SEMESTER-V

Paper-I

Abstract Algebra

Total Marks: 100 (Theory 80, Internal Assessment 20)

No. of Credits: 4

Each unit carries equal credit

Base syllabus: MAT-HC-3026: Group Theory-I (UG CBCS)

Course Level: 300-399

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in senior secondary school or equivalent standard.

Course Objectives: The primary objective of this course is to introduce abstract mathematical objects, viz. groups, rings and fields and study their properties. It is also focussed to study the consequences of these mathematical structures.

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

- Recognize the mathematical objects called group, ring and fields.
- Link the fundamental concepts of groups and symmetries of geometrical objects.
- Explain the significance of the notion of Permutation groups, cosets, cyclic groups, normal subgroups, factor groups.
- Analyse consequences of Lagrange's theorem and Fermat's Little theorem.
- Describe structure preserving mappings between groups and their consequences.
- Describe the fundamental concepts in ring theory such as of the subrings, integral domains, ideals, factor rings and fields.

Unit 1: Definition and examples of groups, Elementary properties of groups, Symmetries of a square, Dihedral groups, order of a group, Order of an element in a group, Subgroups, Subgroup Tests, Subgroup generated by an element of a group, Centre of a group, Centralizer of an element in a group, Cyclic groups, Properties of cyclic groups, Fundamental theorem of cyclic groups.

[1] Chapter 1 to Chapter 4.

(No. of classes: 15, Marks: 20)

Unit 2: Permutations, Permutation group, Properties of permutations, Even and odd permutations, Alternating groups, Cosets, Properties of cosets, Lagrange's Theorem, Fermat's Little Theorem, Normal subgroups, Factor groups.

[1] Chapter 5 (up to theorem 5.7), Chapter 7 (up to theorem 7.2), Chapter 9 (up to theorem 9.2)

(No. of classes: 15, Marks: 20)

Unit 3: Isomorphism of groups, Cayley's Theorem, Properties of isomorphism, Group homomorphism, Kernal of a group homomorphism, Properties of group homomorphism, First isomorphism Theorem of groups.

[1] Chapter 6 (up to theorem 6.3), Chapter 10 (up to theorem 10.4).

(No. of classes: 15, Marks: 20)

Unit 4: Rings, Examples of rings, Properties of rings, Subrings, Zero-Divisors in a ring, Integral domains, Fields, Characteristic of a ring, Ideals, Ideal Test, Factor rings, Prime ideals and maximal ideals of a ring.

[1] Chapter 12 to Chapter 14.

(No. of classes: 15, Marks: 20)

Text Books:

1. Gallian Joseph A., *Contemporary Abstract Algebra* (8th Edition) , Cengage Learning India Private limited, Delhi, Fourth impression, 2015.

Online link: https://ict.iitk.ac.in/wp-content/uploads/CS203-Mathematics-for-Computer-Science-III-Gallian.pdf

Reference Books:

1. David S. Dummit and Richard M. Foote, *Abstract Algebra* (2nd Edition) , John Wiley and Sons (Asia) Pvt. Ltd. , Singapore, 2003.

2. John B. Fraleigh, *A First course in Abstract Algebra*, 7th Edition, Pearson, 2002.

3. G. Santhanam. *Algebra,* Narosa Publishing House, 2017.

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SEMESTER-V

Paper-II

Multivariate Calculus

Total Marks: 100 (Theory 80, Internal Assessment 20)

No. of Credits: 4

(Each unit carries equal credits)

(Use of Scientific calculator is allowed)

Base syllabus: MAT-HC-4016: Multivariate Calculus (UG CBCS)

Course Level: 300-399

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Knowledge on the following topics:

- Functions of single variable, limit, continuity, differentiability and extrema of single variable functions.
- Knowledge of Integration
- Vector valued functions, dot and cross product of vectors.

Course Objectives: To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables. Also, the emphasis will be on the use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding. This course will facilitate to becomeaware of applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.

Course Learning Outcomes: This course will enable the students to:

- Learn the conceptual variations when advancing in calculus from one variable to multivariable discussion.
- Understand the maximization and minimization of multivariable functions subject to the given constraints on variables.
- Learn about inter-relationship amongst the line integral, double and triple integral formulations.
- Familiarize with Green's, Stokes' and Gauss divergence theorems

UNIT 1: Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Higher order partial derivative, Chain rule, Directional derivatives, The gradient, Maximal property of the gradient.

[1] Chapter 11 [(Sections 11.1, 11.2, 11.3, 11.5, Section 11.6 (upto page 592)]

(No. of classes: 15, Marks: 20)

UNIT 2: Extrema of functions of two variables, Method of Lagrange multipliers, Constrained optimization problems; Definition of vector field, Divergence and curl.
[1] Chapter 11 [Section 11.7 (up to page 605), Section 11.8 (pages 610-614)], Chapter13 (Section 13.1)
(No. of classes: 15, Marks: 20)

UNIT 3: Double integration over rectangular and nonrectangular regions, Double integrals in polar coordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals.
[1] Chapter 12 (Sections 12.1-12.4)
(No. of classes: 15, Marks: 20)

UNIT 4: Line integrals, Applications of line integrals**:** Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral; Surface integrals, Stokes' theorem, The Gauss divergence theorem.
[1] Chapter 13 [(Sections 13.2, 13.3), Section 13.4 (pages 712 to 716), Section 13.5 (pages 723 to 726) Section 13.6 (pages 733 to 737), Section 13.7 (pages 742 to 745)]
(No. of classes: 15, Marks: 20)

Text book:

[1] Strauss, Monty J.,Bradley, Gerald L.,& Smith, Karl J.(2007). *Calculus* (3rd ed.).Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011

Reference Books:

1. Marsden, J.E., Tromba, A., & Weinstein,A.(2004).*Basic Multivariable Calculus*.Springer (SIE). First Indian Reprint.
2. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
3. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA,2001.

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SEMESTER-V

Paper-III

Theory of Real Functions

Total Marks: 100 (Theory 80, Internal Assessment 20)

No. of Credits: 4

Base syllabus: MAT-HC-3016: Theory of Real Functions (UG CBCS)

Course Level: 300-399

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Class XII level Mathematics

Course Objective: The primary objective of this course is to study limit point of set and limit of a function. The discussion on continuous functions and differentiability with some related theorems will also be focused in this course.

Course Learning Outcomes: This course will enable the students to:

- Have a rigorous understanding of the concept of limit of a function.
- Learn about continuity and uniform continuity of functions defined on intervals.
- Understand geometrical properties of continuous functions on closed and bounded intervals.
- Learn extensively about the concept of differentiability using limits, leading to a better understanding for applications.
- Know about applications of mean value theorems and Taylor's theorem

UNIT 1: Cluster point or limit point of a set, limits of a function (ε-δ approach), sequential criterion for limits, divergence criteria, limit theorems, one sided limits, infinite limits and limits at infinity.

[1] Chapter 4

(No. of classes: 15, Marks: 20)

UNIT 2: Continuous functions, sequential criterion for continuity and discontinuity, algebra of continuous functions, continuous functions on intervals, maximum-minimum theorem, intermediate value theorem, location of roots theorem, preservation of intervals theorem, uniform continuity, uniform continuity theorem, monotone and inverse functions.

[1] Chapter 5 (5.1 to 5.6)

(No. of classes: 15, Marks: 30)

UNIT 3: Differentiability of a function at a point and in an interval, Caratheodory's theorem, chain rule, derivative of inverse function, Rolle's theorem, mean value theorem, Darboux's theorem, Cauchy mean value theorem, Taylor's theorem and applications to inequalities, Taylor's series expansions of exponential and trigonometric functions, ln(1+x), 1/(ax+b) and $(1+x)^n$.

[1] Chapter 6, and Taylor series as in Section 6.4.

(No. of classes: 30, Marks: 30)

Text Book:

1. R.G. Bartle and D.R. Sherbert, *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons, 2002.

Reference Books:

1. Ajit Kumar and S. Kumaresan, *A Basic Course in Real Analysis*, CRC Press, Indian Ed. 2014.
2. K.A. Ross, *Elementary Analysis: The Theory of Calculus*, Springer, 2004.
3. Mattuck, *Introduction to Analysis*, Prentice Hall, 1999.
4. S.R.Ghorpade and B.V.Limaye, *A Course in Calculus and Real Analysis*, Springer, 2006.

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SEMESTER-V

Paper-IV

Numerical Analysis (with practical)

Total Marks: 100

(Theory: 60, Practical 20, Internal Assessment: 20)

No. of Credits: 4 (Theory 3, Practical 1)

(Use of Scientific calculator is allowed)

Base syllabus: MAT-HG-4026: Numerical Analysis (UG CBCS)

Course Level: 300-399

No. of Contact classes: 75 (15×3+30×1)

No. of Non-Contact classes: 0

Prerequisites: Class XII level Mathematics, Knowledge on computer software and programming

Course Objectives: To comprehend various computational techniques to find approximate value for possible root(s) of non-algebraic equations, to find the approximate solutions of system of linear equations and Quadratic equations.

Course Learning Outcomes: The course will enable the students to:

- Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of asystem of linear equations, up to a certain given level of precision.
- Know about iterative and non-iterative methods to solve system of linear equations
- Know interpolation techniques to compute the values for a tabulated function at points not in the table.
- Integrate a definite integral that cannot be done analytically
- Find numerical differentiation of functional values
- Solve differential equations that cannot be solved by analytical methods

Unit 1: Gaussian elimination method (with row pivoting), Gauss-Jordan method; Iterative methods**:** Jacobi method, Gauss-Seidel method; Interpolation**:** Lagrange form, Newton form, Finite difference operators, Gregory-Newton forward and backward difference interpolations, Piecewise polynomial interpolation (Linear and Quadratic).

[1] Chapter 3(Sections 3.1, and3.2),Chapter 6(Sections 6.1,and 6.2) Chapter 8(Section8.1, Section8.3 (8.3.1, and8.3.2)

[2] Chapter 3(Sections 3.2, and 3.4) Chapter 4(Section 4.2) Chapter 4(Sections 4.3,and 4.4)

[1]Chapter 18 (Sections18.1to18.3)

(No. of classes: 20, Marks: 30)

Unit 2: Numerical differentiation**:** First and second order derivatives; Numerical integration**:** Trapezoid rule, Simpson's rule; Extrapolation methods**:** Richardson extrapolation, Romberg integration; Ordinary differential equation**:** Euler's method, Modified Euler's methods **(**Heun and Mid-point).

[2] Chapter 11 [Sections 11.1(11.1.1,11.1.2,11.1.4), and11.2(11.2.1,11.2.2,11.2.4)]

[1] Chapter 22 (Sections22.1, and 22.2,22.3)

(No. of classes: 25, Marks: 30)

***Practical / Lab work to be performed on a computer*:**

Use of computer aided software (CAS), for example *Matlab/Mathematica/Maple* etc., for developing the following numerical programs:

(i) Lagrange's interpolation method

(ii) Newton's interpolation method

(iii) To calculate forward and backward differences

(iv) Trapezoidal rule

(v) Simpson's rule

Note: For any of the CAS *Matlab/Mathematica/Maple* etc., Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, arrays should be introduced to the students.

(No. of practical classes: 30, Marks: 20)

Text Books:

[1] Chapra, Steven C.(2018).*Applied Numerical Methods with* MATLAB *for Engineers and* Scientists (4^{th} ed.) Mc Graw-Hill Education.

[2] Fausett, Laurene V. (2009). *Applied Numerical Analysis Using* MATLAB. Pearson. India

[3] Jain, M.K., Iyengar, S.R.K., & Jain R.K.(2012). *Numerical Methods for Scientific and Engineering Computation* (6^{th} ed.). New Age International Publishers. Delhi.

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SEMESTER-VI

Paper-I

Linear Algebra

Total Marks: 100 (Theory 80, Internal Assessment 20)

No. of Credits: 4

Each unit carries equal credit

Base syllabus: MAT-HC-5026: Linear Algebra (UG CBCS)

Course Level: 300-399

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites for the paper: Senior Secondary School Mathematics or equivalent