# SIDO KANHU MURMU UNIVERSITY, DUMKA

(A State University recognized under Section 2(f) & 12(B) of the UGC Act, 1956)

# SYLLABUS

**OF**

**FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)**

**FOR**

**MATHEMATICS HONOURS/RESEARCH**

**Accordance with the**

**Implementation of FYUGP in State Universities of Jharkhand Regulations, 2024**

***Implemented from***
***Academic Session 2025-2029 Onwards***

**(Dr. S. N. Adhikary)**

Head, Univ. Dept. of Maths,
SKMU, Dumka (Chairman)

**(Dr. Ziaul Hoque)**

Dept. of Maths,S. P College,
Dumka(Member)

**(Dr. B. N. Yadav)**

Dept. of Maths,NBAP, S. P
College, Dumka(Member)

**(Dr. Arvind Kumar Sah)**

Prof. & Head
University Dept. of Mathematics
TMBU, Bhagalpur

**(Dr. Mukesh Kumar)**

Dept. of Maths,NBAP, A. S. College,
Deoghar(Member)

**(Dr. R. K. Verma)**

NBAP, Univ. Dept. of
Maths,SKMU, Dumka (Member)

**(Dr. S. N. Singh)**

Dept. of Maths,Deoghar
College, Deoghar(Member)

**(Dr. Uttam Kr. Shukla)**

Dept. of Maths,NBAP, Madhupur
College, Madhupur(Member)

**(Mr. Deepak Kumar Das)**

Co-ordinator, NEP
SKMU, Dumka (Member)

## Semester-wise Subject Combination for B.Sc (MATHEMATICS)

| Semester | Course Category | Code | Papers | Credits |
|---|---|---|---|---|
| First Semester | Major | MJ-1 | **Algebra and Trigonometry** | 4 |
| | Associated Core/Associated Vocational | AC-1A | Select any one subject from the Associated Core Table with the guidance of the Class Teacher. | 4 |
| | Multidisciplinary Course | MDC-1 | **Choose any one of the following:**<br>• Mathematical and Computational Thinking Analysis<br>• Gender Studies<br>• Goods and Services Tax (GST)<br>• Pollution Control and Waste Management | 3 |
| | Ability Enhancement Course | AEC-1 | Hindi (Compulsory) | 2 |
| | Skills Enhancement Course | SEC-1 | Introduction to Computer and IT (Compulsory) | 2 |
| | Value Added Course | VAC-1 | Understanding India (Compulsory) | 3 |
| | Indian Knowledge System | IKS-I | Indian Knowledge System (Compulsory) | 2 |
| Second Semester | Major | MJ-2 | **Calculus and Geometry** | 4 |
| | Associated Core/Associated Vocational | AC-2B | Select any one subject either from the Associated Core subjects not studied in Semester-I or from the Associated Vocational subjects, with the guidance of the Class Teacher. | 4 |
| | Multidisciplinary | MDC-2 | **Choose any one of the following:**<br>• Nutrition and Health education<br>• Digital Marketing<br>• Introduction to Indian Values and Ethics<br>• Santhal Tribes and Culture | 3 |
| | Ability Enhancement | AEC-2 | English (Compulsory) | 2 |
| | Skills Enhancement | SEC-2 | Digital Communication and Data Management (Compulsory) | 3 |
| | Value Added Course | VAC-2 | Environmental Studies (Compulsory) | 2 |
| | Indian Knowledge System | IKS-2 | Social Awareness (Compulsory) | 2 |
| Third Semester | Major | MJ-3 | **Real Analysis -1** | 4 |
| | | MJ-4 | **Differential Equation** | 4 |
| | Elective Course | ELC-1A | Elective Paper-1 from the Chosen Associated Core Subject in Semester I | 4 |
| | Multidisciplinary | MDC-3 | **Choose any one of the following:**<br>• Indian Philosophy<br>• Indian Cultural Studies | 3 |

| | | | | |
|---|---|---|---|---|
| | | | • Kautilya's Arthashastra<br>• Vedic Mathematics | |
| | Ability Enhancement | AEC-3 | **Select One Language Course:**<br>Students must choose **one** of the following languages:<br>**Hindi, English, Bangla, Sanskrit, Urdu, Santali, Persian, or Maithili.**<br><br>**Note:** Students are required to study **Paper-I** of the language they choose. | 2 |
| | Skills Enhancement | SEC-3 | Computer Software, Programming and AI (Compulsory) | 3 |
| **Fourth Semester** | Major | MJ-5 | **Mathematics in Ancient India** | 4 |
| | | MJ-6 | **Vector Analysis** | 4 |
| | | MJ-7 | **Partial Differential Equation** | 4 |
| | Elective Course | ELC-1B | Elective Paper-1 from the Chosen Associated Core/Associated Vocational Subject in Semester-II | 4 |
| | Ability Enhancement | AEC-4 | Paper-2 of Selected Language course in Semester-III | 2 |
| | Value Added Course | VAC-3 | Health& Wellness, Yoga Education, Sports & Fitness (Compulsory) | 2 |
| **Fifth Semester** | Major | MJ-8 | **Statics and Dynamics** | 4 |
| | | MJ-9 | **Linear Algebra** | 4 |
| | | MJ-10 | **Real Analysis -2** | 4 |
| | | MJ-11 | **Complex Analysis -1** | 4 |
| | Elective Course | ELC-2A | Elective Paper-2 from the Chosen Associated Core Subject in Semester I | 4 |
| **Sixth Semester** | Major | MJ-12 | **Metric Space** | 4 |
| | | MJ-13 | **Topological Space** | 4 |
| | | MJ-14 | **Theory of Equations** | 4 |
| | | MJ-15 | **Mechanics** | 4 |
| | Elective Course | ELC-2B | Elective Paper-2 from the Chosen Associated Core/Associated Vocational Subject in Semester-II | 4 |
| • In the fourth year, students have two pathways: they can either complete their graduation with **Honours**, or with **Honours with Research**.<br>• Those who wish to graduate with **Honours only** must follow **Table-A**, while those opting for **Honours with Research** must follow **Table-B**. | | | | |
| **TABLE-A FOR HONOURS ONLY**<br>**FOURTH YEAR** | | | | |
| **Seventh Semester** | Major | MJ-16 | **Numerical Analysis and Optimization** | 4 |
| | | MJ-17 | **Spherical Trigonometry** | 4 |
| | | MJ-18 | **Spherical Astronomy** | 4 |
| | Advance Major | AMJ-1 | **Complex Analysis -2** | |

| | | | | |
|---|---|---|---|---|
| | Elective Course | ELC-3A | Elective Paper-3 from the Chosen Associated Core Subject in Semester I | 4 |
| **Eighth Semester** | Major | MJ-19 | **Abstract Algebra and Ring Theory** | 4 |
| | | MJ-20 | **Real Analysis - 3** (GROUP DISCUSSION AND DISSERTATION) | |
| | Advance Major | AMJ-2 | **Foundation course in Modern Algebra** | 4 |
| | | AMJ-3 | **Theory of Numbers** | 4 |
| | Elective Course | ELC-3B | Elective Paper-3 from the Chosen Associated Core/Associated Vocational Subject in Semester-II | 4 |
| **TABLE-B FOR HONS WITH RESEARCH FOURTH YEAR** | | | | |
| **Seventh Semester** | Major | MJ-16 | **Numerical Analysis and Optimization** | 4 |
| | | MJ-17 | **Spherical Trigonometry** | 4 |
| | | MJ-18 | **Spherical Astronomy** | 4 |
| | Research Methodology | RM-1 | **Research Methodology** | 4 |
| | Elective Course | ELC-3A | Elective Paper-3 from the Chosen Associated Core Subject in Semester I | 4 |
| **Eighth Semester** | Major | MJ-19 | **Abstract Algebra and Ring Theory** | 4 |
| | | MJ-20 | **Real Analysis - 3** (GROUP DISCUSSION AND DISSERTATION) | 4 |
| | Research Project/ Dissertation | RC-2 | **Research Project/ Dissertation/ Field work** | 8 |
| | Elective Course | ELC-3B | Elective Paper-3 from the Chosen Associated Core/Associated Vocational Subject in Semester-II | 4 |

**Compulsory Summer Internship:**

***1. If a student exits after Semester II, IV, or VI:***

To receive a Certificate/Diploma/Bachelor's Degree, students must complete a summer internship/project/dissertation worth 4 credits. This should be done during the summer break of any semester within the first three years.

**Note:** The Certificate/Diploma/Bachelor's Degree will not be awarded without completing this internship.

***2. If a student exits after Semester VIII:***

Under the National Education Policy (NEP), all students must complete a 4-credit summer internship to get a Bachelor's Hons/Hons with Research/P.G. Diploma Degree.

There are two ways to complete this requirement:

a. Two internships of 4 weeks each (2 credits each), or

b. One internship of 8 weeks (4 credits total)

The college will help arrange the internship, and students can complete it any time between Semester 1 and Semester 6 Summer Vacation.

**Note:** The Bachelor (Hons)/Hons with Research, or P.G. Diploma will not be awarded without completing the internship.

# INSTRUCTIONS FOR QUESTION SETTER

1. **Semester Internal Examination** (25 Marks)-

   The **Semester Internal Examination (SIE)** will be of **25 marks** in total, which includes **20 marks for the test** and **5 marks for attendance/Class Overall Performance**. The question paper will have **two groups**.

   **Group A** will have two questions:

   - **Question 1:** Five very short answer questions (1 mark each, total 5 marks)
   - **Question 2:** One short answer question of 5 marks

   **Group B** will have two descriptive questions of 10 marks each. Students will have to answer **any one** (total 10 marks).

   The remaining **5 marks** will be given based on **class attendance** as follows:

   - Up to 45% attendance: 1 mark
   - 46% to 54%: 2 marks
   - 55% to 64%: 3 marks
   - 65% to 74%: 4 marks
   - 75% and above: 5 marks

2. **End Semester Examination (75 Marks)**

   The **End Semester Examination (ESE)** will be of **75 marks** and will also have **two groups**.

   **Group A** is compulsory and will have:

   - **Question 1:** Five very short answer questions (1 mark each, total 5 marks)
   - **Questions 2 and 3:** Two short answer questions (5 marks each, total 10 marks)

   **Group B** will have **six descriptive questions**, each carrying **15 marks**. Students need to answer **any four** (total 60 marks).

   Note: Some questions may be divided into smaller parts if needed.

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## PROMOTION CRITERIA

- All students will be promoted in odd Semesters (I, III, V & VII).
- To get a promotion from Semester II to Semester III, from Semester IV to Semester V, and from Semester VI to Semester VII a student has to procure a minimum of 4 CGPA.
- However, it will be necessary to obtain a minimum credit (4) to pass in each of the subjects individually before completion of the course.

## CALCULATION OF MARKS FOR THE PURPOSE OF RESULT

The passing in a subject will be based on the combined marks obtained in ECOh the internal and external examinations of the semester. However, the student must pass the theory and practical examinations separately.

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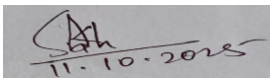

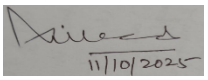

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Dept. of Maths,NBAP, S. P
College, Dumka(Member)

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NBAP, Univ. Dept. of
Maths,SKMU, Dumka (Member)

**(Mr. Deepak Kumar Das)**
Co-ordinator, NEP
SKMU, Dumka (Member)

## SEMESTER – I

**COURSE:** MAJOR -1 (MJ-1) **TOTAL CREDITS:** THEORY-04

**PAPER:Algebra and Trigonometry** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. Introduce the fundamental concepts of set theory, relations, and mappings.
2. Develop an understanding of algebraic structures such as groups, rings, fields, and integral domains.
3. Apply trigonometric and complex number techniques, including De Moivre's theorem and hyperbolic functions.
4. Provide foundational knowledge of linear algebra concepts including matrices, their properties, and methods to solve linear systems.

**COURSE OUTCOMES:**

1. Demonstrate understanding of basic set theory concepts, relations, and functions.
2. Apply group and ring theory to solve algebraic problems.
3. Use trigonometric identities and complex number theory in practical computations.
4. Analyze and solve systems of linear equations using matrix operations.

**THEORY COURSE CONTENTS:**

**UNIT-I Set Theory:** Cartesian product of sets, relation, kinds of Relation, Partition of a set, Index set, Relation of congruence modulo n, Partial and total order relation, Fundamental theorem of equivalence relation, Mapping and Set mapping**.**

**UNIT-II Abstract Algebra-I:** Notionof Group, Subgroup,Properties of groups, Cyclic group,order of an element,Definitions and examples of Ring, Field and Integral domain, Elementary properties of rings.

**UNIT-III Trigonometry:** Application of De-Moivre's Theorem, Complex Argument, Hyperbolic functions, Gregory's Series.

**UNIT-IV LinearAlgebra – I:** Adjoint and Inverse of a Matrix, Orthogonal matrix, Rank of matrix by determinants, Solution of Simultaneous linear equation.

**SUGGESTED READINGS:**


1. Lalji Prasad: Set Theory, Paramount Publication.
2. A. R. Vasishtha: Set Theory, Krishna's publication.
3. K. K. Jha: Advance Set theory, Nav Bharat Prakashan, Patna
4. Lalji Prasad: Abstract Algebra, Paramount publication.
5. A. R. Vasishtha: Modern Algebra, Krishna's publication.
6. K. K. Jha: Abstract Algebra, Nav Bharat Prakashan, Patna
7. Lalji Prasad: Higher Trigonometry, Paramount publication.
8. A. R. Vasishtha: Higher Trigonometry, Krishna's publication.
9. K. K. Jha: Linear Algebra, Nav Bharat Prakashan, Patna.
10. Lalji Prasad: Matrices, Paramount publication.

## SEMESTER – II

**COURSE:** MAJOR -2 (MJ-2) **TOTAL CREDITS:** THEORY-04

**PAPER: Calculus and Geometry** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. Introduce the principles of differential calculus, including higher-order derivatives, partial derivatives, and their applications.
2. Provide knowledge of integral calculus, including techniques of integration and applications to area calculation.
3. Develop understanding of 2D coordinate geometry, focusing on circles and conic sections.
4. Teach fundamentals of 3D geometry, including direction cosines, straight lines, planes, and distances in space.
5. Enhance problem-solving and analytical skills by applying calculus and geometry concepts to mathematical problems.

**COURSE OUTCOMES:**

1. Perform successive differentiation and apply Leibnitz's Theorem; use Euler's Theorem in partial differentiation problems.
2. Determine tangents, normals, and derive pedal equations for given curves.
3. Evaluate definite and indefinite integrals using standard techniques and reduction formulas.
4. Calculate areas bounded by curves in both Cartesian and polar coordinates.
5. Analyze geometric properties of circles, coaxial systems, and conic sections in 2D geometry.
6. Solve problems involving direction cosines, direction ratios, planes, and straight lines in 3D geometry.
7. Compute the shortest distance between two skew lines and solve related 3D problems.

**THEORY COURSE CONTENTS:**

**Unit-I: Differential Calculus:** Successive differentiation and Leibnitz Theorem, Partial Differentiation and Euler's Theorem on homogeneous functions, Tangents and Normals, pedal equations.

**Unit-II: Integral Calculus:** Indefinite Integral, Definite Integral, Reduction formula, Area (Both Cartesian and Polar curve).

**Unit-III: 2D Geometry:** System of circles, Radical axes, coaxial circles, Standard equation of parabola, Hyperbola and Ellipse.

**Unit-IV: 3D Geometry:** Direction Cosines and Direction ratios, Straight line, Plane, Shortest distance between two skew lines and related problems.

**SUGGESTED READINGS:**


1. Lalji Prasad: Differential Calculus, Paramount publication.
2. A. R. Vasishtha: Differential Calculus, Krishna's publication.
3. Shanti Narayan: Differential Calculus, S. Chand
4. Lalji Prasad: Integral Calculus, Paramount publication.
5. Shanti Narayan: Integral Calculus, S. Chand
6. Lalji Prasad: Coordinate Geometry, Paramount publication.
7. A. R. Vasishtha: 2D Coordinate Geometry, Krishna's publication.
8. Lalji Prasad: Solid Geometry 3D, Paramount publication.

## SEMESTER – III

**COURSE:** MAJOR -3 (MJ-3) **TOTAL CREDITS:** THEORY-04

**PAPER: Real Analysis** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. Introduce the formal definition of limits using the ε-δ approach and discuss the concepts of continuity and differentiability for real-valued functions.
2. Provide a deep understanding of fundamental theorems of differential calculus including Rolle's Theorem, Mean Value Theorems, and Taylor's Theorem.
3. Develop the concept of sequences, their convergence, and the foundational ideas behind limits of sequences.
4. Introduce infinite series and equip students with various convergence tests to analyze their behavior.
5. Build logical and analytical reasoning skills required for the study of real analysis and advanced mathematics.

**COURSE OUTCOMES:**

1. Understand and apply the ε-δ definition of limits, and examine the continuity and differentiability of real-valued functions.
2. Apply Rolle's Theorem, Lagrange's Mean Value Theorem, and Taylor's Theorem with various forms of remainder to solve problems.
3. Expand functions into Taylor and Maclaurin series and use them for approximation and analysis.
4. Analyze the behavior of sequences, including monotonic and Cauchy sequences, and determine their convergence using established principles.
5. Evaluate the convergence or divergence of infinite series using various tests such as comparison test, ratio test, root test, Raabe's test, logarithmic test, and others.

**THEORY COURSE CONTENTS:**

**Unit-I:** ε-δ definition of the limit of function, continuity and Differentiability of a function of Single variable, simple properties of function.

**Unit-II:** Rolle's theorem, Lagrange's Mean value theorem, Taylor's theorem with Lagrange's and Cauchy's form of remainder and Taylor's and Maclaurin's series of elementary functions.

**Unit-III:** Sequence and its convergence, limit of a sequence, Monotonic Sequence, Cauchy's Sequence, Cauchy's 1$^{st}$ principle, Cauchy's general principle of convergence.

**Unit-IV:** Infinite series, comparison test, ratio test, Cauchy's root test,Cauchy's condensation test, Raabe's test, De-Morgan's and Bertrand's test, Logarithmic test, Higher logarithmic test.

**SUGGESTED READINGS:**

1. Lalji Prasad: Real Analysis, Paramount publication.
2. S. C. Malik: Mathematical Analysis, New age publishers
3. K. K. Jha: Real Analysis, Nav Bharat Prakashan, Patna.

## SEMESTER – III

**COURSE:** MAJOR -4 (MJ-4) **TOTAL CREDITS:** THEORY-04

**PAPER: Differential Equation** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. Understand the basic concepts of differential equations, including order, degree, and methods of formation.
2. Learn various methods for solving first-order and first-degree differential equations.
3. Explore differential equations that are of first order but not of first degree and understand their solutions.
4. Study linear differential equations with constant coefficients and learn symbolic methods for finding their solutions.
5. Develop the ability to apply differential equations in modeling and solving real-life problems in science and engineering.

**COURSE OUTCOMES:**

1. Identify the order and degree of a differential equation and form differential equations from given relations.
2. Solve first-order, first-degree differential equations using methods such as separable variables, homogeneous and non-homogeneous equations, linear and exact equations.
3. Solve first-order but not first-degree equations, including those solvable for xxx, yyy, and Clairaut's type equations, and identify singular solutions.
4. Solve linear differential equations with constant coefficients using symbolic representation, complementary functions, and particular integrals.
5. Apply differential equation techniques to solve practical problems in physical and engineering contexts.

**THEORY COURSE CONTENTS:**

**Unit-I:** Basic concepts of Differential Equation,Order and Degree of a differential equation, Formation of Differential Equation.

**Unit-II**: Differential equation of first order and first degree, Solution of Differential Equation, Equation in which the Variables and Separable, Homogenous and Non-homogeneous equations, Linear differential equations and equations reducible to the linear form, Exact Differential equations.

**Unit-III:** Differential equation of first order but not first degree, Equation solvable for y, Equation solvable for x, Clairaut's form and singular Solutions.

**Unit-IV:** Linear Equations with Constant Coefficients, Symbolic Representation, Method of Finding Complementary Function, Method of Finding Particular Integrals.

**SUGGESTED READINGS:**

1. Lalji Prasad: Differential Equation, Paramount publication.
2. M. D. Raisinghania: Ordinary Differential Equation, S Chand.
3. K. K. Jha: Differential Equation, Nav Bharat Prakashan, Patna.
4. G. B. Gian Carlo Rota: Ordinary differential Equation

**COURSE:** MAJOR -5 (MJ-5) **TOTAL CREDITS:** THEORY-04

**PAPER: Mathematics in Ancient India** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To understand the historical development of mathematical concepts in the Indian subcontinent.
2. To explore ancient and medieval Indian contributions to arithmetic, algebra, geometry, trigonometry, combinatorics, and calculus.
3. To integrate traditional knowledge systems with modern mathematical thought.
4. To appreciate mathematical treatises and computational methods from Indian texts.
5. To enhance problem-solving skills by learning ancient algorithms and their applications.
6. Connects mathematics to India's cultural and intellectual roots
7. Focus on joyful learning through stories, creativity, and local knowledge
8. Encourages appreciation of India's contribution to world mathematics
9. Supports NEP 2020 goals of integrating IKS into education

**COURSE OUTCOMES:**

1. Explain the origin and evolution of mathematical concepts in India.
2. Analyze Indian algorithms for arithmetic and algebraic computations.
3. Apply ancient geometric and trigonometric techniques in problem-solving.
4. Demonstrate the relevance of Indian combinatorial and calculus ideas to modern mathematics.
5. Develop an appreciation of Indian mathematicians and their contributions to world mathematics.

**THEORY COURSE CONTENTS:**

**Unit-I:** Introduction to Ancient Indian Mathematics, Definition and relevance of Mathematics in ancient times, Development of Indian mathematics during Vedic and Ancient, Mathematics in Indus Valley Civilization. Discovery and significance of Zero and Decimal System, Comparison between Indian and Western approaches to mathematics, Use of mathematics in Indian temples, art, and architecture

**Unit-II:** Life, Background, notable works and mathematical contribution of Aryabhata: Pi (π), trigonometry, place value system. Brahmagupta: Rules of zero, negative numbers, algebra. Bhaskaracharya: The Lilavati – story-based math problems, Kerala School (e.g., Madhava, Neelakantha): Early concepts of calculus, infinite series, Inspiring life and values of ancient Indian scholars,

**Unit-III:** History and salient features of Vedic Mathematics, Vedic mathematics formulae 16 sutras, 13 sub sutras,Mathematical ideas in the Vedas.

**Unit-IV:** Sutras method Addition- Completing the whole, Addition from left to right, Addition of list of numbers- Shudh method, Multiplication by Nikhilam Base Method, Sub Base Method, Multiplication of complimentary numbers, Multiplication by numbers consisting of all 9s, Multiplication by 11, Multiplication by two- digit numbers from right to left, Straight Division, Split Division Method. Squaring numbers ending in 5, Squaring Decimals and Fraction, Squaring numbers near a Base and Subbase, General method of squaring, cubing, roots, and factorization using sutras, Applications to competitive mathematics and mental calculations.

**SUGGESTED READINGS:**

1. Advanced Vedic Mathematics: Rajesh Kumar Thakur
2. Indian Mathematical Luminaries: Dr. BhargabJyoti Saikia
3. Lilavati: Bhaskaracharya
4. Mathematics in India : Kim Plofker

**References:**

5. Sandip Ghanta and Dr. Sankar Prasad Mukherjee“An Overview of Mathematical Evolution in Indus Valley Civilization”
6. B. Dutta and A Singh “History of Hindu Mathematics, Volume I & II, Calcutta, Asian Publishing House
7. K. R. Williams, Vedic Mathematics Teacher’sManual, Inspiration Books, Revised Edition, 20

## SEMESTER – IV

**COURSE:** MAJOR -6 (MJ-6) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Vector Analysis** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To develop an understanding of vectors and their different classifications and operations.
2. To equip students with the ability to apply vector algebra to solve problems in mechanics and geometry.
3. To introduce the concepts of vector differentiation and integration with their basic properties.
4. To study and apply differential operators such as gradient, divergence, and curl in various physical and mathematical contexts.

**COURSE OUTCOMES:**

1. Classify vectors and evaluate scalar, vector, and triple products with their applications.
2. Analyze conditions for coplanarity and compute reciprocal vectors and products of multiple vectors.
3. Apply vector algebra to mechanics, including computation of moments and work done by forces.
4. Perform vector differentiation and integration and utilize their properties in problem-solving.
5. Compute gradient, divergence, and curl of vector fields and apply these concepts to physical problems in fluid dynamics and electromagnetism.

**THEORY COURSE CONTENTS:**

**Unit-I:** Classification of a Vector, Scalar and vector triple product, Condition for coplanarity of three vectors, Scalar and vector product of four vectors,reciprocal vectors,

**Unit-II:** Application of vectors to mechanics, moment of a localized vector about a directed line, work done by a force.

**Unit-III:** Vector differentiation and its elementary properties, Vector Integration.

**Unit-IV:** Gradient, Divergence and Curl and its Applications.

**SUGGESTED READINGS:**

1. Lalji Prasad: Vector Analysis, Paramount Publication.
2. Santi Narayan: Vector Calculus, S Chand Publication.
3. K. K. Jha: Vector Analysis, Nav Bharat Prakashan, Patna.

## SEMESTER – IV

**COURSE:** MAJOR -7 (MJ-7) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Partial Differential Equation** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To introduce the concept, classification, and formation of partial differential equations (PDEs).
2. To develop skills for solving first-order linear and non-linear PDEs using standard methods.
3. To analyze and classify second-order PDEs and solve linear homogeneous equations with constant coefficients.
4. To familiarize students with Monge's method and its applications in solving second-order PDEs.

**COURSE OUTCOMES:**

1. Define, classify, and form partial differential equations by eliminating arbitrary constants and functions.
2. Solve first-order linear PDEs using Lagrange's equation and interpret solutions geometrically.
3. Apply Charpit's general method for solving first-order non-linear PDEs.
4. Classify second-order PDEs and solve linear homogeneous PDEs with constant coefficients.
5. Apply Monge's method to solve second-order PDEs of the form $Rr+Ss+Tt=V$$Rr + Ss + Tt = V$$Rr+Ss+Tt=V.

**THEORY COURSE CONTENTS:**

**Unit-I**: An Introduction to Partial differential Equation, Order and Degree, Classification of Partial Differential Equation, Linear Partial Differential Equation of first order, Derive Partial Differential Equation by elimination of arbitrary constant and arbitrary function.

**Unit-II**: Lagrange's Linear Equation and its geometrical interpretation. Solution of a Partial Differential Equation of first order by Lagrange's equation, Non-Linear partial differential equation of $1^{st}$ order, Charpit's general method of solution,

**Unit-III**: Partial differential Equation of $2^{nd}$ order, classification of linear partial differential Equation of $2^{nd}$ order, Homogenous equations with constant co-efficient, Partial differential Equations reducible to those with constant co-efficient.

**Unit-IV**: Monge's method of the type $(Rr + Ss + Tt = V)$

**SUGGESTED READINGS:**

1. Lalji Prasad: Differential Equation, Paramount Publication.
2. M D Raisinghania: Partial Differential Equation, S Chand Publication.
3. K. K. Jha: Differential Equation, Nav Bharat Prakashan, Patna.

## SEMESTER – V

**COURSE:** MAJOR -8 (MJ-8) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Statics and Dynamics** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To understand the concept of virtual work and its applications in equilibrium of forces.
2. To study the properties of catenary and its various forms including intrinsic and Cartesian equations.
3. To analyze the motion of a particle in a plane using different velocity and acceleration components.
4. To examine the motion of particles under central forces and understand the fundamental principles of planetary motion.

**COURSE OUTCOMES:**

1. Explain and apply the principle of virtual work for systems of coplanar forces and equilibrium conditions.
2. Derive and analyze the common catenary and its properties using intrinsic and Cartesian equations.
3. Describe and compute radial, transverse, tangential, and normal components of velocity and acceleration for planar motion.
4. Analyze particle motion under central forces and explain the significance of central orbits and Kepler's laws of planetary motion.

**THEORY COURSE CONTENTS:**

**Unit-I:** Virtual work and Principle of virtual work, Principle of virtual work for a system of coplanar forces, Equilibrium forces.

**Unit-II:** Common catenary and its properties, Intrinsic Equation, Cartesian Equation

**Unit-III:** Simple Harmonic Motion, Motion of a Particle in one plane ,Radial and Transverse velocities, Radial and Transverse acceleration, Tangential and Normal velocities, Tangential and Normal acceleration of a particle in motion on a plane.

**Unit-IV:** Motion of a particle under central force, central Orbits, Kepler's laws of planetary motion (statement only).

**SUGGESTED READINGS:**

1. P. Singh and D. K. Sen: Degree Level Mechanics, Paramount Bharti Bhawan.
2. M. Ray: A Textbook on Dynamics, S Chand Publication.
3. K. K. Jha: Degree Level Mechanics, Nav Bharat Prakashan, Patna.

## SEMESTER – V

**COURSE:** MAJOR -9 (MJ-9) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Linear Algebra** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To understand the fundamental concepts of matrices, determinants, and their properties.
2. To develop skills in working with special types of matrices (symmetric, skew-symmetric, Hermitian, unitary, and orthogonal).
3. To learn different methods for solving systems of linear equations using matrices.
4. To explore eigenvalues, eigenvectors, and characteristic equations for solving advanced problems.
5. To develop logical thinking and analytical problem-solving skills through mathematical principles.
6. To enable students to apply theoretical concepts to real-life applications in science and engineering.

**COURSE OUTCOMES:**

1. Perform algebraic operations on matrices and apply properties of determinants and transposes.
2. Classify and analyze different types of matrices and compute their ranks using elementary transformations.
3. Solve systems of linear equations using matrix methods, Cramer's rule, and rank methods.
4. Determine the characteristic equation, eigenvalues, and eigenvectors of matrices and apply them to practical problems.
5. Demonstrate the ability to connect mathematical concepts to applications in science, technology, and engineering.
6. Develop a foundation for further studies in mathematics and related disciplines.

**THEORY COURSE CONTENTS:**

**Unit-I:** Algebra of Matrices, Product of Two Determinants, Transpose of a Matrix, Symmetric and skew – symmetric Matrices, Hermitian and Skew- Hermitian Matrices.

**Unit-II:** Orthogonal Matrix and Its properties, Unitary Matrices and Its properties, Rank of a Matrix, Elementary Transformations or Elementary Operations, Echelon form.

**Unit-III:** Linear Equations, Matrix method, Cramer's rule, Solution by the method of elementary transformation, Rank Solution of Simultaneous linear equations.

**Unit-IV:** Characteristic Equations of a Matrix, Eigen Values and Eigen Vectors of Matrices.

**SUGGESTED READINGS:**

1. Lalji Prasad: Matrices, Paramount publication.
2. A. R. Vasishtha: Matrices, Krishna Prakashan.
3. K. K. Jha: Matrices, Nav Bharat Prakashan, Patna

## SEMESTER – V

**COURSE:** MAJOR -10 (MJ-10) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Real Analysis - 2** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To introduce advanced concepts of limits, continuity, and differentiability of functions of two variables.
2. To develop understanding of Fourier series, their convergence, and applications to piecewise functions.
3. To study the theory of Riemann integration, improper integrals, and associated convergence tests.
4. To understand special functions such as Beta and Gamma functions and their properties.

**COURSE OUTCOMES:**

1. Evaluate repeated and simultaneous limits, and analyze continuity and differentiability of real-valued functions of two variables.
2. Apply Schwarz and Young's theorem, implicit function theorem, and expand functions using Fourier series.
3. Demonstrate the integrability of functions and apply the fundamental and mean value theorems of integral calculus.
4. Evaluate improper integrals using comparison tests, Abel's and Dirichlet's tests, and work with Beta and Gamma functions.
5. Differentiate integrals with respect to parameters and apply these techniques in advanced problem-solving.

**THEORY COURSE CONTENTS:**

**Unit-I:** Repeated and simultaneous limits of a Real Valued function of Two Variables, Continuity and differentiability of a Real Valued function of Two Variables, Partialderivation of a Real Valued function of Two Variables.

**Unit-II:** Schawartz and Young's theorem, Implicit function theorem. Fourier series and its convergence, Fourier series, Expansion of Piecewise Monotonic Functions.

**Unit-III:** Riemann integral, integrability of continuous and monotonic functions, Fundamental theorem of Integral Calculus, Mean Value Theorems of Integral Calculus.

**Unit-IV:** Improper Integrals and Their Convergence, Comparison Tests, Abel's and Dirichlet's tests, Beta and Gamma functions and their relations, differentiation of an integral of a function of a parameter.

**SUGGESTED READINGS:**

1. Lalji Prasad: Real Analysis, Paramount publication.
2. S. C. Malik: Mathematical Analysis, New age publishers
3. K. K. Jha: Real Analysis, Nav Bharat Prakashan, Patna

## SEMESTER – V

**COURSE:** MAJOR -11 (MJ-11) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Complex Analysis-1** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To introduce the fundamental concepts of complex numbers, their properties, and the geometry of the complex plane.
2. To understand functions of complex variables, limits, continuity, and analyticity.
3. To study Cauchy-Riemann equations, harmonic functions, and methods to construct analytic functions.
4. To analyze conformal and bilinear transformations, and study their properties and applications.

**COURSE OUTCOMES:**

1. CO1: Represent complex numbers as ordered pairs and apply their algebraic and geometric properties to solve problems.
2. CO2: Analyze functions of a complex variable for limit, continuity, and differentiability, and apply Cauchy-Riemann equations.
3. CO3: Construct analytic functions using Milne-Thompson's method and identify harmonic functions.
4. CO4: Apply and interpret conformal transformations, including magnification, translation, rotation, inversion, and bilinear transformations.
5. CO5: Determine fixed points and cross-ratios of transformations, and analyze the invariance properties of cross-ratio in complex mappings.

**THEORY COURSE CONTENTS:**

**Unit-I:** Complex Number as an ordered pair, Properties of arguments, moduli, Equations of Straight line and circle, Function of Complex Variable, Limit and Continuity.

**Unit-II:** Analytic Function, Cauchy- Riemann Equation Cartesian and Polar form, Harmonic Functions, Milne- Thompson's Method.

**Unit-III:** Conformal Transformation, Some General Transformations- Magnification, Translation, Rotation, Inversion. Bilinear (Mobius) Transformation.

**Unit-IV:** Fixed Points, Cross- ratio, Invariance of Cross-ratio, problems on Invariant points.

**SUGGESTED READINGS:**

1. Lalji Prasad: Complex Analysis, Paramount publication
2. Goyal and Gupta: Function of a complex variable, PragatiPrakashan.
3. Walter Rudin: Complex Analysis, Mc Graw Hill.

## SEMESTER – VI

**COURSE:** MAJOR -12 (MJ-12) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Metric Space** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To introduce the basic concepts and examples of metric and pseudo-metric spaces.
2. To study the properties of open and closed sets, neighborhoods, and spheres in metric spaces.
3. To understand convergence, Cauchy sequences, and the concept of completeness.
4. To explore advanced concepts like the contraction principle, dense subsets, and Baire's category theorem

**COURSE OUTCOMES:**

1. CO1: Define and provide examples of metric and pseudo-metric spaces, and understand related concepts like neighborhoods, interior and limit points.
2. CO2: Analyze open and closed sets, open and closed spheres, and classify bounded and unbounded metric spaces.
3. CO3: Evaluate convergence and Cauchy sequences, and explain the concept of completeness in metric spaces.
4. CO4: Apply the contraction principle to prove fixed point results and understand its significance.
5. CO5: Demonstrate the completeness of the real number system, identify dense subsets, and explain Baire's category theorem with applications.

**THEORY COURSE CONTENTS:**

**Unit-I:** Definition and Examples of Metric Space, Neighbourhoods, Interior Points, Limit Point,Open and Closed Sets.

**Unit-II:** Definition and Examples of Pseudo-Metric Space, The Triangle Inequalities, Bounded and Unbounded Metric Spaces, Open Sphere, Closed Sphere.

**Unit-III:** Open Set, Closed Set, Closure and Interior. Convergent and Cauchy Sequences. Completeness.

**Unit-IV:** Contraction Principal, Real Number System as a Complete Metric Space. Real Number System as Complete Ordered Filed. Dense Subsets, Baire's Category Theorem.

**SUGGESTED READINGS:**

1. Lalji Prasad: Complex Analysis, Paramount publication
2. Goyal and Gupta: Function of a complex variable, PragatiPrakashan.
3. Walter Rudin: Complex Analysis, Mc Graw Hill.

## SEMESTER – VI

**COURSE:** MAJOR -13 (MJ-13) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Topological Space** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To introduce the fundamental concepts of topological spaces, open and closed sets, neighborhoods, closure, and interior.
2. To study various types of topologies, bases, sub-bases, and their interrelationships.
3. To understand continuity, homeomorphism, compactness, and connectedness in topological spaces.
4. To explore separation axioms and their role in characterizing different types of topological spaces.

**COURSE OUTCOMES:**

1. CO1: Define and provide examples of topological spaces, open sets, closed sets, neighborhoods, closure, and interior along with their properties.
2. CO2: Analyze limit points, derived sets, relative topologies, sub-spaces, bases, sub-bases, and compare different topologies.
3. CO3: Characterize continuity and homeomorphisms using open and closed sets and understand the concept of compactness.
4. CO4: Apply the characterization of compactness using closed sets and analyze continuous mappings.
5. CO5: Understand connectedness, its relation to continuity, connectedness of the real line, and various separation axioms (T0, T1, T2).

**THEORY COURSE CONTENTS:**

**Unit-I:** Definition and Example of Topological Space, Open Sets, Closed Sets, Neighbourhood, Closure and interior and their properties.

**Unit-II:** Limit Points, Derived Sets, Topologies and its properties. Relative topology and sub – spaces, base and sub base, Comparison of Topologies, Intersection and Union of Topologies, Metric Topologies.

**Unit-III:** Continuity and Homomorphism and their Characterization by Closed Sets, Closure Set, Basic and Sub basic open set, Compactness, Characterization of Closed Sets.

**Unit-IV:** Compactness and continued Mappings. Notion of connectedness, continuity and connectedness, connectedness of real line. Separation axioms ($T_0$, $T_1$, $T_2$)

**SUGGESTED READINGS:**

1. Lalji Prasad: Topology, Paramount publication.
2. J. N. Sharm: Topology, Krishna's Educational Publisher's.
3. K. K. Jha: Advance Topology, Nav Bharat Prakashan, Patna.

## SEMESTER – VI

**COURSE:** MAJOR -14 (MJ-14) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Theory of Equations** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To study the general properties of polynomials and their graphical representation.
2. To analyze the relationships between roots and coefficients and apply Descartes's rule of signs.
3. To understand symmetric functions of roots and perform various transformations of equations.
4. To learn and apply methods for solving cubic, biquadratic, and numerical equations.

**COURSE OUTCOMES:**

1. CO1: Explain the properties of polynomials and represent them graphically to find maxima and minima.
2. CO2: Apply Descartes's rule of signs and establish relations between roots and coefficients.
3. CO3: Evaluate symmetric functions of roots and perform transformations such as sign changes, reciprocals, and diminutions.
4. CO4: Solve cubic and biquadratic equations using classical methods and numerical equations using Newton's and Horner's methods.

**THEORY COURSE CONTENTS:**

**Unit-I:** General Properties of Polynomials, Graphical Representation of a Polynomial, Maximum and Minimum Values of a polynomial, Elementary Properties of Equation.

**Unit-II:** Descartes's rule of signs, Positive and negative rule, Relation between the roots and the coefficients of equations.

**Unit-III:** Symmetric functions of the roots, Transformation of equations**,** Roots with signs changed, multiplying, Reciprocal roots, Diminish, Some special methods of transformation.

**Unit-IV:** Solutions of cubic equation (Cardon's method), Solution of Biquadratic equations, Solution of numerical equations (Newton's and Horner's method)**.**

**SUGGESTED READINGS:**

1. Lalji Prasad: Theory of Equation, Paramount publication
2. M.L.Khanna: Theory of Equation.
3. K. K. Jha: Theory of Equation, Nav Bharat Prakashan, Patna

## SEMESTER – VI

**COURSE:** MAJOR -15 (MJ-15) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Mechanics** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To study analytical conditions of equilibrium for systems of coplanar and three-dimensional forces.
2. To understand the concepts of central axis, null lines, planes, and conditions of stability.
3. To analyze the behavior of elastic strings, central orbits, and particle motion under inverse square law forces.
4. To explore Newton's law of gravitation, Kepler's laws, laws of motion, and simple harmonic motion of a pendulum.

**COURSE OUTCOMES:**

1. CO1: Apply analytical conditions of equilibrium for coplanar forces and resultant forces in three dimensions.
2. CO2: Determine central axis, null lines, and planes, and analyze stability conditions of equilibrium.
3. CO3: Understand the properties of elastic strings, apply Hooke's law, and analyze motion under central forces and inverse square laws.
4. CO4: Explain Newton's law of gravitation, Kepler's laws, laws of motion, and apply these principles to study the motion of a simple pendulum.

**THEORY COURSE CONTENTS:**

**Unit-I:** Analytical conditions of equilibrium of coplanar forces, Equation of the Resultant forces in three dimensions,

**Unit-II:** Central axis, Null lines and planes, stable and unstable equilibrium.

**Unit-III:** Elastic string and Hook's law, Central orbit, Motion of particle (in a plane) under inverse square law

**Unit-IV:** Newtonian Law of gravitation and Kepler's laws of motion. Law of motion and simple pendulum,

**SUGGESTED READINGS:**


1. P. Singh and D. K. Sen: Degree Level Mechanics, Paramount Bharti Bhawan.
2. M. Ray: A Textbook on Dynamics, S Chand Publication.
3. K. K. Jha: Degree Level Mechanics, Nav Bharat Prakashan, Patna.
4. P. K. Mittal: Mathematics for Degree Students, S Chand Publication.
5. S. L. Lone: Statics,

## SEMESTER – VII

**COURSE:** MAJOR -16 (MJ-16) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Numerical Analysis and Optimization** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To introduce iterative methods for finding solutions of nonlinear equations.
2. To develop skills in solving systems of linear equations using direct and iterative numerical techniques.
3. To understand the basic concepts and formulation of Linear Programming Problems (LPP) and their geometric interpretation.
4. To learn the graphical method and the simplex algorithm for solving LPPs with applications.

**COURSE OUTCOMES:**

1. CO1: Solve nonlinear equations using bisection, Regula-Falsi, and Newton-Raphson methods.
2. CO2: Apply Gauss elimination, Cholesky's method, Gauss-Seidel, and relaxation methods to solve systems of linear equations.
3. CO3: Formulate linear programming problems and analyze feasible and optimum solutions using properties of convex sets.
4. CO4: Solve LPPs using graphical methods and implement the simplex algorithm for maximization and minimization problems, handling cases of degeneracy and infeasibility.

**THEORY COURSE CONTENTS:**

**Unit-I:** Solution of Equation: Method of Bisections, Regula–Falsi Method, Newton–Raphson's Method.

**Unit-II:** Linear Equation: Gauss Elimination Method, Cholesky's Method, Gauss-Seidel Method,Method of Relaxation.

**Unit-III:** Introduction to Linear Programming, Definition and scope of Linear Programming, Formulation of Linear Programming Problems (LPP), LPP in matrix form, Feasible and optimum solutions of L. P. P., some basic properties of convex sets, examples of convex sets.

**Unit-IV:** Graphical solution of two-variable LPP, Feasible region, bounded and unbounded solutions, multiple, unique, and no solution cases, Concept of redundancy, Simplex Method: Basic concepts, Slack, surplus, and artificial variables, Canonical and standard forms, Simplex algorithm for maximization and minimization problems, Degeneracy, unbounded and infeasible solutions.

**Books Recommended:**


1. Lalji Prasad: Numerical Analysis, Paramount publication.
2. M.K. Jain. S.R.K Iyengar and R. K. Jain: Numerical Methods**.**
3. S.S. Sastri: Numerical Analysis.
4. Kanti Swarup, P.K. Gupta & Man Mohan: Operations Research.
5. Hillier and Lieberman: Introduction to Operations Research.
6. Lalji Prasad: Linear Programming.

## SEMESTER – VII

**COURSE:** MAJOR -17 (MJ-17) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Spherical Trigonometry** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To understand the fundamental concepts of spherical geometry, great circles, small circles, and spherical angles.
2. To study the properties and relations of spherical triangles and their polar counterparts.
3. To derive and apply fundamental spherical trigonometric identities and formulas.
4. To learn and use advanced relations such as Napier's and De-Alembert's analogies in solving spherical triangles.

**Course Outcomes (COs):**

1. CO1: Analyze sections of spheres by planes and understand great circles, small circles, spherical angles, and angular distances.
2. CO2: Explain the properties of spherical triangles, polar triangles, and the reciprocity of polarity.
3. CO3: Apply cosine, sine, half-angle, and half-side formulas to solve problems in spherical triangles.
4. CO4: Use Napier's rule of circular parts and analogies to establish relations and solve spherical trigonometry problems.

**THEORY COURSE CONTENTS:**

**Unit-I:** The Section of a Sphere by a Plane, Great Circle and Small Circle, Properties of Pole, Spherical Radius, Angular Distance, Secondaries, Spherical Angle, Poles of Great Circles, Angle between Great Circles.

**Unit-II:** Length of Arc of Small Circles, Spherical Triangles, Polar Triangles, Reciprocity of Polarity, Relations between the Sides and Angles of Polar Triangles, Properties of Spherical Triangles.

**Unit-III:** The Cosine Formula, Supplemental Cosine Formula, Sine Formula, Formula of Half Angle, Formula for Half Side, Sine –Cosine Formula, Relation between Three Side and TwoAngles of a Spherical Triangle, Napier's Analogies, De-Alembert's Analogies.

**Unit-IV:** Spherical Triangle, Napier's Rule of Circular Parts.

**SUGGESTED READINGS:**

1. M. L. Khanna: Spherical Trigonometry, Paramount publication.
2. S. K. D Dubey: A textbook of Spherical Trigonometry and Spherical Astronomy.
3. G. S. Malik: Spherical Astronomy, Kedar Nath Ram Nath publication.

## SEMESTER – VII

**COURSE:** MAJOR -18 (MJ-18) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Spherical Astronomy** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To introduce the basic concepts and coordinate systems of the celestial sphere and their interrelations.
2. To study the phenomena of rising and setting of stars and conditions related to twilight.
3. To understand astronomical refraction, its effects, and various formulas used in its computation.
4. To explore Kepler's laws of planetary motion, energy integrals, and annual aberration in celestial observations.

**COURSE OUTCOMES:**

1. CO1: Explain celestial sphere concepts, different coordinate systems, and their transformations.
2. CO2: Analyze the rising and setting of stars and solve problems related to twilight phenomena.
3. CO3: Evaluate the effects of astronomical refraction using Simpson's, Bradley's, and Cassini's formulas.
4. CO4: Apply Kepler's laws, energy and Laplace integrals, and understand the effects of annual aberration on celestial coordinates.

**THEORY COURSE CONTENTS:**

**Unit-I: Celestial Sphere:** Definition of basic terms, Different co-ordinate system and conversion of one system into another, Rising and setting of stars.

**Unit--II: Twilight*:*** Condition of twilight to last whole night, Problem relating to twilights.

**Unit-III: Refraction*:*** Refraction, Simpson's, Bradley's Formula and Cassini's Hypothesis, Effect of Refraction in the position of the Body.

**Unit-IV: Kepler's law *:*** Kepler's law of Planetary motion, Energy Integrals, and Laplace's Integral. Annual aberration, Effect of aberration on Celestial latitudes and longitude,

**SUGGESTED READINGS:**

1. M. L. Khanna: Spherical Astronomy, Paramount publication.
2. S. K. D. Dubey: A textbook of Spherical Trigonometry and Spherical Astronomy.
3. G. S. Malik: Spherical Astronomy.
4. F.Brunnow: Spherical Astronomy.

## SEMESTER –VIII

**COURSE:** MAJOR -19 (MJ-19) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Abstract Algebra and Ring theory** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To understand the fundamental concepts of groups, cosets, Lagrange's theorem, and homomorphisms.
2. To study normal subgroups, quotient groups, conjugacy relations, and related theorems.
3. To introduce the structure and properties of rings, subrings, ideals, and their classifications.
4. To explore ring homomorphisms, fields of quotients, and polynomial rings with applications.

**COURSE OUTCOMES:**

1. CO1: Apply the concepts of cosets, coset decomposition, and Lagrange's theorem in group computations.
2. CO2: Analyze normal subgroups, quotient groups, conjugacy relations, and the fundamental theorem of groups.
3. CO3: Classify and analyze rings, subrings, ideals, prime and maximal ideals, and their properties.
4. CO4: Demonstrate understanding of ring homomorphisms, fields of quotients, and polynomial rings with examples.

**THEORY COURSE CONTENTS:**

**Unit-I:** Cosets, Coset Decomposition, Lagrange's Theorem, Homomorphism and Isomorphism, Elementary Idea of Normal Subgroup,

**Unit-II:** Quotient Group,Center of a Group, Fundamental Theorem of Group Homomorphism and their Computation, Conjugacy Relation and Normalizer.

**Unit-III:** Definition and Examples of Rings, Properties of Rings, Subrings, Characteristics of Rings, Operation on ideal, Prime and Maximum Ideals,

**Unit-IV:** Ring Homomorphism, Properties of Ring Homomorphism, Integral Domain, Fields of Quotients, Polynomial Rings.

**SUGGESTED READINGS:**

1. Lalji Prasad: Abstract Algebra, Paramount publication.
2. A. R. Vasishtha:Modern Algebra, Krishna's publication.
3. K. K. Jha: Abstract Algebra, Nav Bharat Prakashan, Patna

## SEMESTER – VIII

**COURSE:** MAJOR -20 (MJ-20) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Real Analysis – 3** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To strengthen the understanding of the real number system, its properties, and the fundamental theorems of real analysis.
2. To study convergence of sequences and series of functions, including pointwise and uniform convergence with applications.
3. To develop a deep understanding of Riemann and improper integrals, criteria for integrability, and related theorems.
4. To explore real functions of several variables, their continuity, partial derivatives, and differentiation as linear transformations.

**COURSE OUTCOMES:**

1. CO1: Demonstrate knowledge of the real number system, supremum, infimum, and fundamental theorems like Bolzano-Weierstrass and mean value theorems.
2. CO2: Analyze sequences and series of functions for pointwise and uniform convergence using various tests, and understand Weierstrass approximation theorem.
3. CO3: Evaluate Riemann integrals, improper integrals, and apply criteria for integrability, absolute and conditional convergence.
4. CO4: Understand and apply concepts of neighborhoods, limits, continuity, and differentiation of real-valued and vector-valued functions of several variables.

**THEORY COURSE CONTENTS:**

**Unit-I: Real Number**: system as a Complete Ordered Field, Archimedean Property, Supremum, Infimum, Bolzano-Weierstrass Theorem, Mean value Theorem. Sequence and Series of Functions, Point- Wise and Uniform Convergence, Cauchy Criterion Uniform Convergence, Weierstrass M- test, Abel's and Dirichlet's Test for Uniform Convergence, Uniform Convergence and Differentiation, Weierstrass Approximation Theorem.

**Unit-II: Reimann Integral:** Partition, Refinement, Reimann Integral, Reimann sum associated with partition P, Fundamental Theorem of Integral Calculus, First Mean Value Theorem, Riemann Criterion, Darboux's Theorem,

**Unit-3: Improper Integral***:* Improper Integral, Types of Improper Integral and their Convergence, Divergence, Absolute Convergence, Conditional Convergence,

**Unit -IV: Function of Several Real Variables***:* Notion of Neighborhood of a Point in the Euclidean space, Inner limits, Simultaneous limit and Repeated limit and Continuity, Differentiation for Real Function of Several real Variables and of Vector Valued Functions, Partial Derivative, and derivative as Linear Transformation.

**SUGGESTED READINGS:**

1. Lalji Prasad: Real Analysis, Paramount publication.
2. S. C. Malik: Mathematical Analysis, New Age publishers.
3. K. K. Jha: Real Analysis, Nav Bharat Prakashan, Patna
4. T. M. Apostol: Mathematical Analysis, Narosa.
5. J N Sharma: Real Analysis, Krishna's educational publishers

## SEMESTER – VII

**COURSE:** ADVANCE MAJOR -1 (AMJ-1) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Complex Analysis- 02** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To introduce the fundamental concepts of analytic functions and their properties.
2. To develop an understanding of complex integration and important theorems like Cauchy's theorem and residue theorem.
3. To enable students to analyze and apply conformal mappings and Möbius transformations in complex analysis.
4. To familiarize students with power series, Taylor and Laurent series expansions and their applications.
5. To understand the concept of zeros, singularities, poles and residues, and apply residue calculus for evaluating real integrals.

**COURSE OUTCOMES:**

1. CO1: Define and determine analytic functions and verify Cauchy-Riemann equations in both Cartesian and polar forms.
2. CO2: Evaluate complex line integrals and apply Cauchy's theorem, Cauchy's integral formula and related results.
3. CO3: Demonstrate the properties of conformal mappings and apply Möbius transformations to map complex domains.
4. CO4: Expand analytic functions into power series, Taylor and Laurent series and determine their radius of convergence.

**THEORY COURSE CONTENTS:**

**Unit-I:** Analytic Functions, Conjugate and Harmonic Function, Cauchy – Riemann Equation (in both forms), NASC for a function to be Analytic, Construction of an Analytic Function, Relevant Problems, Complex Integration, Complex line Integral, Cauchy's Goursat Theorem, Cauchy's Integral Formula, Higher Order Derivatives, Morera's Theorem Cauchy's Inequality and Lioville's Theorem, Poisson's Integral Formula,

**Unit-II:** Mobius Transformation path, Smooth path, Piecewise smooth, Angles between paths, Angle Preservation Property, Conformal Mappings, Linear fraction Transformation, Mobius- Transformation, Translation, Inversion, Orientation Principle.

**Unit-III:** Power series, Representation of Analytic Function, Absolute convergence of Power series, Radius of Convergence and Sum Function of Power Series, Taylors Theorem, Laurent's Theorem, Relevant Problems.

**Unit-IV:** Zero of a Function, Order of Zero, Singularities of Analytical Function, Types of Singularities, Poles and zeros, Limiting point of zeros and poles, Reimann's Theorem on Removable Singularities, Weierstrass Theorem, Relevant Problems, Calculus of Residue at finite pole, Residue at infinity, Cauchy's Residue Theorem, Computation of Residue at finite pole, Jordan's Lemma, Evaluation of Real Definite Integral by Contour Integration.

**SUGGESTED READINGS:**


1. Lalji Prasad: Complex Analysis, Paramount publication
2. J. K. Goyal and K. P. Gupta: Function of a complex variable, Pragati Prakashan.
3. Walter Rudin: Complex Analysis, Mc Graw Hill.
4. J. N. Sharma: Complex Variable.
5. H. A. Preistly: Introduction to complex analysis, Clarendon Press, Oxford-1990.
6. J. B. Conway: Function of one Complex Variable, Narosa publishing House – 1980.
7. S. Ponnuswamy: Foundation of Complex Analysis, Narosa publishing House.

## SEMESTER – VIII

**COURSE:** ADVANCE MAJOR -2 (AMJ-2) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Foundation course in Modern Algebra** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. Introduce advanced concepts of group theory, including normal subgroups, quotient groups, Sylow's theorems, and group actions.
2. Provide a strong foundation in ring theory, ideals, factorization, and field theory, including Galois theory.
3. Develop understanding of vector spaces, linear transformations, canonical forms, and algebraic structures associated with vector spaces.
4. Familiarize students with the concepts of modules, submodules, direct sums, and the fundamental theorem for finitely generated modules.
5. Enhance problem-solving skills in abstract algebra through applications of key theorems and structure analysis.

**COURSE OUTCOMES:**

1. CO1: Demonstrate understanding of group theory concepts such as quotient groups, normal subgroups, class equations, and Sylow's theorems, and apply them to solve structural problems.
2. CO2: Analyze and apply ring theory concepts, including prime and maximal ideals, UFDs, PIDs, Euclidean domains, and understand the structure of polynomial rings and finite fields.
3. CO3: Classify and work with field extensions and apply the fundamental results of Galois theory.
4. CO4: Solve problems related to vector spaces, linear transformations, basis changes, and determine canonical, diagonal, and Jordan forms of matrices.

**THEORY COURSE CONTENTS:**

**Unit-I: Group –** Permutation Group, Normal Subgroup, Quotient group, Cayley's Theorem, Class Equation, Maximal Subgroup, Composition Series of the Group and Jordan – Holder Theorem, Solvable Groups, Commutator Subgroup of a Group, Direct product, External and Internal direct products, Cauchy's Theorem on Abelian group, Cauchy's Theorem, Sylow's Theorems (proofs using group actions),

**Unit-II: Ring –** Ring, Ideal, Prime and Maximal ideals, Quotient rings, Unique Factorization Domain, Principal Ideal Domain, Euclidean Domain, Polynomial rings and Irreducibility criteria, Fields, Finite Fields, Field Extension, Galios theory.

**Unit-III: Vector space-** Vector spaces, Subspaces, Linear Dependency, Basis, Dimension, Algebra of Linear Transformations, Matrix Representation of Linear Transformations, Change of Basis, Canonical Forms, Diagonal Forms, Triangular forms, Jordan form.

**Unit-IV: Modules –** Modules, Sub-Modules, Direct sum of Sub-Modules, Homomorphism of Modules, Quotient Modules, Cyclic Modules, Fundamental Theorem on Finitely Generated Modules over Euclidean Rings.

**SUGGESTED READINGS:**

1. Lalji Prasad: Abstract Algebra, Paramount publication.
2. A. R. Vasishtha: Modern Algebra, Krishna's publication.
3. K. K. Jha: Abstract Algebra, Nav Bharat Prakashan, Patna.
4. P.B. Bhattacharya, S.K. Jain and S. R. Nagpal: Basic Algebra
5. I. N. Heirstein: Topics in Algebra, Weilly Ltd.
6. M. Artin: Algebra, Prentice Hall – India

## SEMESTER – VIII

**COURSE:** ADVANCE MAJOR -3 (AMJ-3) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Theory of Numbers** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. Introduce the fundamental concepts of divisibility, prime numbers, and factorization.
2. Develop understanding of congruences, residue systems, and classical number theory theorems like Fermat's and Wilson's theorems.
3. Explore arithmetic functions, Euler's function, and properties of reduced residue systems.
4. Teach the concepts of primitive roots, orders, and Mobius functions with applications in solving congruences.
5. Enhance students' ability to apply number-theoretic methods to solve Diophantine equations and modular arithmetic problems.

**COURSE OUTCOMES:**

1. CO1: Demonstrate understanding of divisibility, prime numbers, GCD, LCM, and unique factorization of integers.
2. CO2: Solve congruences, linear Diophantine equations, and apply the Chinese Remainder Theorem, Wilson's theorem, and Fermat's little theorem.
3. CO3: Work with arithmetic functions, Euler's phi function, and prove Euler's theorem using reduced residue systems.
4. CO4: Analyze and determine primitive roots, orders, and degrees of congruences.
5. CO5: Apply Mobius function, Mobius inversion formula, and arithmetic functions ($\tau$ and $\sigma$) to solve higher-order congruences and number theory problems.

**THEORY COURSE CONTENTS:**

**Unit-I:** Divisibility, the Division Algorithm, G.C.D, Euclidean algorithm for G.C.D, L.C.M Representation of Integers, Prime Numbers, Composite Number, Fundamental Theorem of Arithmetic, Unique Factorization Theorem.

**Unit-II:** Fermat Number, Congruency, Complete system of Residue's Modulo, Linear Diophantine Equation, Linear Congruency, The Chinese Remainder Theorem, System of Linear Congruency in two unknowns, Wilson's Theorem, Fermat's little Theorem.

**Unit-III:** Arithmetic Function, Multiplicative Arithmetic Function, Eulers $\phi$ - Function, Reduced Residue system Modulo m, Euler's Theorem, Order of Modulo m,

**Unit-IV:** Primitive Roots, Solution of Congruences, Degree of Congruences, Lagrange's Theorem, The Function $\tau$ and $\sigma$, Mobius $\mu$ Function, Mobius Inversion Formula.

**SUGGESTED READINGS:**

1. S B Malik: Basic Number Theory, S Chand
2. Irvan Niven, Herbert S, Zuckerman: The Theory of Numbers
3. Bhupinder Singh, Sudhir K: Number Theory, Pragati Prakashan

## SEMESTER - VII

**COURSE:** RESEARCH METHODOLOGY – 1(RM-1) **TOTAL CREDITS:** THEORY-04

**PAPER:** **Research Methodology** **TEACHING HOURS:** THEORY-60

| EVALUATION | | |
|---|---|---|
| | **External Exam** | **Internal Exam** |
| **Full Marks** | **75** | 25<br>(20 Written + 5 Attendance/Overall Class Performance) |
| **Duration of Exam** | 3 Hours | 1 Hour |
| **Pass Marks** | 40 Marks | |

**COURSE OBJECTIVES:**

1. To introduce the fundamental concepts of mathematics including set theory, relations, functions, numbers, and axiomatic foundations.
2. To develop skills in learning, writing, and researching mathematics with emphasis on mathematical communication, proof techniques, and critical thinking.
3. To provide understanding of algorithms and problem-solving techniques, including design, analysis, and implementation of algorithms for various problem types.
4. To equip students with professional tools such as LaTeX for mathematical typesetting and open-source software (Linux and others) for computational tasks and research.
5. To build confidence in presenting and publishing mathematical ideas, both orally and in written form, and to encourage good academic and research practices.

**COURSE OUTCOMES:**

1. CO1: Apply axioms, set-theoretic principles, relations, and functions to solve basic and advanced mathematical problems.
2. CO2: Demonstrate ability to learn mathematics effectively and write rigorous mathematical proofs, solutions, and research documents.
3. CO3: Design, analyze, and implement algorithms for sorting, searching, graph theory, numerical, and combinatorial problems.
4. CO4: Use LaTeX for preparing professional-quality mathematical documents and research papers.

5. CO5: Utilize open-source software tools (Linux, FOSS) for computation, document preparation, and research activities.
6. CO6: Present mathematical work confidently in seminars, prepare well-structured talks, and respond effectively to questions.

**PART 'A'**

**THEORY COURSE CONTENTS:**

**Module-1:** The axiom of extension, the axiom of specification, Unordered pairs, unions and intersections, complements and powers, ordered pairs, relations, functions, families, Inverse and composites, Numbers, The Peano axioms.

**Module-2:** How to learn mathematics, Why Learn mathematics? Studying Mathematics, Homework assignments and problem solving, Tests, Inspirations, How to write Mathematics, What is the goal of mathematical Writing? General principles of mathematical writing, Writing mathematical sentences, a voiding errors, Writing mathematical solutions and proofs, writing longer mathematical works, the revision process, How to research mathematics, What is Mathematical Research? Finding a Research Topic, General advice, taking basic steps, Fixing common problems. using computer resources, Practicing good mathematical judgment. How to present mathematics? Preparing your talk, Dos and DON'Ts, using technology, Answering Questions, Publishing your research,

**Module-3:** Introduction, what is an Algorithm? Fundamentals of Algorithmic Solving, understanding the problem, ascertaining the capabilities of the Computational Device Choosing between Exact and Approximate Problem Solving Algorithm Design Techniques, designing an algorithm and data structures, methods of Specifying an algorithm, proving an Algorithm's Correctness, Analyzing an Algorithm, Coding an Algorithm, Important Problem Types, Sorting, Searching, String Processing, Graph Problems, Combinatorial Problems, Geometric Problems, Numerical Problems, Numerical problems.

**Module-4:** Getting Started with LATEX, what is TEX? What is LATEX? How to create LATEX files, How to create and typeset a simple LATEX document, How to add basic information to your document, How to do elementary mathematical typesetting,

Getting started with Free and Open source software, what is free and open source software? What is Linux? Where to get Linux applications, how is Linux familiar? How is Linux different. how to learn more.

**SUGGESTED READINGS:**

1. Cormen, T. H, Leiserson, C. E, Rivest, R. L, & Stein, C: Introduction to algorithms

2. Essential of mathematics: Introduction to theory, proof, and professional culture, Margie Hale, Vol. 21, AMS, 1996

3. Learning to reason: Nancy Rodgers,

4. Research Methodology in Mathematics: Rama Nand Singh

**PART 'B'**

**PRACTICAL COURSE CONTENTS:**

1. Prepare a proof using Peano axioms and verify properties of natural numbers.
3. Write a short mathematical article (1–2 pages) explaining a theorem using proper mathematical sentences.
4. Prepare a proof-based solution to a problem and rewrite it after self-review and peer-review.
5. Prepare a 5-minute presentation on a mathematical topic and deliver it in class.
6. Implement basic sorting algorithms (Bubble sort, Insertion sort, Selection sort) in any programming language and analyze time complexity.
7. Write and test algorithms for searching (linear and binary search) and graph traversal (BFS/DFS).
8. Solve combinatorial and numerical problems using algorithmic approaches.
9. Install LaTeX (TeXLive/MiKTeX) and create a document containing:
    - Title page
    - Sections/subsections
    - Mathematical equations
    - Figures and tables
    - References and bibliography

**SUGGESTED READINGS:**

- Book: Daniel J. Velleman – *How to Prove It: A Structured Approach*
- Book: Richard Hammack – *Book of Proof* (free online)
- Book: Joseph Gallian – *Contemporary Abstract Algebra* (for axiomatic structures)

2. Mathematical Writing & Communication

- Book: Steven G. Krantz – *A Primer of Mathematical Writing* (AMS)
- Book: Donald Knuth et al. – *Mathematical Writing* (MAA)
- Book: Norman E. Steenrod – *How to Write Mathematics*

3. Algorithms (Sorting, Searching, Graphs, Combinatorics)

- Book: Thomas H. Cormen et al. – *Introduction to Algorithms* (CLRS)
- Book: Seymour Lipschutz – *Data Structures with C* (Schaum's Outline)

- Book: Narasimha Karumanchi – *Data Structures and Algorithms Made Easy*

4. Numerical & Combinatorial Methods

- Book: S.S. Sastry – *Introductory Methods of Numerical Analysis*
- Book: Richard L. Burden & J.D. Faires – *Numerical Analysis*
- Book: Kenneth H. Rosen – *Discrete Mathematics and Its Applications*

5. LaTeX & Document Preparation

- Book: Leslie Lamport – *LaTeX: A Document Preparation System*
- Online: Overleaf tutorials (https://www.overleaf.com/learn)
- Guide: Tobias Oetiker – *The Not So Short Introduction to LaTeX2e* (Free PDF)

6. General Mathematical Foundations

- Book: Erwin Kreyszig – *Advanced Engineering Mathematics* (for calculus, ODEs, vector analysis)
- Book: Walter Rudin – *Principles of Mathematical Analysis* (for real analysis)
- Book: Munkres – *Topology*
- Book: Churchill & Brown – *Complex Variables and Applications*

Journals & Online Resources

- *Mathematics Magazine (MAA)*
- *The American Mathematical Monthly*
- arXiv.org (open access research papers)
- *SIAM Undergraduate Research Online (SIURO)*

## SEMESTER - VIII

**COURSE:** RESEARCH PROJECT/DISSERTATION – 1(RP/D-1) **TOTAL CREDITS:** 08

**PAPER:** **Dissertation/Research Internship/Field Work**

**COURSE OBJECTIVES:**

1. To provide students with hands-on research experience in core areas of mathematics.
2. To enable students to identify and formulate mathematical problems based on concepts from Group Theory, Ring Theory, Linear Algebra, Matrix Theory, Vector Spaces, Topology, Real & Complex Analysis, Differential Calculus, Differential Equations (ODE & PDE), Numerical Analysis, and Vector Analysis.
3. To develop skills in mathematical modeling, proof writing, data analysis, and computational methods.
4. To train students in scientific writing, LaTeX usage, presentations, and publishing techniques.
5. To enhance abilities of independent learning, critical thinking, and research ethics.

**COURSE OUTCOMES:**

1. CO1: Conduct a literature review and analyze existing mathematical results.
2. CO2: Select and clearly formulate a research/project problem in any mathematical discipline.
3. CO3: Apply theoretical, analytical, or computational methods to solve the chosen problem.
4. CO4: Prepare a professional-quality project report/dissertation using appropriate formats (LaTeX/MS Word).
5. CO5: Present mathematical ideas and research findings effectively in oral and written form.
6. CO6: Gain practical exposure through internships/field work and develop teamwork and problem-solving skills.

**THEORY COURSE CONTENTS:**

**Unit : I Topic Selection & Literature Review**

- Select a project topic from one or more of the core areas:
    - Abstract Algebra: Group Theory, Ring Theory, Linear Algebra, Matrix Theory, Vector Spaces
    - Topology, Real and Complex Analysis, Vector Analysis, Differential Calculus, Integral Calculus,
    - Ordinary Differential Equation, Partial Differential Equation and Numerical Analysis
- Conduct a systematic literature review (books, journals, online databases).

**Unit : II Problem Formulation & Methodology**

- Define research objectives.
- Develop theoretical or computational methodology.
- Plan for data collection/experiments if required.

**Unit : III Preliminary Work & Interim Report**

- Mathematical modeling or proof development.
- Run initial computations/analysis.
- Submit an Interim Report summarizing progress.
- Deliver a mid-semester presentation of research proposal and preliminary findings.

**Unit : IV Completion of Research Work**

- Execute full research methodology: proof development, problem-solving, computational experiments, or data analysis.

  Results & Analysis
- Interpret and validate findings.
- Compare with existing literature and highlight originality.

  Final Dissertation
- Prepare a comprehensive research dissertation (using LaTeX or standard formatting).
- Chapters must include: Abstract, Introduction, Literature Review, Methodology, Results, Discussion, Conclusion, References.

Distribution of Marks:

| | |
|---|---|
| (i) Assessment of Project Synopsis: | 50 marks |
| (ii) Assessment of Project Thesis: | 100 marks |
| (iii) Interaction: | 50 marks |

**SUGGESTED READINGS:**

1. C. R. Kothari – Research Methodology: Methods and Techniques (New Age International).
2. Steven G. Krantz – A Primer of Mathematical Writing (AMS).

3. Donald E. Knuth – Mathematical Writing (MAA).
4. Leslie Lamport – LaTeX: A Document Preparation System.

2. Algebra (Group Theory, Ring Theory, Vector Spaces, Matrix Theory)

1. I.N. Herstein – Topics in Algebra.
2. John B. Fraleigh – A First Course in Abstract Algebra.
3. Dummit & Foote – Abstract Algebra.
4. Hoffman & Kunze – Linear Algebra.
5. S. Lang – Linear Algebra.

3. Real & Complex Analysis, Topology

1. Walter Rudin – Principles of Mathematical Analysis ("Baby Rudin").
2. S.C. Malik & Savita Arora – Mathematical Analysis.
3. E.T. Copson – Metric Spaces.
4. James R. Munkres – Topology.
5. Churchill & Brown – Complex Variables and Applications.

4. Differential Calculus, Differential Equations, PDE/ODE

1. Shepley L. Ross – Differential Equations.
2. Simmons – Differential Equations with Applications and Historical Notes.
3. Erwin Kreyszig – Advanced Engineering Mathematics (for ODE, PDE and Vector Calculus).
4. Boyce & DiPrima – Elementary Differential Equations.

5. Numerical Analysis

1. S.S. Sastry – Introductory Methods of Numerical Analysis.
2. Richard L. Burden & J.D. Faires – Numerical Analysis.
3. Chapra & Canale – Numerical Methods for Engineers.

6. Vector Analysis & Applications

1. Murray Spiegel – Vector Analysis (Schaum's Outline).
2. Jerrold E. Marsden & Anthony Tromba – Vector Calculus.

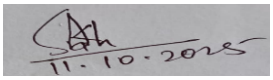
7. Additional Computational/Software Tools

1. SageMath, MATLAB, Octave, Python (NumPy, SciPy, SymPy) online documentations.
2. MAA/AMS resources for undergraduate research problems.

8. Journals & Online Resources

- Mathematics Magazine (MAA)
- American Mathematical Monthly

- SIAM Undergraduate Research Online (SIURO)
- Journal of Undergraduate Research in Mathematics
- arXiv.org (preprints in all math disciplines)

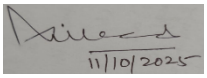


**(Dr. S. N. Adhikary)**

Head, Univ. Dept. of Maths,
SKMU, Dumka (Chairman)

**(Dr. Arvind Kumar Sah)**

Prof. & Head
University Dept. of Mathematics
TMBU, Bhagalpur



**(Dr. S. N. Singh)**

Dept. of Maths,Deoghar
College, Deoghar(Member)

**(Dr. Ziaul Hoque)**

Dept. of Maths, S. P College,
Dumka(Member)

**(Dr. Mukesh Kumar)**

Dept. of Maths,NBAP,
A. S. College, Deoghar(Member)

**(Dr. Uttam Kr. Shukla)**

Dept. of Maths,NBAP, Madhupur
College, Madhupur(Member)

**(Dr. B. N. Yadav)**

Dept. of Maths,NBAP, S. P
College, Dumka(Member)

**(Dr. R. K. Verma)**

NBAP, Univ. Dept. of
Maths,SKMU, Dumka (Member)

**(Mr. Deepak Kumar Das)**

Co-ordinator, NEP
SKMU, Dumka (Member)