for equal interval of differencing.
2. Newton's Gregory forward difference interpolation formula.
3. Newton's backward difference interpolation formula.
4. Newton's divided difference and Lagrange's interpolation formula.
5. Gauss forward, Gauss backward central difference interpolation formula.
6. Stirling's central difference interpolation formula.
7. Lagrange's Inverse interpolation formula.

8. Method of successive approximation or iteration.
9. Method of reversion of series.
10. Trapezoidal Rule, Simpson's one-third rule, Simpson's three-eighth rule, Weddle's rule.
11. Euler-Maclaurin summation formula

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Appostol, T.M. (1987). Mathematical Analysis, 2nd Ed., Narosa Publishing House,New Delhi
- Ghorpade, S.R. and Limaye, B.V. (2006). A Course in Calculus and Real Analysis, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
- Sastry, S.S. (2000). Introductory Methods of Numerical Analysis, 3rd Ed., Prentice Hall of India Pvt. Ltd., New Delhi.

SUGGESTIVE READINGS:

- Bartle, R.G. and Sherbert, D.R. (2002). Introduction to Real Analysis, (3rd Ed.,), John Wiley and Sons (Asia) Pte. Ltd., Singapore.
- Jain, M.K., Iyengar, S.R.K. and Jain, R.K. (2003). Numerical methods for scientific and engineering computation, New age International Publisher, India.
- Malik, S.C. and Arora, S. (1994). Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.
- Mukherjee, Kr. Kalyan (1990). Numerical Analysis. New Central Book Agency.
- Narayan, S. (1987). A course of Mathematical Analysis, 12th revised Ed., S. Chand &Co. (Pvt.) Ltd., New Delhi.
- Somasundram, D. and Chaudhary, B. (1987). A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B.SC. (P)/B.A(P) WITH STATISTICS AS MAJOR

Category II

DISCIPLINE SPECIFIC CORE COURSE – 1: SAMPLING DISTRIBUTIONS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Sampling Distributions	4	3	0	1	**Class XII with Mathematics**	**Major 3/ Minor 2**

Learning Objectives:

The learning objectives include:

- To understand the concept of sampling distributions and their applications in statistical inference.
- To understand the process of hypothesis testing.
- To have a clear understanding of when to apply various tests of hypothesis about population parameters using sample statistics and draw appropriate conclusions from the analysis.

Learning Outcomes:

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

- Understand the basic concepts of hypothesis testing, including framing of the null and alternative hypotheses.
- Apply hypothesis testing based on a single sample and two samples using both classical and p-value approaches.
- Understand the Chi-square distribution.
- Analyze categorical data by using Chi-square techniques.
- Apply t and F distributions

SYLLABUS OF DSC-5

Theory

Unit I **(15 hours)**

Large sample tests

Large sample tests: Definitions of a random sample, parameter, and statistic, sampling distribution of a statistic, sampling distribution of the sample mean, standard errors of the sample mean, and the sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches.

Unit II **(15 hours)**

Chi-square distribution

Chi-square distribution: Definition and derivation of $\chi 2$ distribution with n degrees of freedom (d.f.) using m.g.f., nature of probability curve for different degrees of freedom, mean, variance,

m.g.f., cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution. Tests of significance and confidence intervals based on χ^2 distribution.

Unit III **(15 hours)**

Exact Sampling Distributions

t and F distributions: Student's t and Fishers t-distributions, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. Snedecore's F-distribution: Derivation of F distribution, nature of probability curve with different degrees of freedom, mean, variance and mode. Distribution of $1/F(n_1,n_2)$. Relationship between t, F and $\chi 2$ distributions. Test of significance and confidence intervals based on t and F distributions.

PRACTICAL/LAB WORK - 30 hours

List of Practicals

1. Large Sample Tests:
   a) Testing of significance and confidence intervals for single proportion and difference of two proportions.
   b) Testing of significance and confidence intervals for single mean and difference of two means.
   c) Testing of significance and confidence intervals for difference of two standard deviations.
2. Tests based on Chi-Square Distribution:
   a) To test if the population variance has a specific value and its confidence intervals.
   b) To test the goodness of fit.
   c) To test the independence of attributes.
   d) Test based on 2 x 2 contingency table without and with Yates' corrections.
3. Tests based on t- Distribution and F- Distribution:
   a) Testing of significance and confidence intervals for single mean and difference of two means and paired t – test.
   b) Testing of significance and confidence intervals of an observed sample correlation coefficient.
   c) Testing and confidence intervals of equality of two population variances.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS :

- Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th Ed., S. Chand and Sons. Delhi.
- Goon A M, Gupta M K and Dasgupta B (2018): Fundamentals of Statistics, Volume II, 9th Edition and 4th reprint.
- Rohatgi, V. K. and Saleh, A.K. Md. E. (2009). An Introduction to Probability and Statistics, 2nd Ed., (Reprint) John Wiley and Sons.

SUGGESTIVE READINGS:

- Hogg, R.V. and Tanis, E.A. (2009). A Brief Course in Mathematical Statistics. Pearson Education.
- Mood, M.A., Graybill, F.A. and Boes, C.D. (2007). Introduction to the Theory of Statistics, 3rd Ed., (Reprint).Tata McGraw-Hill Pub. Co. Ltd.
- Johnson, R.A. and Bhattacharya, G.K. (2001). Statistics-Principles and Methods, 4th Ed., John Wiley and Sons.

DISCIPLINE SPECIFIC CORE COURSE – 6: STATISTICAL QUALITY CONTROL

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Quality Control	4	3	0	1	**Class XII with Mathematics**	**Major 3/ Minor 2**

Learning Objectives

The learning objectives include:

- This course will help students to learn techniques and approaches of SQC being used in industry to manufacture goods and services of high quality at low cost.
- This course will also give exposure to sampling inspection plans.

Learning Outcomes:

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

- Comprehend the concept of Statistical Quality Control and its application in Industry.
- Apply Statistical process control tools- Control charts for variables, and attributes.
- Analyse different patterns of variation on Control charts
- Apply statistical product control tools- Sampling inspection plans.

SYLLABUS OF DSC-6

Theory

UNIT I: **(9 hours)**

Basics of Quality

Definition, dimensions of quality, its concept, application, and importance. Introduction to Process and Product Control. Statistical Process Control - Seven tools of SPC, Chance and Assignable Causes of quality variation.

UNIT II: **(21 hours)**

Statistical Control Charts

Construction and Statistical basis of 3-σ Control charts, Control charts for variables: $\underline{X}$& R-chart, $\underline{X}$ & s-chart. chart (for known and unknown parameters) Control charts for attributes: np-chart, p-chart, c-chart (for known and unknown parameters). Revised control limits. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart. Differentiate between Control Limits, Specification Limits and Natural Tolerance Limits. Concept of process capability.

UNIT III: **(15 hours)**

Acceptance sampling plan

Principle of acceptance sampling plans. Single sampling plan its OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation. Introduction to Dodge and Romig's sampling inspection plan tables.

PRACTICAL/LAB WORK - (30 hours)

List of Practical:

1. Construction and interpretation of statistical control charts for

a) $\underline{X}$ and R-chart

b) $\underline{X}$ *and* s-chart

c) np-chart

d) p-chart

e) c-chart

2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Montgomery, D. C. (2009). Introduction to Statistical Quality Control, 6th Ed., Wiley India Pvt. Ltd.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002). Fundamentals of Statistics, Vol. I & II, 8th Ed., The World Press, Kolkata.

SUGGESTIVE READINGS:

- Gupta, S.C. and Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand.
- Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B.Sc. (P)/B.A(P) with Statistics as Non-Major
Category III

DISCIPLINE SPECIFIC CORE COURSE – 3: Elements of SAMPLING DISTRIBUTIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Sampling Distributions	4	3	0	1	**Class XII with Mathematics**	**Major 3/ Minor 2**

Learning Objectives:

The learning objectives include:

- To understand the concept of sampling distributions and their applications in statistical inference.
- To understand the process of hypothesis testing.
- To have a clear understanding of when to apply various tests of hypothesis about population parameters using sample statistics and draw appropriate conclusions from the analysis.

Learning Outcomes:

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

- Understand the basic concepts of hypothesis testing, including framing of the null and alternative hypotheses.
- Apply hypothesis testing based on a single sample and two samples using both classical and p-value approaches.
- Understand the Chi-square distribution.
- Analyze categorical data by using Chi-square techniques.
- Apply t and F distributions

SYLLABUS OF DSC-3

Theory

Unit I **(15 hours)**

Large sample tests

Large sample tests: Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches.

Unit II **(15 hours)**

Chi square distribution

Chi square distribution: Definition and derivation of $\chi 2$ distribution with n degrees of freedom (d.f.) using m.g.f., nature of probability curve for different degrees of freedom, mean, variance,

m.g.f., cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution. Tests of significance and confidence intervals based on $\chi 2$ distribution.

Unit III **(15 hours)**

Exact Sampling Distributions

t and F distributions: Student's t and Fishers t-distributions, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. Snedecore's F-distribution: Derivation of F distribution, nature of probability curve with different degrees of freedom, mean, variance and mode. Distribution of $1/F(n_1,n_2)$. Relationship between t, F and $\chi 2$ distributions. Test of significance and confidence intervals based on t and F distributions.

PRACTICAL/LAB WORK - (30 hours)

List of Practicals

1. Large Sample Tests:

(i) Testing of significance and confidence intervals for single proportion and difference of two proportions.

(ii) Testing of significance and confidence intervals for single mean and difference of two means.

(iii) Testing of significance and confidence intervals for the difference of two standard deviations.

2. Tests based on Chi-Square Distribution:

(i) To test if the population variance has a specific value and its confidence intervals.

(ii) To test the goodness of fit.

(iii) To test the independence of attributes.

(iv) Test based on 2 x 2 contingency table without and with Yates' corrections.

3. Tests based on t- Distribution and F- Distribution:

(i) Testing of significance and confidence intervals for single mean and difference of two means and paired t – test.

(ii) Testing of significance and confidence intervals of an observed sample correlation coefficient.

(iii) Testing and confidence intervals of equality of two population variances.

ESSENTIAL READINGS :

- Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th Ed., S. Chand and Sons. Delhi.
- Rohatgi, V. K. and Saleh, A.K. Md. E. (2009). An Introduction to Probability and Statistics, 2nd Ed., (Reprint) John Wiley and Sons.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003). An Outline of Statistical Theory, Vol. I, 4th Ed., World Press, Kolkata.

SUGGESTIVE READINGS:

- Hogg, R.V. and Tanis, E.A. (2009). A Brief Course in Mathematical Statistics. Pearson Education.
- Mood, M.A., Graybill, F.A. and Boes, C.D. (2007). Introduction to the Theory of Statistics, 3rd Ed., (Reprint).Tata McGraw-Hill Pub. Co. Ltd.
- Johnson, R.A. and Bhattacharya, G.K. (2001). Statistics-Principles and Methods, 4th Ed., John Wiley and Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective
Category-V
Discipline Specific Elective for B. Sc. (H) Statistics

DISCIPLINE SPECIFIC ELECTIVE COURSE-1A: Optimization Techniques

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
~~Operational Research~~ Optimization Techniques	4	3	0	1	Class XII with Mathematics	....

Learning Objectives:

The learning objectives include:

- To create awareness about the term operational research (OR) and acquaint them with the methodologies, scope, limitations and applications of OR and
- To expose the students with the knowledge of formulation of real life problems using the linear programming method.
- To make the students understand about the theory and practical application of transportation problems and assignment problems
- To introduce 'Game Theory-the science of strategy' to the students, which makes possible the analysis of the decision making process of interdependent subjects.
- To provide a framework to develop mathematical models for different types inventory systems.

Learning Outcomes:

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

- Understand the fundamental concepts of Operational Research Techniques
- Apply Linear Programming.
- Solve the Transportation and assignment problems
- Understand the Game Theory
- Use the Inventory Models

SYLLABUS OF DSE-1A

Theory

UNIT I **(15 hours)**

Introduction to OR and LPP

Definition and phases of O.R. Model building, various types of O.R. problems. Linear Programming Problem (L.P.P.): Mathematical formulation of the L.P.P, graphical solutions of L.P.P. Simplex method for solving L.P.P. Charne's M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P. Economic interpretation of Duality. Dual simplex method.

UNIT II **(15 hours)**

Transportation and Assignment Problem

Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem. Assignment problem: Hungarian method to find optimal assignment, special cases of assignment problem.

UNIT III **(15 hours)**

Game Theory and Inventory Management

Game theory: Rectangular game, minimax - maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy. Network flow problems and shortest route problem. Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Mathematical formulation of L.P.P and solving the problem using graphical method.
2. Simplex technique and Charne's Big M method involving artificial variables.
3. Identifying Special cases by Graphical and Simplex method and interpretation:
   a) Degenerate solution
   b) Unbounded solution
   c) Alternate solution
   d) Infeasible solution
4. Allocation problem using Transportation model.
5. Allocation problem using Assignment model.
6. Graphical solution to $mx2$ / $2xn$ rectangular game
7. Mixed strategy
8. To find optimal inventory policy for EOQ models and its variations.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators/ TORA/WINQSB/LINGO

ESSENTIAL READINGS:

- Swarup, K., Gupta, P.K. and Man Mohan (2013). Operations Research, 16th Ed., Sultan Chand and Sons.
- Taha, H. A. (2007). Operations Research: An Introduction, 8thEd., Prentice Hall of India.

SUGGESTIVE READINGS:

- F.S. Hillier. G.J. Lieberman (2010). Introduction to Operations Research- Concepts and Cases, 9th Edition, Tata McGraw Hill.
- Donald Waters (2010): Inventory Control and Management, John Wiley.
- A. Ravindran, D. T. Phillips and James J. Solberg(2005). Operations Research- Principles and Practice, John Wiley & Sons,
- G. Hadley (2002). Linear Programming, Reprint.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 1B: PSYCHOLOGICAL AND EDUCATIONAL STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Psychological and Educational Statistics	4	3	0	1	**Class XII with Mathematics**	**DSC-4**

Learning Objectives:

The learning objectives include:

- To measure psychological traits and mental abilities
- To learn basic methods of test construction, item writing and item analysis
- To check the reliability and validity of test scores.

Learning Outcomes:

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

- Distinguish between Psychological measurement and physical measurement.
- Understand the meaning of Tests in Psychology and Education.
- Appreciate the uses and limitations of Psychological tests.
- Learn the meaning and purpose of Item writing and analysis.
- Understand concepts of reliability and validity of test scores and their differences.
- Convert raw scores into different transformed scores.
- Apply Scaling rankings and ratings in terms of the Normal Probability Curve.

SYLLABUS OF DSE-1B

Theory

Unit I **(15 hours)**

Basics of Educational Statistics

Introduction; need and importance of statistics in psychology and education. Measurements: Levels of measurements. Distinction between psychological and physical measurements; general problems, sources of errors. Tests: Meaning of tests in psychology and education; history of psychological measurement and testing, uses, limitations and varieties, characteristics of a good test, general steps of test construction. Test administration. Item writing - Meaning and types; Item analysis – meaning and purpose. Item difficulty (concepts only). Power tests and speed tests.

Unit II **(15 hours)**

Reliability and Validity

Reliability: Meaning, methods (or types); standard error of measurement, reliability of speed test, factors influencing reliability of test scores, factors for their improvement, estimation of true scores and index of reliability. Reliability of difference and composite scores. Validity: Meaning; content, criterion related and construct validity. Statistical methods for calculating validity, factors influencing validity. Extra validity concerns, relation of validity to reliability.

Unit III **(15 hours)**

Psychological Statistics

Meaning of norm referencing and criterion referencing. Raw score transformations- percentile score, standard scores, normalized standard scores, T-scores, C-scores and Stanine scores. Intelligence: Definition. Types of intelligence test scores. Spearman's two-factor theory and Thomson group factors theory. Psychological scaling methods – Scaling of Individual test items in terms of difficulty, scaling of rankings & ratings in terms of the normal probability curve.

PRACTICAL/LAB WORK - 30 hours

List of Practical:

1. Computation of Reliability by Rulon and Kuder Richardson Formulas.
2. Finding reliability of a test whose length is increased/ decreased n times.
3. Finding index of reliability, standard error of measurement.
4. Finding validity/maximum validity when test length is increased n times/ indefinitely.
5. Finding relative difficulty of questions/ difference in difficulty between different tests.
6. Converting raw scores into Z-scores.
7. Converting raw scores into T-scores.
8. Calculation of T scores for a given frequency distribution.
9. Construction of C-scales and its diagrammatic representation.
10. Construction of Stanine-scales and its diagrammatic representation.
11. Calculation of percentile scores corresponding to rank of an individual among N individuals.
12. Finding numerical scores corresponding to grades or ratings by different judges.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Garrett H. E. (2021). Statistics in psychology and education. Nation Press.
- Gregory R. J. (2016). Psychological testing: History Principles and Applications. (Updated seventh). Pearson.
- Singh, A. K. (2006). Tests, Measurements and Research in Behavioural Sciences. Bharati Bhavan.
- Anastasi A. & Urbina S. (1997). Psychological testing (7th ed.). Prentice Hall.

SUGGESTIVE READINGS:

- Gupta, S. C., & Kapoor, V. K. (2019). Fundamentals of applied statistics. Sultan Chand & Sons.
- Goon A M, Gupta M K and Dasgupta B (2018): Fundamentals of Statistics, Volume II, 9th Edition and 4th reprint.
- Mangal, S. K. (2016). Statistics in Psychology and Education. PHI Learning Pvt. Ltd..

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE FOR B. SC. (P)

DISCIPLINE SPECIFIC ELECTIVE COURSE – 1: TIME SERIES ANALYSIS AND INDEX NUMBERS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Time Series Analysis and Index Numbers	4	3	0	1	**Class XII with Mathematics**	**Minor 1**	Statistics

Learning Objectives

The Learning Objectives of this course are as follows:

- Introduce the concept of time series, its components, and their estimation.
- Introduce the application of time series.
- Introduce the concept, formulation, and application of index numbers.

Learning outcomes

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

- Understand the concepts of time series and index numbers.
- Formulate, solve, and analyse the use of time series and index numbers for real-world problems.

SYLLABUS OF DSE 1

Theory

Unit - 1 **(12 hours)**

Components of Time Series

Introduction to Time Series, Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series, Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and exponential).

Unit - 2 **(15 hours)**

Trend and Seasonality

Fitting of modified exponential, Gompertz and logistic curve, Moving average method, Measurement of seasonal variations by method of simple averages, ratio to trend method, and ratio to moving average method.

Unit - III **(18 hours)**

Index Numbers

Introduction to Index numbers, Problems in the construction of index numbers, Construction of price and quantity index numbers: simple aggregate, weighted aggregate (Laspeyres, Paasche's, Drobish-Bowley, Marshall-Edgeworth's, Walsch and Fisher's Formula), simple and weighted

average of price relatives, and chain base method, Criteria for a good index number, Errors in the measurement of price and quantity index numbers, Consumer price index number, its construction and uses, Uses and limitations of index numbers.

Practical - 30 Hours

List of Practicals:

1. Fitting of linear trend
2. Fitting of quadratic trend
3. Fitting of an exponential curve
4. Fitting of modified exponential curve by the method of
    a. Three selected points
    b. Partial sums
5. Fitting of Gompertz curve by the method of
    a. Three selected points
    b. Partial sums
6. Fitting of logistic curve by the method of three selected points
7. Fitting of trend by moving average method (for n even and odd)
8. Measurement of seasonal indices by
    a. Method of simple averages
    b. Ratio-to-trend method
    c. Ratio-to-moving-average method
9. Construction of price and quantity index numbers by simple aggregate method.
10. Construction of price and quantity index numbers by Laspeyres, Paasche's, Drobish-Bowley, Marshall-Edgeworth, Walsch and Fisher's Formula.
11. Construction of price and quantity index numbers by simple and weighted average of price relatives.
12. Construction of index number by Chain base method.
13. Construction of consumer price index number by
    a. Family budget method
    b. Aggregate expenditure method
14. Time Reversal Test and Factor Reversal Test

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Goon A M, Gupta M K and Dasgupta B (2018): Fundamentals of Statistics, Volume II, 9th Edition and 4th reprint.
- Gupta, S.C. and Kapoor, V.K. (2014). Fundamentals of Applied Statistics, 11th Ed., Sultan Chand.
- Croxton, Fredrick E, Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd edition, Prentice Hall of India Pvt. Ltd.

SUGGESTIVE READING

- Mukhopadhyay, P. (1999). Applied Statistics, New Central Book Agency, Calcutta.
- Allen R.G.D. (1975): Index Numbers in Theory and Practice, Macmillan

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY DEPARTMENT OF STATISTICS CATEGORY-VI

GENERIC ELECTIVES – 3A: SAMPLING DISTRIBUTIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Sampling Distributions	4	3	0	1	**Class XII with Mathematics**	**GE 2A**

Learning Objectives:

The learning objectives include:

- To understand the concept of sampling distributions and their applications in statistical inference.
- To understand the process of hypothesis testing.
- To have a clear understanding of when to apply various tests of hypothesis about population parameters using sample statistics and draw appropriate conclusions from the analysis.

Learning Outcomes:

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

- Understand the basic concepts of hypothesis testing, including framing of the null and alternative hypotheses.
- Apply hypothesis testing based on a single sample and two samples using both classical and p-value approaches.
- Understand the Chi-square distribution.
- Analyze categorical data by using Chi-square techniques.
- Apply t and F distributions

SYLLABUS OF GE-3A

Theory

Unit I **(15 hours)**

Large sample tests

Large sample tests: Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means,

standard deviation and difference of standard deviations by classical and p-value approaches.

Unit II **(15 hours)**

Chi square distribution

Chi square distribution: Definition and derivation of $\chi 2$ distribution with n degrees of freedom (d.f.) using m.g.f., nature of probability curve for different degrees of freedom, mean, variance, m.g.f., cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution. Tests of significance and confidence intervals based on $\chi 2$ distribution.

Unit III **(15 hours)**

Exact Sampling Distributions

t and F distributions: Student's t and Fishers t-distributions, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. Snedecore's F-distribution: Derivation of F distribution, nature of probability curve with different degrees of freedom, mean, variance and mode. Distribution of $1/F(n_1,n_2)$. Relationship between t, F and $\chi 2$ distributions. Test of significance and confidence intervals based on t and F distributions.

PRACTICAL/LAB WORK - 30 hours

List of Practicals

1. Large Sample Tests:

(i) Testing of significance and confidence intervals for single proportion and difference of two proportions.

(ii) Testing of significance and confidence intervals for single mean and difference of two means.

(iii) Testing of significance and confidence intervals for difference of two standard deviations.

2. Tests based on Chi-Square Distribution:

(i) To test if the population variance has a specific value and its confidence intervals.

(ii) To test the goodness of fit.

(iii) To test the independence of attributes.

(iv) Test based on 2 x 2 contingency table without and with Yates' corrections.

3. Tests based on t- Distribution and F- Distribution:

(i) Testing of significance and confidence intervals for single mean and difference of two means and paired t – test.

(ii) Testing of significance and confidence intervals of an observed sample correlation coefficient.

(iii) Testing and confidence intervals of equality of two population variances.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS :

- Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th Ed., S. Chand and Sons. Delhi.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003). An Outline of Statistical Theory, Vol. I, 4th Ed., World Press, Kolkata.

• Rohatgi, V. K. and Saleh, A.K. Md. E. (2009). An Introduction to Probability and Statistics, 2nd Ed., (Reprint) John Wiley and Sons.

SUGGESTIVE READINGS:

• Hogg, R.V. and Tanis, E.A. (2009). A Brief Course in Mathematical Statistics. Pearson Education.
• Mood, M.A., Graybill, F.A. and Boes, C.D. (2007). Introduction to the Theory of Statistics, 3rd Ed., (Reprint).Tata McGraw-Hill Pub. Co. Ltd.
• Johnson, R.A. and Bhattacharya, G.K. (2001). Statistics-Principles and Methods, 4th Ed., John Wiley and Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Major 1/ Minor 1: Descriptive Statistics
Major 3/ Minor 2: Statistical Methods
GE -2A: Introductory Probability

UNIVERSITY OF DELHI

CNC-II/093/1(26)/2023-24/194

Dated: 14.09.2023

NOTIFICATION

Sub: Amendment to Ordinance V

[E.C Resolution No. 14/ (14-1-7/) and 27-1-2/ dated 09.06.2023 and 25.08.2023 respectively]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester-IV, V and VI of the following departments under Faculty of Mathematical Sciences based on Under Graduate Curriculum Framework -2022 implemented from the Academic Year 2022-23.

FACULTY OF MATHEMATICAL SCIENCES

1. Department of Mathematics
2. Department of Statistics
3. Department of Operational Research
4. Department of Computer Science

Semester 4

DEPARTMENT OF STATISTICS

B. Sc. (H) Statistics

Category I

DISCIPLINE SPECIFIC CORE COURSE-10: SAMPLING DISTRIBUTIONS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Sampling Distributions	4	3	0	1	Class XII with Mathematics	Basic knowledge of probability and probability distributions

Learning Objectives:

The learning objectives of this course are as follows:

- To introduce the modes of convergence and their relation to limit laws, with a focus on the central limit theorem.
- To introduce the concept of sampling distributions and their applications in statistical inference.
- To describe the statistical ideas behind the procedure of hypothesis testing.
- To explain the assumptions and conditions under which to apply different tests of hypothesis about population parameters and draw appropriate conclusions from the analysis.

Learning Outcomes:

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

- Understand the basics of convergence theory and its importance in limit laws.
- Apply the concept of the central limit theorem and the relevance of the theorem in inferential statistics.
- Analyze data by using suitable hypothesis testing procedures in real-life applications related to large and small samples.
- Apply the knowledge of the idea of sampling distributions and appreciate their importance in the field of statistics.
- Integrate the knowledge of various sampling distributions like chi-square, t, and F distributions in hypothesis testing problems.

SYLLABUS OF DSC-10

Theory

UNIT I **(10 Hours)**

Modes of Convergence and Central Limit Theorem

Convergence in probability, convergence with probability one, convergence in the mean square, convergence in distribution – definitions and relations between the various modes.

Chebyshev's inequality, Weak Law of Large Numbers (WLLN), and Strong Law of Large Numbers (SLLN) along with examples and applications.

Basic idea and relevance of Central Limit Theorem (CLT), De-Moivre Laplace theorem, Lindeberg Levy theorem, Liapunov Theorem (only statement), and applications of CLT.

UNIT II **(4 Hours)**

Order Statistics

Basic concept and discussion on the area of applications, probability distribution and cumulative distribution function of a single order statistic, joint probability distribution of two and the general case of all order statistics, distribution of range, and distribution of sample median.

UNIT III **(9 Hours)**

Sampling Distributions and Test of Hypotheses

Concepts of parameter, statistic, sampling distribution of a statistic, standard error. Sampling distribution of sample mean, standard errors of the sample mean, sample variance, and sample proportion.

Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region, determination of sample size, confidence intervals, and p-value.

Tests of significance and confidence intervals for - single proportion, difference of two proportions, single mean, difference of two means, and difference of two standard deviations.

UNIT IV **(10 Hours)**

Exact Sampling Distribution

Chi-Square distribution: Definition and derivation of the probability distribution of Chi-square distribution with n degrees of freedom, nature of the curve for different degrees of freedom, mean, mode, variance, moment generating function, cumulant generating function, additive property, and limiting form of the Chi-square distribution, Applications of Chi-Square distribution.

UNIT V **(12 Hours)**

Exact Sampling Distributions (continued)

Student's t-statistic and Fishers t-statistic: definition and derivation of their sampling distributions, nature and characteristics of graph of t distribution, moments, limiting form and applications of the t distribution.

F-statistic: Definition and derivation of the sampling distribution, the graph of F distribution, moments, and applications of the F distribution. Relationship between t, F, and Chi-square distributions.

PRACTICAL / LAB WORK – 30 Hours

List of Practicals:

1. Large Sample Tests:
   a) Testing of significance and confidence intervals for single proportion and difference of two proportions.
   b) Testing of significance and confidence intervals for single mean and difference of two means.
   c) Testing of significance and confidence intervals for the difference of two standard deviations.
2. Tests based on Chi-Square Distribution:
   a) Testing of significance and confidence intervals for the population variance has a specific value.
   b) Testing for the goodness of fit.
   c) Testing of significance for the independence of attributes.
   d) Testing based on a 2 x 2 contingency table without and with Yates' corrections.
3. Tests based on t- Distribution and F- Distribution:
   a) Testing of significance and confidence intervals for single mean and difference of two means and paired t-test.
   b) Testing of significance and confidence intervals of an observed sample correlation coefficient.
   c) Testing and confidence intervals of equality of two population variances.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, Twelfth Edition, S. Chand and Sons. Delhi.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2016). An Outline of Statistical Theory, Volume I, The World Press, Kolkata.
- Mukhopadhyay, P. (2016). Mathematical Statistics, Books and Allied, India.
- Hogg, R.V., Tanis, E.A. and Rao, J.M. (2009). Probability and Statistical Inference, Seventh Edition, Pearson Education, New Delhi.
- Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications, Eight Edition, Pearson Education, Asia.
- Johnson, R.A. and Bhattacharya, G.K. (2001). Statistics-Principles and Methods, Fourth Edition, John Wiley and Sons.

SUGGESTED READINGS

- Bhat, B.R. (2016). Modern Probability Theory- An Introductory Textbook, Fourth Edition, New Age International Publishers.
- Rohatgi, V. K and Saleh M. E. (2015). An Introduction to Probability and Statistics, Third Edition, John Wiley and Sons, Inc., New Jersey.
- Mood, A.M. Graybill, F.A. and Boes, D.C. (2007). Introduction to the Theory of Statistics, Third Edition, (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE-11: TOTAL QUALITY MANAGEMENT

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Total Quality Management	4	3	0	1	Class XII with Mathematics	Introductory statistics and familiarity probability distributions

Learning Objectives:

The learning objectives of this course are as follows:

- To introduce statistical and management techniques,
- To explain the approach of Quality control being used in industry to manufacture goods and services of high quality at low cost.
- To introduce Six-sigma, TQM which is in high demand in the market both in the manufacturing as well as the service sector

Learning Outcomes:

After completing this course, students will be able to:

- Understand the concept of quality, its historical background, and ISO standards.
- Apply the statistical process control tools and product control tools.
- Understand the idea of Six sigma- Lean manufacturing, TQM
- Comprehend the Six sigma training plans, Voice of customers (VOC), Critical to Quality (CTQ)
- Analyze the data to find the root cause of defects through DMAIC (Define-Measure-Analyze-Improve-Control).

SYLLABUS OF DSC-11

Theory

UNIT I **(9 Hours)**

Basics of Quality Management

Quality: Definition, dimensions of quality, its concept, application, and importance. Brief historical perspective of quality control and improvements, Quality Gurus, and Quality Hall of Fame. Quality system and standards: Introduction to ISO quality standards, Quality registration.

Introduction to Process and Product Control, Statistical Process Control - Seven tools of SPC, Chance and Assignable causes of quality variation.

UNIT II **(12 Hours)**

Statistical Control Charts

Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts,. Control charts for variables: X-bar & R-chart, X-bar & s-chart. Rational Sub-grouping, Revised and Modified Control Limits. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on a control chart, estimation of process capability.

UNIT III **(12 Hours)**

Sampling Plans

Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plans, their Operating Characteristic (OC), Acceptance Quality Level (AQL), Lot Tolerance Percent Defective (LTPD), Average Outgoing Quality (AOQ), Average Outgoing Quality Limit (AOQL), Average Sample Number (ASN), and Average Total Inspection (ATI) functions with graphical interpretation, use, and interpretation of Dodge and Romig's sampling inspection plan tables.

UNIT IV **(12 Hours)**

Six-Sigma

Overview of Six Sigma, Lean Manufacturing, and Total Quality Management (TQM). Organizational Structure and Six Sigma training plans- Selection Criteria for Six Sigma roles and training plans. Voice of customers (VOC): Importance and VOC data collection. Critical to Quality (CTQ), Introduction to DMAIC (Define-Measure-Analyze-Improve-Control).

PRACTICAL / LAB WORK – 30 Hours

List of Practical:

1. Construction and interpretation of statistical control charts for
   a) $\bar{X}$ and R-chart for known parameters.
   b) $\bar{X}$ and R-chart with revised control limits for unknown parameters.
   c) $\bar{X}$ *and* s-chart
   d) np-chart
   e) p-chart with fixed sample size
   f) p-chart with variable sample size.
   g) c-chart
   h) u-chart
2. Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, and AOQL curves under a Single sample inspection plan
3. Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, and AOQL curves under a Single sample inspection plan for varying acceptance numbers.
4. Calculation of process capability and comparison of 3-sigma control limits with specification limits.

5. Plan a single sampling plan using Dodge and Romig sampling inspection tables.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Goon A M, Gupta M K and Dasgupta B (2018): Fundamentals of Statistics, Volume I & II, 9th Edition and 4th reprint.
- Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
- Ehrlich, B. Harris (2002): Transactional Six Sigma and Lean Servicing, 2nd Edition, St. Lucie Press.

SUGGESTED READING:

- Gupta S.C., Kapoor V.K.(2007): Fundamentals of Applied Statistics. 4th Edition, Sultan Chand and Sons., New Delhi.
- Hoyle, David (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth Heinemann Publication.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE-12: TIME SERIES ANALYSIS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical / Practice		
Time Series Analysis	4	3	0	1	Class XII with Mathematics	Introductory probability theory and statistics, Calculus, and matrix algebra

Learning Objectives:

The learning objectives of this course are as follows:

- To introduce basic time series analysis, trend, and seasonality,
- To understand spectral analysis,
- To familiarise students with stationary processes,
- To understand various time series models,

- To use nonstationary and seasonal time series models,
- To introduce forecasting techniques and forecasting methods.

Learning Outcomes:

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

- Understand the important time series models and their applications in various fields.
- Formulate real-life problems using time series models.
- Use statistical software to estimate the models from real data, and draw conclusions and develop solutions from the estimated models.
- Use visual and numerical diagnostics to assess the soundness of their models.
- Communicate the statistical analyses of substantial data sets through explanatory text, tables, and graphs.
- Combine and adapt different statistical models to analyze larger and more complex data.
- Possess skills to understand the components and forecast values of a time series at future time points.

SYLLABUS OF DSC-12

Theory

UNIT I **(6 Hours)**

Time Series Data and its Components

Introduction to times series data and its applications; Components of a time series and its decomposition; Estimation of trend and the seasonal component.

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UNIT II **(9 Hours)**

Spectral Analysis and Stationarity

Simple sinusoidal model; Periodogram, and Harmonic Analysis; Variate-difference method; Time series, and Stochastic process; Stationarity; Autocorrelation; meaning, definition, causes, the consequence, and test for autocorrelation.

UNIT III **(15 Hours)**

Time Series Models

Stochastic Models: White noise Process, Random walk, Moving Average (MA), Auto-Regressive (AR), Auto-Regressive Moving Average (ARMA) models, and their properties using correlogram, ACF, and PACF, Yule walker equations; Fitting of AR(1), AR(2), MA(1), MA(2), and ARMA(1,1) processes. Non-Stationary models: Auto-Regressive Integrated Moving Average (ARIMA) and Seasonal Auto-Regressive Integrated Moving Average (SARIMA) models; Dicky Fuller test, Augmented Dickey-Fuller test. Wold's Decomposition Theorem; Non-linear time series models: Auto-Regressive Conditional Heteroskedasticity (ARCH) and Generalized Auto-Regressive Conditional Heteroskedasticity (GARCH) Process.

UNIT IV **(12 Hours)**

Univariate Forecasting Procedures

Principles of Forecasting; Performance Evaluation; Extrapolation of Trend Curves; Exponential smoothing; Holt-Winter's; Box- Jenkins' Methodology.

PRACTICAL / LAB WORK – 30 hours

List of Practicals:

1. Fitting and plotting of modified exponential curves by different methods.
2. Fitting and plotting of Gompertz curve by different methods.
3. Fitting and plotting of logistic curves by different methods.
4. Fitting of the trend by the Moving Average Method for a given extent and for an estimated extent.
5. Measurement of Seasonal indices: a) Fixed and b) Changing Patterns
6. Construction of Periodogram and Harmonic Analysis
7. Estimation of variance of the random component
8. Construction of Correlogram for given AR(1), AR(2), MA(1), MA(2), and ARMA(1,1) processes.
9. Fitting of AR(1), AR(2), MA(1), MA(2), and ARMA(1,1) processes for given datasets.
10. Forecasting by various exponential smoothing procedures.
11. Forecasting by Box-Jenkins methodology.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Goon A M, Gupta M K and Dasgupta B (2018): Fundamentals of Statistics, Volume II, 9th Edition and 4th reprint.
- Galit Shmueli and Kenneth C. Lichtendahl Jr (2016): Practical Time Series Forecasting with R: A Hands-On Guide, 2nd Edition, Axelrod Schnall Publishers
- James D. Hamilton (2012): Time Series Analysis, 1st Indian Edition, Princeton University Press, Levant Books Kolkata.
- Chatfield, C. (1996): The Analysis of Time Series, 5th Edition, Chapman and Hall, New York.

SUGGESTED READING:

- Shumway and Stoffer (2011): Time Series Analysis and its applications, with examples in R, 3rd Edition, Springer.
- Brockwell, Peter J., and Davis, Richard A. (2002). Introduction to Time Series and Forecasting, 2nd edition. Springer-Verlag, New York.
- Montgomery D. C. and Johnson, L A. and (1967): Introduction to Time Series Analysis And Forecasting, 2nd ed. McGraw-Hill, New York.
- Kendall M.G. (1976): Time Series, Charles Griffin.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B.Sc. (P)/B.A(P) with Statistics as Major

Category II

DISCIPLINE SPECIFIC CORE COURSE-7: ~~ELEMENTS~~ Basics OF STATISTICAL INFERENCE

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
~~Elements~~ Basics of Statistical Inference	4	3	0	1	Class XII with Mathematics	Basic probability, probability distributions and sampling distributions

Learning Objectives:

The learning objectives of this course are as follows:

- To understand the concept of estimation theory and testing of hypothesis.
- To draw inferences about the unknown population parameters based on random samples.
- To validate the estimation/ inference about the population using hypothesis testing.

Learning Outcomes:

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

- Understanding of estimation theory, Point and interval estimations.
- Characteristics of a good estimator and different methods of estimation.
- Demonstrate the use of these techniques in data analysis.
- Develop the best/most powerful statistical tests to test the hypotheses regarding unknown population parameters by using Neyman-Pearson theory.

SYLLABUS OF DSC-7

Theory

UNIT I **(15 hours)**

Estimation Theory

Parameter space, sample space, point estimation, requirement of a good estimator, consistency, unbiasedness, efficiency, sufficiency, Minimum variance unbiased estimators, Factorization theorem, Fisher- Neyman Criterion: statement and applications, Cramer- Rao inequality:

statement and application, MVB estimators and their applications, Statement of Rao-Blackwell theorem and Lehmann-Scheffe theorem..

UNIT II **(15 hours)**

Method of Estimation

Maximum likelihood, least squares and minimum variance, Properties of maximum likelihood estimators (illustration), Interval Estimation: confidence interval and confidence limits for the parameters of normal distribution, confidence intervals for large samples.

UNIT III **(15 hours)**

Test of Significance

Principles of test of significance: Null and alternative hypotheses, simple and composite, Type-I and Type-II errors, critical region, level of significance, power of the test, best critical region, most powerful test, uniformly most powerful test, uniformly most powerful unbiased (UMPU) critical region, Neyman- Pearson Lemma: statement and its applications to construct most powerful test.

PRACTICAL / LAB WORK – 30 hours

List of Practical

Practical Based on:

1. Unbiased estimators and consistent estimators.
2. Efficient estimators and relative efficiency of estimators.
3. Sufficient estimators and factorization theorem.
4. Cramer- Rao inequality and MVB estimators.
5. Method of maximum likelihood estimation.
6. Method of least squares and minimum variance.
7. Confidence interval and confidence limits for the parameters of normal distribution.
8. Confidence intervals in case of large samples.
9. Type I and Type II errors, power of the test.
10. Most powerful critical region (NP Lemma).

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, 12th Ed., Sultan Chand and Sons.
- Miller, I. and Miller, M. (2013). John E. Freund's Mathematical Statistics, 8th Ed., Prentice Hall of India.
- Hogg, R. V., Craig, A. T., and Mckean, J. W. (2005): Introduction to Mathematical Statistics, 6th Edition, Pearson Education.
- Goon, A.K., Gupta, M. K. and Das Gupta, B. (2003): An Outline of Statistical Theory (Vol. II), 4th Edition., World Press, Kolkata.

SUGGESTED READINGS:

- Rohtagi, V. K. and Md., A. K. Saleh, E. (2009): An Introduction to Probability and Statistics, 2nd Edition, John Wiley and Sons.
- Casella, G. and Berger, R. L. (2002): Statistical Inference, 2nd Edition, Thomson Duxbury.
- Mood A.M., Graybill F.A. and Boes D.C. (1974). Introduction to the Theory of Statistics, McGraw Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE-8: INTRODUCTION TO VITAL STATISTICS AND DEMOGRAPHY

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Vital Statistics and Demography	4	3	0	1	Class XII with Mathematics	knowledge of basic statistics

Learning Objectives:

The learning objectives of this course are as follows:

- To collect valid Demographic data using different methods.
- To learn basic measures of Mortality, Fertility, and Population Growth.
- To construct life tables.

Learning Outcomes:

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

- Distinguish between Vital Statistics and Demography.
- Understand errors in Demographic data.
- Comprehend sources of data collection on Vital Statistics and errors therein.
- Use methods for measurement of Population.
- Distinguish between Rate and Ratio.
- Understand the basic measures of Mortality.
- Describe and apply the concepts of Stable and Stationary Populations.
- Understand the concept of Life Tables and their construction.
- Understand the basic measures of Fertility.
- Apply measures of Population Growth.

SYLLABUS OF DSC-8
Theory

UNIT I **(10 Hours)**
Introduction to Vital Statistics
Introduction and sources of collecting data on vital statistics, errors in the census, and registration data. Measurement of population, rate, and the ratio of vital events.

UNIT II **(12 Hours)**
Measurements of Mortality
Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR), and Standardized Death Rates. Stationary and Stable population, Central Mortality Rates, and Force of Mortality.

UNIT III **(10 Hours)**
Life Tables
Life(Mortality) Tables: Assumption, description, construction of Life Tables, and Uses of Life Tables.

UNIT IV **(13 Hours)**
Measurements of Fertility
Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR), and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR), and Net Reproduction Rate (NRR).

PRACTICAL/LAB WORK - 30 hours
List of Practicals:
1. To calculate CDR and Age Specific death rate for a given set of data.
2. To find a standardized death rate by (i) Direct method and (ii) Indirect method.
3. To construct a complete life table.
4. To fill in the missing entries in a life table.
5. To calculate CBR, GFR, SFR, TFR for a given set of data.
6. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data.
7. Calculate GRR and NRR for a given set of data and compare them.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II, 9thEd., World Press.
- Biswas, S. (1988). Stochastic Processes in Demography & Application, Wiley Eastern Ltd.

SUGGESTED READING:

- Mukhopadhyay, P. (1999). Applied Statistics, Books and Allied (P) Ltd.

• Keyfitz, N. and Beekman,J.A. (1985). Demography through Problems. S-Verlag, New York.
• Croxton, Fredrick, E. Cowden, Dudley J. and Klein, S. (1973). Applied General Statistics, 3rd Ed., Prentice Hall of India Pvt. Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B.Sc. (P)/B.A(P) with Statistics as Non- Major
Category III

DISCIPLINE SPECIFIC CORE COURSE 4: ~~ELEMENTS~~ Basics OF STATISTICAL INFERENCE

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
~~Elements~~ Basics of Statistical Inference	4	3	0	1	Class XII with Mathematics	Basic probability, probability distributions and sampling distributions

Learning Objectives:

The learning objectives of this course are as follows:

- To understand the concept of estimation theory and testing of hypothesis.
- To infer about the unknown population parameters based on random samples.
- To validate the estimation/ inference about the population using hypothesis testing.

Learning Outcomes:

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

- Understand estimation theory, point and interval estimations.
- Comprehend the characteristics of a good estimator and different methods of estimation.
- Apply the techniques in data analysis.
- Develop the best/most powerful statistical tests to test the hypotheses regarding unknown population parameters by using the Neyman-Pearson theory.

SYLLABUS OF DSC-4

Theory

UNIT I: **(15 hours)**

Estimation Theory:

Estimation: Parameter space, sample space, point estimation, requirement of a good estimator, consistency, unbiasedness, efficiency, sufficiency, Minimum variance unbiased estimators, Factorization theorem, Fisher- Neyman Criterion: statement and applications, Cramer- Rao inequality: statement and application, MVB estimators and their applications, Statement of Rao-Blackwell theorem and Lehmann-Scheffe theorem..

UNIT II **(15 hours)**

Methods of estimation:

Maximum likelihood, least squares and minimum variance, Properties of maximum likelihood estimators (illustration), Interval Estimation: confidence interval and confidence limits for the parameters of normal distribution, confidence intervals for large samples.

UNIT III **(15 hours)**

Test of significance

Principles of test of significance: Null and alternative hypotheses, simple and composite, Type-I and Type-II errors, critical region, level of significance, power of the test, best critical region, most powerful test, uniformly most powerful test, uniformly most powerful unbiased critical region (UMPU), Neyman- Pearson Lemma: statement and its applications to construct most powerful test.

Practical / Lab Work: - 30 hours

List of Practicals: Practicals based on

1. Unbiased estimators and consistent estimators.
2. Efficient estimators and relative efficiency of estimators.
3. Sufficient estimators and factorization theorem.
4. Cramer- Rao inequality and MVB estimators.
5. Method of maximum likelihood estimation.
6. Method of least squares and minimum variance.
7. Confidence interval and confidence limits for the parameters of normal distribution.
8. Confidence intervals in case of large samples.
9. Type I and Type II errors, power of the test.
10. Most powerful critical region (NP Lemma).

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, 12th Ed., Sultan Chand and Sons.
- Miller, I. and Miller, M. (2013). John E. Freund's Mathematical Statistics, 8th Ed., Prentice Hall of India.
- Hogg, R. V., Craig, A. T., and Mckean, J. W. (2005): Introduction to Mathematical Statistics, 6th Edition, Pearson Education.
- Goon, A.K., Gupta, M. K. and Das Gupta, B. (2003): An Outline of Statistical Theory (Vol. II), 4th Edition., World Press, Kolkata.

SUGGESTED READINGS:

- Rohtagi, V. K. and Md., A. K. Saleh, E. (2009): An Introduction to Probability and Statistics, 2nd Edition, John Wiley and Sons.
- Casella, G. and Berger, R. L. (2002): Statistical Inference, 2nd Edition, Thomson Duxbury.
- Mood A.M., Graybill F.A. and Boes D.C. (1974). Introduction to the Theory of Statistics, McGraw Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Discipline Specific Elective
Category-V

DISCIPLINE SPECIFIC ELECTIVE COURSE-2A: COMPUTER PROGRAMMING IN C

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical / Practice		
Computer Programming in C	4	3	0	1	Class XII with Mathematics	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- To introduce computer programming and its roles in problem-solving.
- To describe data structures
- To develop logics that will help to create well-structured programs using C language

Learning Outcomes:

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

- Understand various data types, operators, library functions, Input/Output operations.
- Decision making and branching and looping.
- Use Arrays, Characters, and strings.
- Understand user-defined functions, and recursive functions.
- Storage class of Variables
- Apply Pointers and Structure
- Pre-processors: Macro substitution, macro with argument
- File inclusion in C, I/O operations on files.

SYLLABUS OF DSE-2A

Theory

UNIT I **(6 hours)**

Introduction to C

History and importance of C. Components, basic structure programming, character set, C tokens, Keywords and Identifiers and execution of a C program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, Symbolic Constants, overflow and underflow of data.

UNIT II **(9 hours)**

Expressions and I/O functions

Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement and conditional operators, precedence of operators in an expression. Managing input and output from the standard devices.

UNIT III **(12 hours)**

Branching and Arrays

Decision making and branching - if...else, nesting of if...else, else if ladder, switch. Looping in C: for, while, do...while, jumps in and out of loops.

Arrays: Declaration and initialization of one-dim and two-dim arrays. Character arrays and strings: Declaring and initializing string variables, reading and writing strings from Terminal (using scanf and printf only).

UNIT IV **(9 hours)**

Functions and Storage class

User- defined functions: definition of functions, return values and their types, function prototypes and calls. Category of Functions and recursive function. Passing arrays to functions, Storage class of Variables.

UNIT V **(9 hours)**

Pointers, Macros and Files

Pointers: Declaration and initialization of pointer variables, accessing the address of a variable, accessing a variable through its pointer, pointer expressions, pointer increments/decrement and scale factor. Pointers and arrays, functions returning pointers. Introduction of structure. Pre-processors: Macro substitution, macro with argument, file inclusion in C. Defining and opening a file (only r, w and a modes), closing a file, I/O operations on files-fscanf and fprintf functions.

PRACTICAL/LAB WORK – 30 Hours

List of Practicals:

1. Roots of a quadratic equation (with imaginary roots also)
2. Sorting of an array and hence finding median
3. Mean, Median and Mode of a Grouped Frequency Data
4. Variance and coefficient of variation of a Grouped Frequency Data
5. Preparing a frequency table
6. Value of n! using recursion
7. Random number generation from exponential, normal (using CLT) and gamma distribution calculate sample mean and variance.
8. Matrix addition, subtraction, multiplication, Transpose and Trace
9. Fitting of Binomial distribution and apply Chi-square test for goodness of fit
10. Chi-square contingency table
11. t-test for difference of means
12. Paired t-test
13. F-ratio test
14. Multiple and Partial correlation.
15. Compute ranks and then calculate rank correlation(without tied ranks)

16. Fitting of lines of regression

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Balagurusamy, E. (2019): Programming in ANSI C, 8th Edition, Tata McGraw Hill.
- Gottfried, B.S. (1998): Schaum's Outlines: Programming with C, 2nd Edition, Tata McGraw Hill
- Kernighan, B.W. and Ritchie, D. (1988): C Programming Language, 2ndEdition,Prentice Hall.

SUGGESTED READING:

- Kanetkar, Y. (2020) : Let Us C, 18th Edition, BPB Publications
- Perry, G. and Miller, D. (2015) : C Programming Absolute Beginner's Guide, 3rd Edition, Pearson Publications

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE-2B: ADVANCED TECHNIQUES OF SAMPLE SURVEYS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title and code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
Advanced Techniques of Sample Surveys	4	3	0	1	Class XII with Mathematics	Knowledge of sample surveys

Learning Objectives:

The learning objectives of this course are as follows:

- To introduce advanced techniques relating to stratified and systematic sampling, ratio and regression methods of estimation.
- To introduce cluster and two-stage sampling when the population is divided into groups.
- To describe the errors due to factors other than the inductive process of inferring about the population from a sample.

Learning Outcomes:

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

- Understand Post Stratification,
- Determine the optimum number of strata and their construction
- Comprehend Circular systematic sampling

- Apply Ratio and Regression method of estimation under the Superpopulation model
- Use Cluster sampling, and Two-stage sampling
- Classify non-sampling errors

SYLLABUS OF DSE-2B
Theory

UNIT I **(15 Hours)**

Stratified and Systematic Sampling

Stratified Sampling: Post Stratification, effect of increasing the number of strata, determination of optimum number of strata, construction of strata (Neyman allocation, Proportional allocation and approximate method by Dalenius and Hodges), method of collapsed strata, allocation requiring more than 100% sampling.

Systematic Sampling: Circular systematic sampling, Yates' and Cochran method of estimation of sampling variance.

UNIT II **(15 Hours)**

Superpopulation Model and Cluster Sampling

Superpopulation model, Ratio method of estimation under superpopulation model, regression method of estimation under superpopulation model.

Cluster Sampling (equal-sized clusters): Estimation of population mean and its variance, efficiency of cluster sampling, the effect of formation of clusters randomly, efficiency of cluster sampling in terms of intra-class correlation, estimation of efficiency, optimum size of cluster.

UNIT III **(15 Hours)**

Two-Stage Sampling and Non-Sampling Errors

Two-stage sampling/sub-sampling (Equal first stage units): Estimation of population mean and its variance, Estimator of variance of the sample mean, allocation of sample to two-stages, comparison of two-stage with one-stage sampling.

Non-sampling errors: Classification of non-sampling errors, types of non-sampling errors, bias due to non-response, Hansen and Hurwitz technique, comparison of Hansen and Hurwitz technique with SRS under a cost constraint

PRACTICAL/LAB WORK – 30 Hours
List of Practicals:

Practical Work based on:

1. Dalenius and Hodges method of construction of strata
2. Determination of optimum number of strata
3. Cluster sampling
4. Circular systematic sample
5. Ratio method of estimation under superpopulation model
6. Regression method of estimation under superpopulation model
7. Two-stage sampling

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Cochran, W.G. (2011): Sampling Techniques (3rd Ed.), Wiley Eastern John Wiley and Sons..
- Sukhatme, P. V., Sukhatme, B. V., Sukhatme, S., Asok, C.(1984). Sampling Theories of Survey with Application, IOWA State University Press and Indian Society of Agricultural Statistics.
- Gupta, S.C. and Kapoor, V.K. (2007): Fundamentals of Applied Statistics, Sultan Chand and Sons.
- Singh, D. and Chaudhary, F. S. (2015): Theory and Analysis of Sample Survey Designs.

SUGGESTED READING:

- Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
- Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
- Goon, A. M., Gupta, M. K. and Dasgupta, B. (2001): Fundamentals of Statistics (Vol.2), World Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE-2C: DEMOGRAPHY (Not for category II)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title and code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
Demography	4	3	0	1	Class XII with Mathematics	knowledge of basic statistics

Learning Objectives:

The learning objectives of this course are as follows:

- To introduce various demographic concepts and to explain the nature and scope of population studies.
- To explain evaluation and adjustments in age data using different indices.
- To introduce the construction of abridged life tables and the estimation and projection of population by different methods.
- To describe the Graduation of mortality rates by different methods.

Learning Outcomes:

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

- Understand the various components of Demography, sources of demographic data collection and errors therein.
- Comprehend population potential, density and concentration.
- Analyse the completeness of registration data using the Chandrasekharan-Deming formula.
- Use concepts of Stable and Stationary Populations.
- Use Balancing Equations.

- Use Myer's and UN indices in evaluating age data.
- Apply measures of the aging of population.
- Understand the concept of Abridged life tables and their construction by Reed and Merrell method and Greville's method.
- Synthesize population estimation and projection by different methods.
- Use Graduation of mortality rates by Makeham's and Gompertz graduation formula.
- Fit of Logistic curve and Makeham's formula.
- Understand the scope of population studies and its relationship with other disciplines.

SYLLABUS OF DSE-2C
Theory

UNIT I: **(15 Hours)**
Demographic concepts
Definition of demography and its various components, Major sources of demographic data collection and errors therein; Coverage and content errors, Rate of population change, Population density, Population potential, Population composition, Scale of urbanization and scale of population concentration, Concept of Stationary and stable populations, Nature and scope of population studies and its relationship with other disciplines. Balancing equations and its uses.

UNIT II: **(15 Hours)**
Adjustment of demographic data and abridged life tables
Measures of aging of population: Aged-child ratio, Old-age dependency ratio, Child dependency ratio, Age-dependency ratio, Adjustment of age data at younger age groups and adult ages. Chandrasekharan-Deming formula to check completeness of registration data. Myer's index, United Nation's index.
Abridged life tables: Concept and its construction by Reed-Merrell method and Greville's method.

UNIT III **(15 Hours)**
Population Estimates and Projections and Graduation of Mortality Rates:
Inter-censal and post-censal estimates by mathematical and component method ; Population Projection by the mathematical method: Logistic curve and its fitting by Pearl and Reed method and Rhodes method. Graduation of mortality rates: Makeham's and Gompertz graduation formula. Fitting of Makeham's formula.

PRACTICAL/LAB WORK - 30 hours
List of Practicals:
1. To find the Population density of a place.
2. To find Population Potential.
3. To find Rate of population change
4. To find Age Dependency ratio.
5. To find Aged Child ratio.
6. To find Child Dependency ratio.
7. To construct Abridged Life Table by Reed and Merrell method.
8. To Construct Abridged Life Table by Greville's method.

9. To fit Logistic curve by Pearl and Reed method.
10. To fit Logistic curve by Rhode's method.
11. To fit Makeham's formula by the method of Four Selected Points.
12. To fit Makeham's formula by the method of Partial Sums.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
- Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
- Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
- Pathak, K. B. and F. Ram (1998), *Techniques of Demographic Analysis*, 2nd Edition, Himalaya Publishing House, Bombay.

SUGGESTED READINGS:

- Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.
- Keyfitz N., Beckman John A. (1985): Demography through Problems S-Verlag New York
- Ramakumar R. (1986): Technical Demography. Wiley Eastern Limited.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

UNIVERSITY OF DELHI

CNC-II/093/1(40)/EC-1270/2024-25/156
Dated: 07.08.2024

NOTIFICATION

Sub: Amendment to Ordinance V

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

In pursuant of EC Resolution No. 5-13/ dated 27.07.2024, the following amendment is made based on Undergraduate Curriculum Framework 2022 implemented from the Academic Session 2022-2023:

(i) Addition of a paper titled "Introduction to Vital Statistics and Demography" for students of BSc (Programme) Mathematical Sciences under the Pool of DSEs in Semester-IV (Note: The paper is already running as a DSC paper of BA Prog. (Major) in Sem-IV). – **Annexure-1.**
(ii) Deletion of a Generic Elective paper titled "Introduction to Statistics" in Semester-1.
(iii) Revision of Generic Elective paper titled "Basic Statistics" in Semester-1 - **Annexure-2.**
(iv) Correction in the name/title of following papers:

Existing	**Proposed**
BSc (Hons.) –DSC4 Theory of Probability Distribution	BSc (Hons.) –DSC4 Theory of Probability Distributions
BSc (Hons.) –DSC50 Applied Statistics-I	BSc (Hons.) –DSC5 Applied Statistics
BA Prog./ BSc (Prog.) Mathematical Sciences-DSC3 Sampling Distributions	BA Prog./ BSc (Prog.) Mathematical Sciences-DSC3 Elements of Sampling Distributions
BA Prog./ BSc (Prog.) Mathematical Sciences-DSC4 Elements of Statistics Inference	BA Prog./ BSc (Prog.) Mathematical Sciences-DSC4 Basics of Statistical Inference
BSc. (Prog.) Mathematical Sciences-DSE-1 Index numbers and Time Series Analysis	BSc. (Prog.) Mathematical Sciences-DSE-1 Time Series Analysis and Index numbers
BSc (Hons.) - DSE – Semester-6 Statistical Computing and Data Mining	BSc (Hons.) - DSE – Semester-6 Statistical Computing and Basic Data Mining
BA (Prog.) - DSC-6 – Semester-6 Statistical Methods in Psychology and Education	BA (Prog.) - DSC-6 – Semester-6 Statistical Methods for Psychology and Education

REGISTRAR

Annexure-1

With effect from academic session 2024-2025

DISCIPLINE SPECIFIC ELECTIVE COURSE DSE -2 INTRODUCTION TO VITAL STATISTICS AND DEMOGRAPHY

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Vital Statistics and Demography	4	3	0	1	Class XII with Mathematics	knowledge of basic statistics

Learning Objectives:

The learning objectives of this course are as follows:

- To collect valid Demographic data using different methods.
- To learn basic measures of Mortality, Fertility, and Population Growth.
- To construct life tables.

Learning Outcomes:

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

- Distinguish between Vital Statistics and Demography.
- Understand errors in Demographic data.
- Comprehend sources of data collection on Vital Statistics and errors therein.
- Use methods for measurement of Population.
- Distinguish between Rate and Ratio.
- Understand the basic measures of Mortality.
- Describe and apply the concepts of Stable and Stationary Populations.
- Understand the concept of Life Tables and their construction.
- Understand the basic measures of Fertility.
- Apply measures of Population Growth.

SYLLABUS OF DSC-8
Theory

UNIT I **(10 Hours)**
Introduction to Vital Statistics
Introduction and sources of collecting data on vital statistics, errors in the census, and registration data. Measurement of population, rate, and the ratio of vital events.

UNIT II **(12 Hours)**
Measurements of Mortality
Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR), and Standardized Death Rates. Stationary and Stable population, Central Mortality Rates, and Force of Mortality.

UNIT III **(10 Hours)**
Life Tables
Life(Mortality) Tables: Assumption, description, construction of Life Tables, and Uses of Life Tables.

UNIT IV **(13 Hours)**
Measurements of Fertility
Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR), and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR), and Net Reproduction Rate (NRR).

PRACTICAL/LAB WORK - 30 hours
List of Practicals:
1. To calculate CDR and Age Specific death rate for a given set of data.
2. To find a standardized death rate by (i) Direct method and (ii) Indirect method.
3. To construct a complete life table.
4. To fill in the missing entries in a life table.
5. To calculate CBR, GFR, SFR, TFR for a given set of data.
6. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data.
7. Calculate GRR and NRR for a given set of data and compare them.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II, 9thEd., World Press.
- Biswas, S. (1988). Stochastic Processes in Demography & Application, Wiley Eastern Ltd.

SUGGESTED READING:

- Mukhopadhyay, P. (1999). Applied Statistics, Books and Allied (P) Ltd.

- Keyfitz, N. and Beekman,J.A. (1985). Demography through Problems. S-Verlag, New York.
- Croxton, Fredrick, E. Cowden, Dudley J. and Klein, S. (1973). Applied General Statistics, 3rd Ed., Prentice Hall of India Pvt. Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY DEPARTMENT OF STATISTICS CATEGORY-VI

GENERIC ELECTIVE 4A: BASICS OF STATISTICAL INFERENCE

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the Course			Eligibility Criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basics of Statistical Inference	4	3	0	1	Class XII with Mathematics	Basic knowledge of probability, probability distributions and sampling distributions

Learning Objectives:

The learning objectives of this course are as follows:

- To introduce the concept of estimation theory and testing of hypothesis.
- To infer about the unknown population parameters based on random samples.
- To introduce the estimation/ inference about the population using hypothesis testing.

Learning Outcomes:

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

- Understanding of estimation theory, Point and interval estimations.
- Characteristics of a good estimator and different methods of estimation.
- Demonstrate the use of these techniques in data analysis.
- Develop the best/most powerful statistical tests to test the hypotheses regarding unknown population parameters by using the Neyman-Pearson theory.

SYLLABUS OF GE 4A

Theory

UNIT I: **(15 Hours)**

Estimation Theory

Estimation: Parameter space, sample space, point estimation, requirement of a good estimator, consistency, unbiasedness, efficiency, sufficiency, Minimum variance unbiased estimators, Factorization theorem, Fisher- Neyman Criterion: statement and applications, Cramer- Rao inequality: statement and application, MVB estimators and their applications, Statement of Rao-Blackwell theorem and Lehmann-Scheffe theorem..

UNIT II: **(15 Hours)**

Methods of Estimation

Methods of estimation: maximum likelihood, least squares and minimum variance, Properties of maximum likelihood estimators (illustration), Interval Estimation: confidence interval and confidence limits for the parameters of normal distribution, confidence intervals for large samples.

UNIT III: **(15 Hours)**

Test of Significance

Principles of test of significance: Null and alternative hypotheses, simple and composite, Type-I and Type-II errors, critical region, level of significance, power of the test, best critical region, most powerful test, uniformly most powerful test, uniformly most powerful unbiased critical region (UMPU), Neyman- Pearson Lemma: statement and its applications to construct most powerful test.

PRACTICAL/LAB WORK – 30 Hours

List of Practical / Lab Work:

1. Unbiased estimators and consistent estimators.
2. Efficient estimators and relative efficiency of estimators.
3. Sufficient estimators and factorization theorem.
4. Cramer- Rao inequality and MVB estimators.
5. Method of maximum likelihood estimation.
6. Method of least squares and minimum variance.
7. Confidence interval and confidence limits for the parameters of normal distribution.
8. Confidence intervals in case of large samples.
9. Type I and Type II errors, power of the test.
10. Most powerful critical region (NP Lemma).

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Miller, I. and Miller, M. (2013). John E. Freund's Mathematical Statistics, 8th Ed., Prentice Hall of India.
- S.C. Gupta and V.K. Kapoor (2020): Fundamentals of Mathematical Statistics, 12th Ed., Sultan Chand and Sons.
- R.V. Hogg, A.T. Craig and J.W. Mckean (2005): Introduction to Mathematical Statistics, 6th Edition, Pearson Education.

• A.M. Goon, M.K. Gupta and B. Das Gupta (2003): An Outline of Statistical Theory (Vol. II), 4th Ed.,World Press, Kolkata.

SUGGESTED READING:

• G. Casella and R.L. Berger (2002): Statistical Inference, 2nd Edition, Thomson Duxbury.
• E.J. Dudewicz and S.N. Mishra (1988): Modern Mathematical Statistics, John Wiley and Sons.
• V.K. Rohtagi and A.K. Md. E. Saleh (2009): An Introduction to Probability and Statistics, 2nd Edition, John Wiley and Sons.
• Mood A.M., Graybill F.A. and Boes D.C. (1974). Introduction to the Theory of Statistics, McGraw Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

GENERIC ELECTIVE 4B: STATISTICAL COMPUTING USING R

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Computation using R	**4**	**2**	0	**2**	Class XII pass with Mathematics.	Basic knowledge of computers and basics of Statistics

Learning Objectives:

The learning objectives of this course are as follows:

- Review and expand upon core topics in probability and statistics.
- Practice of graphical interpretation, probability distribution and data analysis using 'R'.

Learning Outcomes:

After completing this course, students would have developed a clear understanding of:

- Various Graphical representation and interpretation of data.
- Automated reports giving detailed descriptive statistics.
- Understanding data and fitting suitable distribution.
- Testing of hypothesis, p-value and confidence interval.

- Random number generation and sampling procedures.
- Importing data, Code editing in R and flow controls if (), for (), while ()

SYLLABUS OF GE 4B
Theory

UNIT I **(07 hours)**
Overview of the R language
Installing R and R studio; working on R studio, scripts and text editors, creating and saving R workspaces, installing packages and loading libraries.
Data types in R (Numeric, Integer, Character, Logical, and Complex) Data structures in R (Vector, Matrix, Data frames, List). Mathematical operators, Relational Operators, and Logical operators and use of functions: class(), names(), head(), tail(),rbind(), cbind(), rownames(), colnames() etc. Learn how to load data, importing a data file viz. .xlsx. handling missing data in R

UNIT II **(10 hours)**
Descriptive statistics and Graphs
Generate automated reports giving detailed descriptive statistics mean, median, mode, variance, skewness, five-point summary , frequency table. Statistical/mathematical functions, scan(), summary(),str(), table(), cut(),cumsum(), cumprod()etc.
Graphical representation of data: bar-plot, pie-chart, boxplot, frequency polygon, ogives , scatter plot, Fitting of curve lm(): linear, quadratic, exponential functions, correlation, and linear and multiple regression with the interpretation of results.

UNIT III **(10 hours)**
Decision-making and distributions
Introduction to flow control: if, if-else, while, and for loops, simple coding. Distribution functions(r,d,p,q) for Binomial, Poisson, Exponential, and Normal . Data distribution: qqplot(), qqnorm()

UNIT IV **(08 hours)**
Testing of Hypothesis and Time series
Basics of statistical inference in order to understand hypothesis testing, and compute p-values and confidence intervals. Applications on t-test, F-test, and Chi-square test with the interpretation of results. Time series analysis, components of a time series data, time series model, ts(), decomposition(), and smoothing with the interpretation of results.

PRACTICAL/LAB WORK – 30 Hours

List of Practical / Lab Work:
1. Graphical representation of data with bar-plot, pie-chart, and boxplot.
2. Histogram with equal and unequal class intervals, frequency polygon
3. Less than and more than Ogives.
4. Fitting of curve linear, quadratic, exponential functions,
5. Scatter plots, correlation
6. Linear and multiple regression

7. Drawing sample using SRSWR, SRSWOR
8. Drawing sample using stratified under proportion allocation and systematic sampling,
9. functions(r,d,p,q) for discrete distributions viz. Binomial, Poisson.
10. functions(r,d,p,q) for continuous distribution viz. Uniform,Exponential, and Normal .
11. Test the goodness of fit for Binomial, Poisson distribution.
12. Chi- Square test for independence of attributes.
13. Single, paired and independent samples t-test.
14. Components of a time series data.
15. decomposition(), and smoothing() under time series data

ESSENTIAL READINGS:

- Braun, W. J., and Murdoch, D. J. (2007). A First Course in Statistical Programming with R. Cambridge University Press. New York.
- Gardener, M. (2012). Beginning R: The Statistical Programming Language, Wiley Publications.

SUGGESTIVE READING:

- Crawley, M. J. (2012). The R Book. 2nd Ed., John Wiley & Sons.
- Dalgaard, P. (2008). Introductory Statistics with R. 2nd Ed., Springer.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Semester 5

DEPARTMENT OF STATISTICS

B. Sc. (H) Statistics

Category I

DISCIPLINE SPECIFIC CORE COURSE – 13: THEORY OF ESTIMATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Theory of Estimation	4	3	0	1	Class XII pass with Mathematics	Basic knowledge of probability, probability distributions and sampling distributions

Learning Objectives

The learning objectives include:

- Characterisation of the population based on sample information
- Understanding process of learning and determining the population characteristics based the available data.
- Strength and weakness of various methods for obtaining point and interval estimators with respect to optimal/desirable properties.

Learning Outcomes:

After completing this course, students will develop a clear understanding of:

- List desirable properties of point estimators based on an unknown parameter of a distribution viz. Unbiasedness, Consistency, Efficiency and Sufficiency.
- Derive the UMVUE of a parameter or function of a parameter (Using Cramer- Rao inequality, Rao-Blackwell theorem, and Lehmann- Scheffé Theorem).
- Understand and apply different techniques of finding optimal point estimators such as Maximum Likelihood Estimation, Method of Least Squares, Method of moments and the method of minimum chi-Squares

- Construct interval estimators, pivot method (Confidence Intervals) for unknown population parameters.

SYLLABUS OF DSC-13
Theory

UNIT I **(18 hours)**
Estimation
Estimation: Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency. Fisher-Neyman Criterion (statement and applications), Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality, Minimum Variance Bound estimators (MVBE) and their applications.

UNIT II **(10 hours)**
Methods of Estimations
Methods of Estimation: Method of moments, method of maximum likelihood estimation and method of minimum Chi-square.

UNIT III **(12 hours)**
Interval estimation
Interval estimation - Confidence intervals for parameters of various distributions, confidence interval for Binomial proportion, confidence interval for population correlation coefficient for Bivariate Normal distribution, pivotal quantity method of constructing confidence intervals, shortest length confidence intervals, large sample confidence intervals.

UNIT IV **(5 hours)**
Censored Data
Failure censored samples, time censored sample, estimation of expected lifetime in failure censored samples for one parameter exponential lifetime distribution

PRACTICAL/LABWORK (30 hours):

List of Practical
1. Unbiased estimators (including unbiased but absurd estimators)
2. Consistent estimators, efficient estimators and relative efficiency of estimators.
3. Cramer-Rao inequality and MVB estimators
4. Sufficient Estimators – Factorization Theorem, Complete Sufficient estimators, Rao-Blackwell theorem.
5. Lehman-Scheffe theorem and UMVUE
6. Maximum Likelihood Estimation
7. Asymptotic distribution of maximum likelihood estimators
8. Estimation by the method of moments,
9. Estimation by method of minimum Chi-square
10. Confidence interval based on large sample test
11. Confidence interval based on exact sample test

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Goon, A.M.; Gupta, M.K.; Dasgupta, B. (2013).: An Out Line of Statistical Theory, Volume 2, The World Press, Kolkata.
- Gupta, S.C. and Kapoor, V.K.(2020): Fundamental of Mematical Statistics, 12th Edn. Sultan Chand and Sons.
- Sinha, S.K. (1986):Reliability and Life testing; Wiley Eastern.

SUGGESTIVE READINGS:

- Hogg, R.V. and Craig, A.T (2018): Introduction to Mathematical Statistics, 8th Edn. Pearson Education.
- Casella, G. and Berger, R.L. (2002): Statistical Inference. 2nd Edition, Duxbury Press, Pacific Grove.
- Hogg, R.V. and Tanis, E.A. (1988): Probability and statistical Inference, 6th Edn. Pearson Education
- Rohatgi V.K, (2013): Statistical Inference- Dover Publication, New York.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE-14: LINEAR MODELS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	tutorials	practical		
Linear Models	4	3	0	1	Class XII pass with Mathema tics	Basic knowledge of matrix theory, probability distributions and sampling distributions

Learning Objectives:

learning objectives include:

- Developing a clear understanding of the fundamental concepts of linear models.
- Developing associated skills allowing the students to work effectively with them.

Learning Outcomes:

After completion of this course, students will develop a clear understanding of:

- Theory and estimation of Linear Models.
- Gauss-Markov Theorem and its use.
- Distribution of quadratic forms.
- Simple and Multiple linear regression models and their applications.

- Fitting of these models to real or synthetic data, derivation of confidence and prediction intervals, and a sound scientific interpretation of the results.
- Techniques of Analysis of Variance and Covariance under fixed effects model.
- Assessment of the quality of the fit using classical diagnostics, awareness of potential problems (outliers, etc.) and application of remedies to deal with them.

SYLLABUS OF DSC-14
THEORY

UNIT I **(10 Hours)**
Estimation theory and Distribution of Quadratic forms
Gauss-Markov setup, Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance. Cochran's theorem and distribution of quadratic forms.

UNIT II **(10 Hours)**
Analysis of Variance
Definition of fixed, random, and mixed effect models, Technique of ANOVA, assumptions for its validity, analysis of variance in one-way classified data and in two-way classified data with an equal number of observations per cell for fixed effect models.

UNIT III **(14 Hours)**
Regression analysis:
Estimation and hypothesis testing in case of simple and multiple linear regression analysis, Confidence intervals, and Prediction intervals, Concept of model matrix and its use in estimation. Effect of orthogonal columns in the X matrix, Partial F-test and Sequential F-test, Bias in regression estimates.

UNIT IV **(4 Hours)**
Analysis of Covariance:
Technique of ANOCOVA, assumptions for its validity, use, and analysis of covariance in one-way classified data with a single concomitant variable.

UNIT V **(7 Hours)**
Model checking and Model Building
Prediction from a fitted model, Residuals and Outliers, Lack of fit and pure error, Violation of usual assumptions concerning normality, Homoscedasticity, and collinearity, Diagnostics using quantile-quantile plots. Techniques for Variable selection. Polynomial Regression models: Orthogonal Polynomials.

PRACTICAL/LABWORK -30 Hours

List of Practicals
1. Estimability when X is a full rank matrix.
2. Estimability when X is not a full rank matrix.
3. Distribution of Quadratic forms.
4. Simple Linear Regression.
5. Multiple Regression.
6. Tests for Linear Hypothesis.
7. Bias in regression estimates.
8. Lack of fit.
9. Stepwise regression procedure.

10. Analysis of Variance of a one-way classified data.
11. Analysis of Variance of two-way classified data with one observation per cell.
12. Analysis of Variance of two-way classified data with m (> 1) observations per cell.
13. Analysis of Covariance of a one-way classified data.
14. Residual Analysis.
15. Orthogonal Polynomials.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Montgomery, D. C., Peck, E. A. and Vining, G. G. (2012): Introduction to Linear Regression Analysis, 5th Ed., John Wiley and Sons.
- Rencher, A. C. and Schaalje, G. B. (2008): Linear Models in Statistics, 2nd Ed., John Wiley and Sons.
- Draper, N. R. and Smith, H. (1998): Applied Regression Analysis, 3rd Ed., John Wiley and Sons.

SUGGESTIVE READINGS:

- Weisberg, S. (2005): Applied Linear Regression, 3rd Ed., John Wiley and Sons.
- Rawlings, John O. Pantula Sastry G. Dickey, David A. (1998) Applied Regression Analysis: A Research Tool, Second Edition
- Bapat, R.B.(1993): Linear Algebra and Linear Models, Hindustan Book Agency.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE 15 –: STOCHASTIC PROCESSES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Stochastic Processes	4	3	0	1	Class XII pass with Mathematics.	Knowledge of probability, probability distributions, and sampling distributions

Learning Objectives:

- To define, design and model

- To analyze transitions through Markov chains
- To identify the real life applications of stochastic processes

Learning Outcomes:
After completing this course, students will develop a clear understanding of:
- The fundamental concepts of stochastic processes.
- Tools needed to analyze stochastic processes.
- Markov processes and Markov chains.
- Markov chain applications.
- Poisson process and its variations.
- Random walk and ruin theory

SYLLABUS OF DSC-15
Theory

UNIT I **(13 hours)**
Introduction of Stochastic Process
Probability Distributions: Generating functions, Bivariate probability generating functions, and their application.
Stochastic Process: Introduction, Covariance stationary, and Stationary Process.

UNIT II **(15 hours)**
Markov Chains
Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities.
Classification of states and chains, stationary process, and stability of Markov system. Generalization of independent Bernoulli trials,

UNIT III **(12 hours)**
Poisson Process
Poisson Process: postulates of Poisson process, and properties of Poisson process and applications.
Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.

PRACTICAL/LAB WORK – (30 hours)
List of Practical:
1. Applications of Partial Fraction Theorem.
2. Problems based on (covariance) stationary processes.
3. Simulation of Markov chains.
4. Calculation of transition probability matrices.
5. To check whether the given chain is irreducible or not.
6. Classification of states.
7. Computation of probabilities in case of generalizations of independent Bernoulli trials.
8. Simulation and applications of Poisson processes.
9. Transition Markov chain in case of gambler's ruin problem .
10. Calculation of probabilities for ruin problems.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Feller, W. (1968). Introduction to probability Theory and Its Applications, Vol I, 3rd Ed., Wiley International.
- Medhi, J. (2019). Stochastic Processes,4th Ed., Reprint, New Age International Publishers.

SUGGESTIVE READINGS:

- Sheldon M. Ross (2007) : Introduction to Probability Models, 9th edition, Academic Press publications
- Karlin & Taylor (1975) : A first course in stochastic processes, 2nd edition, Academic Press publications
- Basu, A.K. (2005). Introduction to Stochastic Processes, Narosa Publishing.
- P. G. Hoel, S. C. Port and C. J. Stone: Introduction to Stochastic Processes.
- J. G. Kemeny, J. L. Snell and A. W. Knapp: Finite Markov Chains.
- Geoffrey R, Grimmett & David R. Stirzaker : Probability and Random Processes
- Bhat,B.R. (2000). Stochastic Models: Analysis and Applications, New Age International Publishers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B.Sc. (P)/B.A(P) with Statistics as Major

Category II

DISCIPLINE SPECIFIC CORE COURSE - 9: INTRODUCTION TO DESIGN OF EXPERIMENTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Design of Experiments	4	3	0	1	Class XII pass with Mathematics	knowledge of inferential statistics, and ANOVA

Learning Objectives:
The learning objectives include

- To design and conduct experiments.
- To analyze and interpret data.

Learning Outcomes:
After completing this course, students will developed a clear understanding of

- The fundamental concepts of Design of Experiments.
- Introduction to planning valid and economical experiments.
- Completely randomized design.
- Randomized block design.
- Latin square design.
- Balanced incomplete block design.
- Full and confounded factorial designs with two levels.
- Fractional factorial designs with two levels.

SYLLABUS OF DSC-9

Theory

UNIT I **(15 hours)**

Experimental designs

Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) - layout, model and statistical analysis, relative efficiency.

UNIT II **(09 hours)**

Balanced Incomplete Block Designs

Balanced Incomplete Block Design (BIBD)- parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD.

UNIT III **(15 hours)**

Factorial experiments

Factorial experiments: Concepts, notations and advantages, 2^2, $2^3 \ldots 2^n$ factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 5$). Factorial experiments in a single replicate.

UNIT IV **(06 hours)**

Fractional factorial experiments

Fractional factorial experiments: Construction of one-half and one-quarter fractions of 2^n ($n \leq 5$) factorial experiments, Alias structure, Resolution of a design.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Analysis of CRD, RBD & LSD.
2. Analysis of 2^2 and 2^3 factorial experiments in CRD and RBD.
3. Analysis of a completely confounded two level factorial designs in 2 and 4 blocks.
4. Analysis of a partially confounded two level factorial design.
5. Analysis of a single replicate of a 2^n design.
6. Analysis of one-half and one-quarter fractions of 2^n factorial design.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics, Vol. II, 8thEd. World Press, Kolkata.
- Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.
- Das., M.N. and Giri, N.C. (1986): Design and Analysis of Experiments, Wiley Eastern.
- Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied (P) Ltd.

SUGGESTIVE READINGS

- Cochran, W.G. and Cox, G.M. (1959): Experimental Design, Asia Publishing House.
- Kempthorne, O. (1965): The Design and Analysis of Experiments, John Wiley.
- Joshi, D.D. (1987): Linear Estimation and Design of Experiments, John Wiley & Sons.
- Dey, Aloke (1986): Theory of Block Designs, Wiley Eastern Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE– 10: STATISTICAL SIMULATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Simulation	4	3	0	1	Class XII pass with Mathematics	knowledge of basic statistics

Learning Objectives

The learning objectives include:

- Concept of simulation and simulation modelling.
- Generation of Pseudo random number generators as well as from standard statistical distributions. Monte-Carlo simulation technique.
- Application of simulation techniques.

Learning Outcomes

After completing this course, students will possess skills concerning:

- How simulation may be used to understand the behavior of real world systems by utilizing mathematical models with an emphasis on simulation.
- How to generate random numbers by the different methods.
- Hands-on experience in using simulation software packages/structured programming languages.

SYLLABUS OF DSC- 10

Theory

UNIT I **(12 Hours)**

Introduction to simulation:

Introduction, Definitions of simulation, Need for simulation, general principles, types of simulation, Simulation models, Phases in simulation models, Event type simulation, Monte Carlo simulation technique.

UNIT II **(18 Hours)**

Random numbers generation:

Methods for the generation of Random numbers, Pseudo random number generators, Mid square method for the generation of random number and its limitations, the inverse transform method; Generating the Discrete and Continuous random variables.

UNIT III **(15 Hours)**

Applications of simulation:

Applications of simulation in different fields of study, simulation of Inventory problems and simulation of Queueing problems. Advantages and disadvantages of simulation, Simulation languages, Scope of simulation techniques.

Practical/Lab Work – (30 hours)

List of Practical:

1. Pseudo random number generators;
2. Generation of U(0,1).
3. Generation using the inverse transform method applied to:
   (a) Discrete distribution and
   (b) Continuous distribution.
4. Monte Carlo simulation method and applications.
5. Problems based on Queueing systems.
6. Problems based on Inventory Controls, etc.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READING:

- Sheldon M. Ross (2022) Simulation, Sixth Edition, Elsevier Academic press publication.
- Taha, H. A. (2010). Operations Research. An Introduction, 9th Ed, Pearson.
- Swarup, K. Gupta, P.K. and Mohan, M. (2019). Operations Research, 15th Ed, Sultan Chand & Sons.

SUGGESTED READINGS:

- Voss, J. (2013). An introduction to statistical computing: A simulation-based approach, 1st Ed., Wiley series in computational statistics.
- Sharma, J. K. (2017). Operations Research: Theory and applications, 6th Edition, Trinity Press.
- Payer T.A. (1982). Introduction to simulation, McGraw Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B.Sc. (P)/B.A(P) with Statistics as Non- Major

Category III

DISCIPLINE SPECIFIC CORE COURSE - 5: INTRODUCTION TO DESIGN OF EXPERIMENTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Design of Experiments	4	3	0	1	Class XII pass with Mathematics	knowledge of inferential statistics, and ANOVA

Learning Objectives:
The learning objectives include

- To design and conduct experiments.
- To analyze and interpret data.

Learning Outcomes:
After completing this course, students will develop a clear understanding of

- The fundamental concepts of Design of Experiments.
- Introduction to planning valid and economical experiments.
- Completely randomized design.
- Randomized block design.
- Latin square design.
- Balanced incomplete block design.
- Full and confounded factorial designs with two levels.
- Fractional factorial designs with two levels.

SYLLABUS OF DSC-5
Theory

UNIT I **(15 hours)**

Experimental designs

Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) - layout, model and statistical analysis, relative efficiency.

UNIT II **(09 hours)**

Balanced Incomplete Block Designs

Balanced Incomplete Block Design (BIBD)- parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD.

UNIT III **(15 hours)**

Factorial experiments

Factorial experiments: Concepts, notations and advantages, 2^2, $2^3 \ldots 2^n$ factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 5$). Factorial experiments in a single replicate.

UNIT IV **(06 hours)**

Fractional factorial experiments

Fractional factorial experiments: Construction of one-half and one-quarter fractions of 2^n ($n \leq 5$) factorial experiments, Alias structure, Resolution of a design.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Analysis of CRD, RBD & LSD.
2. Analysis of 2^2 and 2^3 factorial experiments in CRD and RBD.
3. Analysis of a completely confounded two level factorial designs in 2 and 4 blocks.
4. Analysis of a partially confounded two level factorial design.
5. Analysis of a single replicate of a 2^n design.
6. Analysis of one-half and one-quarter fractions of 2^n factorial design.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics, Vol. II, 8thEd. World Press, Kolkata.
- Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.
- Das., M.N. and Giri, N.C. (1986): Design and Analysis of Experiments, Wiley Eastern.
- Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied (P) Ltd.

SUGGESTIVE READINGS

- Cochran, W.G. and Cox, G.M. (1959): Experimental Design, Asia Publishing House.
- Kempthorne, O. (1965): The Design and Analysis of Experiments, John Wiley.
- Joshi, D.D. (1987): Linear Estimation and Design of Experiments, John Wiley & Sons.
- Dey, Aloke (1986): Theory of Block Designs, Wiley Eastern Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Discipline Specific Elective
Category-V

DISCIPLINE SPECIFIC ELECTIVE COURSE – 3A: ACTUARIAL STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Actuarial Statistics	4	3	0	1	Class XII pass with Mathematics	NIL

Learning Objectives

The learning objectives include:

- To learn basics of Actuarial Science.
- To learn advanced techniques in Actuarial Science with practical applications in daily life.

Learning Outcomes:

After completing this course, students will develop a clear understanding of:

- Basics of Actuarial Science.
- Tools for applying actuarial methods in phenomena for financial research and insurance.
- computation of premiums and settlement of claims

SYLLABUS OF DSE-3A

Theory

UNIT I **(9 Hours)**

Introductory Statistics and Insurance Applications

Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables. Utility theory: Utility functions, expected utility criterion, types of utility function, insurance and utility theory.

UNIT II **(12 Hours)**

Principles of Premium Calculation

Principles of Premium Calculation: Properties of premium principles, examples of premium principles. Individual risk models: models for individual claims, the sum of independent claims, approximations and their applications.

UNIT III **(6 Hours)**

Survival Distribution and Life Tables:

Survival Distribution and Life Tables: Uncertainty of age at death, survival function, time-until-death for a person, curate future lifetime, force of mortality, life tables with examples, deterministic survivorship group, life table characteristics

UNIT IV **(15 Hours)**

Life Insurance
Life Insurance: Models for insurance payable at the moment of death, insurance payable at the end of the year of death and their relationships. Life annuities: continuous life annuities, discrete life annuities. Premiums: continuous and discrete premiums.

PRACTICAL/LAB WORK – (30 hours)
List of Practical:
1. Risk computation for different utility models.
2. Discrete and continuous risk calculations.
3. Calculation of aggregate claims for collective risks.
4. Calculation of aggregate claim for individual risks.
5. Computing Ruin probabilities and aggregate losses.
6. Annuity and present value of contract.
7. Computing premium for different insurance schemes.
8. Practical based on life models and tables.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Dickson, C. M. D. (2005): Insurance Risk And Ruin (International Series On Actuarial Science), Cambridge University Press. Bowers, N. L., Gerber, H. U., Hickman,
- Atkinson, M.E. and Dickson, D.C.M. (2011): An Introduction to Actuarial Studies, Elgar Publishing.

SUGGESTIVE READINGS

- J. C., Jones, D. A. And Nesbitt, C. J. (1997): .Actuarial Mathematics, Society Of Actuaries, Itasca, Illinois, U.S.A.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE– 3B: SIMULATION TECHNIQUES IN STATISTICS (Not for category II)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Simulation Techniques in Statistics	4	3	0	1	Class XII pass with Mathematics	knowledge of basic statistics

Learning Objectives

The learning objectives include:

- The objective of this course is to introduce the nuances of techniques involved in simulation studies as applicable to modeling of systems.
- The programming implementations will be completed using C/MATLAB/R/Python.

Learning Outcomes

After completing this course, students will possess skills concerning:

- Use of simulation to understand the behavior of real world systems.
- Ability to generate Pseudo-random numbers by the different methods.
- Random variable generation from theoretical distributions.
- Use of Monte Carlo methods and regenerative simulation.
- Ability to develop programs for the purpose of simulation.

SYLLABUS OF DSE- 6d

Theory

UNIT I **(12 Hours)**

Introduction to simulation

Introduction, Systems, Simulation models, Classification of simulation models; Simulation and Monte Carlo Methods, Pseudo-random number generators; Statistical tests of Pseudo-random numbers.

UNIT II **(18 Hours)**

Generation of random numbers

Random number generation. Random variable generation- Inverse transform method, Composition method, Acceptance-Rejection method. Generating from common statistical distributions- Discrete and Continuous. Simulation of random vectors, Generating Poisson processes and Markov chain.

UNIT III **(15 Hours)**

Applications of simulation

Discrete event simulation; Monte Carlo integration; Variance reduction techniques; Applications to statistical inference; Point Estimators, Confidence Intervals and hypothesis tests.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

PRACTICAL/ LAB WORK – (30 hours)

List of Practical:

1. Pseudo random number generators.
2. Generation of U (0, 1).
3. Problems based on statistical tests.
4. Application to standard statistical distributions (discrete and continuous):
   (a) The inverse transforms method.

(b) Acceptance-Rejection method.

5. Problems based on Composition Method.
6. Problems based on Monte Carlo integration.
7. Problems based on Regenerative methods.

ESSENTIAL READINGS:

- Rubinstein, R.Y. (2017). Simulation and the Monte Carlo Methods, Wiley.
- Voss, J. (2014). An introduction to statistical computing: a simulation-based approach, Wiley series in computational statistics.
- Sheldon M. Ross (2022) Simulation, Sixth Edition, Elsevier Academic press publication.
- Averill M. Law and W. David Kelton (1991). Simulation modeling and analysis: McGraw-Hill, Inc., New York.

SUGGESTED READINGS:

- Reitman, J. (1971). Computer simulation Applications, John Wiley & Sons.
- Swarup, K. Gupta, P.K. and Mohan, M. (2014). Operations Research, 15th Ed, Sultan Chand & Sons.
- Fishman, G.S. (1996). Monte Carlo-Concepts, Algorithms and Applications, Springer.
- Sheskin, D. J. (2011). Handbook of parametric and nonparametric statistical procedures, CRC Press. Boca Raton, FL.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE-SPECIFIC ELECTIVE COURSE–3C: ENVIRONMENTAL STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Environmental Statistics	4	3	0	1	Class XII pass with Mathematics	knowledge of sampling distributions and linear models

Learning Objectives

The learning objectives include:

· To study the role of Statistics in Environmental Science.

· To study different Statistical distributions, sampling procedures, linear models and analysis of variance.
- To study environmental monitoring.
- To study time-series analysis and Spatial-data analysis.
- To learn about censored data and risk assessment.

Learning Outcomes:

After completing this course, students will develop a clear understanding of:

- The role of Statistics in Environmental Science.
- Uses and applications of different Statistical distributions, sampling procedures, linear models and analysis of variance.
- Environmental monitoring.
- Time-series analysis and Spatial-data analysis.
- Censored data and risk assessment.
- They will be able to do risk analysis using spreadsheet.

SYLLABUS OF DSE – 3C
Theory

UNIT I: (9 hours)
Introduction
The Role of Statistics in Environmental Science: Introduction, Examples, Base-line, Targeted, Regular monitoring, Role of Statistics in Environmental Science. Environmental Sampling: Introduction, Sampling Procedures, Sampling in the wild.

UNIT II: (9 hours)
Models for Data and Environmental Monitoring
Models for Data: Statistical models, Discrete statistical distribution, Continuous statistical distributions, Linear Models, ANOVA. Environmental Monitoring: Detection of changes by ANOVA, Detection of changes using control chart, Chi squared tests for a change in a distribution.

UNIT III: (9 hours)
Time Series and Spatial-Data Analysis
Introduction to Time Series Analysis, Components of Time Series, Serial correlation. Introduction to Spatial-Data Analysis, Types of spatial data, Spatial Patterns in quadrat counts, and Correlation between quadrat counts.

UNIT IV: (9 hours)
Censored Data and Risk Assessment:
Introduction to Censored Data, Single sample estimation, Types of censoring. Introduction to Risk Assessment, Principles for Monte Carlo Risk Assessment, Risk Analysis using spreadsheet.

PRACTICAL/LAB WORK - (30 HOURS)

List of Practical:

1. Collection of environmental data.

2. Fitting different discrete distributions. Case: Estimate the survival rates of salmon in rivers and continuous distributions,
3. Fitting regression model (simple and multiple), Case: Chlorophyll-a in lakes/rivers as an indicator of lake/river water quality, Soil, and Vegetation data.
4. Change detection in the environment using ANOVA, Control Charts, Hypotheses testing- Case: pH values, SO_4 concentrations etc in lakes/rivers, Annual ring widths in trees,
5. Time series analysis- Case: World Temperature data, Annual sunspot data, Rainfall data, or on any environmental issues.
6. Serial correlation- Case: Northern and Southern Hemisphere temperatures
7. Single sample estimation,
8. Correlation between quadrats counts- Case: Correlation between counts for two different species in a water body.
9. Analysis of censored environmental data,
10. Risk analysis- Case: Contaminant uptake in Tap-water

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Bryan F. J. Manly (2009): Statistics for Environmental Science and Management, 2nd Edition, Chapman and Hall.
- Barnett, Vic (2006): Environmental Statistics: Methods and Applications, Reprinted 2004, Wiley.

SUGGESTED READINGS:

- Milalrd, Steben P. and Neeranchal, Nagaraj K (2000): Environmental Statistics with S-plus, CRC Press.
- Gelfand Alan E. (2019): Handbook of Environmental and Ecological Statistics, Chapman and Hall, CRC Press.
- David Valerie (2019): Statistics in Environmental Sciences, Wiley.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 3d: REGRESSION ANALYSIS (Not for category I)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Regression Analysis	4	3	0	1	Class XII pass with Mathematics	knowledge of sampling distributions and matrix theory

Learning Objectives

The learning objectives include:

- Be able to carry out and interpret Correlation Analysis
- Be able to carry out and interpret inference procedures for simple linear regression.
- Know the simple and multiple linear regression models, and be able to state and explain the standard methods of estimation for these models.

Learning Outcomes:

After completing this course, students will develop a clear understanding of:

- Basic concept of matrix, its types and operations,
- correlation and regression techniques, the two very powerful tools in statistics,
- Linear and Multiple Linear regression,
- regression diagnostics, multicollinearity, residual plots and estimation and tests for regression coefficients.
- concept of coefficient of determination and inference on partial and multiple correlation coefficients.

SYLLABUS OF DSE-3d

Theory

UNIT I **(15 hours)**

Introduction

Correlation, Types of correlation, Methods of studying simple correlation - Scatter diagram, Covariance between two variables: Definition, computation, effect of change of origin and scale, Karl Pearson's coefficient of correlation, Spearman's Rank correlation coefficient.

UNIT II **(15 hours)**

Linear Regression

Linear Regression: Meaning of regression, difference between correlation and regression, simple linear regression model, Estimation of regression parameters by least squares method (fitting of regression

model), Interpretation of parameters. Test of significance of regression and confidence interval, Concept of residual, Residual plots, comparison of two models on the basis of residual sum of squares.

UNIT III **(15 hours)**

Multiple Linear Regression

Multiple linear regression: Estimation of regression parameters by least square method and their properties, Interpretation of parameters. Concept of coefficient of determination R^2 and adj R^2. Testing of hypothesis and bias in regression estimates.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Computation of covariance, coefficient of correlation, checking for independence and uncorrelatedness of two variables.
2. Lines of regression, angle between lines and estimation of parameters.
3. Lines of regression and regression coefficients.
4. Spearman rank correlation with/without ties.
5. Fitting of simple linear regression model
6. Testing of hypothesis in SLRM
7. Fitting of multiple linear regression model
8. Testing of hypothesis in MLRM
9. Bias in regression parameters

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Draper, N. R. and Smith, H. (1998). Applied Regression Analysis. 3rdEdition. John Wiley.
- Montgomery, D. C., Peck, E. A. and Vining, G. G. (2013). Introduction to Linear Regression Analysis. 5th Edition. Wiley.

SUGGESTIVE READINGS:

- Hosmer, D. W., Lemeshow, S. and Sturdivant R.X. (2013). Applied Logistic Regression, Wiley Blackwell.
- Neter, J., Kutner, M. H., Nachtsheim, C.J. and Wasserman, W. (1996). Applied Linear Statistical Models, 4th Edition, Irwin USA.
- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2005). An Outline of Statistical Theory, Volume II, World Press.
- Arora, S. and Bansi, L. (1968). New Mathematical Statistics, 1st Ed., Vanita Printers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES
OFFERED BY DEPARTMENT OF STATISTICS
CATEGORY-VI

GENERIC ELECTIVE -5A: INTRODUCTION TO STATISTICAL LINEAR MODELS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	tutorials	practical		
Introduction to Statistical Linear Models	4	3	0	1	Class XII pass with Mathematics	knowledge of sampling distributions and matrix theory

Learning Objectives:
learning objectives include:

- Developing a clear understanding of the fundamental concepts of linear models.
- Developing associated skills allowing the students to work effectively with them.

Learning Outcomes:
After completion of this course, students will have developed a clear understanding of:

- Theory and estimation of Linear Models.
- Gauss-Markov Theorem and its use.
- Distribution of quadratic forms.
- Simple and Multiple linear regression models and their applications.
- Fitting of these models to real or synthetic data, derivation of confidence and prediction intervals, and a sound scientific interpretation of the results.
- Techniques of Analysis of Variance under fixed effects model.
- Assessment of the quality of the fit using classical diagnostics,

SYLLABUS OF GE-5A
THEORY

UNIT I: **(12 hours)**

Introduction:

Statistical linear models and their classification, Estimability of linear parametric functions, Gauss-Markov set-up, Normal equations, and Gauss-Markov theorem: full rank case and non-full rank case (without proof).

UNIT II: **(8 hours)**

Distribution of Quadratic Forms:

Cochran's theorem (without proof), Necessary and sufficient conditions for the mutual independence of quadratic forms and for the mutual independence of a linear function and a quadratic form.

UNIT III: **(13 hours)**

Regression Analysis:

Simple and Multiple linear regression: Estimation and testing of hypothesis, confidence interval, bias in regression estimates, Lack of fit and pure error, Residuals, and their plot. Techniques for Variable selection. Polynomial Regression models: Orthogonal Polynomials.

UNIT IV: **(12 hours)**

Analysis of Variance (ANOVA):

The technique of ANOVA for one-way and two-way classifications with an equal number of observations per cell under a fixed effects model.

PRACTICAL/LABWORK -30 Hours

List of Practicals

1. Estimability when X is a full rank matrix
2. Estimability when X is not a full rank matrix
3. Distribution of Quadratic forms
4. Simple Linear Regression
5. Multiple Regression
6. Tests for Linear Hypothesis
7. Bias in regression estimates
8. Lack of fit
9. Orthogonal Polynomials
10. Analysis of Variance of a one-way classified data.
11. Analysis of Variance of a two-way classified data with one observation per cell.
12. Analysis of Variance of two-way classified data with m (> 1) observations per cell.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Montgomery, D. C., Peck, E. A. and Vining, G. G. (2012): Introduction to Linear Regression Analysis, 5th Ed., John Wiley and Sons.
- Rencher, A. C. and Schaalje, G. B. (2008): Linear Models in Statistics, 2nd Ed., John Wiley and Sons.
- Draper, N. R. and Smith, H. (1998): Applied Regression Analysis, 3rd Ed., John Wiley and Sons.

SUGGESTIVE READINGS:

- Weisberg, S. (2005): Applied Linear Regression, 3rd Ed., John Wiley and Sons.
- Rawlings, John O. Pantula Sastry G. Dickey, David A. (1998) Applied Regression Analysis: A Research Tool, Second Edition
- Bapat, R.B.(1993): Linear Algebra and Linear Models, Hindustan Book Agency.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

GENERIC ELECTIVE – 5b: STATSTICAL TECHNIQUES FOR QUALITY CONTROL

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Techniques for Quality Control	4	3	0	1	Class XII pass with Mathematics	knowledge of basic statistics

Learning Objectives

The learning objectives include:

- This course will help students to learn techniques and approach of SQC being used in industry to manufacture goods and services of high quality at low cost.
- This course will also give exposure to Sampling Inspection Plan.

Learning Outcomes:

After completing this course, students will develop a clear understanding of:

- Quality, Historical background, ISO standards.
- Statistical process control tools- Control charts for variables, attributes.
- Statistical product control tools- Sampling inspection plans, Dodge and Romig plans.

SYLLABUS OF GE-5b

Theory

UNIT I **(10 hours)**

Introduction, historical perspective and ISO Quality Standards

Quality: Definition, dimensions of quality, its concept, application and importance. Brief historical perspective of quality control and improvements. Quality system and standards: Introduction to ISO quality standards. Introduction to Process and Product Control, Statistical Process Control, Chance and Assignable causes of variation.

UNIT II **(20 hours)**

Statistical Control Charts

Construction and Statistical basis of 3-σ Control charts. Control charts for variables: X-bar & R-chart, X-bar & s-chart. Rational Sub-grouping, Revised and Modified Control Limits. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability.

UNIT III **(15 hours)**

Acceptance sampling plan

Principle of acceptance sampling plans. Single sampling plans their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Construction and interpretation of statistical control charts $\bar{X}$& R-chart for known parameters.
2. Construction and interpretation of statistical control charts $\bar{X}$ & R-chart with revised control limits for unknown parameters.
3. Construction and interpretation of statistical control charts $\bar{X}$ & s-chart with revised control limits for unknown parameters.
4. Construction and interpretation of statistical control charts np chart.
5. Construction and interpretation of statistical control charts p-chart with fixed sample size.
6. Construction and interpretation of statistical control charts p-chart with variable sample size.
7. Construction and interpretation of statistical control charts c-chart.
8. Construction and interpretation of statistical control charts u-chart.
9. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves.
10. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves for varying acceptance number.
11. Calculation of process capability and comparison of 3-sigma control limits with specification limits.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Montogomery, D. C. (2013). Introduction to Statistical Quality Control, 7th Edition, Wiley India Pvt. Ltd.

SUGGESTIVE READINGS:

- Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
- Gupta S.C., Kapoor V.K.(2007): Fundamentals of Applied Statistics. 4th Edition, Sultan Chand and Sons., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Semester 6

DEPARTMENT OF STATISTICS

B. Sc. (H) Statistics

Category I

DISCIPLINE SPECIFIC CORE COURSE – 16: TESTING OF HYPOTHESIS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Testing of Hypothesis	4	3	0	1	Class XII pass with Mathematics	Basic knowledge of sampling distributions

Learning Objectives

The learning objectives of this course are to introduce:

- Hypothesis testing as a statistical procedure for testing whether chance is a plausible explanation of a random experiment
- The logic of hypothesis testing with focus on theory and implementation of hypothesis testing with knowledge about types of error type, power and the correct computation and interpretation of p-values
- Use of nonparametric test as an alternative when assumptions of parameterization of distribution or the family itself is violated.
- Sequential Probability Ratio test with its entities like OC Curve, ASN etc.

Learning Outcomes:

After completing this course, students will develop a clear understanding of:

- The notion of statistical hypothesis test, error and its nature and the idea of acceptance and rejection region.
- Identify simple and composite hypothesis. Find critical region, size and power of the test.
- Apply Neymann-Pearson lemma to find most powerful test. Find UMP and UMPU test. Make use of likelihood ratio principle for testing of hypothesis
- Make distinction between parametric and nonparametric test. Identify suitable nonparametric test for both location and scale (Kolmogorov- Smirnov one sample and two sample tests, sign test, Wilcoxon signed rank test, run test. Median test, Kruskal-Wallis one-way analysis of variance by ranks, Friedman two way analysis of variance by ranks).
- Derive SPRT for test the parameters of normal distribution, binomial and Poisson distributions also find OC function, Average sample Number etc. of a SPRT.

SYLLABUS OF DSC-16

Theory

UNIT I **(15 hours)**

Principles of test of significance

Principles of test of significance: Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, level of significance, size and power, best critical region, most powerful test, uniformly most powerful test, uniformly most powerful unbiased critical region (UMPU). Neyman Pearson Lemma and its application to construct most powerful tests.

Unit II **(10 hours)**

Likelihood ratio test

Likelihood ratio test and its application, properties of likelihood ratio tests (without proof).

UNIT III **(10 hours)**

Sequential Probability Ratio Test

Sequential Probability Ratio Test. Determination of stopping bounds A and B, OC and ASN functions of SPRT.

UNIT IV **(10 hours)**

Non-Parametric tests

Non-Parametric tests. Empirical distribution function, one sample and two-sample sign test. Wald-Wolfowitz run test. Run test for randomness, Median test, Wilcoxon-Mann-Whitney U-test. Kolmogorov-Smirnov one-sample test, Kruskal-Walli's test.

PRACTICAL/LAB. WORK(30 hours):

List of Practical

1. Type I and Type II errors
2. Most powerful critical region (NP Lemma)
3. Uniformly most powerful critical region
4. Unbiased critical region
5. Power curves of hypothesis tests.
6. Likelihood ratio test
7. Non Parametric test based on quantile and Empirical distribution
8. Test for location and scale both one and two samples
9. Test of Association for bivariate samples
10. SPRT for binomial, Poisson and Normal distribution
11. OC Curve and ASN function

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Goon, A.M., Gupta, M.K., and Dasgupta, B. (2005).: An Out Line of Statistical Theory, Volume 2, Third Edition.
- Gupta, S.C. and Kapoor, V.K.(2020): Fundamental of Mathematical Statistics, 12th Edn. Sultan Chand and Sons.

SUGGESTIVE READINGS:

- Hogg, R.V, McKean, J. and Craig, A.T. (2012): Introduction to Mathematical Statistics, 7th Edn. Pearson Education.
- Casella, G. and Berger, R.L. (2002): Statistical Inference. 2nd Edition, Duxbury Press, Pacific Grove.
- Siegel, S. (1956). Nonparametric statistics for the behavioral sciences. McGraw-Hill.
- Lehmann, E. and Romano. J. (2005): Testing statistical hypotheses,3rd Edn. Springer, New York.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –17: DESIGN OF EXPERIMENTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Design of Experiments	4	3	0	1	Class XII pass with Mathematics	knowledge of sampling distributions and linear models

Learning Objectives

The learning objectives include:

- To design and conduct experiments.
- To analyze and interpret data.

Learning Outcomes:

After completing this course, students will develop a clear understanding of:

- The fundamental concepts of design of experiments.
- Introduction to planning valid and economical experiments within given resources.
- Completely randomized design.
- Randomized block design.
- Latin square design.
- Balanced incomplete block design.
- Full and confounded factorial designs with two levels.
- Introduction to factorial designs at three levels.
- Fractional factorial designs with two levels

SYLLABUS OF DSC-17

Theory

UNIT I **(13 hours)**

Experimental designs
Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with one missing observation in case of RBD.

UNIT II **(10 hours)**
Incomplete Block Designs
Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD, Complimentary BIBD, Residual BIBD, Dual BIBD, Derived BIBD.

UNIT III **(12 hours)**
Factorial experiments
advantages, notations and concepts, 2^2, 2^3,..., 2^n, 3^2 factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 6$), Factorial experiments in a single replicate.

UNIT IV **(10 hours)**
Fractional factorial experiments: Construction of one-half and one-quarter fractions of 2^n ($n \leq 6$) factorial experiments, Alias structure, Resolution of a design.

PRACTICAL/LAB WORK – (30 hours)
List of Practical:

1. Analysis of a CRD with equal and unequal replicates.
2. Analysis of RBD.
3. Analysis of LSD.
4. Analysis of RBD with one missing observation.
5. Analysis of 2^2 and 2^3 factorial in CRD, RBD and LSD.
6. Analysis of 3^2 factorial in CRD, RBD.
7. Analysis of a completely confounded two level factorial design in 2 blocks.
8. Analysis of a completely confounded two level factorial design in 4 blocks.
9. Analysis of a partially confounded two level factorial design.
10. Analysis of a single replicate of a 2^n design.
11. Analysis of one half fraction of 2^n factorial design.
12. Analysis of one quarter fraction of 2^n factorial design.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Das., M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8th Edition. World Press, Kolkata.
- Montgomery, D. C. (2008): Design and Analysis of Experiments. John Wiley.
- Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd.

SUGGESTIVE READINGS:

- Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
- Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
- Federer, W. T. (1955): Experimental Design, Macmillan, N. Y.
- Anderson, V. L. and McLean, R. A. (1974): Design of Experiments, Marcel Dekker, Inc., N. Y.

• Dean, A. and Voss, D. (1999). Design and Analysis of Experiments, Springer. First Indian Reprint 2006

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –18: ECONOMETRICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Econometrics	4	3	0	1	Class XII pass with Mathematics	knowledge of sampling distributions and linear models

Learning Objectives

A broad knowledge of regression analysis relevant for analyzing economic data.

- Interpretation and critical evaluation of the outcomes of empirical analysis.
- Distinguish the results of violating the assumptions of a classical regression model.
- To judge the validity of the economic theories and carry out their evaluation in numerical terms.
- To extract useful information about important economic policy issues from the available data.
- The course is designed to provide the students with the basic quantitative techniques needed to undertake applied research projects.
- The students learn to quantify and examine economic relationships employing statistical methods based on observed data.

Learning Outcomes:

After completing this course, students will develop a clear understanding of:

- Students will be trained to write a good quality undergraduate research paper in applied statistics using the econometric methods taught in this class.
- The fundamental concepts of econometrics.
- Specification of the model.
- Multiple Linear Regression.
- Multicollinearity.
- Heteroscedasticity.
- Autocorrelation.
- Autoregressive and Lag models

SYLLABUS OF DSC-18

Theory

UNIT I **(15 hours)**

Introduction

Objective behind building econometric models, Nature and scope of econometrics, model building, role of econometrics. General linear model (GLM). Estimation under linear restrictions.

UNIT II **(10 hours)**

Multicollinearity

Introduction and concepts, detection of multicollinearity, consequences, remedies Multicollinearity, tests and solutions of multicollinearity.

UNIT III **(10 hours)**

Generalized least squares and Autocorrelation

Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

UNIT IV **(10 hours)**

Heteroscedastic disturbances

Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Qualitative Forecasting Methods.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Problems based on estimation of General linear model.
2. Testing of parameters of General linear model.
3. Forecasting of General linear model.
4. Problems related to consequences of Multicollinearity.
5. Diagnostics of Multicollinearity.
6. Problems related to consequences of Autocorrelation (AR(I)).
7. Diagnostics of Autocorrelation.
8. Estimation of General linear model under Autocorrelation.
9. Problems related to consequences Heteroscedasticity.
10. Diagnostics of Heteroscedasticity.
11. Estimation of problems of General linear model under Heteroscedastic disturbance terms.
12. Problems concerning specification errors as a reason for induction of Autocorrelation, Heteroscedasticity and Multicollinearity.
13. Problems related to General linear model under (Aitken Estimation).
14. Forecasting methods.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Gujarati, D. and Guneshker, S. (2007). Basic Econometrics, 4th Ed., McGraw Hill Companies.
- Johnston, J. (1972). Econometric Methods, 2nd Ed., McGraw Hill International.

SUGGESTED READINGS:

- Koutsoyiannis, A. (2004). Theory of Econometrics, 2 Ed., Palgrave Macmillan Limited.
- Maddala, G.S. and Lahiri, K. (2009). Introduction to Econometrics, 4 Ed., John Wiley & Sons.
- Greene, W. H. (2002) Econometric Analysis.5th Edition, Prentice Hall.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B.Sc. (P)/B.A(P) with Statistics as Major

Category II

DISCIPLINE SPECIFIC ELECTIVE COURSE –: 11 SURVEY SAMPLING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Survey Sampling	4	3	0	1	Class XII pass with Mathematics	knowledge of basic statistics

Learning Objectives:

The learning objectives of this course are to introduce:

- Tools and techniques for selecting a representative sample from a target population keeping in mind the objectives to be fulfilled.
- Obtain an estimator of the population parameter on the basis of the selected sample and study its properties.

Learning Outcomes:

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

- Understand the fundamental concepts of population and sample and the principles of sample survey
- Describe the value and methodologies for sample surveys versus other approaches to collecting information from populations.
- Determine the appropriate sample size and its allocation for nationwide sample surveys or for surveys to be conducted in a program area.
- Identify a proper sampling frame and select primary sample points.
- Apply steps involved in selecting a sample using Simple Random Sampling with or without replacement, Stratified Sampling, Systematic Sampling and Ratio and Regression Methods of Estimation

SYLLABUS OF DSC-11
Theory

Unit I **(15 Hours)**

Basic Concepts and Simple Random Sampling

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling basic principles of sample survey, Steps involved in survey sampling.

Simple random sampling (SRS)with and without replacement, their properties, procedures of selecting a simple random sample, estimation of population mean, and total sampling for proportions, determination of sample size.

Unit 2 **(10 Hours)**

Stratified random sampling:

Estimation of population mean and its variance. Allocation of samples in different strata using equal, proportional, and Neyman allocation. Comparison of Stratified sampling under proportional and Neyman allocation with SRSWOR. Practical difficulties in adopting Neyman allocation.

Unit 3 **(10 Hours)**

Systematic sampling:

Estimation of population mean, and total. Comparison of systematic sampling with simple random sampling and stratified sampling in the presence of linear trend. Definition and concept of circular systematic sampling.

Unit 4 **(10 Hours)**

Introduction to Indian Official Statistics:

Present official Statistical System in India, Methods of collection official statistics, their reliability and limitations. Role of Ministry of Statistics and Programme Implementation (MOSPI), Central Statistical Office CSO, NSSO.

PRACTICAL/LAB.. WORK: (30 Hours)

List of Practicals:

1. To select SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square, and population variance. Enumerate all possible samples of size 2 by WR and WOR.
3. Estimate mean standard error and the sample size for SRSWOR.
4. Allocation of sample to strata by proportional method.
5. Allocation of sample to strata by Neyman methods.
6. Compare the efficiencies of proportional and Neyman allocation relative to SRS.
7. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

Essential Readings:

- Cochran WG (2011) Sampling techniques (3rd edition) Wiley Eastern John Wiley and sons.
- Goon AM Gupta MK and Dasgupta B. (2001) Fundamentals of statistics, volume 2, World Press Gupta SC and Kapoor VK (2007) Fundamentals of Applied Statistics, Sultan Chand and sons.
- Murthy MN (1977) Sampling theory and sampling methods, Statistical Pub. Society, Calcutta.
- Singh D and Chaudhary FS (2015): Theory and Analysis of Sample Survey Designs.

- Sukhatme PV Sukhatme BV, Sukhatme S, Asok C (1984) Sampling Theories of Survey with Application, Iowa State University press and Indian Society of agricultural statistics.
- Guide to current official statistics CSO, GOI, New Delhi

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE –: 12 STATISTICAL METHODS FOR PSYCHOLOGY AND EDUCATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Methods For Psychology and Education	4	3	0	1	Class XII pass with Mathematics	knowledge of basic statistics

Learning Objectives:

The learning objectives include:
- To measure psychological traits and mental abilities
- To learn basic methods of test construction, item writing and item analysis
- To check the reliability and validity of test scores.

Learning Outcomes:

After successful completion of this course, students should be able to:
- Distinguish between Psychological measurement and physical measurement.
- Understand the meaning of Tests in Psychology and Education.
- Appreciate the uses and limitations of Psychological tests.
- Learn the meaning and purpose of Item writing and analysis.
- Understand concepts of reliability and validity of test scores and their differences.
- Convert raw scores into different transformed scores.
- Apply Scaling rankings and ratings in terms of the Normal Probability Curve.

SYLLABUS OF DSC-12
Theory

Unit 1: **(15 Hours)**
Importance of statistics in psychology and education.

Importance of statistics in psychology and education. Levels of measurement: nominal ordinal interval and ratio scales. Distinction between psychological and physical measurements. General problems and sources of errors in measurements.
Meaning and types of tests in psychology and education. History of psychological measurement and testing. Uses and limitations of tests. Varieties of tests. Characteristics of a good test. General steps of test construction. Test administration and scoring.
Item writing and item analysis: Meaning and types of test items, Purpose and methods for evaluating test items.

Unit 2: **(15 Hours)**

Reliability and Validity:

Reliability: definition Methods of determining reliability: Test-retest, Alternate or parallel forms, Split half technique, Rational equivalence. Effect upon reliability of lengthening or repeating or test. Reliability coefficient as a measure of true variance. Estimating true scores by way of regression equation and reliability coefficient. Index of reliability.
Validity: meaning; Estimation of validity; Types of validity: validity and test length; comparison between reliability and validity.

Unit 3: **(15 Hours)**

Test Scores:

Meaning and differences between norm referencing and criterion referencing.
Raw score transformations- percentile scores, standard score, normalised standard scores, T- scores and Stanine scores.
Intelligence: definition. Types of intelligence test scores. Psychological scaling methods- scaling of individual test items in terms of difficulty, scaling of rankings and ratings in terms of the normal probability curve.

PRACTICAL LAB WORK (30 hours)

List of Practical:

1. Computation of reliability by Rulon and Kuder Richardson formulas.
2. Computing reliability of a test whose length is increased/decreased.
3. Computing index of reliability standard error of measurement.
4. Computing validity oblique maximum validity then test length is increased.
5. Computing relative difficulty of questions difference in difficulty between different tests.
6. Problem based on Z scores.
7. Problem based on t scores.
8. Problem based on Stanine scales.
9. Problem based on percentile scores.
10. Computing numerical scores corresponding to grades or ratings.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Anastasia, A. and Urbina, S. (1997) Psychological testing (7th edition), Prentice Hall
- Garrett H.E. (2021), Statistics in Psychology and Education. Nation press.
- Gregory RJ (2016), Psychological testing: History, Principles and Applications. (updated 7th edition) Pearson
- Singh, A.K. (2006)Test, Measurements and Research in Behavioural Sciences Bharati bhavan
- Mangal S.K. (2016) Statistics in Psychology and Education. PHI learning Pvt ltd.

SUGGESTED READINGS:

- Gupta S.C. and Kapoor V.K. (2019) Fundamentals of Applied statistics, Sultan Chand and sons.
- Goon A.M., Gupta M.K. and Dasgupta, B. (2001) Fundamental of Statistics, Volume 2, World Press Pvt ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B.Sc. (P)/B.A(P) with Statistics as Non- Major

Category III

DISCIPLINE SPECIFIC CORE COURSE –: 6 SURVEY SAMPLING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Survey Sampling	4	3	0	1	Class XII pass with Mathematics	knowledge of basic statistics

Learning Objectives:

The learning objectives of this course are to introduce:

- Tools and techniques for selecting a representative sample from a target population keeping in mind the objectives to be fulfilled.
- Obtain an estimator of the population parameter on the basis of the selected sample and study its properties.

Learning Outcomes:

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

- Understand the fundamental concepts of population and sample and the principles of sample survey
- Describe the value and methodologies for sample surveys versus other approaches to collecting information from populations.
- Determine the appropriate sample size and its allocation for nationwide sample surveys or for surveys to be conducted in a program area.
- Identify a proper sampling frame and select primary sample points.

- Apply steps involved in selecting a sample using Simple Random Sampling with or without replacement, Stratified Sampling, Systematic Sampling and Ratio and Regression Methods of Estimation

SYLLABUS OF DSC-6
Theory

Unit I **(15 Hours)**
Basic Concepts and Simple Random Sampling
Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling basic principles of sample survey, Steps involved in survey sampling.
Simple random sampling (SRS)with and without replacement, their properties, procedures of selecting a simple random sample, estimation of population mean, and total sampling for proportions, determination of sample size

Unit 2 **(10 Hours)**
Stratified random sampling:
Estimation of population mean and its variance. Allocation of samples in different strata using equal, proportional, and Neyman allocation. Comparison of Stratified sampling under proportional and Neyman allocation with SRSWOR. Practical difficulties in adopting Neyman allocation.

Unit 3 **(10 Hours)**
Systematic sampling:
Estimation of population mean, and total. Comparison of systematic sampling with simple random sampling and stratified sampling in the presence of linear trend. Definition and concept of circular systematic sampling.

Unit 4 **(10 Hours)**
Introduction to Indian Official Statistics:
Present official Statistical System in India, Methods of collection official statistics, their reliability and limitations. Role of Ministry of Statistics and Programme Implementation (MOSPI), Central Statistical Office CSO, NSSO.

PRACTICAL/ LAB WORK (30 HOURS)
List of Practicals:
1. To select SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square, and population variance. Enumerate all possible samples of size 2 by WR and WOR.
3. Estimate mean standard error and the sample size for SRSWOR.
4. Allocation of sample to strata by proportional method.
5. Allocation of sample to strata by Neyman methods.
6. Compare the efficiencies of proportional and Neyman allocation relative to SRS.
7. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Cochran WG (2011) Sampling techniques (3rd edition) Wiley Eastern John Wiley and sons.

- Goon AM Gupta MK and Dasgupta B. (2001) Fundamentals of statistics, volume 2, World Press Gupta SC and Kapoor VK (2007) Fundamentals of Applied Statistics, Sultan Chand and sons.
- Murthy MN (1977) Sampling theory and sampling methods, Statistical Pub. Society, Calcutta.
- Singh D and Chaudhary FS (2015): Theory and Analysis of Sample Survey Designs.
- Sukhatme PV Sukhatme BV, Sukhatme S, Asok C (1984) Sampling Theories of Survey with Application, Iowa State University press and Indian Society of agricultural statistics.
- Guide to current official statistics CSO, GOI, New Delhi

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Discipline Specific Elective
Category V

DISCIPLINE SPECIFIC ELECTIVE COURSE –4A: BIOSTATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biostatistics	**4**	**3**	0	**1**	Class XII pass with Mathematics .	knowledge of Statistical Inference and stochastic processes

Learning objectives:

- Parametric Models for Survival data.
- Different types of censoring and its application in public health.
- Estimation of death probabilities by using the theory of competing risks.
- Non-parametric methods for incomplete survival data.
- Computation of the probability of gametes in different generations under random mating.

Learning Outcomes:

After completing this course, students will develop a clear understanding of:

- The fundamental concepts of survival functions and their interrelationship.
- Survival models and their applications.
- Handling censored data and estimating mean survival time of the patients.
- Actuarial and Kaplan-Meier methods.
- Competing Risk Theory.
- Basic concept of Statistical genetics.

SYLLABUS OF DSE-4A

Theory

UNIT I **(11 Hours)**

Survival Analysis

Survival Analysis: Functions of survival times, survival distributions and their applications exponential, gamma, Weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shaped hazard function.

UNIT II **(13 Hours)**

Censoring Schemes

Censoring Schemes: Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for Type I and Type II censored data with numerical examples. Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.

UNIT III **(10 Hours)**

Competing Risk Theory:

Indices for measurement of the probability of death under competing risks and their inter-relations. Estimation of probabilities of death using maximum likelihood method and modified chi squire method.

UNIT IV **(11 Hours)**

Statistical Genetics:

Statistical Genetics: Introduction, concepts-Genotype, Phenotype, Dominance, Recessiveness, Linkage and Recombination, Coupling, and Repulsion. Mendelian laws of Heredity, Random mating, Gametic array, Genotypic array, Relation between genotypic array and gametic array under random mating. Distribution of genotypes under random mating. Hardy-Weinberg law. Concept of gene frequencies.

PRACTICAL/ LAB. WORK (30 HOURS)

List of Practical:

1. Estimation of survival function, death density function and hazard function.
2. Estimation of mean survival time using various parametric survival models.
3. To Identify and analyse type-I censored data.
4. To Identify and analyse type-II censored data.
5. To Identify and analyse progressively type I censored data.
6. Estimation of mean survival time and variance of the estimator for type I censored data.
7. Estimation of mean survival time and variance of the estimator for type II censored data.
8. Estimation of mean survival time and variance of the estimator for progressively type I censored data.
9. To estimate the survival function and variance of the estimator using Actuarial methods.
10. To estimate the survival function and variance of the estimator using Kaplan-Meier method.
11. To estimate Crude probability of death.
12. To estimate Net-type I probability of death.
13. To estimate Net-type II probability of death.
14. To estimate partially crude probability of death.
15. To estimate gene frequencies.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Biswas, S. (2007). Applied Stochastic Processes: A Biostatistical and Population Oriented Approach, Reprinted 2nd Ed., New Central Book Agency.
- Lee, E.T. and Wang, J.W. (2003). Statistical Methods for Survival data Analysis, 3rd Ed., John Wiley & Sons.
- Indrayan, A. (2008). Medical Biostatistics, 2nd Ed., Chapman and Hall/CRC.

SUGGESTIVE READINGS:

- Narayan P. (1999). Statistical Genetics, New Age International Pvt. Ltd.
- Miller, R. G. (2011). Survival Analysis. John Wiley & Sons.
- Elandt-Johnson R.C (1971).Probability models and Statistical Methods in Genetics, John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 4b: ORDER STATISTICS AND ITS APPLICATIONS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Order Statistics and its Applications	4	3	0	1	Class XII pass with Mathematics	knowledge of statistical distributions and stochastic processes

Learning Objectives

The learning objective of this course is to make the students aware of the properties and applications of order statistics.

Learning Outcomes:

On successful completion of the course, the student will be able to:

- Find joint, marginal distributions and conditional distributions of order statistics in the continuous and discrete case.
- Find the distribution of sample range and other systematic statistics in case of sampling from an arbitrary continuous population and from some specific continuous distributions such as uniform and exponential.
- Understand the Markov Chain property of order statistics in the continuous case.
- Learn how to obtain distribution-free confidence intervals for population quantile for population distributions based on order statistics.
- Understand the distribution-free bounds for moments of order statistics and of the range.
- Derive the recurrence relations and identities for moments of order statistics drawn from an arbitrary population (discrete or continuous), as well as from some specific distributions.
- Understand the concept of L-moments and L-moments estimation of parameters.
- Derive the Linear estimation of location and scale parameters based on the moments of order statistics.

SYLLABUS OF DSE-4b

Theory

UNIT I **(15 hours)**
Introduction to Order Statistics

Definition and applications of order statistics. Basic distribution theory. Joint and marginal distributions of order statistics in the continuous case. Distribution of the median, range and other systematic statistics. Order statistics for a discrete parent. Examples based on discrete and continuous distributions.

UNIT II **(10 hours)**

Conditional distribution of order statistics

Conditional distribution of order statistics. Order statistics as a Markov Chain. Distribution-free confidence intervals for population quantiles. Distribution-free bounds for moments of order statistics and of the range.

UNIT III **(10 hours)**

Moments of order statistics

Moments of order statistics. Recurrence relations and identities for moments of order statistics from an arbitrary distribution. Recurrence relations for moments of order statistics from some specific distributions.

UNIT IV **(10 hours)**

Order statistics in statistical inference

Order statistics in statistical inference. L-moments and L-moments estimation. Linear estimation based on order statistics. Examples based on some specific continuous distributions.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Problem-solving using joint, marginal, and conditional distributions of order statistics for some specific continuous distributions.
2. Distribution-free confidence intervals for population quantiles for various distributions.
3. Calculating Means, variances, and covariances by using exact expressions for the moment of order statistics for some specific continuous distribution.
4. Calculating Means, variances, and covariances by using recurrence relations for some specific continuous distributions.
5. Calculation of L-moments for some specific continuous distributions.
6. L-moments estimation of parameters for some specific continuous distributions.
7. Calculation of linear unbiased estimation for location and scale parameters for some specific continuous distributions.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- David, H. A. and Nagaraja, H. N. (2003). Order Statistics, 3rd ed., John Wiley & Sons.

SUGGESTIVE READINGS:

- Arnold, B. C., Balakrishnan, N. and Nagaraja H. N. (2008). A First Course in Order Statistics, SIAM Publishers.
- Arnold, B.C. and Balakrishnan, N. (1989). Relations, Bounds and Approximations for Order Statistics, Vol. 53, Springer-Verlag.
- Ahsanullah, M., Nevzorav, V.B. and Shakil, M. (2013). An Introduction to Order Statistics, Atlantis Studies in Probability and Statistics, Vol. III. Atlantis Press.
- Gibbons, J.D. and Chakraborti, S. (1992). Nonparametric Statistical Inference, 3rd ed., Marcel Dekker.

- Shahbaz, M. Q., Ahsanullah, M., Shahbaz, S. H. and Al-Zahrani, B. M. (2016). Ordered Random variables: Theory and Applications. Springer.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 4c: STATISTICAL COMPUTING AND BASIC DATA MINING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Computing and Basic Data Mining	4	3	0	1	Class XII pass with Mathematics	Knowledge of MATLAB / OCTAVE / R / Python / C

Learning Objectives

learning objectives include:

- Understand the theoretical foundations and practical aspects of statistical computing and data mining.
- Develop skills in the use of statistical computing and data mining software to solve problems and analyze data. The programming implementations will be completed using MATLAB/OCTAVE/R/Python/C.

Learning Outcomes:

After completion of this course, students will develop a clear understanding of:

- Apply knowledge of statistical computing and data mining techniques to solve problems and analyze data.
- Communicate effectively about statistical computing and data mining concepts and techniques both orally and in writing.
- Develop ability for programming implementation using MATLAB/OCTAVE/R/Python/C.

SYLLABUS OF DSE-4C

Theory

UNIT I **(15 hours)**

Simulation techniques
Random number generation: Review; Simulating multivariate distributions; Simulating stochastic processes. Variance reduction methods.

UNIT II **(12 hours)**
Markov Chain Monte Carlo methods
Markov Chain Monte Carlo methods: The Metropolis–Hastings Algorithm; Gibbs sampling.

UNIT III **(18 hours)**
Data Mining and its applications
Introduction to Data Mining and its Applications. Data Pre-processing Techniques: Data Cleaning, Data Integration, Data Transformation, and Data Reduction. Exploratory Data Analysis. Classification Techniques: Decision Trees, Naive Bayes, k-Nearest Neighbors (k-NN). Clustering Techniques: K-Means, Hierarchical Clustering. Association rule mining. Evaluation of Data Mining Models.

PRACTICAL/LAB WORK – (30 hours)
List of Practical:

1. Practical based on random number generation: univariate and multivariate distributions.
2. Practical on simulating stochastic processes; variance reduction.
3. Simple practical problems on MCMC.
4. Practical based on Data pre-processing, transformation, reduction.
5. Practical based on classification and clustering.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Rubinstein, R.Y. (2017). Simulation and the Monte Carlo Methods, Wiley.
- Voss, J. (2014). An introduction to statistical computing: a simulation-based approach,Wiley series in computational statistics.
- Tan, P. N., Steinbach, M., & Kumar, V. (2016). Introduction to data mining. Pearson Education India.
- Han, J., Kamber, M., & Pei, J. (2012). Data mining concepts and techniques third edition. University of Illinois at Urbana-Champaign Micheline Kamber Jian Pei Simon Fraser University.
- Witten, I. H., Frank, E., Hall, M. A., & Pal, C. J. (2017). Data Mining: Practical machine learning tools and techniques, Elsevier Inc.

SUGGESTIVE READINGS:

- Vetterling, William T., Saul A. Teukolsky, William H. Press, and Brian P. Flannery. Numerical recipes in C: the art of scientific computing. Cambridge university press, 1999.
- Christian, P. R., & George, C. (1999). Monte Carlo statistical methods. Springer Texts in Statistics.
- Hancock, M. F. (2012). Practical data mining. CRC Press.
- Shmueli, G., Bruce, P. C., Yahav, I., Patel, N. R., & Lichtendahl Jr, K. C. (2017). Data mining for business analytics: concepts, techniques, and applications in R. John Wiley & Sons.
- Shmueli, G., Bruce, P. C., Gedeck, P., & Patel, N. R. (2019). Data mining for business analytics: concepts, techniques and applications in Python. John Wiley & Sons.
- Hastie, T., Tibshirani, R., Friedman, J. (2008). The Elements of Statistical Learning: Data Mining, Inference and Prediction, 2nd ed., Springer.
- Murphy, K. P. (2012). Machine Learning: A Probabilistic Perspective. United States: MIT Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 4d : RESEARCH METHODOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives:

The learning objectives include

- To provide scientific approaches to develop the domain of human knowledge through empirical studies.
- To enable the student researchers to understand basic concepts and aspects related to research, data collection, analyses, interpretation and report writing.

Learning Outcomes:

After completion of this course, students will develop a clear understanding of

- Research Methods.

- Research Problems.
- Research Designs.
- Comparative study of different methods of data collection.
- Guidelines for construction of questionnaires.
- Processing and Analysis of data.
- Interpretation and Report writing.

SYLLABUS OF DSE – 4D

Theory

UNIT I **(09 hours)**

Introduction to Research:

Importance and need for research ethics, Objectives of research, Types of research, Research approaches, Review of literature, Mode of literature survey: Books and Monographs, Journals, Conference proceedings, Abstracting and Indexing Journals, E-Journals/Books, Formulation of a research problem, Identifying variables, Constructing hypothesis, Conceptualization of a research design.

UNIT II **(09 hours)**

Methods & Techniques of Data Collection:

Survey methodology and Data collection, Source of data collection-Use of secondary data, Methods of collecting primary data, Develop a questionnaire, Questions and answers in surveys, Non-response, Errors in surveys, Sample size, sampling frames and coverage error.

UNIT III **(15 hours)**

Data Processing & Analysis:

Data processing, Exploratory data analysis, Review of various techniques (Parametric and Nonparametric tests, Correlation and Regression analysis, ANOVA, Multivariate Techniques) for data analysis covered in core statistics papers, Techniques of interpretation, Precaution in interpretation.

Report writing:

Discussions, Conclusions, Referencing and various formats for reference writing, Bibliography, Thesis writing, Formats of publications in research journals including subject classification, Impact factor, Citation index.

UNIT IV **(12 hours)**

Computer Application:

Data Communication and networks, Website, Webpage, Search Engines, Scientific search engines. Scientific Word Processing with LaTeX and MS-Word, MS Equation editor, Slides making-Power Point Features, Slide preparation, SPSS, Statistical Programming with R, Simulation.

PRACTICAL/LAB WORK – (30 hours)

PROJECT WORK (using a spreadsheet, Scientific Word Processing with LaTeX and MS-Word, MS Equation editor, Slides making-Power Point Features, Slide preparation, SPSS, Statistical Programming with R, Simulation.)

ESSENTIAL READINGS

- Kothari, C.R., Garg, Gaurav (2015): Research Methodology: Methods and Techniques, 3rd Edition (Reprint), New Age International Publishers.
- Kumar, R. (2011): Research Methodology: A Step-by-Step Guide for Beginners, SAGE publications.

- Anderson, J., Durston, B.H., Pooole, M. (1970): Thesis and Assignment Writing, Wiley Eastern. Ltd., New Delhi.
- Braun, J., Duncan, W. and Murdock, J. (2008): A First Course in Statistical Programming with R, Cambridge University Press, London.
- Lamport, L. (1999): LATEX: A Document Preparation System, Addison, Wesley, 2nd Edition, New York.
- Cunningham, B.J. (2012): Using SPSS: An Interactive Hands-On Approach, SAGE South Asia Edition.
- Voss, J. (2014): An Introduction to Statistical Computing: A Simulation-based Approach, Wiley series in computational statistics.

SUGGESTIVE READINGS

- Pannerselvan, R. (2006): Research Methodology, Prentice-Hall of India Pvt., New Delhi.
- Landau, Sabine and Everitt, Brian S. (2004): A Handbook of Statistical Analyses using SPSS, Chapman & Hall/CRC.
- Dalgaard, P. (2008): Introductory Statistics with R, Springer Science, New York.
- Gardener, M. (2012): Beginning R: The Statistical Programming Language, Wiley Publications.
- Robert, C.P. and Casella, G. (2004): Monte Carlo Statistical Methods, Springer Science, New York.
- Rubinstein, R.Y. (1981): Simulation and the Monte Carlo Methods, Wiley.
- Venkataraman, M.K. (1998): Numerical Methods in Science and Engineering, The National Publishing Company, Chennai.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

OFFERED BY DEPARTMENT OF STATISTICS

Category VI

GENERIC ELECTIVE COURSE – 6a: SURVEY SAMPLING AND DESIGN OF EXPERIMENTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Survey Sampling and Design of Experiments	4	3	0	1	Class XII pass with Mathematics	knowledge of basics statistics

Learning Objectives

The learning objectives include:

- To learn about sample surveys, its need and objectives.
- To learn to draw appropriate sample and interpret the result.
- To learn to design and conduct experiments.
- To analyse and interpret the data.

Learning Outcomes:

After completing this course, students will develop a clear understanding of:

- The basic concept of sample survey and its need.
- Simple random sampling.
- Stratified random sampling
- One-way and two-way analysis of variance.
- Basic concepts of design of experiments.
- Completely randomized design.
- Randomized design.
- Latin square design.
- Factorial experiments.

SYLLABUS OF GE-6a

Theory

UNIT I **(11 hours)**

Sample Surveys

Basic concepts of sample survey, concept of sampling, need for sampling, complete enumeration v/s sampling, principles of sampling theory, principal steps in a sample surveys, planning and organization of a sample survey, sampling and non-sampling errors.
Simple random sampling (SRSWR and SRSWOR): Definition and procedures of selecting a sample, properties of simple random sample, estimation of mean and sampling variance of sample mean.

UNIT II **(12 Hours)**

Stratified random sampling

Introduction, estimation of population mean and its variance, choice of sample sizes in different strata, comparison of stratified sampling under proportional and Neyman allocation with SRSWOR in terms of precision.

Unit III **(12 Hours)**

Analysis of variance and Design of experiments

One-way and two-way classified data with one observation per cell only. Design of experiments: Principles of Design of experiments, uniformity trails, completely randomized, Randomized block and Latin square designs.

Unit IV **(10 Hours)**

Factorial Experiments and Designs

Factorial experiments: 2^2 and 2^3, Factorial Design: construction and analysis.

PRACTICAL/LAB WORK – (30 hours)
List of Practical:

1. Select a SRS with and without replacement.
2. For a population of size 5, estimate population means, the population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size.
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Compare the efficiencies of the above two methods relative to SRS.
5. Estimation of gain in precision in stratified sampling.
6. Analysis of Variance of one-way classified data
7. Analysis Variance of two-way classified data
8. Analysis of CRD
9. Analysis of RBD.
10. Analysis of LSD.
11. Analysis of 2^2 and 2^3 factorial in CRD and RBD.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

Essential Readings:

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005). Fundamentals of Statistics, Vol. II, 8th Ed., World Press, Kolkata.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005). An Outline of Statistical Theory, Vol. II, 3rd Ed., World Press, Kolkata.
- Gupta, S.C. and Kapoor, V.K. (2008). Fundamentals of Applied Statistics, 4th Ed., Sultan Chand and Sons.

Suggested Readings:

- Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Ashok, C. (1984). Sampling Theory of Surveys with Applications, Iowa State University Press, Iowa, USA.
- Mukhopadhyay, P. (1998). Theory and Methods of Surveys Sampling, Prentice Hall of India.
- Montgomery, D.C. (2001). Designs and Analysis of Experiments, John Wiley and Sons, New York.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

GENERIC ELECTIVE COURSE – 6B: Statistics in Actuaries

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistics in Actuaries	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives

The learning objectives include:

- To learn about Utility theory
- To learn the principles of premium calculations
- To understand the survival distribution and life tables
- To learn Life Insurance models and life annuities

Learning Outcomes:

After completing this course, students will develop a clear understanding of:

- Statistics and Insurance applications
- Utility theory
- Principles of premium calculations
- Survival distribution and life tables
- Life insurance models and Life annuities.

SYLLABUS OF GE-6B

Theory

UNIT I **(11 hours)**

Introductory Statistics and Insurance applications

Introductory Statistics and Insurance applications: discrete, continuous, and mixed probability distributions. Insurance applications, sum of random variables. Utility theory: Utility functions expected utility criterion, types of utility function, insurance and utility theory.

UNIT II **(12 Hours)**

Principles of premium calculation
Principles of premium calculation: Properties of premium principles, examples of premium principles

Unit III **(12 Hours)**
Survival distribution and life tables
Survival distribution and life tables: Uncertainty of age and death, survival function, time-until-death for a person, curate future lifetime, the force of mortality, life tables with examples

Unit IV **(10 Hours)**
Life Insurance and annuities
Life insurance: Models for insurance payable at the moment of death, insurance payable at the end of the year of death, and their relationships. Life annuities: continuous life annuities, discrete life annuities.

PRACTICAL/LAB WORK – (30 hours)
List of Practical:
1. Risk computation for different utility models
2. Discrete and continuous risk calculations
3. Calculation of aggregate claims for collective risks
4. Calculation of aggregate claim for individual risks
5. Computing ruin probabilities and aggregate losses
6. Annuity and present value of contract
7. Computing premium for different insurance schemes
8. Practical based on life models and tables

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

Essential Readings:

- Dixon C. M. D. (2005) Insurance Risk and Ruin (International Series on Actuarial Science), Cambridge University Press.
- Atkinson M.E. and Dickson, D.C.M. (2011): An Introduction to Actuarial Studies, Elgar Publishing.

Suggested Readings:

- Bowers N.L., Gerber H.U., Hickman J.C., Jones D.A., and Nesbitt C.J. (1997): Actuarial Mathematics, Society of Actuaries, Itasca, Illinois USA.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

A.C. 27.12.2024

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Department of Statistics

B.Sc.(H), Statistics Semester-VII

Category I

DISCIPLINE-SPECIFIC CORE COURSE – 19: MULTIVARIATE ANALYSIS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Multivariate Analysis	4	3	0	1	-	Knowledge of Probability Distributions and Statistical Inference.

Learning Objectives

The learning objectives include:

- To study Bivariate Normal Distribution along with their properties.
- To study Multivariate Normal Distribution with their properties alongwith its applications analysis.
- Concepts of Multiple and partial correlation coefficients along with their interpretation.
- Analysis of multivariate data using discriminant analysis, principal component analysis, factor analysis and cluster analysis.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The basic concepts associated with Multivariate Normal Distributions and their properties with special emphasis on Bivariate Normal Distribution.
- The understanding of Multiple and partial correlation coefficients.
- Analysis of multivariate data using dimension reduction techniques like principal component analysis, factor analysis and cluster analysis.
- The classificatory method namely discriminant analysis.

SYLLABUS OF DSC-19

Theory

UNIT 1

Bivariate Normal Distribution **(15 hours)**

Probability density function of Bivariate Normal Distribution (BVN). Moment generating function, marginal distribution, conditional distribution of BVN and properties of BVN. Introduction of random vector, probability mass function, probability density functions of random vector, distribution function, mean vector, dispersion matrix, marginal distributions and conditional distributions of random vector.

UNIT 2

Multivariate Normal distribution **(15 hours)**

Probability density function of Multivariate Normal distribution (MVN). Moment generating function, marginal and conditional distribution of MVN. Properties of MVN. Sampling distribution of sample mean vector and sample variance-covariance matrix. Regression planes. Multiple and partial correlation coefficients with their properties and interpretations.

UNIT 3

Multivariate Data Analysis **(15 hours)**

Dimension reduction techniques: Principal component analysis and its applications, factor analysis and its applications, cluster analysis and its applications.

Classification technique: Discriminant analysis and its applications.

PRACTICAL/LAB WORK: (30 HOURS)

List of Practical:

1. Bivariate Normal Distribution and its properties.
2. Mean vector and dispersion matrix of Multivariate Normal Distribution.
3. Marginal distributions of Multivariate Normal Distribution.
4. Conditional distributions of Multivariate Normal Distribution.
5. Regression plane.
6. Partial Correlation Coefficient.
7. Multiple Correlation Coefficient.
8. Principal Component Analysis.
9. Discriminant Analysis.
10. Factor Analysis.
11. Cluster Analysis

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, 3rd Ed., John Wiley& Sons.
- Johnson, R.A. and Wichern, D.W. (2007). Applied Multivariate Analysis, 6th Ed., Prentice Hall.
- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2005). An Outline of Statistical Theory, Volume II, World Press.
- Applied multivariate data analysis, second edition, Brian.S.Everett and Graham Dunn,Oxford University Press,2001

SUGGESTED READINGS:

- S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 12th Ed., Sultan Chand and Sons, 2020.
- Kshirsagar, A.M. (1972). Multivariate Analysis, 1st Ed., Marcel Dekker.
- Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, John Wiley.
- Arora, S.andBansi, L. (1968). New Mathematical Statistics, 1st Ed., Vanita Printers.
- Rao, C. R. (2000). Linear Statistical Inference, John Wiley & Sons.
- Approaching multivariate analysis -A practical introduction, second edition, Pat Dugard,JohnTodman and Harry Staines, Routledge,2010.
- An R and S-plus companion to multivariate analysis, Brian Everitt,Springer texts in Statistics,Springer,2004.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Discipline Specific Elective Course for B.Sc. (H) Statistics Semester-VII

DISCIPLINE SPECIFIC CORE COURSE – 5A: FINANCIAL STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Financial Statistics	4	3	0	1	Class XII pass with Mathematics.	Basic knowledge of Stochastic processes, Calculus and Probability theory and Financial markets

Learning Objectives

The learning objectives include:

- To study the Financial Statistics which deals primary and secondary financial markets and the mathematical models used by these markets?
- To study the Stochastic Calculus, this is the study of infinitesimal changes in stochastic processes and the methods of dealing with such changes over time.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Primary financial markets and their products such as equity, bonds and cash deposits
- Secondary financial markets and their products such as futures, forwards and options (American and European)
- Stochastic calculus- Stochastic differentiation and integration
- Stochastic differential equations and methods of solving them
- Applications of stochastic differential equations in formulating models to price various secondary financial markets products.
- Hedging techniques

SYLLABUS OF DSE- 5a

Theory

UNIT I **(10 hours)**

Introduction to investment and markets, Cash flows. Net present value, Future value, Internal rate of return, criteria for project appraisal, Basic theory of interest, different interest rates and their relationships, discount rates, bonds-pricing and yields, yield curves, spot rates, spot rate curves, Zero-coupon bonds, perpetual bonds and discount bonds,

Introduction to derivatives, Tools Needed for Option Pricing: Forward contracts, spot price, forward price, future price, Call and put options, binary one period model

Pricing derivatives: Arbitrage relations and perfect financial markets, Pricing futures, Put call parity for European and American options, Relationship between strike price and option price.

UNIT II **(15 hours)**

Discrete Stochastic Processes- Binomial processes, General random walks, Geometric random walks, Binomial models, Trinomial models.

Continuous time processes – Brownian motion, Geometric Brownian motion, Wiener process;

Introduction to stochastic calculus: stochastic integration, stochastic differential equations and their solutions; Itô's lemma. Black-Scholes differential equation

UNIT III **(15 hours)**

Intrinsic of option markets:, Black-Scholes formula for European options, Implied volatility, Binomial Model for European options, Hedging portfolios: Delta, Gamma and Theta hedging.

Cox-Ross-Rubinstein approach to option pricing. Discrete dividends, Trinomial model for American options, pricing American options, put call parity for American options, relationship between American and European options.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Relationship between various interest rates
2. Present value and future value
3. Relationship between interest rates and discount rates
4. To compute NPV and to obtain IRR of the investments.
5. To compute bond price and yields
6. Determination of spot rate curve
7. To verify "no arbitrage" principle.
8. To price future / forward contracts
9. Simulation of continuous time stochastic processes
10. To price options using Black – Scholes formula.
11. Pricing of options using discrete time models.
12. Impact of dividend on option prices.
13. Call-put parity for European options.
14. Application of Greeks to hedge investment portfolios.
15. Pricing of American options
16. Put call parity for American options.

ESSENTIAL READINGS:

- David, G. L. (2015). *Investment Science*, Oxford University Press(South Asian edition)
- Franke, J., Hardle, W.K. and Hafner, C.M. (2011). *Statistics of Financial Markets: An Introduction*, 3rd Ed., Springer Publications
- John C. Hull and Sankarshan Basu (10th edition) Options, Future and other derivatives, Pearson Indian edition.

SUGGESTIVE READINGS:

- Ovidiu Calin (2015): *An informal introduction to stochastic calculus and its applications* , World Scientific
- Baxter, M., Rennie, A., & Rennie, A. J. (1996). Financial calculus: an introduction to derivative pricing. Cambridge university press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 5B: ADVANCED DESIGN OF EXPERIMENTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Design of Experiments	4	3	0	1	Class XII pass with Mathematics	Basic Knowledge of Design of Experiments

Learning Objectives

The learning objectives include:

- To design and conduct experiments.
- To analyse and interpret data.
- To construct designs.
- To apply experimental design techniques in real world problems.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Application of ANOVA technique for two –way classification, fixed effect models with unequal number of observations per cell, Random effect models with one observation per cell and the concept of Mixed effects models.
- Design and analysis of incomplete block designs, understand the concepts of orthogonality, connectedness and balancing.
- Understand the concepts of finite fields and finite geometries and apply them in the construction of MOLS, balanced incomplete block designs.
- Apply techniques of Response surface methodology and appreciate the concepts of orthogonality, rotatability and blocking.
- Understand the concept of mixture experiments that are useful in our day to day life, food industry, chemical industry, pharmaceutical companies.

- Understand and apply Crossover designs in practical situations.

SYLLABUS OF DSE-5b

Theory

UNIT I **(6 hours)**

Analysis of Variance

Fixed effect models (2-way classification with unequal number of observations per cell), Random effect models (2-way classification with one observation per cell) and the concept of Mixed effect models.

UNIT II **(12 hours)**

Incomplete Block Designs

Concepts of Connectedness, Orthogonality and Balance. Intrablock analysis of General Incomplete Block design. B.I.B designs with and without recovery of interblock information.

UNIT III **(13 hours)**

Finite fields

Finite Geometries- Projective geometry and Euclidean geometry. Construction of complete set of mutually orthogonal latin squares. Construction of B.I.B.D. using finite Abelian groups, MOLS, finite geometry and method of differences.

UNIT IV **(14 hours)**

Some Useful Designs

Response surface designs for first and second order models, concepts of orthogonality, rotatability and blocking. Mixture Experiments–models and designs, Cross-over designs

PRACTICAL/LAB. WORK (30 HOURS)

List of Practical:

1. Based on ANOVA for 2-way classification with unequal number of observations per cell under fixed effects model
2. Based on ANOVA 2-way classification with one observation per cell under random effects model
3. Based on ANOVA 2-way classification with one observation per cell under mixed effects model
4. Based on Intrablock analysis of an IBD
5. Based on analysis of a BIBD with and without interblock analysis.
6. Based on response designs for first and second order models.
7. Based on mixture designs,
8. Based on Cross-over designs.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (1980). An Outline of Statistical Theory, Vol 2, The world Press Private Limited.
- Das, M.N. and Giri, N.C. (1986). Design and Analysis of Experiments, Wiley Eastern Limited.
- Dey, A. (1986). Theory of Block Designs, John Wiley & Sons.
- Hinkelmann, K. and Kempthorne, O. (2005). Design and Analysis of Experiments, Vol. 2: Advanced Experimental Design, John Wiley & Sons.
- Bose, M. and Dey, A. (2009). Optimal Crossover Designs, World Scientific.
- Cornell, John A. (2002). Experiments with Mixtures, John Wiley & Sons.
- Myers, R. H. and Montgomery, D. C. (2002). Response Surface Methodology: Process
- and Product Optimization using Designed Experiments, John Wiley & Sons.

SUGGESTED READINGS

- Chakrabarti, M.C. (1962). Mathematics of Design and Analysis of Experiments, Asia Publishing House, Bombay.
- Dean, A. and Voss, D. (1999). Design and Analysis of Experiments, Springer. First Indian Reprint 2006.
- John, P.W.M. (1971). Statistical Design and Analysis of Experiments, Macmillan Co., New York.
- Kshirsagar, A.M. (1983). A Course in Linear Models, Marcel Dekker, Inc., N.Y.
- Montgomery, D. C. (2005). Design and Analysis of Experiments, 6th ed., John Wiley & Sons.
- Raghavarao, D. and Padgett, L. V. (2005). Block Designs: Analysis, Combinatorics, and Applications, World Scientific.
- Raghavarao, D. (1970). Construction and Combinatorial Problems in Design of Experiments, John Wiley & Sons.
- Wu, C. F. J. and Hamada, M. (2000). Experiments: Planning, Analysis and Parameter Design Optimization, John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE –5C : ADVANCED THEORY OF BIOSTATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced theory of Biostatistics	**4**	**3**	0	**1**	Studied Biostatistics	Basic knowledge of survival analysis and survival models

Learning objectives:

The learning objectives include:

- Comparison of Survival in two groups
- Epidemiological Study and epidemic models.
- Independent and dependent risks in Competing risk theory.
- Concept of Relative Risk, Odds Ratio and Attributable Risk.
- Concept of Clinical trials.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Different methods for comparing survival rates of two groups of patients.
- Concept of Prospective, Retrospective and cross-sectional studies. Different epidemic models.
- Distinction between Relative Risk, Odds Ratio and Attributable Risk and their confidence interval.
- Different phases of clinical trials.

SYLLABUS OF DSE – 5c

Theory

UNIT I **(11 hours)**

Comparison of Survival in two groups:

Log-rank test, Gehan's generalized Wilcoxon test, Cox-Mantel test, Mantel-Haenszel Test, Comparison of two exponential survival distributions: Likelihood ratio test, Cox's F-test,
Concept of covariates and proportional hazard, Cox's proportional hazard model.

UNIT II **(12 hours)**

Epidemiological Study:

Prospective study, Retrospective study, cross-sectional study and their comparison. Sensitivity, specificity and predictivity of medical tests. Likelihood ratio of a positive and negative test result.
Epidemic Model: Concept of epidemic and epidemic models, Simple Stochastic Epidemic model (including derivations), Duration of an epidemic. General epidemic model & Carrier-borne epidemic model (concept and definition only)

UNIT III **(16 hours)**

Competing Risk Theory:

Concept of Competing risk theory with independent and dependent risks. Bivariate Normal dependent risk model and its derivations.
Concept of risk, hazard and odds, definition of relative risk (RR), relative risks in independent sample, attributable risk in independent samples, definition of odds ratio (OR), odds ratio in two independent samples, confidence interval and test of hypothesis for relative risk and odds ratio (independent samples)

UNIT IV **(6 hours)**

Clinical Trials:

Planning and designing clinical trials, Phase-I, Phase-II and Phase-III clinical trials. Single, double and triple blinding.

PRACTICAL/LAB WORK (30 HOURS)

List of Practicals:

1. Comparison of survival of two groups using Log-rank test.
2. Comparison of survival of two groups using Gehan's generalized Wilcoxon test.
3. Comparison of survival of two groups using Cox-Mantel test.
4. Comparison of survival of two groups using Mantel-Haenszel test.
5. Comparison of survival of two groups using Likelihood ratio test.
6. Comparison of survival of two groups using Cox's F-test.
7. Computation of Sensitivity and specificity of a medical test.
8. Computation of likelihood ratio of a medical test.
9. Computation of positive and negative predictivities and hence predictive validity of a medical test.
10. Calculation of relative risk and it's confidence interval.
11. Calculation of odds ratio and it's confidence interval.
12. Calculation of attributable risk and it's confidence interval.
13. Calculation of probability of r susceptible getting infected by time t.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Biswas, S. (2007): Applied Stochastic Processes: A Biostatistical and Population Oriented Approach, Reprinted 2nd Ed., New Central Book Agency.
- Lee, E.T. and Wang, J.W. (2003): Statistical Methods for Survival data Analysis, 3rd Ed., John Wiley & Sons.
- Indrayan, A. (2008): Medical Biostatistics, 2nd Ed., Chapman and Hall/CRC.

SUGGESTED READINGS:

- Miller, R. G. (2011): Survival Analysis. John Wiley & Sons.
- Elandt-Johnson R.C (1971): Probability model and Statistical Methods in Medical Biostatistics, 2nd Ed., Chapman and Hall/CRC. Genetics, John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 5D: RESEARCH METHODOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives:

The learning objectives include

- To provide scientific approaches to develop the domain of human knowledge through empirical studies.
- To enable the student researchers to understand basic concepts and aspects related to research, data collection, analyses, interpretation and report writing.

Learning Outcomes:

After completion of this course, students should have developed a clear understanding of

- Research Methods.
- Research Problems.
- Research Designs.
- Comparative study of different methods of data collection.
- Guidelines for construction of questionnaires.
- Processing and Analysis of data.
- Interpretation and Report writing.

SYLLABUS OF DSE – 5d

Theory

UNIT I **(09 hours)**

Introduction to Research:
Importance and need for research ethics, Objectives of research, Types of research, Research approaches, Review of literature, Mode of literature survey: Books and Monographs, Journals, Conference proceedings, Abstracting and Indexing Journals, E-Journals/Books, Formulation of a research problem, Identifying variables, Constructing hypothesis, Conceptualization of a research design.

UNIT II **(09 hours)**

Methods & Techniques of Data Collection:
Survey methodology and Data collection, Source of data collection-Use of secondary data, Methods of collecting primary data, Develop a questionnaire, Questions and answers in surveys, Non-response, Errors in surveys, Sample size, sampling frames and coverage error.

UNIT III **(15 hours)**

Data Processing & Analysis:
Data processing, Exploratory data analysis, Review of various techniques (Parametric and Nonparametric tests, Correlation and Regression analysis, ANOVA, Multivariate Techniques) for data analysis covered in core statistics papers, Techniques of interpretation, Precaution in interpretation.
Report writing: Discussions, Conclusions, Referencing and various formats for reference writing, Bibliography, Thesis writing, Formats of publications in research journals including subject classification, Impact factor, Citation index.

UNIT IV **(12 hours)**

Computer Application:
Data Communication and networks, Website, Webpage, Search Engines, Scientific search engines.
Scientific Word Processing with LaTeX and MS-Word, MS Equation editor, Slides making-Power Point Features, Slide preparation, SPSS, Statistical Programming with R, Simulation.

PRACTICAL/LAB WORK – (30 hours)
PROJECT WORK (using a spreadsheet, Scientific Word Processing with LaTeX and MS-Word, MS Equation editor, Slides making-Power Point Features, Slide preparation, SPSS, Statistical Programming with R, Simulation.)

ESSENTIAL READINGS

- Kothari, C.R., Garg, Gaurav (2015): Research Methodology: Methods and Techniques, 3rd Edition (Reprint), New Age International Publishers.
- Kumar, R. (2011): Research Methodology: A Step-by-Step Guide for Beginners, SAGE publications.
- Anderson, J., Durston, B.H., Pooole, M. (1970): Thesis and Assignment Writing, Wiley Eastern. Ltd., New Delhi.
- Braun, J., Duncan, W. and Murdock, J. (2008): A First Course in Statistical Programming with R, Cambridge University Press, London.
- Lamport, L. (1999): LATEX: A Document Preparation System, Addison, Wesley, 2nd Edition, New York.
- Cunningham, B.J. (2012): Using SPSS: An Interactive Hands-On Approach, SAGE South Asia Edition.
- Voss, J. (2014): An Introduction to Statistical Computing: A Simulation-based Approach, Wiley series in computational statistics.

SUGGESTIVE READINGS

- Pannerselvan, R. (2006): Research Methodology, Prentice-Hall of India Pvt., New Delhi.
- Landau, Sabine and Everitt, Brian S. (2004): A Handbook of Statistical Analyses using SPSS, Chapman & Hall/CRC.

- Dalgaard, P. (2008): Introductory Statistics with R, Springer Science, New York.
- Gardener, M. (2012): Beginning R: The Statistical Programming Language, Wiley Publications.
- Robert, C.P. and Casella, G. (2004): Monte Carlo Statistical Methods, Springer Science, New York.
- Rubinstein, R.Y. (1981): Simulation and the Monte Carlo Methods, Wiley.
- Venkataraman, M.K. (1998): Numerical Methods in Science and Engineering, The National Publishing Company, Chennai.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Category II

B.A.(Prog) with Statistics as Non-Major/Major Semester-VII

DISCIPLINE SPECIFIC CORE COURSE–7: STOCHASTIC PROCESSES AND QUEUEING THEORY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Stochastic Processes and Queueing Theory	4	3	0	1		Basic knowledge of Probability theory and Probability distributions

Learning Objectives:

The learning objectives include:

- To understand the concept of stochastic process and markov chain.
- To analyze the queueing models with applications;
- To identify the real life applications of stochastic processes.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of stochastic processes.
- Tools needed to analyze stochastic processes.
- Markov processes and Markov chains.
- Stability of Markov chains.
- Poisson process and its variations.
- Queuing systems.
- Random walk and ruin theory.

SYLLABUS OF DSC-7

Theory

UNIT I

Probability Generating Function **(12 Hours)**

Probability Distributions: Generating functions, Bivariate probability generating functions.

Stochastic Process: Introduction, Stationary Process.

UNIT II

Markov Chain (18 Hours)

Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Classification of states and chains, stability of Markov system. Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.

UNIT III

Poisson Process and Queuing theory (15 Hours)

Postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process. Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof).

PRACTICAL/ LAB WORK – (30 hours)

List of Practical:

1. Problems based on probability generating function to compute exact and approximate probabilities using partial fraction theorem.
2. Problems based on (covariance) stationary processes.
3. Markov Chains:
   a) Simulation of Markov chains and Calculation of transition probability matrices.
   b) Stability of Markov chains.
   c) To check whether the given chain is irreducible or not.
4. Simulation and applications of Poisson processes.
5. Calculation of probabilities for given birth and death processes.
6. Calculation of probabilities for ruin problems.
7. Problems based on (M/M/1) queuing models.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READING:

- Medhi, J. (2009). Stochastic Processes, New Age International Publishers.
- Gross, Donald and Harris, Carl M (2008) Fundamentals of Queueing Theory, 4th Edition, Wiley International.
- Feller, W. (1968). Introduction to probability Theory and Its Applications, Vol I, 3rd Ed., Wiley International.

SUGGESTED READINGS:

- Basu, A.K. (2005). Introduction to Stochastic Processes, Narosa Publishing.
- Bhat, B.R.(2000).Stochastic Models: Analysis and Applications, New Age International Publishers.
- Taha, H. (1995). Operations Research: An Introduction, Prentice- Hall India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Discipline Specific Elective Course

Discipline Specific Elective Course for B.A.(Prog) Semester-VII

DISCIPLINE SPECIFIC ELECTIVE COURSE – 5A: LINEAR PROGRAMMING TECHNIQUES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Linear Programming Techniques	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives:

The learning objectives include:

- Concept of mathematical formulation to a real-life problem through Linear Programming.
- This course develops the ideas underlying the Simplex Method for Linear Programming Problem.
- The course covers Linear Programming with applications to Transportation and Assignment problem. Such problems arise in manufacturing, resource planning and financial sectors.

Learning Outcomes:

After completing this course, students will possess skills concerning:

- Learn about the graphical solution of linear programming problem with two variables.
- Learn about the relation between basic feasible solutions and extreme points.
- Understand the theory of the simplex method used to solve linear programmingproblems.
- Learn about two-phase and Big-M methods to deal with problems involving artificial variables
- Solve transportation and assignment problems.

SYLLABUS OF DSE – 5a

Theory

Unit I: **(14 Hours)**

Introduction to Linear Programming:

Linear programming problem**:** Standard, Canonical and matrix forms, Formulation of Linear Programming Problem, Graphical solution; Basic solutions, Basic feasible solutions.

Unit II: **(16 Hours)**

Methods of Solving Linear Programming Problem:

Simplex method**:** Optimal solution, Termination criteria for optimal solution of the linear programming problem, Unique and alternate optimal solutions, Unboundedness; Artificial variables, Two-phase method, Big-M method.

Unit III: **(15 Hours)**

Transportation and Assignment Problems:

Transportation Problem**:** Definition and formulation; Methods of finding initial basic feasible solutions; Northwest-corner rule. Least- cost method; Vogel's approximation method; Algorithm for solving transportation problem.

Assignment Problem**:** Mathematical formulation and Hungarian method of solving Assignment problem.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Graphical representation of Linear Programming Problem and its solution.
2. Graphical identification of basic solutions, basic feasible solution and optimal solution.
3. Solution of Linear Programming Problem by Simplex method.
4. Solution of Linear Programming Problem by Big-M method.
5. Solution of Transportation Problem as a Linear Programming Problem.
6. Solution of Assignment Problem as a Linear Programming Problem.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

Essential Reading:

- Hadley, G. (2002). Linear Programming. Narosa Publishing House. New Delhi.
- Taha, H. A. (2010). Operations Research. An Introduction, 9th Ed, Pearson.
- Swarup, K. Gupta, P.K. and Mohan, M. (2019). Operations Research, 15th Ed, Sultan Chand & Sons.

Suggested Readings:

- Hillier, Frederick S. & Lieberman, Gerald J. (2015). Introduction to OperationsResearch (10th ed.). McGraw-Hill Education (India) Pvt. Ltd.
- Sharma, J. K. (2017). Operations Research: Theory and applications, 6th Edition, Trinity Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE-5B: INTRODUCTION TO STATISTICAL LINEAR MODELS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	practical		
Introduction to Statistical Linear Models	**4**	**3**	**0**	**1**		Basic knowledge of Matrix theory and Probability distributions

Learning Objectives:

Learning objectives include:

- Developing a clear understanding of the fundamental concepts of linear models.
- Developing associated skills allowing the students to work effectively with them.

Learning Outcomes:

After completion of this course, students should have developed a clear understanding of:

- Theory and estimation of Linear Models.
- Gauss-Markov Theorem and its use.
- Distribution of quadratic forms.
- Simple and Multiple linear regression models and their applications.
- Fitting of these models to real or synthetic data, derivation of confidence and prediction intervals, and a sound scientific interpretation of the results.
- Techniques of Analysis of Variance under fixed effects model.
- Assessment of the quality of the fit using classical diagnostics.

SYLLABUS OF DSC-14

THEORY

UNIT I **(12 Hours)**

Introduction

Statistical Linear Models and their classification, Estimability of linear parametric functions, Gauss-Markov setup, Normal equations and Gauss-Markov theorem, full rank case and non-full rank case (without proof)

UNIT II **(8 Hours)**

Distribution of quadratic forms

Cochran's theorem (without proof), Necessary and sufficient conditions for the mutual independence of quadratic forms and for the mutual independence of a linear function and a quadratic form.

UNIT III **(13 Hours)**

Regression analysis:

Simple and Multiple linear regression: Estimation of parameters and testing of hypotheses, Confidence intervals, Bias in regression estimates Lack of fit and pure error, Residuals and their plot. Techniques for variable selection. Polynomial Regression models: Orthogonal Polynomials.

UNIT IV **(12 Hours)**

Analysis of Variance:

Technique of analysis of variance (ANOVA) in one-way and two-way classifications with an equal number of observations per cell under fixed effect model.

PRACTICAL/LABWORK -30 Hours

List of Practical:

1. Estimability when X is a full rank matrix.
2. Estimability when X is not a full rank matrix.
3. Distribution of Quadratic forms.
4. Simple Linear Regression.
5. Multiple Linear Regression
6. Tests for Linear Hypothesis.
7. Bias in regression estimates.
8. Lack of fit.
9. Orthogonal Polynomials.
10. Analysis of Variance of a one-way classified data.
11. Analysis of Variance of two-way classified data with one observation per cell.
12. Analysis of Variance of two-way classified data with m (> 1) observations per cell.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

Essential Readings

- Montgomery, D. C., Peck, E. A. and Vining, G. G. (2012): Introduction to Linear Regression Analysis, 5th Ed., John Wiley and Sons.
- Rencher, A. C. and Schaalje, G. B. (2008): Linear Models in Statistics, 2nd Ed., John Wiley and Sons.
- Draper, N. R. and Smith, H. (1998): Applied Regression Analysis, 3rd Ed., John Wiley and Sons.

Suggestive Readings:

- Weisberg, S. (2005): Applied Linear Regression, 3rd Ed., John Wiley and Sons.
- Rawlings, John O. Pantula Sastry G. Dickey, David A. (1998) Applied Regression Analysis: A Research Tool, Second Edition
- Bapat, R.B.(1993): Linear Algebra and Linear Models, Hindustan Book Agency.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE –5C: STATISTICAL METHODS IN PSYCHOLOGY AND EDUCATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Methods in Psychology and Education	4	3	0	1	Class XII pass with Mathematics	Knowledge of basic statistics and probability distributions

Learning Objectives:

The learning objectives include:

- To measure psychological traits and mental abilities
- To learn basic methods of test construction, item writing and item analysis
- To check the reliability and validity of test scores.

Learning Outcomes:

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

- Distinguish between Psychological measurement and physical measurement.
- Understand the meaning of Tests in Psychology and Education.
- Appreciate the uses and limitations of Psychological tests.
- Learn the meaning and purpose of Item writing and analysis.
- Understand concepts of reliability and validity of test scores and their differences.
- Convert raw scores into different transformed scores.
- Apply Scaling rankings and ratings in terms of the Normal Probability Curve.

SYLLABUS OF DSC-5c

Theory

Unit 1: **(15 Hours)**

Importance of statistics in psychology and education.

Importance of statistics in psychology and education. Levels of measurement: nominal ordinal interval and ratio scales. Distinction between psychological and physical measurements. General problems and sources of errors in measurements.

Meaning and types of tests in psychology and education. History of psychological measurement and testing. Uses and limitations of tests. Varieties of tests. Characteristics of a good test. General steps of test construction. Test administration and scoring.

Item writing and item analysis: Meaning and types of test items, Purpose and methods for evaluating test items.

Unit 2: **(15 Hours)**

Reliability and Validity:
Reliability: definition Methods of determining reliability: Test-retest, Alternate or parallel forms, Split half technique, Rational equivalence. Effect upon reliability of lengthening or repeating or test. Reliability coefficient as a measure of true variance. Estimating true scores by way of regression equation and reliability coefficient. Index of reliability.
Validity: meaning; Estimation of validity; Types of validity: validity and test length; comparison between reliability and validity.

Unit 3: **(15 Hours)**
Test Scores:
Meaning and differences between norm referencing and criterion referencing.
Raw score transformations- percentile scores, standard score, normalised standard scores, T- scores and Stanine scores.
Intelligence: definition. Types of intelligence test scores. Psychological scaling methods- scaling of individual test items in terms of difficulty, scaling of rankings and ratings in terms of the normal probability curve.

PRACTICAL LAB WORK (30 hours)
List of Practical:

1. Computation of reliability by Rulon and Kuder Richardson formulas.
2. Computing reliability of a test whose length is increased/decreased.
3. Computing index of reliability standard error of measurement.
4. Computing validity oblique maximum validity then test length is increased.
5. Computing relative difficulty of questions difference in difficulty between different tests.
6. Problem based on Z scores.
7. Problem based on t scores.
8. Problem based on Stanine scales.
9. Problem based on percentile scores.
10. Computing numerical scores corresponding to grades or ratings.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Anastasia, A. and Urbina, S. (1997) Psychological testing (7th edition), Prentice Hall
- Garrett H.E. (2021), Statistics in Psychology and Education. Nation press.
- Gregory RJ (2016), Psychological testing: History, Principles and Applications. (updated 7th edition) Pearson
- Singh, A.K. (2006)Test, Measurements and Research in Behavioural Sciences Bharati bhavan
- Mangal S.K. (2016) Statistics in Psychology and Education. PHI learning Pvt ltd.

SUGGESTED READINGS:

- Gupta S.C. and Kapoor V.K. (2019) Fundamentals of Applied statistics, Sultan Chand and sons.
- Goon A.M., Gupta M.K. and Dasgupta, B. (2001) Fundamental of Statistics, Volume 2, World Press Pvt ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 5D: RESEARCH METHODOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives:

The learning objectives include

- To provide scientific approaches to develop the domain of human knowledge through empirical studies.
- To enable the student researchers to understand basic concepts and aspects related to research, data collection, analyses, interpretation and report writing.

Learning Outcomes:

After completion of this course, students should have developed a clear understanding of

- Research Methods.
- Research Problems.
- Research Designs.
- Comparative study of different methods of data collection.
- Guidelines for construction of questionnaires.
- Processing and Analysis of data.
- Interpretation and Report writing.

SYLLABUS OF DSE – 5d

Theory

UNIT I **(09 hours)**

Introduction to Research:

Importance and need for research ethics, Objectives of research, Types of research, Research approaches, Review of literature, Mode of literature survey: Books and Monographs, Journals, Conference proceedings, Abstracting and Indexing Journals, E-Journals/Books, Formulation of a research problem, Identifying variables, Constructing hypothesis, Conceptualization of a research design.

UNIT II **(09 hours)**

Methods & Techniques of Data Collection:

Survey methodology and Data collection, Source of data collection-Use of secondary data, Methods of collecting primary data, Develop a questionnaire, Questions and answers in surveys, Non-response, Errors in surveys, Sample size, sampling frames and coverage error.

UNIT III **(15 hours)**

Data Processing & Analysis: Data processing, Exploratory data analysis, Review of various techniques (Parametric and Nonparametric tests, Correlation and Regression analysis, ANOVA, Multivariate Techniques) for data analysis covered in core statistics papers, Techniques of interpretation, Precaution in interpretation.

Report writing: Discussions, Conclusions, Referencing and various formats for reference writing, Bibliography, Thesis writing, Formats of publications in research journals including subject classification, Impact factor, Citation index.

UNIT IV **(12 hours)**

Computer Application:

Data Communication and networks, Website, Webpage, Search Engines, Scientific search engines. Scientific Word Processing with LaTeX and MS-Word, MS Equation editor, Slides making-Power Point Features, Slide preparation, SPSS, Statistical Programming with R, Simulation.

PRACTICAL/LAB WORK – (30 hours)

PROJECT WORK (using a spreadsheet, Scientific Word Processing with LaTeX and MS-Word, MS Equation editor, Slides making-Power Point Features, Slide preparation, SPSS, Statistical Programming with R, Simulation.)

ESSENTIAL READINGS

- Kothari, C.R., Garg, Gaurav (2015): Research Methodology: Methods and Techniques, 3rd Edition (Reprint), New Age International Publishers.
- Kumar, R. (2011): Research Methodology: A Step-by-Step Guide for Beginners, SAGE publications.
- Anderson, J., Durston, B.H., Pooole, M. (1970): Thesis and Assignment Writing, Wiley Eastern. Ltd., New Delhi.
- Braun, J., Duncan, W. and Murdock, J. (2008): A First Course in Statistical Programming with R, Cambridge University Press, London.
- Lamport, L. (1999): LATEX: A Document Preparation System, Addison, Wesley, 2nd Edition, New York.
- Cunningham, B.J. (2012): Using SPSS: An Interactive Hands-On Approach, SAGE South Asia Edition.
- Voss, J. (2014): An Introduction to Statistical Computing: A Simulation-based Approach, Wiley series in computational statistics.

SUGGESTIVE READINGS

- Pannerselvan, R. (2006): Research Methodology, Prentice-Hall of India Pvt., New Delhi.
- Landau, Sabine and Everitt, Brian S. (2004): A Handbook of Statistical Analyses using SPSS, Chapman & Hall/CRC.
- Dalgaard, P. (2008): Introductory Statistics with R, Springer Science, New York.
- Gardener, M. (2012): Beginning R: The Statistical Programming Language, Wiley Publications.
- Robert, C.P. and Casella, G. (2004): Monte Carlo Statistical Methods, Springer Science, New York.
- Rubinstein, R.Y. (1981): Simulation and the Monte Carlo Methods, Wiley.
- Venkataraman, M.K. (1998): Numerical Methods in Science and Engineering, The National Publishing Company, Chennai.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Category III

B.Sc. (Prog) Mathematical Sciences with Statistics Semester-VII

DISCIPLINE SPECIFIC CORE COURSE–7: STOCHASTIC PROCESSES AND QUEUEING THEORY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Stochastic Processes and Queueing Theory	4	3	0	1		Basic knowledge of Probability theory and Probability distributions

Learning Objectives:

The learning objectives include:

- To understand the concept of stochastic process and markov chain.
- To analyze the queueing models with applications;
- To identify the real life applications of stochastic processes.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of stochastic processes.
- Tools needed to analyze stochastic processes.
- Markov processes and Markov chains.
- Stability of Markov chains.
- Poisson process and its variations.
- Queuing systems.
- Random walk and ruin theory.

SYLLABUS OF DSC-7

Theory

UNIT I

Probability Generating Function **(12 Hours)**

Probability Distributions: Generating functions, Bivariate probability generating functions. Stochastic Process: Introduction, Stationary Process.

UNIT II

Markov Chain (18 Hours)

Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Classification of states and chains, stability of Markov system. Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.

UNIT III

Poisson Process and Queuing theory (15 Hours)

Postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process. Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof).

PRACTICAL/ LAB WORK – (30 hours)

List of Practical:

1. Problems based on probability generating function to compute exact and approximate probabilities using partial fraction theorem.
2. Problems based on (covariance) stationary processes.
3. Markov Chains:
   d) Simulation of Markov chains and Calculation of transition probability matrices.
   e) Stability of Markov chains.
   f) To check whether the given chain is irreducible or not.
4. Simulation and applications of Poisson processes.
5. Calculation of probabilities for given birth and death processes.
6. Calculation of probabilities for ruin problems.
7. Problems based on (M/M/1) queuing models.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READING:

- Medhi, J. (2009). Stochastic Processes, New Age International Publishers.
- Gross, Donald and Harris, Carl M (2008) Fundamentals of Queueing Theory, 4th Edition, Wiley International.
- Feller, W. (1968). Introduction to probability Theory and Its Applications, Vol I, 3rdEd., Wiley International.

SUGGESTED READINGS:

- Basu, A.K. (2005). Introduction to Stochastic Processes, Narosa Publishing.
- Bhat, B.R.(2000).Stochastic Models: Analysis and Applications, New Age International Publishers.
- Taha, H. (1995). Operations Research: An Introduction, Prentice- Hall India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Discipline Specific Elective Course

Discipline Specific Elective Course for B.Sc. (Prog) Mathematical Sciences Semester-VII

DISCIPLINE SPECIFIC ELECTIVE COURSE – 5A: LINEAR PROGRAMMING TECHNIQUES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Linear Programming Techniques	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives:

The learning objectives include:

- Concept of mathematical formulation to a real-life problem through Linear Programming.
- This course develops the ideas underlying the Simplex Method for Linear Programming Problem.
- The course covers Linear Programming with applications to Transportation and Assignment problem. Such problems arise in manufacturing, resource planning and financial sectors.

Learning Outcomes:

After completing this course, students will possess skills concerning:

- Learn about the graphical solution of linear programming problem with two variables.
- Learn about the relation between basic feasible solutions and extreme points.
- Understand the theory of the simplex method used to solve linear programmingproblems.
- Learn about two-phase and Big-M methods to deal with problems involving artificial variables
- Solve transportation and assignment problems.

SYLLABUS OF DSE – 5a

Theory

Unit I: **(14 Hours)**

Introduction to Linear Programming:

Linear programming problem**:** Standard, Canonical and matrix forms, Formulation of Linear

Programming Problem, Graphical solution; Basic solutions, Basic feasible solutions.

Unit II: (16 Hours)

Methods of Solving Linear Programming Problem:

Simplex method**:** Optimal solution, Termination criteria for optimal solution of the linear programming problem, Unique and alternate optimal solutions, Unboundedness; Artificial variables, Two-phase method, Big-M method.

Unit III: (15 Hours)

Transportation and Assignment Problems:

Transportation Problem**:** Definition and formulation; Methods of finding initial basic feasible solutions; Northwest-corner rule. Least- cost method; Vogel's approximation method; Algorithm for solving transportation problem.

Assignment Problem**:** Mathematical formulation and Hungarian method of solving Assignment problem.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

7. Graphical representation of Linear Programming Problem and its solution.
8. Graphical identification of basic solutions, basic feasible solution and optimal solution.
9. Solution of Linear Programming Problem by Simplex method.
10. Solution of Linear Programming Problem by Big-M method.
11. Solution of Transportation Problem as a Linear Programming Problem.
12. Solution of Assignment Problem as a Linear Programming Problem.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

Essential Reading:

- Hadley, G. (2002). Linear Programming. Narosa Publishing House. New Delhi.
- Taha, H. A. (2010). Operations Research. An Introduction, 9th Ed, Pearson.
- Swarup, K. Gupta, P.K. and Mohan, M. (2019). Operations Research, 15th Ed, Sultan Chand & Sons.

Suggested Readings:

- Hillier, Frederick S. & Lieberman, Gerald J. (2015). Introduction to OperationsResearch (10th ed.). McGraw-Hill Education (India) Pvt. Ltd.
- Sharma, J. K. (2017). Operations Research: Theory and applications, 6th Edition, Trinity Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE-5B: INTRODUCTION TO STATISTICAL LINEAR MODELS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	practical		
Introduction to Statistical Linear Models	**4**	**3**	**0**	**1**		Basic knowledge of Matrix theory and Probability distributions

Learning Objectives:

Learning objectives include:

- Developing a clear understanding of the fundamental concepts of linear models.
- Developing associated skills allowing the students to work effectively with them.

Learning Outcomes:

After completion of this course, students should have developed a clear understanding of:

- Theory and estimation of Linear Models.
- Gauss-Markov Theorem and its use.
- Distribution of quadratic forms.
- Simple and Multiple linear regression models and their applications.
- Fitting of these models to real or synthetic data, derivation of confidence and prediction intervals, and a sound scientific interpretation of the results.
- Techniques of Analysis of Variance under fixed effects model.
- Assessment of the quality of the fit using classical diagnostics.

SYLLABUS OF DSC-14

THEORY

UNIT I **(12 Hours)**

Introduction

Statistical Linear Models and their classification, Estimability of linear parametric functions, Gauss-Markov setup, Normal equations and Gauss-Markov theorem, full rank case and non-full rank case (without proof)

UNIT II **(8 Hours)**

Distribution of quadratic forms

Cochran's theorem (without proof), Necessary and sufficient conditions for the mutual independence of quadratic forms and for the mutual independence of a linear function and a quadratic form.

UNIT III **(13 Hours)**

Regression analysis:

Simple and Multiple linear regression: Estimation of parameters and testing of hypotheses, Confidence intervals, Bias in regression estimates Lack of fit and pure error, Residuals and their plot. Techniques for variable selection. Polynomial Regression models: Orthogonal Polynomials.

UNIT IV **(12 Hours)**

Analysis of Variance:

Technique of analysis of variance (ANOVA) in one-way and two-way classifications with an equal number of observations per cell under fixed effect model.

PRACTICAL/LABWORK -30 Hours

List of Practical:

1. Estimability when X is a full rank matrix.
2. Estimability when X is not a full rank matrix.
3. Distribution of Quadratic forms.
4. Simple Linear Regression.
5. Multiple Linear Regression
6. Tests for Linear Hypothesis.
7. Bias in regression estimates.
8. Lack of fit.
9. Orthogonal Polynomials.
10. Analysis of Variance of a one-way classified data.
11. Analysis of Variance of two-way classified data with one observation per cell.
12. Analysis of Variance of two-way classified data with m (> 1) observations per cell.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

Essential Readings

- Montgomery, D. C., Peck, E. A. and Vining, G. G. (2012): Introduction to Linear Regression Analysis, 5th Ed., John Wiley and Sons.
- Rencher, A. C. and Schaalje, G. B. (2008): Linear Models in Statistics, 2nd Ed., John Wiley and Sons.
- Draper, N. R. and Smith, H. (1998): Applied Regression Analysis, 3rd Ed., John Wiley and Sons.

Suggestive Readings:

- Weisberg, S. (2005): Applied Linear Regression, 3rd Ed., John Wiley and Sons.
- Rawlings, John O. Pantula Sastry G. Dickey, David A. (1998) Applied Regression Analysis: A Research Tool, Second Edition
- Bapat, R.B.(1993): Linear Algebra and Linear Models, Hindustan Book Agency.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE –5C: STATISTICAL METHODS IN PSYCHOLOGY AND EDUCATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Methods in Psychology and Education	4	3	0	1	Class XII pass with Mathematics	Knowledge of basic statistics and probability distributions

Learning Objectives:

The learning objectives include:

- To measure psychological traits and mental abilities
- To learn basic methods of test construction, item writing and item analysis
- To check the reliability and validity of test scores.

Learning Outcomes:

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

- Distinguish between Psychological measurement and physical measurement.
- Understand the meaning of Tests in Psychology and Education.
- Appreciate the uses and limitations of Psychological tests.
- Learn the meaning and purpose of Item writing and analysis.
- Understand concepts of reliability and validity of test scores and their differences.
- Convert raw scores into different transformed scores.
- Apply Scaling rankings and ratings in terms of the Normal Probability Curve.

SYLLABUS OF DSC-5c

Theory

Unit 1: **(15 Hours)**

Importance of statistics in psychology and education.

Importance of statistics in psychology and education. Levels of measurement: nominal ordinal interval and ratio scales. Distinction between psychological and physical measurements. General problems and sources of errors in measurements.

Meaning and types of tests in psychology and education. History of psychological measurement and testing. Uses and limitations of tests. Varieties of tests. Characteristics of a good test. General steps of test construction. Test administration and scoring.

Item writing and item analysis: Meaning and types of test items, Purpose and methods for evaluating test items.

Unit 2: **(15 Hours)**

Reliability and Validity:
Reliability: definition Methods of determining reliability: Test-retest, Alternate or parallel forms, Split half technique, Rational equivalence. Effect upon reliability of lengthening or repeating or test. Reliability coefficient as a measure of true variance. Estimating true scores by way of regression equation and reliability coefficient. Index of reliability.
Validity: meaning; Estimation of validity; Types of validity: validity and test length; comparison between reliability and validity.

Unit 3: **(15 Hours)**
Test Scores:
Meaning and differences between norm referencing and criterion referencing.
Raw score transformations- percentile scores, standard score, normalised standard scores, T- scores and Stanine scores.
Intelligence: definition. Types of intelligence test scores. Psychological scaling methods- scaling of individual test items in terms of difficulty, scaling of rankings and ratings in terms of the normal probability curve.

PRACTICAL LAB WORK (30 hours)
List of Practical:
1. Computation of reliability by Rulon and Kuder Richardson formulas.
2. Computing reliability of a test whose length is increased/decreased.
3. Computing index of reliability standard error of measurement.
4. Computing validity oblique maximum validity then test length is increased.
5. Computing relative difficulty of questions difference in difficulty between different tests.
6. Problem based on Z scores.
7. Problem based on t scores.
8. Problem based on Stanine scales.
9. Problem based on percentile scores.
10. Computing numerical scores corresponding to grades or ratings.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Anastasia, A. and Urbina, S. (1997) Psychological testing (7th edition), Prentice Hall
- Garrett H.E. (2021), Statistics in Psychology and Education. Nation press.
- Gregory RJ (2016), Psychological testing: History, Principles and Applications. (updated 7th edition) Pearson
- Singh, A.K. (2006)Test, Measurements and Research in Behavioural Sciences Bharati bhavan
- Mangal S.K. (2016) Statistics in Psychology and Education. PHI learning Pvt ltd.

SUGGESTED READINGS:

- Gupta S.C. and Kapoor V.K. (2019) Fundamentals of Applied statistics, Sultan Chand and sons.
- Goon A.M., Gupta M.K. and Dasgupta, B. (2001) Fundamental of Statistics, Volume 2, World Press Pvt ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 5D: RESEARCH METHODOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives:

The learning objectives include

- To provide scientific approaches to develop the domain of human knowledge through empirical studies.
- To enable the student researchers to understand basic concepts and aspects related to research, data collection, analyses, interpretation and report writing.

Learning Outcomes:

After completion of this course, students should have developed a clear understanding of

- Research Methods.
- Research Problems.
- Research Designs.
- Comparative study of different methods of data collection.
- Guidelines for construction of questionnaires.
- Processing and Analysis of data.
- Interpretation and Report writing.

SYLLABUS OF DSE – 5d

Theory

UNIT I **(09 hours)**

Introduction to Research:

Importance and need for research ethics, Objectives of research, Types of research, Research approaches, Review of literature, Mode of literature survey: Books and Monographs, Journals, Conference proceedings, Abstracting and Indexing Journals, E-Journals/Books, Formulation of a research problem, Identifying variables, Constructing hypothesis, Conceptualization of a research design.

UNIT II **(09 hours)**

Methods & Techniques of Data Collection:

Survey methodology and Data collection, Source of data collection-Use of secondary data, Methods of collecting primary data, Develop a questionnaire, Questions and answers in surveys, Non-response, Errors in surveys, Sample size, sampling frames and coverage error.

UNIT III **(15 hours)**

Data Processing & Analysis: Data processing, Exploratory data analysis, Review of various techniques (Parametric and Nonparametric tests, Correlation and Regression analysis, ANOVA, Multivariate Techniques) for data analysis covered in core statistics papers, Techniques of interpretation, Precaution in interpretation.

Report writing: Discussions, Conclusions, Referencing and various formats for reference writing, Bibliography, Thesis writing, Formats of publications in research journals including subject classification, Impact factor, Citation index.

UNIT IV **(12 hours)**

Computer Application:

Data Communication and networks, Website, Webpage, Search Engines, Scientific search engines. Scientific Word Processing with LaTeX and MS-Word, MS Equation editor, Slides making-Power Point Features, Slide preparation, SPSS, Statistical Programming with R, Simulation.

PRACTICAL/LAB WORK – (30 hours)

PROJECT WORK (using a spreadsheet, Scientific Word Processing with LaTeX and MS-Word, MS Equation editor, Slides making-Power Point Features, Slide preparation, SPSS, Statistical Programming with R, Simulation.)

ESSENTIAL READINGS

- Kothari, C.R., Garg, Gaurav (2015): Research Methodology: Methods and Techniques, 3rd Edition (Reprint), New Age International Publishers.
- Kumar, R. (2011): Research Methodology: A Step-by-Step Guide for Beginners, SAGE publications.
- Anderson, J., Durston, B.H., Pooole, M. (1970): Thesis and Assignment Writing, Wiley Eastern. Ltd., New Delhi.
- Braun, J., Duncan, W. and Murdock, J. (2008): A First Course in Statistical Programming with R, Cambridge University Press, London.
- Lamport, L. (1999): LATEX: A Document Preparation System, Addison, Wesley, 2nd Edition, New York.
- Cunningham, B.J. (2012): Using SPSS: An Interactive Hands-On Approach, SAGE South Asia Edition.
- Voss, J. (2014): An Introduction to Statistical Computing: A Simulation-based Approach, Wiley series in computational statistics.

SUGGESTIVE READINGS

- Pannerselvan, R. (2006): Research Methodology, Prentice-Hall of India Pvt., New Delhi.
- Landau, Sabine and Everitt, Brian S. (2004): A Handbook of Statistical Analyses using SPSS, Chapman & Hall/CRC.
- Dalgaard, P. (2008): Introductory Statistics with R, Springer Science, New York.
- Gardener, M. (2012): Beginning R: The Statistical Programming Language, Wiley Publications.
- Robert, C.P. and Casella, G. (2004): Monte Carlo Statistical Methods, Springer Science, New York.
- Rubinstein, R.Y. (1981): Simulation and the Monte Carlo Methods, Wiley.
- Venkataraman, M.K. (1998): Numerical Methods in Science and Engineering, The National Publishing Company, Chennai.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES
OFFERED BY DEPARTMENT OF STATISTICS (Semester-VII)

Category VI

GENERAL ELECTIVE COURSE – 7A: NONPARAMETRIC METHODS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nonparametric Methods	4	3	0	1	Class XII pass with Mathematics	Knowledge of hypothesis testing

Learning Objectives

The learning objectives include:

- Utility of Nonparametric/distribution free tests and its role for different type of data
- Quantile and Empirical distributions and their utility
- Test for randomness, location and scales under nonparametric setup
- Test association of bivariate samples

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Distinguish between parametric and nonparametric test and appreciate different measurement scales.
- Understands quantile and empirical distribution function and its utility.
- Use nonparametric test for both one/two samples problem, Test for randomness, Kolmogorov- Smirnov one sample and two sample tests, sign test, Wilcoxon signed rank test, run test. Median test, Mann Whitney U test, Kruskal-Wallis one-way analysis of variance by ranks.
- Test association of bivariate samples using Kendall Tau and Spearman's rank correlation.

SYLLABUS OF GE-7A

Theory

UNIT I **(15 hours)**

Nonparametric Tests:

Introduction and Concept, Non-parametric tests-their advantages and disadvantages, comparison with parametric tests. Measurement scale-nominal, ordinal, interval and ratio. The quantile function, the empirical distribution function, Test for randomness based on total number of runs.

UNIT II **(15 hours)**

One-Sample, two-sample problem, and Paired-Sample Procedures: the sign test, treatment of ties in rank tests, Wilcoxon signed-rank test, Wald-Wolfowitz runs test, Kolmogorov-Smirnov one and two-sample test, median test, and the Mann-Whitney U test.

UNIT III **(15 hours)**

Linear Rank Tests for the Location and Scale Problem:

Definition of linear rank statistics, Wilcoxon rank-sum test; Tests of the Equality of k Independent Samples: The Kruskal-Wallis one-way ANOVA test; Measures of Association for Bivariate Samples: definition of measures of association in a bivariate population, Kendall's Tau coefficient, Spearman's coefficient of rank correlation.

PRACTICAL/LABWORK(30 hours):

List of Practical

1. Obtaining quantile and Empirical Distribution
2. Test for randomness
3. Sign test
4. Wilcoxon Signed rank test
5. Wald-Wolfowitz runs test,
6. Kolmogorov-Smirnov one sample test,
7. median test and the Mann-Whitney U test.
8. Wilcoxon rank-sum test
9. The Kruskal-Wallis one-way ANOVA test
10. Test based on Kendall's Tau coefficient.
11. Spearman's coefficient of rank correlation

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Gibbons, J. D., and Chakraborti, S. (2020): Nonparametric statistical inference. CRC press.
- Siegel, S. (1956). Nonparametric statistics for the behavioral sciences. McGraw-Hill.

SUGGESTIVE READINGS:

- Kloke, J., and McKean, J. W. (2014) : Nonparametric statistical methods using R. CRC Press.
- Hollander, M., Wolfe, D. A., and Chicken, E. (2013): Nonparametric statistical methods (Vol. 751). John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

GENERAL ELECTIVE COURSE – 7B: INTRODUCTION TO BAYESIAN INFERENCE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction To Bayesian Inference	4	3	0	1	Class XII pass with Mathematics	Knowledge of Probability Distribution and Statistical Inference

Learning Objectives:

The learning objectives of this course is

- To introduce students to the Bayesian approach to statistics
- To make students understand the basic difference between the commonly-taught
- Frequentist approach and the Bayesian Paradigm.
- To demonstrate the benefits of using a Bayesian approach and obtaining results that are
- more interpretable

Learning Outcomes:

After completion of this course, students should have developed a clear understanding of:

- Bayes theorem for random variables
- Prior and posterior distributions
- Conjugate prior
- Non-informative priors
- Bayesian point estimation
- Bayesian Credible intervals
- Bayes factor

SYLLABUS OF GE-7b

Theory

UNIT I: **(5 Hours)**

Bayes Theorem for Random Variables

Revision of some basic distributions; Bayes theorem for events; Bayes theorem for random variables; Concept of likelihood function, prior distribution and posterior distribution.

UNIT II: **(12 Hours)**

Conjugate Prior and Non-Informative Priors

Thumb rule for constructing a conjugate prior; Conjugate families for samples from various standard distributions: Uniform prior; Jeffreys' non-informative priors.

UNIT III: **(15 Hours)**

Bayes Estimation and Credible Interval

Elements of Bayes Decision Theory; Loss Functions; Squared error loss function; Bayes risk; Normal and Extensive form of analysis; Bayesian credible intervals.

UNIT IV: **(13 hours)**

Hypothesis Testing

Prior and posterior odds; Bayes factor for simple versus simple hypothesis; Lindley's procedure for test of significance.

PRACTICAL/LAB WORK: (30 HOURS)

List of Practical

Practical Work based on:

1. Plotting of Prior and posterior distributions for Binomial distribution case.
2. Plotting of Prior and posterior distributions for Poisson distribution case.
3. Bayes Estimation using Normal distribution and Squared error loss function.
4. Bayes Estimation using Binomial distribution and Absolute error loss function.
5. Construction of credible intervals and their comparison with corresponding classical confidence interval for Normal distribution case.
6. Construction of credible intervals and their comparison with corresponding classical confidence interval for Binomial distribution case.
7. Normal Approximation to Posterior Distribution.
8. Construction of HPD credible interval for Normal distribution case.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Barnett, V. (1982). Comparative Statistical Inference, J. Wiley, New York.
- Bansal, A.K. (2007). Bayesian Parametric Inference, Narosa Publishing House.
- Berger, J.O. (1985). Statistical Decision Theory and Bayesian analysis, Second Edition, Springer-Verlag, New York.

SUGGESTED READINGS:

- Box, G.E.P. and Tiao, G.C. (1973). Bayesian Inference in Statistical Analysis, Addison-Wesley.
- Lee, P. M. (1997). Bayesian Statistics: An Introduction, Arnold Press.
- O'Hagan, A. and Forster, J. (2004). Kendall's Advanced theory of Statistics, Volume 2B, Bayesian Inference, Oxford University Press, New York.
- Robert, C.P. (2001). The Bayesian Choice: A Decision Theoretic Foundations to Computational Implementation, Second Edition, Springer-Verlag, New York.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

GENERAL ELECTIVE COURSE – 7C: ELEMENTS OF STOCHASTIC PROCESS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Elements of Stochastic Process	4	3	0	1	Class XII pass with Mathematics.	Basic knowledge of Statistics, Probability theory, and discrete Probability distributions

Learning Objectives:

The learning objectives include:

- Introduce the concept of probability generating function
- To understand transitions through Markov chains
- To identify real-life applications of stochastic processes.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of stochastic processes.
- The basic concepts of probability generating functions and it's applications.
- Tools needed to analyze stochastic processes.
- Markov processes and Markov chains.
- Basic applications of Markov chains.
- Poisson processes and its properties.

SYLLABUS OF GE-7c

Theory

UNIT I **(15 hours)**

Generating functions, probability generating functions and their applications in discrete distributions. Stochastic Process: Parametric space and State space with examples. Covariance Stationary processes.

UNIT II **(15 hours)**

Markov Chains: Definition of Markov Chain, States of Markov chain, transition probability matrix, order of Markov chain, higher transition probabilities of Markov chain.

Classification of States as Transient, Persistent, Null, Non-null, and Ergodic. Reducible and irreducible Markov chains, Stability of Markov system(numerical only).

UNIT III **(15 hours)**

Poisson Process: postulates of Poisson process, properties and applications of Poisson process.

PRACTICAL/LAB WORK – (30 hours)

List of Practicals:

1. Generating probability distributions- Binomial, Poisson and geometric and obtaining their pgfs.
2. Generating sequence of numbers using the given generating function.
3. Computing probability generating function using the given sequence of probabilities and obtaining the mean & variance of the r.v. from the pgf.
4. Extracting probability distributions from the probability generating functions.
5. Examining covariance stationarity of a stochastic process.
6. Constructing the transition probability matrix from the given problem and calculating various probabilities.
7. Computing higher order probabilities from a given t.p.m.
8. Classifying the states of a Markov chain
9. Determining irreducibility of a Markov chain
10. Obtaining stable solution of a Markov chain.
11. Verifying additive property of a Poisson process.
12. Decomposition of a Poisson process.
13. Obtaining the autocorrelation function of a Poisson process.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Medhi, J. (2009). Stochastic Processes, New Age International Publishers.
- Gupta and Kapoor (2020). Fundamentals of Statistics, 12th edition, Sultan Chand and sons.

SUGGESTIVE READINGS:

- Basu, A.K. (2005). Introduction to Stochastic Processes, Narosa Publishing.
- Bhat,B.R. (2000). Stochastic Models: Analysis and Applications, New Age International Publishers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B. Sc. (H) Statistics Semester-VIII

Category I

DISCIPLINE SPECIFIC CORE COURSE-20: BAYESIAN INFERENCE

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title and code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	practicals		
Bayesian Inference	**4**	**3**	**0**	**1**	Class XII pass with Mathematics	Knowledge of Probability Distribution and Statistical Inference

Learning Objectives:

The learning objectives of this course is

- To introduce students to the Bayesian approach to statistics.
- To make students understand the basic difference between the commonly-taught Frequentist approach and the Bayesian Paradigm.
- To demonstrate the benefits of using a Bayesian approach and obtaining results that are more interpretable.

Learning Outcomes:

After completion of this course, students should have developed a clear understanding of:

- Bayes theorem for random variables
- Prior and posterior distributions
- Conjugate prior
- Non-informative priors
- Bayesian point estimation
- Bayesian Credible intervals
- Bayes factor

SYLLABUS OF DSC-20

Theory

UNIT I **(5 Hours)**

Bayes Theorem for Random Variables

Concept of inverse probability; Bayes theorem for random variables; Concept of likelihood function, prior distribution and posterior distribution.

UNIT II **(12 Hours)**

Conjugate Prior and Non-Informative Priors

Thumb rule for constructing a conjugate prior; Conjugate families for samples from various standard distributions; Uniform prior; Jeffreys' non-informative priors; Normal approximations to posterior distribution.

UNIT III **(15 Hours)**

Bayes Estimation and Credible Interval

Elements of Bayes Decision Theory; Loss Functions such as Squared error loss function, Bilinear loss function; Bayes risk; Normal and Extensive form of analysis; Duality between loss and prior; Generalised maximum likelihood estimate; Bayesian credible intervals; Difference between Bayesian credible intervals and classical confidence intervals; Application in linear regression model.

UNIT IV **(13 hours)**

Hypothesis Testing

Prior and posterior odds; Bayes factor for simple versus simple hypothesis; Bayes factor for composite versus composite hypothesis; Lindley's procedure for test of significance.

PRACTICAL / LAB WORK – 30 Hours

List of Practicals:

1. Plotting of Prior and posterior distributions for Binomial distribution case.
2. Plotting of Prior and posterior distributions for Poisson distribution case.
3. Bayes Estimation using Normal distribution and Squared error loss function.
4. Bayes Estimation using Binomial distribution and Absolute error loss function.
5. Construction of credible intervals and their comparison with corresponding classical confidence interval for Normal distribution case.
6. Construction of credible intervals and their comparison with corresponding classical confidence interval for Binomial distribution case.
7. Normal Approximation to Posterior Distribution.
8. Construction of HPD credible interval for Normal case.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Bansal, A.K. (2007). Bayesian Parametric Inference, Narosa Publishing House.
- Barnett, V. (1982). Comparative Statistical Inference, J. Wiley, New York.
- Berger, J.O. (1985). Statistical Decision Theory and Bayesian analysis, Second Edition, Springer-Verlag, New York.

SUGGESTED READINGS:

- Box, G.E.P. and Tiao, G.C. (1973). Bayesian Inference in Statistical Analysis, Addison-Wesley.
- Lee, P. M. (1997). Bayesian Statistics: An Introduction, Arnold Press.
- O'Hagan, A. and Forster, J. (2004). Kendall's Advanced theory of Statistics, Volume 2B, Bayesian Inference, Oxford University Press, New York.
- Robert, C.P. (2001). The Bayesian Choice: A Decision Theoretic Foundations to Computational Implementation, Second Edition, Springer-Verlag, New York.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Discipline Specific Elective for B. Sc. (H) Statistics Semester-VIII

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6A: NON-PARAMETRIC TESTING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nonparametric Testing	4	3	0	1	Class XII pass with Mathematics	Knowledge of Hypothesis testing

Learning Objectives

The learning objectives include:

- Usefulness of Nonparametric/distribution free tests their strength and weaknesses
- Quantile and Empirical distributions and their utility
- Test for randomness, location and scales under nonparametric setup
- Test association of bivariate samples

Learning Outcomes

After completing this course, students should have developed a clear understanding of:

- Make distinction between Parametric and Nonparametric test and measurement scales.
- Appreciate the role of quantile and empirical distribution function and associated tests.
- Identify suitable nonparametric test for both location and scale and able to apply one/two tests including Kolmogorov- Smirnov one sample and two sample tests, sign test, Wilcoxon signed rank test, run test. Median test, Kruskal-Wallis one-way analysis of variance by ranks, Friedman two way analysis of variance by ranks.

- Test association of bivariate samples using Kendall tau and Spearman's rank correlation.

SYLLABUS OF DSE-6A

Theory

UNIT I **(15 hours)**

Introduction

Nonparametric Tests: Non-parametric tests-their advantages and disadvantages, comparison with parametric tests. Measurement scale-nominal, ordinal, interval and ratio. The quantile function, the empirical distribution function, Glivenko Cantelli Theorem (without proof), Kolmogorov Goodness of fit test, confidence interval for a population quantile, hypothesis testing for a population quantile.

UNIT II **(15 hours)**

One sample and two sample tests

One-Sample, two-sample problem and Paired-Sample Procedures: the sign test and confidence interval for the median, rank-order statistics, treatment of ties in rank tests, Wilcoxon signed-rank test, confidence interval, Wald-Wolfowitz runs test, Kolmogorov-Smirnov one and two-sample test, median test and the Mann-Whitney U test.

UNIT III **(15 hours)**

K sample tests

Linear Rank Tests for the Location and Scale Problem: Definition of linear rank statistics, Wilcoxon rank-sum test; Tests of the Equality of k Independent Samples: The Kruskal-Wallis one-way ANOVA test and multiple comparisons.; Measures of Association for Bivariate Samples: definition of measures of association in a bivariate population, Kendall's Tau coefficient, Spearman's coefficient of rank correlation.

PRACTICAL/LAB WORK (30 hours):

List of Practical:

1. Obtaining quantile and Empirical Distribution
2. Test for randomness
3. Sign test
4. Wilcoxon Signed rank test
5. Wald-Wolfowitz runs test,
6. Kolmogorov-Smirnov one and two-sample test,
7. median test and the Mann-Whitney U test.
8. Wilcoxon rank-sum test
9. The Kruskal-Wallis one-way ANOVA test
10. Test based on Kendall's Tau coefficient.
11. Spearman's coefficient of rank correlation

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Gibbons, J. D., and Chakraborti, S. (2020): Nonparametric statistical inference. CRC press.
- Siegel, S. (1956). Nonparametric statistics for the behavioral sciences. McGraw-Hill.

SUGGESTIVE READINGS:

- Kloke, J., and McKean, J. W. (2014) : Nonparametric statistical methods using R. CRC Press.
- Hollander, M., Wolfe, D. A., and Chicken, E. (2013): Nonparametric statistical methods (Vol. 751). John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6B: RELIABILITY THEORY AND LIFE TESTING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reliability Theory And Life Testing	4	3	0	1	Class XII pass with Mathematics	Knowledge of Probability Distribution and Statistical Inference

Learning Objectives

The learning objectives include:

- To understand the reliability and their application area.
- To develop the thinking of students so that they can use the concepts of reliability in real life scenario.
- To determine if the performance of components, equipment, and systems, either under closely controlled and known stress conditions in a testing laboratory or under field use conditions.
- To determine the growth in the mean life and/or the reliability of units during their research, engineering and development phase.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Concept of Reliability and life testing.
- Various estimation procedures of reliability function(s).

- Comparison of various estimates of reliability through simulation study using different software.
- Real data fitting in reliability modelling

SYLLABUS OF DSE-6B

THEORY

UNIT I **(12 hours)**

Reliability and reliability measures

Definition of components and systems, coherent systems, Reliability, Maintainability and Availability; Lifetime distributions, failure rates, MTTF, Bathtub failure rate, reliability of coherent systems in terms of paths and cuts, modular decomposition, reliability importance of components; Parametric families of some common lifetime distributions and their properties (Exponential, Weibull and Gamma).

UNIT II **(10 hours)**

Reliability estimation

Various methods of reliability estimation (Classical and Bayesian);Exponential, Weibull and Gamma lifetime distributions, Reliability estimation under complete, truncated and censored samples, estimates based on components of ordered statistics.

UNIT III **(10 hours)**

Stress-Strength and multicomponent reliability

Stress-Strength reliability: concepts and its estimation for exponential, Weibull and gammadistributions, k-out-of-n (exponential and gamma). Mixture distribution, convolutions and competing risks: introduction, mixture of exponentials, mixture of Weibull, competing risk.Bayesian Approximation and Reliability: Lindley's expansion, reliability estimation (Normal and Weibull)

UNIT IV **(13 hours)**

Reliability systems and life testing

Reliability of series/parallel systems: introduction, series systems with identical components. Reliability bounds (classical and Bayesian approaches), parallel systems.Different types of redundancy and use of redundancy in reliability improvement. Problems of life testing.Notions of Ageing: IFR, IFRA, NBU, DMRL, NBUE and HNBUE classes, their duals and relationship between them.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Calculation of reliability function and its estimates
2. Calculation of hazard rate, MTBF for various systems.
3. Calculation of stress-strength reliability and its estimates.
4. Various reliability and hazard rate plots.
5. Validation of reliability estimates through simulation study.
6. Behavior of reliability estimates corresponding to sample size.
7. Behavior of hazard rates corresponding to different values of parameter(s).
8. Effect of different sample sizes on reliability estimates.
9. Comparison of various methods of estimation of reliability through simulation study.

10. Other relevant problems.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Balagurusamy (2017): Reliability Engineering; Wiley
- Sinha, S.K. (1986): Reliability and Life testing; Wiley Eastern.

SUGGESTIVE READINGS:

- Barlow, R.E. and Proschan F. (1985): Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.
- Lawless, J.F. (2003): Statistical Models and Methods of Life Time Data; John Wiley.
- Bain L.J. and Max Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.
- Nelson, W (2003): Applied Life Data Analysis; John Wiley.
- Rand M and Hoyland A (2004): System reliability theory, Models, Statistical methods and itsapplications;Wiley.
- Zacks, S(1992): Introdcution to Reliability Analysis, Springer Verlag

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE-6C: GENERALIZED LINEAR MODELS

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	tutorials	practical		
Generalized Linear Models	**4**	**3**	**0**	**1**	Class XII pass with Mathematics	Knowledge of general linear models

Learning Objectives:

learning objectives include:

- Provide the ability to learn and use linear and non-linear models for normal data
- Developing ability to learn generalized linear models for normal and non-normal responses.

Learning Outcomes:

After completion of this course, students should have developed a clear understanding of:

- Use linear and Non-linear models, apply data transformations, and appreciate the need and uses of generalized linear models.
- Use logistic and Poisson regression models.
- Understand deviance, analysis of deviance, Lack-of-Fit tests in Logistic and Poisson regression, and the concept of overdispersion.
- Use Log linear models for contingency tables, and likelihood ratio tests for various hypotheses including independence, marginal and conditional independence, and partial association.
- Understand graphical and non-graphical models.
- Use the concepts of Generalized Linear Models in real life problems.

SYLLABUS OF DSE-6C

UNIT I **(11 Hours)**

Nonlinear Regression Models

Review of linear regression models, Nonlinear regression models, Origins of Nonlinear Models, Transforming to a Linear Model, Estimation of parameters and Statistical Inferences in nonlinear regression.

UNIT II **(12 Hours)**

Logistic regression models

Logistic regression models, Estimation of parameters, Statistical Inferences on model parameters, Confidence Intervals, Lack-of-Fit tests, and Diagnostic checking in Logistic regression.

UNIT III **(12 Hours)**

Poisson Regression Models

Poisson regression models, Estimation of parameters in Poisson regression, Applications in Poisson regressions. Overdispersion in Logistic and Poisson regression models. Link function.

UNIT IV **(10 Hours)**

Log-Linear Models

Log-linear models for contingency tables: interpretation of parameters, Estimation of parameters, likelihood ratio tests for various hypotheses, Graphical and decomposable models.

PRACTICAL/LABWORK -30 Hours

List of Practicals

1. Fitting of non-linear regression model.
2. Fitting of logistic regression model.
3. Tests of hypotheses about parameters.
4. Analysis of deviance.
5. Lack-of-Fit tests in Logistic regression.

6. Fitting of Poisson regression model.
7. Log-linear models for contingency tables.
8. Tests for independence,
9. Tests for marginal and conditional independence,
10. Tests for partial association.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Dobson, A.J. and Barnett, A.G. (2018): Introduction to Generalized Linear Models, 4th ed., Chapman and Hall/CRC. London.
- Myers, R.H., Montgomery, D.C., Vining, G.G. and Robinson, T.J. (2010): Generalized Linear Models with Applications in Engineering and the Sciences, 2nd ed., John Wiley & Sons.

SUGGESTED READINGS:

- McCullagh, P. and Nelder, J.A. (1989): Generalized Linear Models, 2nd ed., Chapman and Hall.
- Montgomery, D. C., Peck, E. A. and Vining, G. G. (2012): Introduction to Linear Regression Analysis, 5th Ed., John Wiley and Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6D: ADVANCED STOCHASTIC PROCESSES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Stochastic Processes	4	3	0	1	Class XII pass with Mathematics.	Advanced knowledge of Probability theory and Probability distributions

Learning Objectives:

The learning objectives include:

- To define, design and build stochastic models
- To model and analyze transitions through Markov chains
- To identify the real life applications of stochastic processes.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Tools needed to analyze stochastic processes.
- Markov chain applications.
- Concept of population growth and extinction of population with Branching Process.
- Recurrence of events based on renewal theory.
- Poisson processes and their applications in Birth and Death models.
- Queuing models and their applications

SYLLABUS OF DSE-6d

Theory

UNIT I **(13 hours)**

Determination Of Higher Transition Probabilities, Aperiodic Chain: Limiting Behaviour, Graph Theoretic Approach, Finite Reducible Chains with a Single non- trivial Closed Class

UNIT II **(15 hours)**

Concept of Characteristic functions, Laplace, and Inverse Laplace Transformations.
Branching Process , properties of generating functions of branching processes, probability of ultimate extinction, and its application.
Renewal Processes in Discrete Time, Relation Between F(s) and P(s) and Renewal Interval.

UNIT III **(12 hours)**

Pure Birth Process, Pure Death Process, Birth And Death Process, Linear Growth Models, Queueing Processes, Steady State Distribution, Little's Formula, Poisson Queuing Models M/M/1: GD/∞/∞ and its characteristics, waiting time distribution under this model, M/M/1: GD/N/∞ and characteristics, Average system length, Average queue length, M/M/C: GD/∞/∞ and its characteristics average queue length, average system length, average waiting time, and problems based on all three models.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Simulation of Markov chains.
2. Calculation of higher transition probability matrices.
3. To check whether the given chain is irreducible or not using the concept of stationarity
4. Classification of states.
5. Extinction of population under GW branching Process.
6. Problems based on Renewal theory.
7. Simulation and applications of Poisson processes.
8. Generate the Yule-Furry process and verify that the process follows a geometric distribution.
9. Mean size of population and probability of extinction under linear growth process.
10. Computation of expected customers in the system and expected queue length under (M/M/1);(GD/∞/∞) queuing system.
11. Computation of the Average length of a non-empty queue and the fluctuation (variance) of the number of customers in the system under (M/M/1);(GD/∞/∞) queuing system.
12. Computation of expected number of customers in the system and expected queue length under (M/M/1);(GD/N/∞) queuing system.
13. Computation of expected number of customers in the system and expected queue length under (M/M/C);(GD/N/∞) queuing system .

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Feller, W. (1968). Introduction to probability Theory and Its Applications, Vol I, 3rd Ed., Wiley International.
- Medhi, J. (2009). Stochastic Processes, New Age International Publishers.
- Sheldon M. Ross (2007) : Introduction to Probability Models, 9th edition, Academic Press publications
- Karlin & Taylor (1975) : A first course in stochastic processes, 2nd edition, Academic Press publications

SUGGESTIVE READINGS:

- Basu, A.K. (2005). Introduction to Stochastic Processes, Narosa Publishing.
- P. G. Hoel, S. C. Port and C. J. Stone: Introduction to Stochastic Processes.
- J. G. Kemeny, J. L. Snell and A. W. Knapp: Finite Markov Chains.
- Geoffrey R, Grimmett & David R. Stirzaker : Probability and Random Processes

Bhat,B.R. (2000). Stochastic Models: Analysis and Applications, New Age International Publishers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B.A(Prog) with Statistics as Non-Major/Major Semester-VIII

Category II

DISCIPLINE SPECIFIC CORE COURSE –8: FUNDAMENTALS OF ECONOMETRICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Fundamentals of Econometrics	4	3	0	1	Class XII pass with Mathematics	knowledge of sampling distributions

Learning Objectives

The learning objectives include:

- Interpretation and critical evaluation of the outcomes of empirical analysis.
- To judge the validity of the economic theories
- To carry out evaluation of economic theories in numerical terms
- To extract useful information about important economic policy issues from the available data.
- The course is designed to provide the students with the basic quantitative techniques needed to undertake applied research projects.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of econometrics.
- Specification of the model.
- Simple Linear Regression.
- Multiple Linear Regression.
- Multicollinearity.
- Heteroscedasticity.
- Autocorrelation.

SYLLABUS OF DSC-8

Theory

UNIT I **(15 hours)**

Introduction

Nature and Scope of Econometrics: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, interpretation of regression, nature and sources of data for econometric analysis, different measurement scales of variables

UNIT II (15 hours)

Regression Models

Simple and Multiple Linear Regression Model: Estimation of model by method of ordinary least squares(OLS), properties of estimators, goodness of fit, tests of hypotheses, confidence intervals, coefficient of determination, Gauss-Markov theorem and forecasting.

UNIT III (5 hours)

Autocorrelation

Autocorrelation: Concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

UNIT IV (10 hours)

Multicollinearity and Heteroscedasticity

Violations of Classical Assumptions: Multicollinearity- Concept, Consequences, Detection and Remedies. Heteroscedasticity and serial correlation– Concept and Consequences.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Problems based on estimation of simple linear model.
2. Testing of parameters of simple linear model.
3. Multiple Regression.
4. Problems concerning specification errors.
5. Problems related to consequences of Multicollinearity.
6. Diagnostics of Multicollinearity.
7. Problems related to consequences Heteroscedasticity.
8. Diagnostics of Heteroscedasticity.
9. Estimation of problems of General linear model under Heteroscedastic distance terms.
10. Problems related to selection of best regression model.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Gujarati, D. and Guneshker, S. (2007). Basic Econometrics, 4th Ed., McGraw Hill Companies.
- Johnston, J. (1972). Econometric Methods, 2nd Ed., McGraw Hill International.

SUGGESTIVE READINGS:

- Koutsoyiannis, A. (2004). Theory of Econometrics, 2 Ed., Palgrave Macmillan Limited.

- Maddala, G.S. and Lahiri, K. (2009). Introduction to Econometrics, 4 Ed., John Wiley & Sons.
- Greene, W. H. (2002) Econometric Analysis.5th Edition, Prentice Hall.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Discipline Specific Elective for B.A. (Prog) with Statistics as Non-Major/Major Semester-VIII

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6A: INTRODUCTION TO NON-PARAMETRIC METHODS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Non-Parametric Methods	4	3	0	1	Class XII pass with Mathematics	Knowledge of elementary Statistical Inference

Learning Objectives

learning objectives include:

- To understand the basic principles and concepts of non-parametric statistics.
- To learn the different types of non-parametric statistical tests and their applications.

Learning Outcomes:

After completion of this course, students should have developed a clear understanding of:

- Develop an understanding of the differences between parametric and non-parametric statistical tests and their advantages and disadvantages.
- Be able to apply and interpret the results of various non-parametric tests for hypothesis testing, goodness-of-fit testing, testing for randomness, and measuring the association between variables.

SYLLABUS OF DSE-6A

Theory

UNIT I **(11 hours)**

Introduction

Introduction: Definition of non-parametric statistics, Various scales of measurements – the Nominal or categorical scale, the Ordinal or ranking scale, the interval scale and the ratio scale. The differences between parametric and non-parametric statistical tests. Advantages and disadvantages of non-parametric statistical tests.

UNIT II (15 hours)

One Sample Tests

One-Sample Tests: Chi-Square Goodness of Fit Test for testing whether a sample comes from a specific distribution; Kolmogorov-Smirnov Test for goodness of fit, One Sample Runs Test for Randomness to test for independence of the order of observations in the sequence. Testing the difference between the median of a sample and a hypothesized value: Sign Test, Wilcoxon Signed-Rank Test.

UNIT III (19 hours)

K Sample Tests

Two-Sample Tests: Whether two samples come from the same continuous distribution-Wald-Wolfowitz Runs test, Kolmogorov-Smirnov test. Test for the difference between the medians of two independent samples - Median Test, Mann-Whitney U Test. Comparison of medians of *k* independent samples - Kruskal-Wallis one-way analysis of variance by ranks. Measure of association between two variables - Spearman Rank-Order correlation coefficient and significance.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

Practicals based on

1. Chi-Square Goodness of Fit Test
2. Kolmogorov-Smirnov One Sample Test
3. One Sample Runs Test for Randomness
4. Sign Test
5. Wilcoxon Signed-Rank Test.
6. Wald-Wolfowitz Runs Test
7. Kolmogorov-Smirnov Two-Sample Test
8. Median Test
9. Wilcoxon-Mann-Whitney U Test
10. Kruskal-Wallis one-way analysis of variance by ranks
11. Spearman Rank-Order correlation coefficient

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Gun, A. M., Gupta, M. K., & Dasgupta, B. (2013). An outline of statistical theory. World Press Pvt Limited.
- Siegel, Sidney, and N. John Jr. "Castellan. 1988. Nonparametric Statistics for the Behavioral Sciences." New York (6).
- Gibbons, J. D., & Chakraborti, S. (2014). Nonparametric statistical inference. CRC press.

SUGGESTIVE READINGS:

- Sprent, P., & Smeeton, N. C. (2016). *Applied nonparametric statistical methods*. CRC press.
- Sheskin, D. J. (2011). Handbook of parametric and nonparametric statistical procedures, CRC Press. Boca Raton, FL.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6B: RELIABILITY THEORY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reliability Theory	4	3	0	1	Class XII pass with Mathematics	knowledge of probability distributions

Learning Objectives

The learning objectives include:

- To describe the theoretical aspects of reliability along with their application area.
- To determine the growth in the mean life and/or the reliability of units during their research, engineering and development phase.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Concept of Reliability, Maintainability and Availability.
- Various estimation procedures of reliability function(s).
- Calculate the Reliability of series and parallel systems.

SYLLABUS OF DSE-6B

Theory

UNIT I **(10 hours)**

Reliability measures

Definition of Components, systems and coherent systems. Reliability functions, hazard rate function, reverse hazard rate function, residual lifetime, inactivity time, mean residual lifetime function, mean inactivity time, reliability bounds, cut and path sets.

UNIT II **(08 hours)**

Common lifetime distributions

Common lifetime distributions and their properties (Exponential, Weibull and Gamma), scale model, proportional hazard rate model, proportional reverse hazard rate model, MTTF, Bathtub failure rate, reliability importance of components.

UNIT III **(12 hours)**

Estimation of reliability functions

Various methods of reliability estimation (Classical); of some common lifetime distributions, Reliability estimation under complete and various censored samples. Stress-Strength reliability: concepts and its estimation for exponential and Weibull, k-out-of-n (exponential) and its application.

UNIT IV **(15 hours)**

Reliability systems and ageing

Reliability of series/parallel systems: introduction, series systems with identical components. Different types of redundancy. Notions of Ageing: Different ageing classes, ageing properties of common lifetime distributions, closure properties of different ageing classes under formation of coherent structures.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

Practical based on

1. Calculation of reliability function and its estimates
2. Calculation of hazard rate for various models.
3. Calculation of stress-strength reliability.
4. Various reliability and hazard rate plots.
5. Behavior of reliability estimates corresponding to sample size.
6. Practicals on ageing.
7. Other relevant problems.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Sinha, S.K. (1986): Reliability and Life testing; Wiley Eastern.

SUGGESTIVE READINGS:

- Barlow, R.E. and Proschan F. (1985): Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.
- Lawless, J.F. (2003): Statistical Models and Methods of Life Time Data; John Wiley.
- Bain L.J. and Max Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6C: MULTIVARIATE DATA ANALYSIS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Multivariate Data Analysis	4	3	0	1	Class XII pass with Mathematics	knowledge of sampling distributions

Learning Objectives

The learning objectives include:

- To study the concept of Bivariate Normal Distribution along with their properties.
- To study the concept of Multivariate Normal Distribution along with their properties and analysis of multivariate data.
- Concepts of regression plane, multiple and partial correlation coefficients.
- Applications of discriminant analysis, principal component analysis and factor analysis.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The basic concepts associated with Multivariate Normal Distributions and their properties with special emphasis on Bivariate Normal Distribution.
- The understanding of regression plane, multiple and partial correlation coefficients.
- Analysing multivariate data using data reduction techniques like principal component analysis, factor analysis.
- Classification method namely discriminant analysis.

SYLLABUS OF DSE-6C

Theory

UNIT 1 **(16 hours)**

Bivariate Normal Distribution:

Probability density function of Bivariate Normal Distribution. Moment generating function, marginal, conditional pdf of BVN and properties of BVN. Introduction of random vector, probability mass/ density functions, distribution function, mean vector and dispersion matrix. Marginal and conditional distributions of random vector.

UNIT 2 **(16 hours)**

Multivariate Normal distribution:

Probability density function and properties of Multivariate Normal distribution. Moment generating function, marginal and conditional pdf of MVN. Sampling distribution for mean vector and variance-covariance matrix. Regression plane, multiple and partial correlation coefficient and their properties.

UNIT 3 **(13 hours)**

Data Analysis

Data Reduction Techniques: Principal component analysis and its applications, Factor analysis and its applications. Discriminant analysis and its applications.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

Practicals based on

1. Bivariate Normal Distribution and its properties.
2. Mean vector and dispersion matrix of Multivariate Normal Distribution.
3. Marginal distributions of Multivariate Normal Distribution.
4. Conditional distributions of Multivariate Normal Distribution.
5. Regression space.
6. Partial Correlation Coefficient.
7. Multiple Correlation Coefficient.
8. Principal Component Analysis.
9. Discriminant analysis.
10. Factor Analysis.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Anderson, T.W. (2003). *An Introduction to Multivariate Statistical Analysis*, 3rd Ed., John Wiley & Sons.
- Johnson, R.A. and Wichern, D.W. (2007). *Applied Multivariate Analysis*, 6th Ed., Prentice Hall.
- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2005). *An Outline of Statistical Theory*, Volume II, World Press.
- Brian S. Everett and Graham Dunn. (2001). *Applied multivariate data analysis*, second edition, Oxford University Press.

SUGGESTED READINGS

- S.C. Gupta and V.K. Kapoor (2020). *Fundamentals of Mathematical Statistics*, 12th Ed., Sultan Chand and Sons.
- Kshirsagar, A.M. (1972). *Multivariate Analysis*, 1st Ed., Marcel Dekker.
- Muirhead, R.J. (1982). *Aspects of Multivariate Statistical Theory*, John Wiley.
- Arora, S. and Bansi, L. (1968). *New Mathematical Statistics*, 1st Ed., Vanita Printers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6D: STATISTICAL SIMULATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Simulation	4	3	0	1	Class XII pass with Mathematics	knowledge of basic statistics

Learning Objectives

The learning objectives include:

- Concept of simulation and simulation modelling.
- Generation of Pseudo random number generators as well as from standard statisticaldistributions. Monte-Carlo simulation technique.
- Application of simulation techniques.

Learning Outcomes

After completing this course, students will possess skills concerning:

- How simulation may be used to understand the behavior of real world systems by utilizing mathematical models with an emphasis on simulation.
- How to generate random numbers by the different methods.
- Hands-on experience in using simulation software packages/structured programming languages.

SYLLABUS OF DSE- 6D

Theory

Unit I **(12 Hours)**

Introduction to simulation:

Introduction, Definitions of simulation, Need for simulation, general principles, types of simulation, Simulation models, Phases in simulation models, Event type simulation, Monte Carlo simulation technique.

Unit II **(18 Hours)**

Random numbers generation:

Methods for the generation of Random numbers, Pseudo random number generators, Mid square method for the generation of random number and its limitations, the inverse transform method; Generating the Discrete and Continuous random variables.

Unit III **(15 Hours)**

Applications of simulation:

Applications of simulation in different fields of study, simulation of Inventory problems and simulation of Queueing problems. Advantages and disadvantages of simulation, Simulation languages, Scope of simulation techniques.

Practical/Lab Work–(30 hours)

List of Practical:

1. Pseudo random number generators;
2. Generation of U(0,1).
3. Generation using the inverse transform method applied to:
4. Discrete distribution and
5. Continuous distribution.
6. Monte Carlo simulation method and applications.
7. Problems based on Queueing systems.
8. Problems based on Inventory Controls, etc.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READING:

- Sheldon M. Ross (2022) *Simulation, Sixth Edition,* Elsevier Academic press publication.
- Taha, H. A. (2010). *Operations Research. An Introduction*, 9th Ed, Pearson.
- Swarup, K. Gupta, P.K. and Mohan, M. (2019). *Operations Research, 15th Ed,* Sultan Chand & Sons.

SUGGESTED READINGS:

- Voss, J. (2013). *An introduction to statistical computing: A simulation-based approach,* 1st Ed., Wiley series in computational statistics.
- Sharma, J. K. (2017). *Operations Research: Theory and applications, 6th Edition,* Trinity Press.
- Payer T.A. (1982). *Introduction to simulation,* McGraw Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

B.Sc. (Prog) Mathematical Sciences with Statistics Semester-VIII

Category II

DISCIPLINE SPECIFIC CORE COURSE –8: FUNDAMENTALS OF ECONOMETRICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Fundamentals of Econometrics	4	3	0	1	Class XII pass with Mathematics	knowledge of sampling distributions

Learning Objectives

The learning objectives include:

- Interpretation and critical evaluation of the outcomes of empirical analysis.
- To judge the validity of the economic theories
- To carry out evaluation of economic theories in numerical terms
- To extract useful information about important economic policy issues from the available data.
- The course is designed to provide the students with the basic quantitative techniques needed to undertake applied research projects.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of econometrics.
- Specification of the model.
- Simple Linear Regression.
- Multiple Linear Regression.
- Multicollinearity.
- Heteroscedasticity.
- Autocorrelation.

SYLLABUS OF DSC-8

Theory

UNIT I **(15 hours)**

Introduction

Nature and Scope of Econometrics: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, interpretation of regression, nature and sources of data for econometric analysis, different measurement scales of variables

UNIT II (15 hours)

Regression Models

Simple and Multiple Linear Regression Model: Estimation of model by method of ordinary least squares(OLS), properties of estimators, goodness of fit, tests of hypotheses, confidence intervals, coefficient of determination, Gauss-Markov theorem and forecasting.

UNIT III (5 hours)

Autocorrelation

Autocorrelation: Concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

UNIT IV (10 hours)

Multicollinearity and Heteroscedasticity

Violations of Classical Assumptions: Multicollinearity- Concept, Consequences, Detection and Remedies. Heteroscedasticity and serial correlation– Concept and Consequences.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Problems based on estimation of simple linear model.
2. Testing of parameters of simple linear model.
3. Multiple Regression.
4. Problems concerning specification errors.
5. Problems related to consequences of Multicollinearity.
6. Diagnostics of Multicollinearity.
7. Problems related to consequences Heteroscedasticity.
8. Diagnostics of Heteroscedasticity.
9. Estimation of problems of General linear model under Heteroscedastic distance terms.
10. Problems related to selection of best regression model.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Gujarati, D. and Guneshker, S. (2007). Basic Econometrics, 4th Ed., McGraw Hill Companies.
- Johnston, J. (1972). Econometric Methods, 2nd Ed., McGraw Hill International.

SUGGESTIVE READINGS:

- Koutsoyiannis, A. (2004). Theory of Econometrics, 2 Ed., Palgrave Macmillan Limited.

- Maddala, G.S. and Lahiri, K. (2009). Introduction to Econometrics, 4 Ed., John Wiley & Sons.
- Greene, W. H. (2002) Econometric Analysis.5th Edition, Prentice Hall.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

Discipline Specific Elective for B.Sc. (Prog) Mathematical Sciences with Statistics Semester-VIII

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6A: INTRODUCTION TO NON-PARAMETRIC METHODS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Non-Parametric Methods	4	3	0	1	Class XII pass with Mathematics	Knowledge of elementary Statistical Inference

Learning Objectives

learning objectives include:

- To understand the basic principles and concepts of non-parametric statistics.
- To learn the different types of non-parametric statistical tests and their applications.

Learning Outcomes:

After completion of this course, students should have developed a clear understanding of:

- Develop an understanding of the differences between parametric and non-parametric statistical tests and their advantages and disadvantages.
- Be able to apply and interpret the results of various non-parametric tests for hypothesis testing, goodness-of-fit testing, testing for randomness, and measuring the association between variables.

SYLLABUS OF DSE-6A

Theory

UNIT I **(11 hours)**

Introduction

Introduction: Definition of non-parametric statistics, Various scales of measurements – the Nominal or categorical scale, the Ordinal or ranking scale, the interval scale and the ratio scale. The differences between parametric and non-parametric statistical tests. Advantages and disadvantages of non-parametric statistical tests.

UNIT II **(15 hours)**

One Sample Tests

One-Sample Tests: Chi-Square Goodness of Fit Test for testing whether a sample comes from a specific distribution; Kolmogorov-Smirnov Test for goodness of fit, One Sample Runs Test for Randomness to test for independence of the order of observations in the sequence. Testing the difference between the median of a sample and a hypothesized value: Sign Test, Wilcoxon Signed-Rank Test.

UNIT III **(19 hours)**

K Sample Tests

Two-Sample Tests: Whether two samples come from the same continuous distribution-Wald-Wolfowitz Runs test, Kolmogorov-Smirnov test. Test for the difference between the medians of two independent samples - Median Test, Mann-Whitney U Test. Comparison of medians of *k* independent samples - Kruskal-Wallis one-way analysis of variance by ranks. Measure of association between two variables - Spearman Rank-Order correlation coefficient and significance.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

Practicals based on

1. Chi-Square Goodness of Fit Test
2. Kolmogorov-Smirnov One Sample Test
3. One Sample Runs Test for Randomness
4. Sign Test
5. Wilcoxon Signed-Rank Test.
6. Wald-Wolfowitz Runs Test
7. Kolmogorov-Smirnov Two-Sample Test
8. Median Test
9. Wilcoxon-Mann-Whitney U Test
10. Kruskal-Wallis one-way analysis of variance by ranks
11. Spearman Rank-Order correlation coefficient

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Gun, A. M., Gupta, M. K., & Dasgupta, B. (2013). An outline of statistical theory. World Press Pvt Limited.
- Siegel, Sidney, and N. John Jr. "Castellan. 1988. Nonparametric Statistics for the Behavioral Sciences." New York (6).
- Gibbons, J. D., & Chakraborti, S. (2014). Nonparametric statistical inference. CRC press.

SUGGESTIVE READINGS:

- Sprent, P., & Smeeton, N. C. (2016). *Applied nonparametric statistical methods*. CRC press.
- Sheskin, D. J. (2011). Handbook of parametric and nonparametric statistical procedures, CRC Press. Boca Raton, FL.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6B: RELIABILITY THEORY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reliability Theory	4	3	0	1	Class XII pass with Mathematics	knowledge of probability distributions

Learning Objectives

The learning objectives include:

- To describe the theoretical aspects of reliability along with their application area.
- To determine the growth in the mean life and/or the reliability of units during their research, engineering and development phase.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Concept of Reliability, Maintainability and Availability.
- Various estimation procedures of reliability function(s).
- Calculate the Reliabilityg of series and parallel systems.

SYLLABUS OF DSE-6B

Theory

UNIT I **(10 hours)**

Reliability measures

Definition of Components, systems and coherent systems. Reliability functions, hazard rate function, reverse hazard rate function, residual lifetime, inactivity time, mean residual lifetime function, mean inactivity time, reliability bounds, cut and path sets.

UNIT II **(08 hours)**

Common lifetime distributions

Common lifetime distributions and their properties (Exponential, Weibull and Gamma), scale model, proportional hazard rate model, proportional reverse hazard rate model, MTTF, Bathtub failure rate, reliability importance of components.

UNIT III **(12 hours)**

Estimation of reliability functions

Various methods of reliability estimation (Classical); of some common lifetime distributions, Reliability estimation under complete and various censored samples. Stress-Strength reliability: concepts and its estimation for exponential and Weibull, k-out-of-n (exponential) and its application.

UNIT IV **(15 hours)**

Reliability systems and ageing

Reliability of series/parallel systems: introduction, series systems with identical components. Different types of redundancy. Notions of Ageing: Different ageing classes, ageing properties of common lifetime distributions, closure properties of different ageing classes under formation of coherent structures.

PRACTICAL/LAB WORK – (30 hours)
List of Practical:

Practical based on
1. Calculation of reliability function and its estimates
2. Calculation of hazard rate for various models.
3. Calculation of stress-strength reliability.
4. Various reliability and hazard rate plots.
5. Behavior of reliability estimates corresponding to sample size.
6. Practicals on ageing.
7. Other relevant problems.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Sinha, S.K. (1986): Reliability and Life testing; Wiley Eastern.

SUGGESTIVE READINGS:

- Barlow, R.E. and Proschan F. (1985): Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.

- Lawless, J.F. (2003): Statistical Models and Methods of Life Time Data; John Wiley.
- Bain L.J. and Max Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6C: MULTIVARIATE DATA ANALYSIS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Multivariate Data Analysis	4	3	0	1	Class XII pass with Mathematics	knowledge of sampling distributions

Learning Objectives

The learning objectives include:

- To study the concept of Bivariate Normal Distribution along with their properties.
- To study the concept of Multivariate Normal Distribution along with their properties and analysis of multivariate data.
- Concepts of regression plane, multiple and partial correlation coefficients.
- Applications of discriminant analysis, principal component analysis and factor analysis.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The basic concepts associated with Multivariate Normal Distributions and their properties with special emphasis on Bivariate Normal Distribution.
- The understanding of regression plane, multiple and partial correlation coefficients.
- Analysing multivariate data using data reduction techniques like principal component analysis, factor analysis.
- Classification method namely discriminant analysis.

SYLLABUS OF DSE-6C

Theory

UNIT 1 **(16 hours)**

Bivariate Normal Distribution:

Probability density function of Bivariate Normal Distribution. Moment generating function, marginal, conditional pdf of BVN and properties of BVN. Introduction of random vector,

probability mass/ density functions, distribution function, mean vector and dispersion matrix. Marginal and conditional distributions of random vector.

UNIT 2 **(16 hours)**

Multivariate Normal distribution:

Probability density function and properties of Multivariate Normal distribution. Moment generating function, marginal and conditional pdf of MVN. Sampling distribution for mean vector and variance-covariance matrix. Regression plane, multiple and partial correlation coefficient and their properties.

UNIT 3 **(13 hours)**

Data Analysis

Data Reduction Techniques: Principal component analysis and its applications, Factor analysis and its applications. Discriminant analysis and its applications.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

Practicals based on

1. Bivariate Normal Distribution and its properties.
2. Mean vector and dispersion matrix of Multivariate Normal Distribution.
3. Marginal distributions of Multivariate Normal Distribution.
4. Conditional distributions of Multivariate Normal Distribution.
5. Regression space.
6. Partial Correlation Coefficient.
7. Multiple Correlation Coefficient.
8. Principal Component Analysis.
9. Discriminant analysis.
10. Factor Analysis.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- Anderson, T.W. (2003). *An Introduction to Multivariate Statistical Analysis*, 3rd Ed., John Wiley & Sons.
- Johnson, R.A. and Wichern, D.W. (2007). *Applied Multivariate Analysis*, 6th Ed., Prentice Hall.
- Gun, A.M., Gupta, M.K. and Dasgupta, B. (2005). *An Outline of Statistical Theory,* Volume II, World Press.
- Brian S. Everett and Graham Dunn. (2001). *Applied multivariate data analysis*, second edition, Oxford University Press.

SUGGESTED READINGS

- S.C. Gupta and V.K. Kapoor (2020). *Fundamentals of Mathematical Statistics*, 12th Ed., Sultan Chand and Sons.
- Kshirsagar, A.M. (1972). *Multivariate Analysis*, 1st Ed., Marcel Dekker.
- Muirhead, R.J. (1982). *Aspects of Multivariate Statistical Theory*, John Wiley.

- Arora, S. and Bansi, L. (1968). *New Mathematical Statistics*, 1st Ed., Vanita Printers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6D: STATISTICAL SIMULATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistical Simulation	4	3	0	1	Class XII pass with Mathematics	knowledge of basic statistics

Learning Objectives

The learning objectives include:

- Concept of simulation and simulation modelling.
- Generation of Pseudo random number generators as well as from standard statisticaldistributions. Monte-Carlo simulation technique.
- Application of simulation techniques.

Learning Outcomes

After completing this course, students will possess skills concerning:

- How simulation may be used to understand the behavior of real world systems by utilizing mathematical models with an emphasis on simulation.
- How to generate random numbers by the different methods.
- Hands-on experience in using simulation software packages/structured programming languages.

SYLLABUS OF DSE- 6D

Theory

Unit I **(12 Hours)**

Introduction to simulation:

Introduction, Definitions of simulation, Need for simulation, general principles, types of simulation, Simulation models, Phases in simulation models, Event type simulation, Monte Carlo simulation technique.

Unit II **(18 Hours)**

Random numbers generation:
Methods for the generation of Random numbers, Pseudo random number generators, Mid square method for the generation of random number and its limitations, the inverse transform method; Generating the Discrete and Continuous random variables.

Unit III **(15 Hours)**

Applications of simulation:
Applications of simulation in different fields of study, simulation of Inventory problems and simulation of Queueing problems. Advantages and disadvantages of simulation, Simulation languages, Scope of simulation techniques.

Practical/Lab Work–(30 hours)

List of Practical:

1. Pseudo random number generators;
2. Generation of U(0,1).
3. Generation using the inverse transform method applied to:
4. Discrete distribution and
5. Continuous distribution.
6. Monte Carlo simulation method and applications.
7. Problems based on Queueing systems.
8. Problems based on Inventory Controls, etc.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READING:

- Sheldon M. Ross (2022) *Simulation, Sixth Edition,* Elsevier Academic press publication.
- Taha, H. A. (2010). *Operations Research. An Introduction*, 9th Ed, Pearson.
- Swarup, K. Gupta, P.K. and Mohan, M. (2019). *Operations Research, 15th Ed,* Sultan Chand & Sons.

SUGGESTED READINGS:

- Voss, J. (2013). *An introduction to statistical computing: A simulation-based approach,* 1st Ed., Wiley series in computational statistics.
- Sharma, J. K. (2017). *Operations Research: Theory and applications, 6th Edition,* Trinity Press.
- Payer T.A. (1982). *Introduction to simulation,* McGraw Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES
OFFERED BY DEPARTMENT OF STATISTICS (SEMESTER- VIII)
CATEGORY-VI

GENERIC ELECTIVE COURSE – 8A: ORDER STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Order Statistics	4	3	0	1	Class XII pass with Mathematics	knowledge of statistical distributions and stochastic processes

Learning Objectives

The learning objective of this course is:

- To make the students aware of the properties and applications of order statistics.

Learning Outcomes:

After completion of this course, students should have developed a clear understanding of:

- Find joint, marginal, and conditional distributions of order statistics in the continuous and discrete cases.
- Find the distribution of sample range and other systematic statistics in case of sampling from an arbitrary continuous population and, in particular, from some specific continuous distributions such as uniform and exponential.
- Understand the Markov Chain property of order statistics in the continuous case.
- Understand the distribution-free bounds for moments of order statistics and of the range.
- Derive the recurrence relations and identities for moments of order statistics drawn from an arbitrary population (discrete or continuous), as well as from some specific distributions.
- Learn how to obtain distribution-free confidence intervals for population quantile and distribution-free tolerance intervals for population distributions based on order statistics

SYLLABUS OF GE-8a

Theory

UNIT I **(15 hours)**

Introduction

Introduction to order statistics. Basic distribution theory. Joint and marginal distributions of order statistics in the continuous case. Distribution of the range, median and other systematic statistics. Examples based on some specific continuous distributions.

UNIT II **(10 hours)**

Conditional distribution of order statistics

Conditional distributions. Order statistics as a Markov Chain. Order statistics for a discrete parent. Examples based on some specific discrete distributions.

UNIT III **(10 hours)**

Moments of order statistics

Moments of order statistics. Need of Recurrence relations and identities for moments of order statistics. Recurrence relations and identities for single and product moments of order statistics from an arbitrary distribution. Recurrence relations for single and product moments of order statistics from some specific distributions.

UNIT IV **(10 hours)**

Distribution- free intervals of order statistics

Distribution-free confidence intervals for population quantiles and distribution-free tolerance intervals. Distribution-free bounds for moments of order statistics and of the range.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

1. Problem solving using joint, marginal and conditional distributions of order statistics for some specific continuous distributions.
2. Distribution-free confidence intervals for population quantiles for various distributions.
3. Calculating Means, variances, and covariances by using exact expressions for the moment of order statistics for some specific continuous distribution.
4. Problems based on Markov Chain property of order statistics in the continuous case.
5. Distribution of sample range and other systematic statistics in sampling from differentdistributions.
6. Conditional distribution of order statistics in sampling from different distributions.
7. Calculating exact moments of order statistics by using recurrence relations for arbitrary continuous distributions.
8. Calculating exact moments of order statistics by using recurrence relations for some specific distributions.
9. Distribution-free confidence intervals for population quantiles for various distributions.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- David, H. A. and Nagaraja, H. N. (2003). *Order Statistics*, 3rd ed., John Wiley & Sons.

SUGGESTIVE READINGS:

- Arnold, B.C., Balakrishnan, N. and Nagaraja H. N. (2008). *A First Course in OrderStatistics*, SIAM Publishers.
- Arnold, B.C. and Balakrishnan, N. (1989). *Relations, Bounds and Approximations forOrder Statistics*, Vol. 53, Springer-Verlag.
- Ahsanullah, M., Nevzorav, V.B. and Shakil, M. (2013). *An Introduction to OrderStatistics, Atlantis Studies in Probability and Statistics*, Vol. III. Atlantis Press.
- Shahbaz, M. Q., Ahsanullah, M., Shahbaz, S. H. and Al-Zahrani, B. M. (2016). *OrderedRandom variables: Theory and Applications*. Springer.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

GENERIC ELECTIVE COURSE – 8B: STATISTICS IN FINANCE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Statistics in Finance	4	3	0	1	Class XII pass with Mathematics.	Basic knowledge of Calculus , Probability theory and Financial markets

Learning Objectives

The learning objectives include:

- To study the Financial Statistics which deals primary and secondary financial markets and the mathematical models used by these markets?
- To study to deal with the risks in financial markets

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Primary financial markets and their products such as equity, bonds and cash deposits
- Secondary financial markets and their products such as futures, forwards and options (American and European)
- Applications of stochastic models to price various secondary financial markets products.
- Hedging techniques

SYLLABUS OF GE-8B

Theory

UNIT I **(12 hours)**

Theory of interest rates

Theory of interest rates- Simple and compound interest, Nominal and effective rates of interest, interest rates of varying frequencies, continuous rates, accumulation and discount factors, relationship between interest rates and discount rates, present value, future value.

Unit II **(14 hours)**

Project appraisal and investment performance

Project appraisal and investment performance- Net present value, IRR, effect of taxation, Valuation of securities- fixed asset securities, related assets, perpetuities, bonds, coupon rates, bond-pricing formula.

Unit III **(14 hours)**

Introduction to derivative pricing

An introduction to derivative pricing- arbitrage, futures and forwards, European options- Call and put, put call parity, volatility, Black-Scholes option pricing formula, binomial model of option pricing. Hedging- delta, gamma and theta.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

Practical based on

1. Relationship between various interest and discount rates
2. Calculation of present values and future values of cashflows
3. To compute NPV and to obtain IRR of the investments.
4. To compute bond price and yields
5. To verify "no arbitrage" principle.
6. To price future / forward contracts
7. To price options using Black – Scholes formula.
8. Pricing of options using discrete time models.
9. Call-put parity for options.
10. Application of Greeks to hedge investment portfolios.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS

- David, G. L. (2015). *Investment Science*, Oxford University Press(South Asian edition)
- John C. Hull and SankarshanBasu (10^{th} edition) Options, Future and other derivatives, PearsonIndian edition

SUGGESTIVE READINGS:

- Franke, J., Hardle, W.K. and Hafner, C.M. (2011). *Statistics of Financial Markets: An Introduction*, 3rd Ed., Springer Publications.
- Garrett S. J. (2013) *An introduction to the mathematics of Finance: A deterministic approach*, 2^{nd} edition, Elsevier
- Ambrose Lo (2018): Derivative Pricing: A problem based primer, Chapman & Hall

Note: Examination scheme and mode shall be as prescribed by the Examination Branch University of Delhi, from time to time.

GENERIC ELECTIVE COURSE – 8C: INTRODUCTION TO RELIABILITY THEORY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Reliability Theory	4	3	0	1	Class XII pass with Mathematics	Knowledge of Probability Distribution and Statistical Inference

Learning Objectives

The learning objectives include:

- To describe the theoretical aspects of reliability along with their application area.
- To determine the growth in the mean life and/or the reliability of units during their research, engineering and development phase.

Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Concept of Reliability, Maintainability and Availability.
- Various estimation procedures of reliability function(s).
- Calculate the Reliability of series and parallel systems.

SYLLABUS OF GE-8c

Theory

UNIT I **(10 hours)**

Reliability measures

Definition of Components, systems and coherent systems. Reliability functions, hazard rate function, reverse hazard rate function, residual lifetime, inactivity time, mean residual lifetime function, mean inactivity time, reliability bounds, cut and path sets.

UNIT II **(08 hours)**

Common lifetime distributions

Common lifetime distributions and their properties (Exponential, Weibull and Gamma), scale model, proportional hazard rate model, proportional reverse hazard rate model, MTTF, Bathtub failure rate, reliability importance of components.

UNIT III **(12 hours)**

Estimation of reliability functions

Various methods of reliability estimation (Classical); of some common lifetime distributions, Reliability estimation under complete and various censored samples. Stress-Strength reliability: concepts and its estimation for exponential and Weibull, k-out-of-n (exponential) and its application.

UNIT IV **(15 hours)**

Reliability systems and ageing

Reliability of series/parallel systems: introduction, series systems with identical components. Different types of redundancy. Notions of Ageing: Different ageing classes, ageing properties of common lifetime distributions, closure properties of different ageing classes under formation of coherent structures.

PRACTICAL/LAB WORK – (30 hours)

List of Practical:

Practical based on

1. Calculation of reliability function and its estimates
2. Calculation of hazard rate for various models.
3. Calculation of stress-strength reliability.
4. Various reliability and hazard rate plots.
5. Behavior of reliability estimates corresponding to sample size.
6. Practicals on ageing.
7. Other relevant problems.

Practical work to be conducted using electronic spreadsheet / EXCEL/ Statistical Software Package/ SPSS/ calculators.

ESSENTIAL READINGS:

- Sinha, S.K. (1986): Reliability and Life testing; Wiley Eastern.

SUGGESTIVE READINGS:

- Barlow, R.E. and Proschan F. (1985): Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.
- Lawless, J.F. (2003): Statistical Models and Methods of Life Time Data; John Wiley.
- Bain L.J. and Max Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.

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