Course Title: Fundamentals of Statistics	**L**	**T**	**P**	**S**	**Semester:** Ist
Course Code: STA100MN	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course objective: The objective of this course is to familiarize students with fundamental statistical concepts and techniques for organizing, summarizing and analyzing data. It aims to equip students with the ability to compute and interpret descriptive statistics, study relationships between variables using correlation and regression analysis and construct and apply index numbers for real-life data interpretation.

Course Outcomes: On completing the course, the student will be able to:

1. Use a wider range of summary measures available for data analysis.
2. Establish the linear relationship between the two variables by using scatter plots and other correlation methods.
3. Regression Analysis is performed by using least square methodology.
4. Know specialized averages under the domain of index numbers.

Unit I: Statistics a conceptual frame work; Statistical enquiry; Collection of data; Scales of measurement: nominal, ordinal, interval and ratio; Classification and tabulation of data; Diagrammatic and Graphic presentation of data.

Unit II: Measures of central tendency: Mean, median, mode, geometric and harmonic mean; Measures of dispersion: range, mean deviation, quartile deviation, standard deviation and variance; Measure of skewness: Karl-Pearson's and Bowley's methods; Measures of Kurtosis.

Unit III: Correlation Analysis: Conceptual frame work; Methods of studying correlation: Scatter diagram, Karl Pearson's correlation coefficient, Spearman's rank correlation coefficient.
Regression Analysis: Definition and uses; Linear and non-linear regression; Regression equations and regression coefficient; Properties of regression coefficient.

Unit IV: Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Marshall-Edgeworth and Fisher's Ideal index numbers; Errors in index numbers; Chain index numbers; Conversion of fixed based to chain based index numbers and vice-versa; Consumer price index numbers; Uses and limitations of index numbers.

Textbooks/References:

1. Fundamentals of Statistics by S.C. Gupta
2. Fundamentals of Statistics by D.N. Elhance, V. Elhance B.M Aggarwal, Kitab Mahal
3. New Mathematical Statistics (A problem-Oriented First course) by Sanjay Arora & Bansi Lal.
4. Business Mathematics & Statistics, Asian Books Private Ltd. By A.P Verma.

Course Title: Introductory Mathematics: A Foundation for Statistics	**L**	**T**	**P**	**S**	**Semester:** 2nd
Course Code: STA150MN	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: To build a strong foundation in essential mathematical concepts such as sets, functions, limits, differentiation and matrices; and to enable students to apply these principles in analyzing functional behavior and solving problems in statistics and related fields.

Course Outcomes: On completing the course, the student will be able to:

1. Demonstrate understanding of fundamental concepts of sets, relations and classify various types of functions.
2. Evaluate limits and determine the continuity and differentiability of functions using standard techniques.
3. Use derivatives to analyze function behavior and solve problems involving maxima, minima and rates of change.
4. Solve problems involving matrices, find eigenvalues/eigenvectors and apply the Cayley-Hamilton theorem in linear algebra.

Unit I: Sets, Relations and Functions: Concepts & Types of functions: One-one, onto, many-one, constant, identity, polynomial, Exponential, logarithmic, Modulus, signum, greatest integer and Inverse functions.

Unit II: Limits, properties of limits, techniques for evaluating limits, Continuity of a function, Differentiation of exponential, logarithmic, polynomial and trigonometric functions by Abnitio method, Applications of differentiation product and quotient rules and higher order derivatives.

Unit III: Increasing and decreasing functions and the derivative tests, Maxima and minima of a function, Integration of some elementary functions, Definite integral, properties of definite integral, area of region between two curves.

Unit IV: Matrix, types of matrix, properties of matrix, addition and multiplication of matrices, transpose of a matrix, symmetric and skew symmetric matrix, orthogonal matrix, inverse of a square matrix, Elementary matrices, rank of a matrix, characteristic equation, Eigen values and Eigen vectors, Cayley Hamilton's theorem.

Textbooks/References

1. Bali, N. P., & Goyal, M. (2007). A Textbook of Engineering Mathematics. Laxmi Publication (P) LTD.
2. Grewal, B. S. (Year of publication not provided). Advanced Engineering Mathematics.

3. Raisingania, M. D. (Year of publication not provided). Ordinary and Partial Differential Equations.
4. James Stewart, Calculus, Early Transcedentals.
5. Hari Arora, A Textbook of Engineering Mathematics Vol I, II. (Calculus and Linear Algebra).

Course Title: Probability Theory	**L**	**T**	**P**	**S**	**Semester:** 3rd
Course Code: STA200MN	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: The students will get an overview of basic fundamental concepts in Probability & Statistics to solve applied problems and to acquire the knowledge of various distributions and its applications.

Course Outcomes: On satisfying the requirement of this course, students will be able to:

1. Extend and formalize knowledge of the theory of probability and random variables.
2. Compute conditional probabilities directly and using Baye's theorem and check for independence of events.
3. Perform probability calculations relating to probability distributions for discrete continuous random variables and compute Mathematical Expectation and variance.
4. Apply various distributions to solve real life problems.

Unit I: Probability: Introduction, random experiments, sample space, events and algebra of events; Counting principle: permutations and combinations; Definitions of Probability: Classical, statistical and axiomatic; Conditional probability; Addition and multiplication law of probability; Independent events; Theorem of total probability; Bayes theorem and its applications.

Unit II: Random variables: Discrete and continuous random variables; Probability mass function; Probability density function and Cumulative distribution function; Properties of random variables; Mathematical expectation of a random variable; Laws of expectation; Moments; Moment generating function and characteristic function with illustrations.

Unit III: Two dimensional random variables: Discrete and continuous type; Joint distribution function for two random variables (discrete and continuous case); Marginal and conditional distributions; Expectation of sum of random variables and its properties; Covariance; Independence of random variables.

Unit IV: Standard probability distributions: Binomial, Poisson, normal, exponential, beta and gamma along with their properties.

Textbooks/References:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I, 8th Ed. The World Press, Kolkata.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2017). An Outline of statistical theory, Vol. I, The World Press, Kolkata.
3. Gupta, S. C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th Edn., S. Chand and Sons. Delhi.
4. Chung, K.L. (2000). A Course in Probability Theory, 3rd Edn. Academic Press.
5. Feller, W. (1968) An introduction to probability theory and its applications. Vol. I, 3rd Edn. John Wiley & Sons Inc., New York.

Course Title: Sampling Theory	**L**	**T**	**P**	**S**	**Semester:** 4th
Course Code: STA250MN	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: The main objective is to provide the knowledge of concept of sample and population in statistics and also the various sampling schemes and estimation of population parameters and their respective standard errors.

Course Outcome: After completing this course, students will be able to:

1. Learning the basic concept of sampling and related terminologies.
2. Understanding various types of sampling schemes, with their advantages and disadvantages, and estimation of population parameters with their standard errors.
3. Learning the use of auxiliary information in the ratio and regression method of estimation.
4. Understanding non-sampling errors and use of some estimation techniques.

Unit I: Concept of population; Sampling unit; Sample and sampling frame; Sampling design; Random (probability) and non-random (non-probability) sampling with examples; Sampling v/s complete enumeration; Advantages of sample survey over census; Principles of sample survey; Sampling and non-sampling errors.

Unit II: Simple Random sampling (SRS) with and without replacement; Merits and demerits of simple random sampling (SRS); Methods of selecting SRS; Estimation of mean, its variance and estimate of its variance; Unbiased estimate of population mean square; Determination of sample size.

Unit III: Stratified random sampling: Estimation of mean, its variance; Need for stratification; Advantage of stratified sampling over simple random sampling; Allocation of sample size under proportional and optimum allocation; Comparison of stratified sampling over SRS system of sampling and its use; Systematic sampling: Estimation of mean and sampling variance; comparison of systematic sampling with stratified and S.R.S.

Unit IV: Cluster sampling: Estimation of mean and its variance for equal and unequal clusters; Two-stage sampling: (a) Equal first stage unit: Estimation of population mean and its variance and estimates of variance; Comparison with one stage sampling; (b) Unequal first stage unit: Estimation of population mean; Expected values and variance of different estimates including the case of probability proportional to size; Quota sampling, its merits and demerits.

Textbooks/References:

1. Sukhatme, P.V., Sukhatme, B.V., Sukhatme,S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and Indian Society of Agricultural Statistics.
2. Cochran, W. G: Sampling Techniques, 3rd edition, John Wiley and Sons.

3. Mukhopadhyay, P. (2000): Theory and Methods of Survey Sampling, Prentice Hall of India, Private limited, New Delhi.
4. Murthy, M. N. (1977): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
5. S.C. Gupta and V.K. Kapoor (1984): Fundamentals of Applied Statistics, Sultan Chand & Sons, New Delhi.

Course Title: Statistical Package for Data Analysis	**L**	**T**	**P**	**S**	**Semester:** 6th
Course Code: STA300MN	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: This course aims to provide a practical introduction to the R programming language and SPSS. By the end of the course, the user will be able to use R and SPSS for effective data analysis.

Course Outcome: After completing this course, students will be able to:

1. Work with various data structures in R such as vectors, matrices, lists, and data frames, and perform data import/export operations.
2. Apply descriptive statistical methods and data manipulation techniques using built-in R functions and apply-family functions.
3. Develop reusable R scripts and functions for solving practical data analysis problems.
4. Define, modify, and manage variables within SPSS using the Variable View for accurate and efficient data handling.
5. Navigate the SPSS interface, manage datasets, and conduct basic statistical analyses using SPSS tools.

Unit I: Fundamentals of R programming; overview of R environment; using R as a calculator; assignment operator, object name rules, basic operations on objects; vectors, data frames, matrices and lists; sub-setting vectors, data frames and matrices using indices, logical conditions, names, and other subset functions; applying basic mathematical functions on vectors, data frames and matrices for summarization and transformation.

Unit II: Working with matrices, arrays, and lists, indexing, and operations, sub-setting using indices and logical conditions; applying basic functions for summarization and transformation; setting and managing the working directory; importing data from CSV files; exporting processed data to external files; exploring and analyzing default datasets available in R for practice and demonstration. Writing and calling functions in R; creating basic graphics using base plotting system;

Unit III: SPSS interface: variable view, data view, menus and dialogue boxes; data management: entering and coding data, defining and modifying variables, inserting new variables, descriptive statistics for categorical and continuous variables; compute new variables.

Unit IV: Split file and select cases analysis, recoding variables, importing files; correlation and simple linear regression analysis, one-sample and two-sample t-tests, paired t-test, one-way ANOVA, graphics and plots in SPSS.

Textbooks/References:

1. Matloff, N. (2016). The art of R programming: A tour of statistical software design. No Starch Press.
2. Gardener, M. (2017). Beginning R: The statistical programming language, Wiley.
3. Cotton, R., Learning R: a step by step function guide to data analysis. 1st edition. O'reilly Media Inc.
4. Field, A. (2017). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE Publications.
5. Jasrai, L. (2020). *Data analysis using SPSS*. SAGE Publications.

Course Title: Statistical Inference	**L**	**T**	**P**	**S**	**Semester:** 5th
Course Code: STA350MN	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: To develop an understanding of the fundamental concepts and theoretical framework of statistical inference and to equip students with methods of estimation and hypothesis testing for practical data analysis and decision-making.

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

1. Explain and derive properties of order statistics and their applications in inference.
2. Understand and apply the principles of estimation, including unbiasedness, consistency, efficiency and sufficiency.
3. Employ various estimation techniques such as method of moments, maximum likelihood and least squares in parameter estimation.
4. Conduct hypothesis testing using Z, t, F and chi-square distributions for different population parameters.
5. Apply non-parametric methods like Sign Test, Wilcoxon tests and Kolmogorov–Smirnov tests to analyze real-world data when parametric assumptions are not valid.

Unit I: Order statistics: Definition and derivation of p.d.f. of ith order statistics for a random sample of size n from a continuous distribution; Density of smallest and largest observations; Derivation of joint p. d. f. of i^{th} and j^{th} order statistics; Statement of distribution of the sample range; Distribution of the sample median; Extreme values and their asymptotic distribution (statement only) with applications.

Unit II: Concept of Statistical inference; Sampling method and complete enumeration; Definitions: Population, parameter, parameter space; Concept: Estimation, estimator and estimate; Criteria of a good estimator: Unbiasedness, consistency, efficiency and sufficiency; uniformly minimum variance unbiased estimators; Fisher information matrix: Illustration with one and two parameters; Cramer-Rao inequality; Minimum variance bound estimator-examples.

Unit III: Estimation Methods: Method of moments, Maximum likelihood estimation, Method of minimum Chi Square, Method of least squares and Interval estimation; Hypothesis: Simple and composite hypothesis; Critical region; Type I and type II errors; Size and power of a test; Concept of p-value; Level of significance; Hypothesis testing for population parameters with large and small samples; Hypothesis testing based on Z, F and t-distribution.

Unit IV: Chi-Square test for goodness of fit; Chi-square test for population variances; Chi-square test for association; Non-parametric inference; Advantages of non-parametric methods over parametric methods; One-sample problem; Sign Test; Wilcoxon-Signed rank test; Kolmogorov-Smirnov test; General Two Sample Problem: Sign Test , Wilcoxon-Mann- Whitney Test, Kolmogorov-Smirnov two sample test (for samples of equal size); Median test.

Textbooks/References:

1. Casella G, Berger R. L. (2001). Statistical Inference, 2/e, Cengage Learning Pvt. Ltd.
2. Rohatgi, V. K. and Saleh, A.K. Md. E. (2001). Introduction to Probability and Statistics, John Wiley & Sons, New York.
3. Kale, B.K. & Muralidharan, K. (2015) Parametric Inference: An Introduction, Alpha Science International Ltd.
4. Lehmann, E. L. and Romano, J. (2005). Testing Statistical Hypotheses, Springer
5. Lehmann, E.L. and Casella, G. (1998). Theory of Point Estimation. Springer, New York

Course Title: Optimization	**L**	**T**	**P**	**S**	**Semester:** 7th
Course Code: STA400MN	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: The aim of the course is to give knowledge to students to use quantitive methods and techniques for effective decisions–making; model formulation and applications that are used in solving business decision problems.

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

1. Identify and develop operational research models from the verbal description of the real system.

2. Understand the mathematical tools that are needed to solve optimization problems.
3. Solve various linear programming, transportation, assignment and game problems related to real life.

Unit I: Linear programming: Concept and uses of linear programming; Formulation of linear programming problem; Solution of LP problem: Graphical and simplex method; Duality in linear programming; Properties of the primal-dual pair; Dual simplex method.

Unit II: Transportation and Assignment problems: Formulation of transportation and assignment problems as linear programs; Methods of obtaining the initial basic feasible solution to a transportation problem; Solution of the Transportation problem by MODI Method; Unbalanced transportation problems and their solutions; Degeneracy in Transportation problem and its resolution; Solution of Assignment problem by Hungarian method; Traveling salesman problem as an assignment problem (Formulation only).

Unit III: Sequencing problems: Problems with n jobs and 2 machines; problems with n jobs and k machines; Games and Strategies: Two person zero-sum games; Maximin-Minimax Principle; Mixed strategies; Solution of 2×2 and $m\times n$ games.

Unit IV: Concept of PERT/CPM networks; Estimating the activity time; Determination of earliest expected and latest allowable times; Determination of critical path; Drawing network diagram; Probability consideration in PERT networks PERT/CPM; Cost analysis; Applications of PERT/CPM; Simulation: Meaning and uses; Monte Carlo method; Random number generation; waiting line simulation model.

Textbooks/References:

1. Gass, S.I.: Linear Programming-Methods & Applications.
2. Hillier & Liberman: Introduction to Operations Research, Mc. Graw Hill Book Co.
3. Taha, H.A.: Operations Research-An introduction, Pentice Hall of India Pvt. Ltd. New Delhi. (7th Edition-2003).
4. Swaroop K, Gupta, P.K. & Mohan, M.: Operations Research, Sultan Chand & Sons, New Delhi.
5. Sharma S.D.: 'Operational Research', Kedar Nath Ram Nath and Co., Meerut.

Course Title: Design of Experiments	**L**	**T**	**P**	**S**	**Semester:** 8th
Course Code: STA450MN	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: The aim of the course is to give knowledge in statistical experimental design in regards to designing and conducting experiments and analysis of data generated from experiments. Experiments that are given special focus in the course include single factor experiments, randomized blocks, Latin squares, factorial experiments (e.g. 2k factorial experiments) and analysis of variance. Different applications of experimental design and analysis of variance are given much focus in the course. The course provides a basis for further advanced studies and research studies in Statistics.

Course Outcomes: Students will be able to:

1. Understand the potential practical problems and applications of design of experiments in various fields.
2. Build a deeper understanding, and tools for analysis of experiments.
3. Describe how the analysis of the data from the experiment should be carried out.
4. Appreciate the advantages and disadvantages of a design for a particular experiment.

Unit I: Planning of experiment; Introduction to basic designs and their analysis; Principles of Experimental design: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD); Missing plot techniques in RBD with one and two missing observations; Analysis of LSD with one missing observation.

Unit II: Introduction to Incomplete block design: Intra block analysis (estimability); Estimates of estimable linear parametric function; Balanced Incomplete Block Design; Intra block analysis; recovery of inter block information.

Unit III: Analysis of covariance; Practical situations where analysis of covariance is applicable; Model for analysis of covariance in CRD and RBD; Estimation of parameters; Preparation of analysis of covariance (ANOCOVA) table; Test for $\beta = 0$; Test for equality of treatment effects (computational technique only); Numerical illustrations.

Unit IV: General description of factorial experiments; Factorial effects; Analysis of factorial experiment (2^n,3^n); Main and interaction effects; Advantages and disadvantages; Total and partial confounding.

Textbooks/References:

1. Goon, Gupta, Dasgupta: Fundamental of Statistics, Vol. I and II, The World Press Pvt. Ltd. Kolkata.
2. Montgomery, D.C.: Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi.
3. Cochran, W.G. and Cox, G.M.: Experimental Design, John Wiley and Sons, Inc., New York.
4. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Applied Statistics, S. Chand & Sons, New Delhi.
5. Das, M.N. and Giri, N.C.: Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi.