FYUP Course Outline for Semester V

S. No.	Course Code	Course Title	Credits	Category
1	MTHS300MJ	Abstract Algebra	4	Major
2	MTHS301MJ	Numerical Methods	3	Major
3	MTHS302MJ	Sampling	4	Major
4	MTHS303MJ	Complex Analysis	4	Major
5	MTHS304MJ	Probability Distributions	3	Major
6	DOMS300MV	SPSS/Sage Math	4	Minor Vocational
7	DOMS300SE	Internship	2	Skill Enhancement

Note: Students have to choose elective subject either MTHS302MJ or MTHS303MJ

B.Sc. Mathematical Sciences- FYUGP

Course Title : Abstract Algebra ***Semester-V***
Course Code : MTHS300MJ
Credit hrs. : 4

Course Objective: The course introduces the students 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:

1. Students will learn about and use key algebraic structures such as groups, rings, and fields as well as their characteristics, substructures and homomorphisms, to create a solid foundation in abstract algebra.
2. Students will improve their abilities to generate formal proofs and solve issues requiring algebraic structures by using logical reasoning and abstract thinking to investigate theorems and their applications.
3. Students will learn how to apply abstract algebraic approaches to issues in various fields of mathematics and allied sciences such as cryptography, coding theory and combinatorics demonstrating the importance and utility of abstract algebra.

Unit I: Sets and equivalence relations, binary operations, properties of binary operations, groups, finite and infinite groups, properties of groups, modular arithmetics, understanding the group formed by addition and multiplication modulo n, abelian and cyclic groups and properties of cyclic groups.

Unit II: Subgroups, examples, criterion for a subgroup to be a group, Union and intersection of subgroups , product of two subgroups , cosets, left and right cosets, Lagrange's theorem and simple groups.

Unit III: Normal subgroups, quotient groups, homomorphism, homomorphic image of a group, isomorphism and related theorems, permutation groups, even and odd permutations with examples, symmetric and alternating groups.

Unit IV: Rings and fields, examples, subrings and subfields, ring homomorphism, ideals and quotient rings, polynomial rings, characterization of a ring, prime and maximal ideal with examples and their characterization in terms of the associated quotient ring.

Textbook: Topics in Algebra by I.N. Herstein

- Elements of Modern Abstract Algebra by Kenneth Miller
- Algebra by Serge Lang
- Topics in Algebra by I.N. Herstein
- Modern Algebra by Frank Ayres, Schaum's Outlines Series
- A Textbook of Modern Algebra by Shanti Narayan
- Modern Algebra by Q. Zameer-u-din & S. Singh
- Introduction to Abstract Algebra by Fraleigh , Addison Wesley
- Introduction to Abstract Algebra by Gallian , Houghton Mifflin Harcourt (HMH)

B.Sc. Mathematical Sciences- FYUGP

Course Title : Numerical Methods ***Semester-V***
Course Code : MTHS301MJ
Credit hrs. : 3

Course Objective: Introduces students the analysis of numerical methods as well as the design and use of algorithms for scientific computing.

Course Outcome: After completion of this course student will be able to

Understand the applications of numerical methods in a large number of engineering subjects which require solutions of linear systems, finding eigen values, eigenvectors, interpolation and applications, solving ODEs, PDEs

Unit I: Solutions of equations, Newton's method, interpolation, Lagrange interpolation; Divided differences, interpolation formulas using differences, Numerical differentiation and integration

Unit II: Ordinary differential equations: Euler method, single-step methods, Runge-Kutta's method; multi-step methods, methods based on numerical integration and differentiation, boundary value problems.

Unit III: Approximations: Different types of approximations, least squares polynomial approximation; polynomial approximation, approximation with trigonometric functions, exponential functions, rational functions.

Textbooks: Numerical Methods, Problems and Solutions by Jain, Iyengar and Jain

Supplementary texts:

- Introduction to numerical Analysis by C.E. Froberg
- Numerical Analysis – A Practical Approach by M. Maron
- Numerical Methods by Burda and Faires. Thomson Brooks/Cole

B.Sc. Mathematical Sciences- FYUGP

Course Title	**:**	Introduction to Sampling Theory	***Semester-V***
Course Code	**:**	MTHS302MJ	
Credit hrs.	**:**	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: -

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.

References:

- 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.

- Cochran, W. G: Sampling Techniques, 3rd edition, John Wiley and Sons.
- Mukhopadhyay, P. (2000): Theory and Methods of Survey Sampling, Prentice Hall of India, Private limited, New Delhi
- Des Raj & Chandak(1998): Sampling Theory, Narosa.
- Murthy, M. N. (1977): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
- S.C. Gupta and V.K. Kapoor (1984): Fundamentals of Applied Statistics, Sultan Chand & Sons, New Delhi.

B.Sc. Mathematical Sciences- FYUGP

Course Title	**:**	Complex Analysis	***Semester-V***
Course Code	**:**	MTHS303MJ	
Credit hrs.	**:**	4	

Course Objective: To provide a solid, classical foundation for the subject while exposing trails leading off in interesting directions.

Course Outcome:

1. Learn the basic techniques of contemporary complex analysis as well as applications of these techniques in harmonic analysis, univalent functions theory and special functions.
2. Evaluate integrals along a path, compute the Taylor and Laurent expansions, determine the nature of the singularities and calculating residues.

Unit I: Complex numbers, algebraic and geometric properties of complex numbers, the complex plane, functions of complex variables, limits, continuity,

Unit II: Differentiation, Cauchy-Riemann Equations, sufficient conditions for differentiability, analytic functions, exponential function, logarithmic function, trigonometric function, derivatives

Unit III: Contour integrals, Cauchy's theorem and Cauchy's integral formula, Liouville's Theorem, Fundamental Theorem of Algebra, Maximum Modulus Principle, Schwarz Lemma,

Unit IV: Power series, regions of convergence, Taylor and Laurent series, classification of singularities, residues, poles, Cauchy's Residue Theorem

Text Books: Complex Variables and Application by J. Brown and R. Churchill

- Introduction to Complex Analysis, 2nd ed by H.A. Priestley, Oxford Publications
- Complex Variables by Spiegel, Lipschutz, Schiller and Spellman
- Complex Analysis by Lars V. Ahlfors
- Functions of a Complex Variable by John B. Conway
- Complex Variables: Introduction and Applications by M. J. Ablowitz & A. S. Fokas, 2nd ed. Cambridge University Press.

B.Sc. Mathematical Sciences- FYUGP

Course Title	**:**	Probability distributions	***Semester-V***
Course Code	**:**	MTHS304MJ	
Credit hrs.	**:**	3	

Course Objective: The main objective is to integrate the foundational concepts of discrete and continuous probability distributions by exploring their properties, key differences, and practical applications.

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

a) Demonstrate a comprehensive understanding of discrete and continuous probability distributions and their structural properties.
b) To examine the role of probability models in predicting outcomes, understanding relationships and approximation cases.
c) Analyze real-world problems by formulating and solving them using appropriate probability models.

Unit –I: Discrete Probability Distributions: Geometric, Negative Binomial, Hyper-geometric, Multinomial and Power Series distributions along with their characteristic properties and limiting/approximation cases. Solving real-world problems through the formulation and application of suitable discrete probability models.

Unit –II: Continuous Probability Distributions: Gamma, Beta, Weibull, Logistic, Pareto, t, $\chi 2$ and F distributions along with their characteristic properties and limiting/approximation cases. Application of these continuous probability models to handle real world problems.

Unit –III: Compound, truncated and mixture probabilistic models, bivariate normal and bivariate exponential distributions with properties and applications, generalized exponential and log-logistic distributions with structural properties and applications to handle real world problems.

References:

- Rohatgi V.K & A.K. MD. Ehsanes Saleh (2001): An Introduction to Probability Theory and Statistics, 2nd. John Wiley and Sons.
- Rohatgi,V.K.(1990) : An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd.
- Johnson, N.L. and Kotz, S. (1969): Distributions in Statistics; Discrete distributions. John Wiley and Sons, New York.
- Hogg, R.V. and Craig ,A.T.(1989) : Introduction to Mathematical Statistics, Macmillan Publishing Company

- Johnson, N.L., Kotz, S. and Balakrishnan, N (1994): Continuous Univariate Distributions-1, 2nd Edition John Wiley and Sons, New York.
- Johnson, N.L., Kotz, S. and Balakrishnan, N (1995): Continuous Univariate Distributions-2, 2nd Edition , John Wiley and Sons, New York.
- Johnson, N.L., Kemp, A.W. and Kotz, S. (2005): Univariate Discrete Distributions, 3nd Edition , John Wiley and Sons, New York.
- Wackerly D.D; Mendenhall III, William and Scheaffer, R.L.: Mathematical Statistics with applicable Duxbury, 2002.
- Consul, P.C. and Famoye, F. (2006): Lagrangian Probability Distributions.

B.Sc. Mathematical Sciences- FYUGP

Course Title	**:**	SPSS & Sage	***Semester-V***
Course Code	**:**	DOMS300MV	
Credit hrs.	**:**	4	

Objective: To learn the SPSS software for data analysis and to develop and analyze solutions for problems in discrete mathematics, combinatorics, and graph theory using SageMath.

Course Outcomes: After the completion of paper student will be able to:

1. Understand basic functions of statistical software package for managing variables and generate descriptive statistics to describe the data and analyze data through graphs and charts.
2. Analysing data to compare significance of difference between two or more groups: parametric and nonparametric methods.
3. Identify relationships between variables and develop models for predicting dependent variables on the basis of independent variables. Evaluating association between disease (outcome) and one or more exposures.
4. Solve problems in algebra, calculus, number theory, linear algebra, and combinatorics using SageMath.
5. Simulate real-world scenarios such as optimization, differential equations, and scientific models.

Unit I: Introduction to SPSS-Variable view and data view. Working with data files, SPSS windows, menus, dialogue boxes. Preparing the data file: Creating data file and entering data, defining the variables, entering data, modifying data file and import file. Descriptive statistics: Categorical variables, continuous variables, checking normality, outliers checking.

Unit II: Running correlation, simple linear regression and multiple linear regression analysis. Conducting one sample and two independent sample t test, paired sample t test, one way analysis of variance in SPSS. Graphics and plots in SPSS. Non-parametric inference, one-sample and two sample Sign Test, Wilcoxon-Signed rank test, Kolmogrove Smirnov test (one-sample and two-sample tests), Wilcoxon-Mann- Whitney Test, Median test.

Unit III: Introduction to SageMath. What is SageMath. Overview and history. Comparison with other tools (e.g., MATLAB, Mathematica, Python libraries like NumPy/SciPy). Installation and setup. Using SageMath locally vs. cloud services (e.g., CoCalc). SageMath interface: Command line, Jupyter Notebook, and CoCalc

Unit IV: Basics of SageMath Programming SageMath syntax and structure. Variables, data types, and basic operations. Functions and control structures. Loops (for, while). Conditionals (if, else, elif). Importing and using Python libraries in SageMath, Algebraic Computations Basic algebraic

operations. Simplifying expressions. Factoring and expanding. Solving equations (linear, quadratic, and higher-order). Working with polynomials. Symbolic computation

References:

1. Sheridan J Coakes: SPSS 12.0 version for Windows , Wiley.
2. Cromley, Ellen K. and McLafferty, Sara L., (2002): GIS and public health. Guilford Press, New York.
3. SPSS 14.0 Brief Guide – SPSS Inc.
4. SPSS regression models 14.0 - SPSS Inc.
5. P. Zimmermann et.al., Computational Mathematics with SageMath

B.Sc. Mathematical Sciences- FYUGP

Course Title **:** Internship ***Semester-V***
Course Code **:** DOMS300SE
Credit hrs. **:** 2