Course Outline for Semester V (Batch 2024)

S. No.	Category	Course Code	Course Title	Credits	L	T	P	S	Hours per week
1	Major	MTHS305MJ	Discrete Mathematics	4	3	0	2	0	5
		MTHS306MJ	Applied Statistics	4	4	0	0	0	4
		MTHS307MJ	Financial Mathematics	4	3	0	2	0	5
		MTHS300MJ	Abstract Algebra	4	4	0	0	0	4
		MTHS302MJ	Sampling Theory	4	4	0	0	0	4
2	Minor 5		Students to choose	4					

Note: Students have to choose one subject from the Major Category — either **Abstract Algebra** (**MTHS300MJ)** or **Sampling Theory (MTHS302MJ)**.

Course Title: Discrete Mathematics	**L**	**T**	**P**	**S**	**Semester: 5th**
Course Code: MTHS305MJ	**3**	**x**	**2**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: The course aims to introduce students to the fundamental concepts of discrete mathematical structures and their applications across various branches of science. It also focuses on developing skills in Python programming for graph modelling, analysis and visualization, enabling students to connect theoretical concepts with practical computational tools.

Course Outcomes: After completing this course:

1. Students will apply Boolean algebra and logic to analyse and simplify logical structures.
2. Students will apply graph concepts to model and analyse real-world problems.
3. Students will analyse graph structures, trees, and matrices to solve connectivity and optimization problems.
4. Students will use Python to model, visualize, and analyse graphs and their matrices using NetworkX and Matplotlib.

Unit 1: Boolean Algebra, Postulates of Boolean Algebra, theorems of Boolean algebra, Sum of product and product of sums, Simplification, NAND and NOR implementation, Posets and Lattices and Hasse Diagrams.

Unit II: Propositional logic, applications of propositional logic, propositional equivalences, predicates and Quantifiers, First order logic, nested quantifiers, Rules of inference.

Unit III: History, definitions and terminologies, graph, vertices, edges, degree, paths and cycles, degree sequence of a graph, types of graphs: definition and examples of directed, undirected, bipartite, complete and regular graphs complement and subgraphs, Real-life scenarios and applications of different types of graphs in science, technology and data analysis.

Unit IV: Eulerian and Hamiltonian graph structures, isomorphism in graphs, trees and its properties, rooted and binary trees, spanning trees, minimum spanning trees and Kruskal's Algorithms, coloring in graph structures, Adjacency Matrix, Degree Matrix and Laplacian Matrix associated with graphs.

Practical's:

- Implementation and Visualization of Boolean Algebra and Hasse Diagram using Python
- Visualizing social networks (simple graphs) with NetworkX and Matplotlib.
- Representing graph structure, empty graphs, path, cycle graph, complete graph using Python programming.
- Node and edge deletion
- Python code for adjacency and Laplacian matrix computation of some simple graphs and their eigen values.

Textbooks/ References:

1. C.L. Liu: Elements of Discrete Mathematics, Tata Mc-Graw Hill.
2. Reinhard Diestel, *Graph Theory* (Graduate Texts in Mathematics).
3. Narsingh Deo, *Graph Theory with Applications to Engineering and Computer Science*.
4. Bondy and Murty, *Graph Theory and Applications*.
5. S. Pirzada, An Introduction to Graph Theory, Universities Press, Bangalore, 2012.

Course Title: Applied Statistics	**L**	**T**	**P**	**S**	**Semester: 5th**
Course Code: MTHS306MJ	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: To make the students aware of different type of data sets and their graphical representations introducing of descriptive statistical measures, including those for two variables. The main objective is also to build the practical foundation of testing of hypothesis.

Course Outcomes: After completion of this course student will able to

1. Understand basic concepts of statistical data.
2. Recognize different diagrammatic tools for visualization of data
3. Apply different statistical measures to describe the data.
4. Asses relationship between two variables.
5. Apply different statistical test procedures for different testing of hypothesis problems.

Unit I. Statistics a conceptual frame work, Statistical enquiry, collection of data, Classification, Seriation and tabulation of data. Diagrammatic and Graphic presentation of data. Measures of central tendency: mean, median, mode. 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 II. Correlation Analysis - conceptual frame work .Methods of studying correlation-Scatter diagram, Karl Pearson's correlation coefficient, Spearman's rank correlation coefficient and concurrent deviation methods. Probable error (ungrouped data), coefficient of determination.
Regression Analysis - definition and uses, Linear and Non-linear regression (definition only). Regression equations and regression coefficient, Properties of regression coefficient, multiple regression (definition only)

Unit III: Population and sample; population parameter and sample statistics; Sampling distributions, Sampling distribution of mean, Variance and proportions. Hypothesis testing, general procedure and errors in hypothesis testing, hypothesis testing for population parameters with large and small samples, Hypothesis testing based on F-distribution and t-distribution. Chi-Square test for goodness of fit, chi-square test for population variances, chi-square test for association.

Unit IV: Analysis of variance, assumptions for ANOVA test, ANOVA for one-way and two-way classified data. 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.

Textbook / References

1. An Introduction to probability Theory and Mathematical Statistics by V.K. Rohtagi and Saleh
2. A First Course on Parametric Inference, Narosa Publishing by Kale, B.K. (1999)

3. Applied non parametric statistical methods, second edition by H.C. Tuckwll.
4. Fundamentals of Statistics by S.C. Gupta
5. Fundamentals of Statistics by Ellance D N, Veena Elhance & Aggarwal B. M, Kitab Mahal.

Course Title: Financial Mathematics	**L**	**T**	**P**	**S**	**Semester: 5th**
Course Code: MTHS307MJ	**4**	**3**	**2**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: To make the student conversant with basic of data analysis and cash flow model, various types of Interest rate used in application , real and money interest rates , types of level annuity contract , types of variable annuity contract and preparing a loan schedule.

Course Outcomes: On completion of the course the students will be able to

1. Describe how to consider the time value of money using the concepts of compound interest and discounting.
2. Demonstrate a knowledge and understanding of real and money interest rates.
3. Calculate the present value and the accumulated value of a stream of equal or unequal payments using specified rates.
4. Describe how a loan may be repaid by regular installments of interest and capital.

Unit I: Interest rates: Nominal and effective rate of interest. Accumulation factors- Principle of consistency- The force of interest- Present values- The basic compound interest functions- Interest payable monthly.

Unit II: Real and money interest rates: Definition- Deflationary conditions- Usefulness. Discounting and accumulating: Present value of continuous cash flows- Valuing cashflows- Interest income

Unit III: Level annuities: Present values and Accumulations -Payments made in arrear- Payments made in advance- Continuously payable annuities- Annuities payable monthly- Non-integer values- Perpetuities, Deferred and increasing annuities: Deferred annuities- Varying annuities- Decreasing payments- Irregular payments- Sudden changes in interest rates- Simple and Compound increasing annuities.

Unit IV: Equations of value: Uncertain payment or receipt- Loan schedules- Calculation of capital outstanding- Calculation of interest and capital elements- Installments payable more frequently than annually.

Text Books / References:

1. McCutcheon, J. J.; Scott, W. F. Heinemann, “An introduction to the mathematics of finance”, 1986.
2. Mark S. Joshi, “The concepts and practice of Mathematical Finance”, Cambridge University Press, 2nd Edition (2008).
3. Dixit S.P., Modi C.S., Joshi R.V, “Mathematical Basis of Life Assurance”, First edition Insurance Institute of India.
4. S.M. Ross “An Introduction to Mathematical finance” Cambridge University Press.
5. J J McCutcheon and Dr W F Scott, “An Introduction to the Mathematics of Finance” Heinemann, 1986.

Course Title: Abstract Algebra	**L**	**T**	**P**	**S**	**Semester: 5^{th}**
Course Code: MTHSS300MJ	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: The course introduces the student's basic concepts of modern algebra. Topics include the nature of proofs, sets and equivalence relations, binary operations, groups and subgroups, cyclic groups, groups of permutations and polynomial Rings.

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

1. Understand group through symmetries in nature and can identify patterns.
2. Apply these concepts in linear classical groups to solve problems arising in physics, computer science, economics and engineering etc.

Unit I: Equivalence relation and partition, Equivalence Classes partition, binary operations, introduction to groups, symmetries of a square, finite and infinite groups, abelian & non-abelian groups, elementary properties of groups, uniqueness of identity/ inverse and cancellation laws, modular arithmetic, understanding the group formed by addition and multiplication modulo n, cyclic groups and properties of cyclic groups.

Activity based on modular arithmetic in Python.

Unit II: Finite groups: Order of a group and order of an element, definition of subgroups, examples, criterion for a non-empty subset to be a subgroup (subgroup tests), Union and intersection of subgroups, product of two subgroups, cosets, Lagrange's theorem with applications in number theory and problem-solving and simple groups. Use Python to generate subgroups of Z_n.

Unit III: Normal subgroups, Quotient groups, Homomorphism, kernel of a homomorphism, Fundamental theorem of homomorphism, Isomorphism theorems (statements only), homomorphic image of a group, permutation groups, Definitions and examples of even and odd permutations, symmetric and alternating groups, program to calculate the order of a group and its subgroups and use Python program to illustrate Fermat's Little Theorem.

Unit IV: Rings: Definition & Examples, elementary properties of rings, rings with & without zero divisors, Integral domains & skew fields. Definitions & examples of Fields, Subrings, Ideals, Quotient rings and Boolean rings. A finite integral domain is a field. Ring homomorphism, fundamental theorem of homomorphism. Prime, Maximal and Principal ideals (Definitions & examples only).

Textbooks/ References:

1**.** I. N. Herstein, Topics in Algebra, John Wiley, 1975.
2. Joseph A. Gallian, Contemporary Abstract Algebra, International Edition, 2022.
3. Fraleigh J. B, A First Course in Abstract Algebra, 7^{th} Edition, 2013.
4. D. S. Dumit and R. M. Foote, Abstract Algebra, John Wiley, 2003
5. Surjeet Singh and Qazi Zameeruddin, Modern Algebra, Vikas Publishing House Pvt Ltd, eighth Edition 2006.

Course Title: Sampling Theory	**L**	**T**	**P**	**S**	**Semester: 5th**
Course Code: MTHSS302MJ	**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 the completion of this course, students shall 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. Sampling v/s complete enumeration. Advantages of sample survey over census. Principles of sample survey. Sampling and non-sampling errors. Random (probability) and Non-random (non-probability) sampling with examples, types of Non random sampling.

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. Estimation of population proportion

Unit III: Stratified random sampling: estimation of mean, its variance. Need for stratification. Advantage of stratified sampling over simple random sampling, determination of optimum number of strata, construction of strata Neyman allocation, Proportional allocation and approximate method by Dalenius and Hodges). 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 SRS.

Unit IV: Cluster sampling with equal and unequal clusters, estimation of population mean and its variance, optimum cluster size, Relative efficiency of Cluster sampling with SRS and stratified random sampling.

Text Books / 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. Des Raj & Chandak(1998): Sampling Theory, Narosa.

5. S.C. Gupta and V.K. Kapoor (1984): Fundamentals of Applied Statistics, Sultan Chand & Sons, New Delhi.