# MANGALORE UNIVERSITY

**Mathematics Syllabus for Three Major B. Sc. Programme from the Academic year 2024-25**

(Semester Scheme)

## Preamble:

The B.Sc. Mathematics course aims to provide students with a comprehensive foundation in mathematical principles, theories, and applications. This program is designed to develop critical thinking, analytical skills, and problem-solving abilities essential for various scientific and technical careers.

The Mathematics syllabus for B.Sc. (Two Major Programme) in use at present was introduced from the academic year 2021-22 as per NEP-2020 structure and guidelines given by the state government in 2021. Based on the directions and guidelines from the Higher Education Council of the Government of Karnataka (GO: ED 166 UNE 2023 Bangalore, Date: 08.05.2024), Mangalore University has issued new guidelines to launch the Three Major B.Sc. degree programme starting from the academic year 2024-25. Consequently, the revised and restructured syllabus for Mathematics as an optional subject in the B.Sc. (Three Major Programme) has been prepared according to the new regulations of the University, by modifying the earlier syllabus, including Lab components and introducing new text and reference books.

The following new syllabus for Mathematics as an optional subject in the B.Sc. (Three Major Programme) at Mangalore University has been framed by the Board of Studies in Mathematics for the UG programme. This syllabus will be implemented starting from the academic year 2024-25.

### Aims and objectives of the restructured syllabus

- Equip students with a deep understanding of core mathematical concepts and methodologies.
- Improve the perspective of students on mathematics as per modern requirement and develop a spirit of inquiry and scientific temper in the student.
- Initiate students to enjoy mathematics, pose and solve meaningful problems, to use abstraction to perceive relationships and structure and to understand the basic structure of mathematics.
- Create a student-friendly learning environment by encouraging experimental, problem-solving, and discovery-based approaches to learning mathematics.
- To orient students towards relating mathematics applications and improve retention of mathematical concepts in the student.

- To enable the teacher to demonstrate, explain and reinforce abstract mathematical ideas by using concrete objects, models, charts, graphs, pictures, posters with the help of FOSS tools on a computer.
- Encourage analytical and research-oriented thinking to prepare students for advanced studies and professional careers.
- Provide scope for greater involvement of both the mind and the hand and help the student build interest and confidence in learning the subject.
- Facilitate an interdisciplinary approach by integrating mathematics with other scientific and technical fields.
- Introduce new and relevant textbooks and reference materials to ensure students have access to current knowledge and resources.

**Program outcomes:**

On successful completion of the program, the student will be able to -

1. Verbally communicate mathematical ideas, write logically sound proof, accurately work with formulae and numerical information.
2. Apply solving techniques of differential equations in Mathematics, Physics, Chemistry and Biology.
3. Understand the actual theories behind solving techniques of problems in Calculus, Algebra and Analysis.
4. Connect theoretical and practical aspects of Mathematics.
5. Solve problems in the post graduate entrance exams with ease.
6. Acquire mathematical skill set to clear various aptitude tests conducted by multi-national companies.

**Program specific outcomes:**

1. The syllabus imparts various technical skills solving mathematical problems and apply them to other fields.
2. Student will be acquiring knowledge to compete at national and international level.
3. Employability will be improved with the knowledge of Mathematical softwares.
4. Domain knowledge will be upgraded with the knowledge of applications.
5. Student will be able to handle the challenges due to upgradation of softwares.

This syllabus has been carefully curated by the Board of Studies in Mathematics, incorporating feedback from academic experts, industry professionals, educational policymakers, and all the stakeholders. It is designed to meet the evolving demands of education and industry, ensuring that graduates are well-prepared to contribute effectively in their chosen fields. The implementation of this syllabus will commence from the academic year 2024-25, marking a significant step towards academic excellence and innovation in the field of mathematics.

# COURSE PATTERN AND SCHEME OF EXAMINATION
# MAJOR SUBJECT: MATHEMATICS

| Particulars of Courses | Theory(T)/ Practical(P) | Instruction Hours/ Week | Duration of Exam | Marks | | | Number of Credits |
|---|---|---|---|---|---|---|---|
| | | | | IA | Semester End Exam | Total Marks | |
| **Semester – I** | | | | | | | |
| **BSCMTCS101** : Calculus | T | 4 | 3 | 20 | 80 | 100 | 3 |
| **BSCMTPS101**: Practical-I | P | 4 | 3 | 10 | 40 | 50 | 2 |
| **Semester – II** | | | | | | | |
| **BSCMTCS201** : Advanced Calculus and Differential Equations | T | 4 | 3 | 20 | 80 | 100 | 3 |
| **BSCMTPS201**: Practical-II | P | 4 | 3 | 10 | 40 | 50 | 2 |
| **Semester – III** | | | | | | | |
| **BSCMTCS301** : Number Theory and Higher Order Differential Equations | T | 4 | 3 | 20 | 80 | 100 | 3 |
| **BSCMTPS301**: Practical-III | P | 4 | 3 | 10 | 40 | 50 | 2 |
| Elective-1<br>**BSCMTES301** : Mathematical Logic and Set theory<br>**BSCMTES302 :** Quantitative Mathematics | T | 2 | 2 | 10 | 40 | 50 | 2 |
| **Semester - IV** | | | | | | | |
| **BSCMTCS401** : Group Theory, Sequences and Series | T | 4 | 3 | 20 | 80 | 100 | 3 |
| **BSCMTPS401** : Practical-IV | P | 4 | 3 | 10 | 40 | 50 | 2 |
| Elective-2<br>**BSCMTES401 :** Basic Combinatorial Theory<br>**BSCMTES402 :** Vedic Mathematics | T | 2 | 2 | 10 | 40 | 50 | 2 |
| **Semester - V** | | | | | | | |
| **BSCMTCS501**: Ring Theory and Laplace Transforms | T | 4 | 3 | 20 | 80 | 100 | 3 |
| **BSCMTCS502** : Graph Theory<br>**BSCMTCS503 :**Total Differential Equations and Partial Differential Equations | T | 4 | 3 | 20 | 80 | 100 | 3 |
| **BSCMTPS501** : Practicals on Ring Theory and Laplace Transforms | P | 4 | 3 | 10 | 40 | 50 | 2 |
| **Semester - VI** | | | | | | | |
| **BSCMTCS601** : Complex Analysis and Linear Algebra | T | 4 | 3 | 20 | 80 | 100 | 3 |
| **BSCMTCS602** : Numerical Analysis<br>**BSCMTCS603** : Linear Programming | T | 4 | 3 | 20 | 80 | 100 | 3 |
| **BSCMTPS601**: Practicals on Complex Analysis and Linear Algebra | P | 4 | 3 | 10 | 40 | 50 | 2 |
| Compulsory Skill/Practicals<br>**BSCMTMS456** : **Mini Project in Applications of Mathematics** | T | 2 | Viva + Presentation | 40 (Project) | 10 (Viva + Presentation) | 50 | 2 |

**Note:**

1. In 3rd semester, course **BSCMTES301** or **BSCMTES302**, and in 4th Semester, **BSCMTES401** or **BSCMTES402** are Discipline Electives. Any B.Sc. student with Mathematics as one of the major subjects may choose these courses
2. For 5th and 6th semesters, **BSCMTCS501** and **BSCMTCS601** respectively are compulsory courses. In the 5th semester, a student has to choose one of the special courses either **BSCMTCS502** or **BSCMTCS503**. In the 6th semester, a student has to choose one of the special Courses from **BSCMTCS602** or **BSCMTCS603**.
3. **BSCMTMS456-Mini Project in Applications of Mathematics** is a Compulsory Skill/ Practical Course is to be taken either in Semester IV or V or VI.
4. Theory and Lab internal assessment marks should be based on two tests.

# Syllabus

## I Semester

| | | | |
|---|---|---|---|
| **BSCMTCS101** | **Calculus** | **3 Credits** | **(48 Hours, 4 hours/ week)** |

**Course Objectives:**

1. To review and strengthen understanding of the fundamental concepts of differentiable functions, including properties of differentiation, and critical points.
2. To provide a thorough understanding of key theorems in calculus such as Rolle's Theorem, Mean Value Theorem, and Cauchy's Mean Value Theorem.
3. To apply calculus concepts to practical problems, including curve sketching, optimization problems, and evaluating integrals using various techniques.
4. To develop proficiency in different integration techniques and their applications, including the use of reduction formulae.
5. To introduce and explore the concepts of functions of several variables, including limits, continuity, partial derivatives, and their applications.

**Course Outcomes (COs):**

1. Students will be able to understand and apply properties of differentiation, and solve problems involving local extrema and concavity.
2. Students will be able to understand and apply key theorems such as Rolle's Theorem, Mean Value Theorem, and Cauchy's Mean Value Theorem in various contexts.
3. Students will develop the ability to solve applied optimization problems, sketch curves, and use asymptotes effectively in analysis.
4. Students will be able to evaluate definite and indefinite integrals using techniques such as reduction formulae, partial fractions, etc.
5. Students will gain a solid understanding of the behavior of functions of several variables, and get ability to compute and interpret directional derivatives and gradients.
6. Students will be able to find and classify extreme values and saddle points for functions of two variables, using second derivative tests and other techniques.

**Unit I (12 Hours)**

Recapitulation: Definition and examples of differentiable functions, Properties of differentiation, Increasing and decreasing functions, critical points, local extrema.

Rolle's Theorem, The mean value theorem. Concavity, Points of inflection, Second derivative test for concavity, Second derivative test for local extrema, Asymptotes (horizontal, vertical and oblique), Sketching curves $y = f(x)$, Applied optimization problems.

**Unit II (12 Hours)**

Indeterminate Forms (all types), L'Hôpital's rules (First form and stronger form), Cauchy's mean value theorem, Taylor's and Maclaurin's series.

Vector Calculus: Directional derivatives, Gradient of functions of two or three variables, Properties of directional derivatives, Gradients and tangents to level curves, Level surfaces, Tangent planes and normal lines to level surfaces.

**Unit III (12 Hours)**

Integration: Techniques of integration, definite integrals, Mean value theorem for definite integrals, Fundamental theorem of calculus (Part 1 and 2). Derivation of reduction formulae for $\int \sin^n x\, dx$, $\int \cos^n x\, dx$, $\int \tan^n x\, dx$, $\int \log^n x\, dx$, $\int \sec^n x\, dx$, $\int \sin^n x \cos^m x\, dx$, etc.

Evaluation of integrals using reduction formulae, Integration of rational functions by partial fractions, trigonometric integrals.

**Unit IV (12 Hours)**

Functions of several variables: Domain, Range, Interior points, Boundary points, Closed, Open, Bounded and unbounded regions in the plane, Level curves and level surfaces. Limits and Continuity, Two-Path tests for non-existence of limits, Partial derivatives, Implicit partial differentiation, Partial derivatives and continuity, Higher order partial derivatives, Mixed derivative theorem, Differentiability, Chain rule for differentiation. Extreme values and saddle points for functions of two variables, Second derivative test for local extrema.

**Text Book:**

Maurice D. Weir, George B. Thomas, Jr., Joel Hass, Frank R. Giordano, *Thomas' Calculus*, 11th Ed., Pearson, 2008.

**References:**

[1] Lipman Bers, *Calculus*, Holt, Rinehart & Winston of Canada Ltd., 1969.

[2] Louis Leithold, *Calculus with Analytic Geometry*, 5th Ed., Harper and Row International, 1986.

[3] G. B. Thomas and R. L. Finney, *Calculus and Analytic Geometry*, Addison-Wesley, 1992.

[4] J. Edwards, *Integral Calculus for Beginners*, Arihant Publishers, 2016 (original 1896).

[5] Shanti Narayan and P. K. Mittal, *Differential Calculus*, S Chand and Company Ltd. New Delhi 2014.

[6] Shanti Narayan and P K Mittal, *Integral Calculus*, S. Chand and Company Ltd. New Delhi, 2005.

| BSCMTPS101 | Practical-I | 2 Credits | (4 hours/ week) |
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**Practicals for I Semester**

**Mathematics practicals with Free and Open Source Software (FOSS) tools for computer programs**

**Course Objectives:**

1. To learn programming skills in Maxima through listed programs.
2. To apply the programming skills in Science and Engineering problems.

**Course Outcomes (COs):**

1. Students will have the knowledge and skills to implement the programs listed below in the Scilab/Maxima programming language.
2. Students can be expected to apply these programming skills of computation in science and Engineering.

**Programs:**

1) Finding the limit of a function and checking the continuity of a function at a point.
2) Checking the differentiability of conditional functions.
3) Plotting of standard Cartesian curves using Maxima.
4) Finding the solutions of optimization problems.
5) Verification of Rolle's theorem and Lagrange's theorem.
6) Verification of Cauchy's mean value theorem.
7) Generating Taylor's series and Maclaurin's series.
8) Finding the equation of the tangent plane to the surface $z = f(x, y)$ and plot them.
9) Finding the average value and verification of fundamental theorem.
10) Finding the area enclosed between two curves.
11) Find the definite integrals using the reduction formula manually and then verification using maxima command.
12) Finding the partial derivatives and verification of Laplace equation.
13) Euler's theorem and Illustration examples for its verification.
14) Finding the extreme values of functions of two variables.

**Note:** The above list may be changed annually with the approval of the BOS in UG (Mathematics).

## II Semester

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| **BSCMTCS201** | **Advanced Calculus and Differential Equations** | **3 Credits** | **(48 Hours, 4 Hrs/week)** |

**Course Objectives:**

1. To develop a comprehensive understanding of polar coordinates, their applications in graphing, and the analysis of conic sections.
2. To gain proficiency in evaluating line integrals and multiple integrals, and understanding their applications in various coordinate systems.
3. To provide a solid foundation in differential equations, including methods for solving first-order differential equations.
4. To explore practical applications of differential equations in various fields, enhancing problem-solving skills.
5. To understand more complex differential equations, including nonlinear equations and orthogonal trajectories, and their solutions.

**Course Outcomes (COs):**

1. Students will be able to convert between polar and Cartesian coordinates, graph equations in polar coordinates, and calculate areas and lengths.
2. Students will classify and analyze conic sections by eccentricity, and work with their polar equations to sketch and identify various conics.
3. Students will evaluate line integrals over plane and space curves, understanding their applications and computations.
4. Students will master double and triple integrals, including changing between Cartesian and polar coordinates, and apply these techniques to calculate volumes, areas, and averages.
5. Students will understand and solve first-order differential equations using various methods, including separation of variables and integrating factors.
6. Students will apply differential equations to model and solve real-world problems in physics, chemistry, and other fields.

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**Unit I (12 Hours)**

Polar Co-ordinates: Definition, Polar equations and graphs, Relating Polar and Cartesian co-ordinates, Graphing in Polar co-ordinates, Areas and lengths in Polar co-ordinates, Area of a surface of revolution.

Conic Sections: Classifying conic sections by eccentricity, Conic Sections in Polar co-ordinates, Polar equation for lines, ellipse, parabola and hyperbola with eccentricity. Identification by finding eccentricity, and drawing the sketch.

**Unit II (12 Hours)**

Line Integrals: Definition and examples, Evaluating line integrals over plane curves and over space curves.

Multiple Integrals : Double integrals over rectangles, Double integrals as volumes, Fubini’s theorem for calculating double integrals, Finding regions of integration, Double integrals over bounded non-rectangular regions, Volume of solids, Evaluating the double integrals, Finding regions, Reversing the order, Areas of bounded regions in the plane, Average, Volume of an integrable function, Evaluating double integrals in Polar co-ordinates, Finding limits of function, Area in Polar co-ordinates. Changing Cartesian integral to Polar co-ordinates, Triple integrals in rectangular co-ordinates, Evaluating triple integrals.

**Unit III (12 Hours)**
Recapitulation: Definitions, Families of curves, Examples of differential equations, Families of solutions, Equations of order one, Separation of variables.
Equations with homogeneous coefficients, Exact equations, The linear equation of order one, The general solution of a linear equation, Integrating factors found by inspection, The determination of integrating factors, Substitution suggested by the equation, Bernoulli's equation.

**Unit IV (12 Hours)**
Applications of Differential Equations: Elementary applications - Velocity of escape from the Earth, Newton's law of cooling, Simple chemical conversion, Logistic growth and the price of commodities.
Orthogonal Trajectories: Cartesian and Polar co-ordinates.
Non-linear equations, Factoring the left member, Singular solutions, Eliminating the dependent variable, Clairaut's equation, Dependent variable missing, Independent variable missing.

**Text Books:**

[1] Maurice D. Weir, George B. Thomas, Jr., Joel Hass, Frank R. Giordano, *Thomas' Calculus*, 11th Ed., Pearson, 2008.

[2] Earl D Rainville and Philip E Bedient, *Elementary Differential Equations*, Pearson, 8th Ed., 2016.

[3] Narayanan and Manicavachagom Pillay, *Differential Equations*, Viswanathan (Printers and Publisher) PVT Ltd., 1991.

**References:**

[1] Louis Leithold, *Calculus with Analytic Geometry*, 5th Ed., Harper and Row International, 1986.

[2] Lipman Bers, *Calculus*, Holt, Rinehart & Winston of Canada Ltd., 1969.

[3] Earl D Rainville and Philip E Bedient, *A Short Course in Differential Equations*, Macmillan Ltd., 4th Ed., 1969.

[4] Narayanan and Manicavachagom Pillay, *Differential Equations*, Viswanathan (Printers and Publisher) PVT Ltd., 1991.

[5] Joseph Edwards, *Integral Calculus for Beginners*, Arihant Publishers, 2016 (original 1896).

[6] M. D. Raisinghania, *Ordinary Differential Equations & Partial Differential Equations*, S. Chand & Company, New Delhi, 20th Edition - 2020.

| BSCMTPS201 | Practical-II | 2 Credits | (4 hours/ week) |
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**Practicals for II Semester**

**Mathematics practicals with Free and Open Source Software (FOSS) tools for computer programs**

**Course Objectives:**

1. To learn programming skills in Maxima through listed programs.
2. To apply the programming skills in Science and Engineering problems.

**Course Outcomes (COs):**

1. Students will have the knowledge and skills to implement the programs listed below in the Scilab/Maxima programming language.
2. Students can be expected to apply these programming skills of computation in science and Engineering.

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**Programs:**

1) General and Particular Solutions of ordinary differential equations of first order.
2) Solving the differential equations of manually.
3) Verification of the exactness of a differential equation.
4) Differential equations which are solvable for p.
5) Solving Differential equations of Clairaut's form.
6) Plotting the orthogonal trajectories.
7) Area and length of the polar curves.
8) Tracing the polar curves.
9) Identifying the conic and tracing the conic.
10) Evaluation of line integrals.
11) Evaluation of double integrals with constant and variable limits.
12) Evaluation of triple integrals with constant and variable limits.

**Note:** The above list may be changed annually with the approval of the BOS in UG (Mathematics).

# III Semester

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| **BSCMTCS301** | **Number Theory and Higher Order Differential Equations** | **3 Credits** | **(48 Hours, 4 Hrs/week)** |

**Course Objectives:**

1. To develop a solid understanding of basic concepts in number theory, including the division algorithm, gcd, and the fundamental theorem of arithmetic.
2. To explore more complex topics in number theory such as congruences, Fermat's and Wilson's Theorems, Euler's Phi-Function, and continued fractions.
3. To provide knowledge and techniques for solving linear differential equations with constant coefficients, both homogeneous and non-homogeneous.
4. To introduce and apply advanced methods for solving differential equations, such as reduction of order and variation of parameters.
5. To apply differential equation solving techniques to real-world problems in physics and engineering, such as vibrations and electrical networks.

**Course Outcomes (COs):**

1. Students will be able to apply the division algorithm, calculate gcd using the Euclidean algorithm, solve Diophantine equations, and understand the fundamental theorem of arithmetic.
2. Students will understand and use the basic properties of congruences, solve linear congruences, and apply the Chinese Remainder Theorem.
3. Students will be able to state and apply Fermat's Theorem, Wilson's Theorem, and Euler's Theorem, and compute Euler's Phi-Function.
4. Students will solve linear differential equations with constant coefficients, including finding the complementary function and particular integral for various forms of the non-homogeneous term.
5. Students will use methods such as reduction of order and variation of parameters to solve more complex differential equations.
6. Students will apply differential equation techniques to model and solve practical problems, including mechanical vibrations, electrical networks, and other systems.

**Unit I (12 Hours)**

Number Theory: Division Algorithm, The Greatest Common Divisor (g.c.d), Euclidean Algorithm, Diophantine Equations, Fundamental Theorem of Arithmetic.

Theory of Congruences, Basic Properties of Congruences, Binary and Decimal Representation of Integers.

**Unit II (12 Hours)**

Number Theory: Linear Congruences and The Chinese Remainder Theorem, Fermat's Theorem, Wilson's Theorem, Euler's Phi-Function, Euler's Theorem, Some Properties of Phi-Function, Simple continued fractions.

**Unit III (12 Hours)**

Linear Equations with Constant Coefficients: Introduction, The operator D, The Auxiliary Equation, solution of homogeneous equations with constant coefficients (Distinct roots, Repeated Roots, Imaginary Roots).

Non-homogeneous Equations: Complementary function of a linear equation with constant coefficients, Particular integral, General method of finding particular integral, Special methods for finding particular integral when RHS of the non-homogeneous differential equation is of the form: $e^{ax}$, cos $ax$, sin $ax$, $x^m$ $e^{ax}V(x)$, where $V(x)$ is sin $ax$, cos $ax$ or $x^m$. Solution of non-homogeneous equations by the method of Undetermined Coefficients.

**Unit IV (12 Hours)**

Method of Reduction of Order, Variation of Parameters, Solution of $y'' + y = f(x)$ reducing to normal form, change of independent variable method.

Applications: Vibration of a Spring, Undamped Vibrations Applications to Electrical Networks. The Simple Pendulum. Solution of simultaneous equations.

**Text Books:**

[1] David M. Burton., *Elementary Number Theory*, 7th Ed., McGraw Hill, 2011.

[2] Earl D Rainville and Philip E Bedient, *Elementary Differential Equations*, Pearson, 8th Ed., 2016.

[3] Narayanan and Manicavachagom Pillay, Differential Equations, Viswanathan (Printers and Publisher) PVT Ltd., 1991.

**References:**

[1] Gareth A. Jones and J. Marry Jones, *Elementary Number Theor*y, Springer, 1998.

[2] Earl D Rainville and Philip E Bedient, *A Short Course in Differential Equations*, Macmillan Ltd., 4th Ed., 1969.

[3] William E. Boyce, Richard C. DiPrima, *Elementary Differential Equations*, 10th Ed., Wiley Publishers, 2012.

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|---|---|---|---|
| **BSCMTPS301** | **Practical-III** | **2 Credits** | **(4 hours/ week)** |

**Practicals for III Semester**

**Mathematics practicals with Free and Open Source Software (FOSS) tools for computer programs**

**Course Objectives:**

1. To learn programming skills in Maxima through listed programs.
2. To apply the programming skills in Science and Engineering problems.

**Course Outcomes (COs):**

1. Students will have the knowledge and skills to implement the programs listed below in the Scilab/Maxima programming language.
2. Students can be expected to apply these programming skills of computation in science and Engineering.

**Programs:**

1) On Euclidian algorithm., to find the GCD, LCM and verification of GCD LCM theorem.
2) Divisibility test (a number divisible by 9 and 11).
3) To find the solutions of Diophantine equations.
4) Solving the simultaneous equations using Chinese remainder theorem.
5) Verification of Fermat's theorem, Wilson's theorem and Euler's theorem.
6) To compute Euler's phi function for positive integers and to find the sum of all positive divisors of n.
7) Expressing a rational function as a finite continued fraction.
8) To find a rational number corresponding to a given continued fraction.
9) Solving higher order differential equations with variable coefficients manually.
10) Finding the complimentary function and particular integral of a linear differential equations.
11) Solutions of second ordered differential equations by finding the complimentary function.
12) Program to illustrate damped and undamped vibrations.
13) Solving simultaneous differential equations.

**Note:** The above list may be changed annually with the approval of the BOS in UG (Mathematics).

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|---|---|---|---|
| **BSCMTES301** | **Mathematical Logic and Set theory** | **2 Credits** | **(28 Hours, 2 hours/ week)** |

**Course Objectives:**

1. To develop a thorough understanding of propositional and predicate logic, including applications and equivalences.
2. To introduce various methods and strategies for constructing mathematical proofs, emphasizing rules of inference and proof structures.
3. To provide a comprehensive understanding of sets, relations, and functions, including operations, properties, and applications.
4. To explore advanced topics such as equivalence relations, partial orders, and different types of functions, including one-to-one and onto functions.

**Course Outcomes (COs):**

1. Students will be able to construct and evaluate propositional logic statements, understand and apply logical equivalences, and solve problems using propositional logic.
2. Students will be able to construct valid mathematical proofs using various methods, including direct proof, indirect proof, and proof by contradiction, applying appropriate rules of inference.

3. Students will understand and work with Cartesian products, equivalence relations, and partial orders, and apply these concepts to classify and analyze relationships between elements.
4. Students will be able to define and work with various types of functions, including one-to- one, onto, inverse functions, and compositions of functions, understanding their properties and applications.

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**Unit I (14 Hours)**
Mathematical Logic: Propositional Logic, Applications of Propositional Logic, Propositional Equivalence, Predicates and Quantifiers, Nested Quantifiers, Rules of Inference, Introduction to Proofs, Proof Methods and Strategies.

**Unit II (14 Hours)**
Relations and Functions: Sets and subsets, Set Operations and the Laws of Set Theory, Cartesian Products and Relations, Equivalence relation and partition, Partial Order. Functions - Definition and Examples, One-to-one and Onto functions, Inverse Functions and Composition of Functions.

**Text Book:**

Ralph P. Grimaldi, *Discrete Combinatorial Mathematics*, 5th Ed., Pearson, 2006.

**References**

[1] David J. Hunter, *Essentials of Discrete Mathematics*, 4th Ed.,Jones & Bartlett Learning Company, 2021.

[2] Kenneth H. Rosen, *Discrete Mathematics and its Applications*, 7th Ed., McGraw Hill, 2012.

[3] D. I. A. Cohen, *Basic Techniques of Combinatorial Theory*, John Wiley and Sons, New York, 1978.

[4] Fred S. Roberts and Barry Tesman, *Applied Combinatorics*, 2nd Ed., CRC Press, 2009.

[5] G. E. Martin, *Counting: The Art of Enumerative Combinatorics*, UTM, Springer, 2001.

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| **BSCMTES302** | **Quantitative Mathematics** | **2 Credits** | **(28 Hours, 2 hours/ week)** |

**Course Objectives:**

1. Gain foundational knowledge of number systems, divisibility tests, HCF, LCM, decimal fractions, and simplification techniques.
2. Enhance skills in solving problems related to averages, numbers, and ages through practical applications.
3. Learn to calculate percentages, profit and loss, ratios, proportions, and understand the concepts of partnership.
4. Tackle calendar and clock problems, and apply mathematical principles to solve problems involving heights and distances.

**Course Outcomes (COs):**

Upon successful completion of this course,

1. Students will be able to apply knowledge of number systems, divisibility, HCF, LCM, and decimal fractions to solve mathematical problems.
2. Students get ability to Solve arithmetic problems, handle simplification tasks, compute averages, and solve number and age-related problems effectively.
3. Students will be able to calculate percentages, understand profit and loss, and solve problems involving ratios, proportions, and partnerships.
4. Students will be able to address practical scenarios, solve calendar and clock problems, and apply mathematical concepts to determine heights and distances.

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**Unit I (14 Hours)**

Number System, Divisibility Tests, HCF and LCM of numbers. Decimal Fractions, Simplification, Average, Problems on numbers, Problems on ages.

**Unit II (14 Hours)**

Percentage, Profit and Loss, Ratio and Proportion, Partnership, Calendar Problems, Clock Problems, Heights and Distances.

**Text Book:**

R.S. Agarwal, *Quantitative Aptitude*, S. Chand and Company Limited, New Delhi, 2021.

**References**


[1] Abhijit Guha, *Quantitative Aptitude*, Mc.Grawhill publications, 5thEdition, 2014.

[2] R. V. Praveen, *Quantitative Aptitude and Reasoning*, PHI publishers, 3rd Edition, 2016.

[3] R. S. Aggarwal, *Objective Arithmetic*, S. Chand & Company Ltd, Revised Edition, 2018.

[4] Qazi Zameeruddin,Vijay K. Khanna and S. K. Bhambri, *Business Mathematics*, S. Chand publications, 2ndEdition, 2009.

[5] S. K. Sharma and Gurmeet Kaur, *Business Mathematics*, Sultan Chand & Sons, 2019.

[6] Hazarika Padmalochan, *A Text Book of Business mathematics for B.Com and BBA Course*, S. Chand Publication, 2017.

[7] N. G. Dasand, J. K. Das, *Business Mathematics and Statistics*, Mc.Grawhill Education, 2017.

# IV Semester

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| **BSCMTCS401** | **Group Theory, Sequences and Series** | **3 Credits** | **(48 Hours, 4 hours/ week)** |

**Course Objectives:**

The course will help the students

1. To introduce the fundamental concepts of group theory, including binary operations, group structures, and subgroups.
2. To explore deeper aspects of group theory such as cosets, normal subgroups, homomorphisms, and isomorphism theorems.
3. To provide a comprehensive understanding of sequences, their properties, and the theorems related to sequence limits and convergence.
4. To develop skills in analyzing series, including tests for convergence, and understanding the behavior of series with positive terms and alternating series.

**Course Outcomes (COs):**

1. Students will understand and apply concepts of binary operations, group structures, and subgroups, including cyclic subgroups and permutation groups.
2. Students will be able to work with cosets, direct products, finitely generated abelian groups, and understand and apply theorems related to homomorphisms and factor groups.
3. Students will understand and apply various tests for series convergence, analyze geometric and harmonic series, and distinguish between absolute and conditional convergence.
4. Students will be able to apply the theoretical concepts of group theory and sequence analysis to solve complex problems in mathematics.

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**Unit I (12 Hours)**

Group Theory: Binary Operations, Isomorphic Binary Structures, Groups, Examples (Abelian and non-abelian), Finite Groups and Group Tables, Subgroups, Cyclic subgroups, Cyclic Groups, Structure of Cyclic Groups, Subgroups of Finite Cyclic Groups, Groups of Permutations - Orbits, Cycles and Alternating Groups.

**Unit II (12 Hours)**

Group Theory (contd.): Cosets and the Theorem of Lagrange, Direct Products and Finitely Generated Abelian Groups. Homomorphisms, Kernel of a Homomorphism, Normal Subgroups, Factor Groups, Isomorphism Theorems (First, Second and Third).

**Unit III (12 Hours)**

Sequences: Recapitulation of number system - Real line, bounded sets, supremum and infimum of a set, Archimedean property of R. Intervals, Neighborhood of a point, open sets, closed sets, limit points. Sequences of real numbers, Bounded sequences. Limit of a sequence, convergent, divergent, and oscillatory sequences. Monotonic sequences, Algebra of convergent sequences. Limit points of a sequence, Bolzano-Weierstrass theorem for sequence. Cauchy’s first and second theorems on limits of a sequence. Cauchy’s general principle for convergence of a sequence. Subsequence and their properties.

**Unit IV (12 Hours)**

Definitions of convergent, divergent and oscillatory series. Series of non-negative terms, Cauchy's general principle of convergence. Geometric series, *p*-series (Harmonic series). Comparison tests for positive term series. D'Alembert's ratio test, Raabe's test. Cauchy's Root test and Cauchy's integral test. Alternating series. Leibnitz's theorem. Absolute convergence and conditional convergence of a series.

**Text Books:**

[1] J. B. Fraleigh and N. Brand, *A First Course in Abstract Algebra*, 8th Edition, Pearson, 2014. (For Unit I and Unit-II)

[2] S.C. Mallik and Savita Arora, *Mathematical Analysis*, New Age International Publishers, 6th edition 2022. (For Unit III and Unit-IV)

**References**

[1] N. S Gopalakrishnan, *University Algebra*, 3rd Ed., New Age International Publications, 2015.

[2] G. D. Birkoff and S Maclane, *A brief Survey of Modern Algebra*, 2nd Ed., IBH Publishing Company, Bombay, 1967.

[3] Joseph Gallian, *Contemporary Abstract Algebra*, Narosa, 1999.

[4] I. N. Herstein, *Topics in Algebra*, 2nd Ed., Wiley Publishers, 1975.

[5] S.C Mallik, *Principles of Real Analysis*, New Age International Publications, 2008.

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|---|---|---|---|
| **BSCMTPS401** | **Practical-IV** | **2 Credits** | **(4 hours/ week)** |

**Practicals for IV Semester**

**Mathematics practicals with Free and Open Source Software (FOSS) tools for computer programs**

**Course Objectives:**

1. To learn programming skills in Maxima through listed programs.
2. To apply the programming skills in Science and Engineering problems.

**Course Outcomes (COs):**

1. Students will have the knowledge and skills to implement the programs listed below in the Scilab/Maxima programming language.
2. Students can be expected to apply these programming skills of computation in science and Engineering.

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**Programs:**

1. Verification of binary operation.
2. Finding the identity and inverse element in a group.
3. Finding all possible subgroups of a group.

4. Construction of the Cayley's table.
5. Finding the generators of a cyclic group.
6. Finding the left and right cosets and index of a group.
7. Verification of the Lagrange's theorem.
8. Testing the convergence of the sequence.
9. Convergence of positive term series using Cauchy's criterion
10. Convergence of geometric series, p–series, convergence using limit form.
11. Convergence of positive term series using D'Alembert's test , nth root test, Cauchy's integral test, Raabe's test.
12. Convergence of alternating series using Leibnitz's test.

**Note:** The above list may be changed annually with the approval of the BOS in UG (Mathematics).

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| **BSCMTES401** | **Basic Combinatorial Theory** | **2 Credits** | **(28 Hours, 2 hours/ week)** |

**Course Objectives:**

The course will help the students

1. To introduce students to the basic principles of counting, including permutations, combinations, and binomial coefficients, and their applications.
2. To explore advanced counting methods such as the Pigeon-hole Principle, Principle of Inclusion-Exclusion, and derangements, and their applications in solving combinatorial problems.
3. To develop proficiency in generating functions as a tool for solving combinatorial problems, including partition of integers and applications of exponential generating functions.
4. To understand and solve first and second-order linear homogeneous and non-homogeneous recurrence relations using methods such as generating functions.

**Course Outcomes (COs):**

1. Students will be able to apply counting principles to solve problems involving permutations, combinations, and binomial coefficients.
2. Students will apply the Pigeon-hole Principle, Principle of Inclusion-Exclusion, and derangements to solve complex combinatorial problems.
3. Students will be proficient in using generating functions to solve problems related to partitioning integers and other combinatorial applications.
4. Students will understand and solve first and second-order linear homogeneous and non-homogeneous recurrence relations, applying techniques such as generating functions to find solutions.
5. Students will develop strong problem-solving skills in combinatorial mathematics, applying counting principles, generating functions, and recurrence relations to solve a variety of problems.

**Unit I (14 Hours)**
Counting: The Basics of Counting, Pigeon-hole Principle, Permutations and Combinations, Binomial Coefficients and identities, Generalized Permutations and Combinations.
Advanced Counting Techniques: Principle of Inclusion-Exclusion, Generalizations of the Principle, Derangements.

**Unit II (14 Hours)**
Generating Functions: Introductory Example, Calculation Techniques, Partition of integers, Exponential Generating Function, The Summation operator.
Recurrence Relations: The First Order Linear Recurrence Relations, Second Order Linear Homogeneous Recurrence Relations with Constant Coefficients, Non-homogeneous Recurrence Relations, The method of Generating Functions.

**Text Book:**

Ralph P. Grimaldi, *Discrete Combinatorial Mathematics*, 5th Ed., Pearson, 2006.

**References:**

[1] David J. Hunter, *Essentials of Discrete Mathematics*, 4th Ed., Jones & Bartlett Learning Company, 2021.
[2] Kenneth H. Rosen, *Discrete Mathematics and its Applications*, 7th Ed., McGraw Hill, 2012.
[3] D. I. A. Cohen, *Basic Techniques of Combinatorial Theory*, John Wiley and Sons, New York, 1978.
[4] Fred S. Roberts and Barry Tesman, *Applied Combinatorics*, 2nd Ed., CRC Press, 2009.
[5] JG. E. Martin, *Counting: The Art of Enumerative Combinatorics*, UTM, Springer, 2001.

| BSCMTES402 | Vedic Mathematics | 2 Credits | (28 Hours, 2 hours/ week) |
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**Course Objectives:**
1. Learn the 16 Sutras and 13 Sub-sutras of Vedic methods, terms, operations, and concepts of base and deficiency in Vedic mathematics.
2. Apply Vedic methods for addition, subtraction, multiplication, and division, including special techniques and practical applications.
3. Study osculators, divisibility tests, bar numbers, and the Vertically and Crosswise method for simplifying and comparing fractions.
4. Use Vedic techniques for squaring numbers, finding square roots, and calculating cubes and cube roots.

**Course Outcomes (COs):**
Upon successful completion of this course,
1. Students will be able to apply Vedic Sutras and Sub-sutras to perform arithmetic operations efficiently and accurately.
2. Students will get used to Vedic techniques for quick addition, subtraction, multiplication, and division, enhancing calculation speed and accuracy.

3. Students get ability to implement advanced methods like osculation, bar numbers, and the vertically and crosswise method for solving complex arithmetic problems.
4. Students will be able to calculate squares, square roots, cubes, and cube roots using Vedic methods, improving problem-solving skills in various mathematical contexts.
5. Students will be able to simplify and compare fractions effectively using Vedic arithmetic techniques, facilitating easier and faster computation.

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**Unit I (14 Hours)**
Introduction, 16 Sutras, 13 Sub-sutras of Vedaganitha, Terms and Operations, Vinculum Numbers, The concept of Base and Deficiency.
Addition: Digit Sums, Adding Digits, Nine Point Circle, Casting out Nines, Digit Sum Puzzles, Digit Sum Check.
Subtraction: All from 9 and Last from 10 rule for Subtraction, Application in day-to-day life.
Multiplication: Multiplication of two numbers using Base and Sub-base methods in different cases, Ekadhikena Purvena and Urdhva Tiryagbhyam methods, Nikhilam Navatashcaramam Dashatah combined operations. Multiplication by Doubling and Halving.

Division: Special methods of Division, Number splitting, Division by 9 and 11, Division by two-digit number using Nikhilam Navatashcaramam Dashatah Sutras.

**Unit II (14 Hours)**
Osculators, Divisibility tests using the osculation process.
Bar Numbers, methods for removing and creating bar numbers.
Multiplication of binomials, simplification and comparison of fractions by Vertically and Crosswise method.
Square of numbers below 50, near a base or sub-base, General Method for Squaring.
Square Roots, Reverse squaring to find square roots of numbers ending in 25, Square root of perfect squares, General method of Square Roots, Cube and Cube Roots.

**Text Books:**
[1] Sri Bharati Krsna Tirthaji, *Vedic Mathematics*, Motilal Banarsidass, 1965.
[2] State Council of Educational Research & Training, New Delhi, *Fundamentals and Applications of Vedic Mathematics*, SCERT, Ghaziabad (U.P.), 2014.
[3] Kenneth R. Williams, *Vedic Mathematics Teacher's Manual: Elementary Level*. Inspiration Books, 2002.

**References**
[1] K. R. Williams, *Discover Vedic Mathematics*, Vedic Mathematics Research Group, 1984.
[2] K. R. Williams, and Mark Gaskell, *The Cosmic Calculator: A Vedic Mathematics Course for Schools*, Motilal Banarsidass, 2002.
[3] A. P. Nicholas, K. R. Williams, and J. Pickles, *Vertically and Crosswise: Applications of the Vedic Mathematics Sutra*, Inspiration Books, 1984.
[4] S. K. Kapoor, *Vedic Ganita: Vihangama Drishti–1*. Siksha Sanskriti Uthana Nyasa, 2014.
[5] *Vedic Mathematics: Past, Present and Future*. Siksha Sanskriti Uthana Nyasa, 2015.

# V Semester

| BSCMTCS501 | Ring theory and Laplace Transforms | 3 Credits | (48 Hours, 4 hours/ week) |
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**Course Objectives:**

The course will help the students

1. To introduce the fundamental concepts of Ring theory, including binary operations, Integral Domains, and fields.
2. To explore deeper aspects of Ring theory such as Ideals, homomorphisms, and isomorphism theorems.
3. To find Laplace transform and inverse Laplace transform of various functions
4. Able to take more courses on wave equation, heat equation, and Laplace equation.
5. To Solve Ordinary Differential equation by Laplace Transforms

**Course Outcomes (COs):**

1. Students will understand and apply concepts of Ring operations, fields, Integral domain
2. Students will be able to work with ideals, kernel, homomorphisms, Isomorphisms
3. Students will be able to find the Laplace transform of some standard functions, Step functions, Periodic functions
4. Students will be able to solve ordinary differential equations using Laplace Transforms

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**UNIT I (12 Hours)**

Ring Theory: Commutative Ring, Unit element, Properties, Zero divisors, Integral domains, Field, Division ring (Skew field), regular elements, Finite Integral domains, Theorems.

Ring Homomorphisms: Kernel of a ring homomorphism, Isomorphism Ideals, Simple Rings, Left and right ideals, Sum and Product of two ideals, Quotient rings, First Isomorphism Theorem.

**UNIT 2 (12 Hours)**

Prime and Maximal Ideals, Factorization, Divisibility, units and associates, Irreducible elements, Prime elements, g.c.d., Relatively prime elements, Euclidian Domain - Definition, Examples, Existence of g.c.d., Factorization Theorem.

**Unit 3 (12 Hours)**

The Laplace Transforms: Definition of Laplace transforms; Transforms of elementary functions, transforming initial value problems: transforms of derivatives; Derivatives of Transforms. The Gamma functions, periodic functions.

**Unit 4 (12 Hours)**

Inverse Transforms: Definition of an inverse transform, Step function, convolution theorem, simple initial value problems, special integral equation.

**Text Book:**


[1] N. S. Gopalakrishnan, *University Algebra*, Revised 4th edition, New Age International Publishers, 2021

[2] Earl D Rainville and Philip E Bedient, *Elementary Differential Equations*, Pearson, $8^{th}$ Ed., 2016

**References:**


[1] I. N. Herstein, *Topics in Algebra*, 2nd ed, Wiley Eastern Ltd., New Delhi, 1975.
[2] V. K. Khanna and S. K. Bhambri, *A Course in Abstract Algebra*, Vikas Publications, 1998.
[3] M. Artin, *Algebra*, 2nd ed, Pearson, 2015.
[4] J. A. Gallian, *Contemporary Abstract Algebra*, 10th ed, Taylor and Francis Group, 2021.
[5] R. Murray and L. Spiegel, *Laplace Transforms*, Schaum's Series, McGraw Hill Education, 2005.
[6] J. K. Goyal and K. P. Gupta, *Laplace and Fourier Transforms*, Pragathi Prakashan, 2016.
[7] S. Kumar, *Integral Transform Methods in Science & Engineering*, CBS Engineering Series, CBS, 2017.


| BSCMTCS502 | Graph Theory | 3 Credits | (48 Hours, 4 hours/week) |
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**Course Objectives:**

1. To introduce the basic concepts of graph theory such as graphs, subgraphs, walks, paths, circuits, and trees.
2. To explore key properties of Eulerian and Hamiltonian graphs and their applications.
3. To study graph connectivity and separability, including planar graphs and their representations.
4. To understand graph colorability and the application of chromatic numbers and polynomials.
5. To apply matrix representations and vector spaces associated with graphs for deeper analysis.
6. To familiarize students with advanced topics such as digraphs, graph enumeration, and labelled trees.

**Course Outcomes (COs):**

By the end of the course, students will be able to:

1. Define and explain fundamental graph theory concepts like graphs, trees, and circuits.
2. Analyze and identify properties of Eulerian and Hamiltonian graphs and solve related problems.
3. Examine the connectivity and planarity of graphs and construct geometric duals.
4. Apply concepts of graph colorability and chromatic numbers to solve coloring problems.
5. Use matrix representations and understand the vector space associated with a graph.
6. Work with directed graphs and perform enumeration of graphs and counting of labelled trees.

**Unit I (12 Hours)**

Graph, finite and infinite graphs, Incidence and degree, Isolated vertex, Pendent vertex, Null graph, Isomorphism, Sub-graphs, Walks, Paths, Circuits, Connected and disconnected graphs, Components, Euler graphs, Operation on graphs, Hamiltonian paths and Circuits.

**Unit II (12 Hours)**

Trees and some properties of trees, Rooted and binary tree, Spanning tree and fundamental circuits. Cutsets, Properties, Fundamental cut sets, Connectivity, Seperability, Planar graphs, Kuratowski's graphs, Euler's formula, Geometric duals.

**Unit III (12 Hours)**
Colourability, chromatic number, Chromatic Polynomial, five-colour theorem, four-colour problem. Matrix representation of graphs - incident, adjacent, circuit and path matrices.

**Unit IV (12 Hours)**
Vector Space Associated with a Graph, Basis Vectors of a Graph, Circuit and Cut-Set Subspaces, Directed graphs, Matrices of digraphs.

**Text Books:**

[1] Gary Chartrand and Ping Zhang, *A First Course in Graph Theory*, Dover Publications, Inc., New York, 2012.

[2] Narsingh Deo, *Graph Theory with Applications to Engineering and Computer Science*, PHI Learning Private Limited, 2004.

[3] R. Balakrishnan and K. Ranganathan, *A Textbook of Graph Theory*, Second Edition, Universitext, Springer, New York, 2012

**Reference Books:**

[1] S. Arumugam and S. Ramachandran, *Invitation to graph theory*, Scitech Publications (India) Pvt. Ltd., 2013.

[2] Douglas B. West, *Introduction to Graph Theory*, Pearson, 2017.

[3] K. Chandrasekhara Rao, *Discrete Mathematics*, Narosa Publishing House, 2012.

[4] Robin J Wilson, *Introduction to Graph Theory*, 5th Ed., Pearson, 2010.

[5] J.A. Bondy and U.S.R. Murty, *Graph Theory with Applications*, Macmillan, 1976.

| **BSCMTCS503** | **Total and Partial Differential Equations** | **3 Credits** | **(48 Hours, 4 Hrs/week)** |
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**Course Objectives:**

1. To introduce the concept of simultaneous differential equations and techniques for solving total differential equations, including Pfaffian forms.
2. To provide a strong foundation in first-order partial differential equations, including methods like Lagrange’s and Charpit’s methods.
3. To develop skills for solving higher-order linear PDEs with constant coefficients, including homogeneous and non-homogeneous forms.
4. To classify and solve second-order PDEs, and introduce canonical forms and physical models like the heat, wave, and Laplace equations.
5. To enhance analytical and problem-solving skills relevant to mathematics, physics, and engineering contexts.

**Course Outcomes (COs):**
By the end of the course, students will be able to:

1. Solve simultaneous differential equations and apply methods to solve Pfaffian and total differential equations.
2. Derive and classify first-order PDEs, and apply Lagrange’s and Charpit’s methods for solving them.
3. Solve higher-order PDEs with constant coefficients and determine complementary and particular integrals.

4. Classify second-order PDEs as hyperbolic, parabolic, or elliptic and reduce them to canonical forms.
5. Solve standard physical PDEs such as the heat equation, wave equation, and Laplace's equation using the method of separation of variables.
6. Apply acquired knowledge in modeling and solving real-world problems in engineering and physical sciences using differential equations.

**Unit I (12 Hours)**

Solutions of simultaneous differential equations of the form $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$. Pfaffian Differential Forms and Total differential equations (Pfaffian differential Equations in 3 variables). Necessary and sufficient condition for integrability of a total differential equation $Pdx + Qdy + Rdz = 0$. Method of Solving Total differential equations – (i) Solution by inspection, (ii) One variable regarded as constant, (iii) Homogeneous equations, (iv) Method of auxiliary equations.

**Unit II (12 Hours)**

Partial Differential Equations(PDEs) of the First Order: Derivation of Partial Differential Equations – (i) by elimination of arbitrary constants, (ii) By the Elimination of arbitrary functions. Classification of Integrals, Linear and non-linear PDEs, Lagrange's Method of Solving linear Equations, Charpit's Method, Special types of first order equations – Standard forms I, II, III and IV.

**Unit III (12 Hours)**

Higher Order Partial Differential Equations: Origin/Derivation of the second order differential Equations, (Linear) PDEs with constant coefficients, Homogeneous PDEs with constant coefficients - Methods/Rules of finding complementary function, Methods/Rules of finding Particular Integral and Solving Problems, Non-Homogeneous linear PDEs with constant coefficients-Methods of finding CF and PI, and Solving Problems.

**Unit IV (12 Hours)**

Equations reducible to Homogeneous linear PDEs with constant coefficients.
PDEs of Second order - Classification of second order linear equations as hyperbolic, parabolic, and elliptic. Canonical forms - Reduction of second order linear equations into canonical forms. Solutions of the Heat equation, Laplace equation and Wave equation (using separation of variables).

**Text Books:**

[1] S. Narayanan and T. K. Manicavachagom Pillay, *Differential Equations*, Revised Ninth Edition, S. Viswanathan (Printers and Publishers) PVT LTD, 1985.

[2] M. D. Raisinghania, *Ordinary and Partial Differential Equations*, 20th Edition, S. Chand & Company, New Delhi, 2020.

**Reference Books:**

[1] K. Sankara Rao, *Introduction to Partial Differential Equations*, PHI, 3rdEdition, 2015.

[2] J. N. Sharma and K. Singh, *Partial Differential Equations for Engineers and Scientists*, Narosa Publishing House, Chennai, 2001.

[3] J. N. Sharma and R. K. Gupta, *Differential Equations*, 53rd Edition, Krishna Prakashan Media (P) Ltd., Meerut, 2019

[4] I. N. Sneddon, *Elements of Partial differential equations*, McGraw-Hill International Editions, 1986.
[5] W. E. Boyce and Richard C. DiPrima, *Elementary Differential Equations and Boundary Value Problems*, John Wiley and Sons, Inc., New York, 1986.
[6] S. L. Ross, *Differential Equations*, 3rd Edition, John Wiley and Sons, Inc., New York, 1984.

## Practicals for V Semester

| BSCMTPS501 | Practicals on Ring Theory and Laplace Transforms | 2 Credits | (4 hours/week) |
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**Course Objectives:**
1. To learn programming skills in WxMaxima through listed programs.
2. To apply the programming skills in Science and Engineering problems.

**Course Outcomes (COs):**
1. Students will have the knowledge and skills to implement the programs listed below in the/Maxima programming language.
2. Students can apply these programming skills of computation in science and Engineering.

**Programs:**
1. Checking whether a given set is a ring with respect to given binary operations.
2. Checking whether a given set is an integral domain or field with respect to given binary operations.
3. Finding zero divisors and units in finite rings.
4. Verification of the given mapping for ring homomorphism.
5. Problems on Prime Ideals and Maximal Ideals
6. Finding the Laplace transforms of some standard functions.
7. Finding the Laplace transforms of some periodic and step functions.
8. Finding the inverse Laplace transform of simple functions
9. Verification of Convolution Theorem.
10. To solve ordinary linear differential equation using Laplace transform.

**Note:** The above list may be changed annually with the approval of the BOS in UG (Mathematics).

# VI Semester

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|---|---|---|---|
| **BSCMTCS601** | **Complex Analysis and Linear Algebra** | **3 Credits** | **(48 Hours, 4 hours/ week)** |

**Course Objectives:**

1. Introduce foundational concepts in complex analysis, including algebraic properties, exponential forms, and differentiability of complex functions.
2. Develop an understanding of analytic, entire, and harmonic functions and apply them to study classical functions such as exponential, logarithmic, and trigonometric forms.
3. Familiarize students with vector space theory, emphasizing key concepts like subspaces, linear independence, and basis construction.
4. Explore the structure and properties of inner product spaces to deepen conceptual grasp and analytical reasoning in linear algebra.
5. Investigate the structure of linear transformations, their matrix representations, change of basis, and the role of eigenvalues and eigenvectors in understanding linear operators.

**Course Outcomes (COs):** At the end of the course, the student will be able to:

1. Analyze and interpret complex functions using Cauchy-Riemann equations and concepts of differentiability and continuity.
2. Analyze elementary complex functions and distinguish between analytic, harmonic, and entire functions in applied contexts.
3. Construct and validate vector spaces and subspaces, determining linear independence, spans, and basis dimensions.
4. Demonstrate competence in inner product spaces and apply inequalities such as Schwarz's inequality in theoretical proofs.
5. Represent linear transformations in matrix form, determine rank, nullity, and minimal polynomials, and compute eigenvalues and eigenvectors to classify linear operators.

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**Unit I (12 Hours)**

**Complex Analysis:** (Recapitulation of algebra, conjugate and modulus of Complex numbers) Polar and Exponential Forms, roots of complex numbers, Functions of a Complex variable, Limits, Continuity, Differentiability, Cauchy-Riemann Equations.

**Unit II (12 Hours)**

**Complex Analysis:** Analytic functions, Entire functions, and Harmonic functions, Elementary functions: Exponential functions, Logarithmic functions. Trigonometric functions, Contour integrals.

**Unit III (12 Hours)**

**Vector Spaces:** Vector Space, Subspaces, Linear Span, Linear Independence, Basis and Dimension, Basis of a Vector Space, Sums of Subspaces, Quotient Space, Inner product spaces, Schwartz inequality.

**Unit IV (12 Hours)**

**Linear Transformations:** Linearity, Rank and Nullity, Isomorphisms, Matrix Representation, minimal polynomial, Change of Basis, Space of Linear Transformations. Eigen values and Eigen vectors of Linear operators.

**Text Books:**

[1] R.V. Churchil & J.W. Brown, *Complex Variables and Applications*, 8th ed., McGraw Hill 2009.

[2] N. S Gopalakrishnan, *University Algebra*, 3rd edition, New Age International Publications, 2015.

**Reference Books:**

[1] L. V. Ahlfors, *Complex Analysis*, 3rd Edition, McGraw Hill Education, 1979.

[2] S. Ponnusamy, *Foundations of Complex Analysis*, 2nd Edition, Alpha Science International Limited, 2005.

[3] Bruce P. Palka, *Introduction to the Theory of Function of a Complex Variable*, Springer, 1991.

[4] Serge Lang, *Complex Analysis*, Springer, 1999.

[5] Shanthi Narayan and P. K. Mittal, *Theory of Functions of a Complex Variable*, S. Chand Publishers, 2005.

[6] B. S. Grewal and J. S. Grewal, *Higher Engineering Mathematics*, 42nd Edition, Khanna Publishers, New Delhi, 1996.

[7] G. D. Birkhoff and S. Maclane, *A Brief Survey of Modern Algebra*, 2nd Edition, IBH Publishing Company, Bombay, 1967.

[8] Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra*, 4th Edition, Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.

[9] Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.

[10] S. Kumaresan, *Linear Algebra - A Geometric Approach*, Prentice Hall of India, 2000

| **BSCMTCS602** | **Numerical Analysis** | **3 Credits** | **(48 Hours, 4 hours/ week)** |
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**Course Objectives:**

The course will help the students

1. To introduce the fundamental concepts of Numerical Analysis including solution of Algebraic and transcendental equations and simultaneous equations.
2. To learn the deeper aspects of Polynomial interpolation
3. To find the derivatives and integrals using Numerical formulae
4. To solve the initial value problems using different methods.

**Course Outcomes (COs):**

At the end of this course, students will be able to:

1. Compute approximate roots of algebraic and transcendental equations using iterative methods
2. Find integrals and derivatives.
3. Solve problems on interpolation using suitable numerical techniques.
4. Obtain approximate solutions to initial value problems using various numerical techniques.

**Unit I (12 Hours)**

Algebraic and Transcendental Equations: Solutions to algebraic and transcendental equations - Bisection method, Regula-Falsi method, Iterative method, Newton-Raphson method.
System of Linear Algebraic Equations: Direct Methods – Gauss elimination method, Gauss-Jordan method and Iterative methods: Jacobi method, Gauss Seidal method.

**Unit II (12 Hours)**

Finite differences - Forward, Backward differences and shift operators, definitions, properties and problems.
Polynomial interpolation - Newton-Gregory forward and backward interpolation formulae, Lagrange's interpolation formula. Newton's divided difference and Newton's general interpolation formula.

**Unit-III: (12 Hours)**

Numerical Differentiation and Integration: Formula for derivatives based on Newton-Gregory forward and backward interpolation formulae, Numerical Integration: General quadrature formula, Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule with derivations

**UNIT IV : (12 Hours)**

Numerical Solution of Ordinary Differential Equations: Introduction, Solution by Taylor's series method, Picard's method, Euler's method, Modified Euler's method, Runge-Kutta methods, Predictor-Corrector methods - Adams-Bashforth method.

**Text Books:**

[1] S. S. Sastry, Introductory methods of Numerical Analysis, 5th Edition, PHI Learning Private Limited, 2012

[2] B .S. Grewal, Numerical methods in Engineering and Science with programs in C, C++, 9th edition, Khanna Publishers, 2010.

**References:**

[1] E. Isaacson and H. B. Keller, *Analysis of Numerical Methods*, Dover Publications, 1966.

[2] E. Kreyszig, *Advanced Engineering Mathematics*, Wiley India Pvt. Limited, 1972.

[3] M. K. Jain, S. R. K. Iyengar, and R. K. Jain, *Numerical Methods for Scientific and Engineering Computation*, 4th Edition, New Age International, 1985.

[4] H. C. Saxena, *Finite Difference and Numerical Analysis*, S. Chand Publishers, 2010.

[5] B. D. Gupta, *Numerical Analysis*, Konark Publishers Pvt. Ltd., 1990

| BSCMTCS603 | Linear Programming and its Applications | 3 Credits | (48 Hours, 4 hours/ week) |
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**Course Objectives:**

1. To develop an understanding of the fundamental concepts and structure of linear programming.
2. To build skills in interpreting solutions within the context of practical applications such as resource allocation, cost minimization, and profit maximization.
3. To equip students with analytical tools to identify optimal solutions using appropriate mathematical techniques.
4. To understand the role of Linear Programming as a fundamental tool in Operational Research for decision-making and optimization.
5. To develop the ability to identify constraints, decision variables, and objective functions in practical scenarios.
6. To provide the mathematical foundation needed to solve optimization problems using graphical and Simplex methods.

**Course Outcomes (COs):**

1. Formulate real-life optimization problems as linear programming models with appropriate objective functions and constraints.
2. Apply mathematical reasoning to evaluate and transform linear programming problems into canonical and standard forms for solution.
3. Solve linear programming problems using graphical and algebraic methods, including the Simplex Algorithm.
4. Understand the fundamental concepts of Linear Programming and its importance in solving real-life optimization problems.
5. Identify and define decision variables, constraints, and objective functions in the context of given problems.

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**UNIT 1 (12 Hours)**

Geometric Linear Programming: Profit Maximization and cost Minimization, Cost Minimization, Canonical forms for Linear Programming Problems, Polyhedral Convex sets.
The Simplex Algorithm: Canonical stack for Linear Programming Problems, Tucker Tableaus, Pivot Transformation, pivot Transformation for Maximum and Minimum Tableaus, Simplex Algorithm for Maximum Basic Feasible Tableaus., Simplex Algorithm for Maximum Tableau.

**UNIT 2 (12 Hours)**

Negative Transposition: The Simplex Algorithm for Minimum tableaus.
Non-Canonical Linear Programming Problems: Unconstrained variables, Equation of Constraint.
Duality Theory: Duality in Canonical Tableaus, Dual Simplex Algorithm, Matrix formulation of Canonical tableaus, The Duality Equation. The Duality Theorem: Duality in Non-Canonical Tableaus.

**UNIT 3 (12 Hours)**

Matrix Games: Two Persons Zero Sum Matrix Game, Linear Programming Formulation of Matrix Games, The Von Neumann Minimax Theorem.

**UNIT 4 (12 Hours)**

Transportation and Assignment Problem: The Balanced Transportation Problem, The Vogel

Advanced Start Method (VAM), The Transportation Algorithm, Unbalanced Transportation Problems, The Assignment Problem, The Hungarian Algorithm.
Apply graphical and Simplex methods to determine optimal solutions to Linear Programming Problems.

**Text Book:**

James K Strayer, *Linear Programming and its applications*, Springer-Verlag,1989.

**Reference Books**:

[1] Kanti Swarup, P.K. Gupta, and Man Mohan, *Operations Research*, Sultan Chand & Sons, 1978.

[2] Frederick S. Hillier and Gerald J. Lieberman, *Introduction to Operations Research*, McGraw Hill Education, 2021.

[3] Mokhtar S. Bazaraa, John J. Jarvis, and Hanif D. Sherali, *Linear Programming and Network Flows*, Wiley, 2011.

[4] Robert J. Vanderbei, *Linear Programming: Foundations and Extensions*, Springer, 2020.

[5] Taha H. A., *Operations Research: An Introduction*, Pearson, 2017.

## Practicals for VI Semester

| | | | |
|---|---|---|---|
| **BSCMTPS601** | **Practicals on Complex Analysis and Linear Algebra** | **2 Credits** | **(4 hours/ week)** |

**Course Objectives:**

1. To learn programming skills in Scilab/Maxima through listed programs.
2. To apply the programming skills in Science and Engineering problems.

**Course Outcomes (COs):**

1. Students will have the knowledge and skills to implement the programs listed below in the Scilab/Maxima programming language.
2. Students can apply these programming skills of computation in science and Engineering.

**Programs:**

1. Program to find the roots of a given complex number.
2. Program to verify the Cauchy–Riemann equations in Cartesian form and test for analyticity.
3. Program to verify the Cauchy–Riemann equations in Polar form and test for analyticity.
4. Program to check whether a given function is harmonic.
5. Program to construct an analytic function using the Milne–Thomson method.
6. Program to verify linear dependence and independence.
7. Program to find basis and dimension of the subspaces.
8. Program to find the matrix of linear transformation.
9. Program to find the Eigen values and Eigen vectors of a given linear transformation.
10. Program to find the minimal polynomial of given transformation.

**Note:** The above list may be changed annually with the approval of the BOS in UG (Mathematics).

## Compulsory Skill/Practicals
## Internship/Mini Project Work

(May be offered in either IV, V or VI Semester)

| | | | |
|---|---|---|---|
| **BSCMTMS456** | **Mini project in Applications of Mathematics** | **2 Credits** | **(28 Hours, 2 hours/week)** |

**Internship/Mini project has to be compulsorily carried out in one of the last three semesters (i.e. Semester IV, V or VI) with a workload of 2 hours per week under the supervision of a teacher. Report on the internship/Mini project has to be submitted for evaluation.**

**Course Objectives:**

1. To enable students to apply mathematical concepts and techniques to solve real-world problems through structured project-based learning.
2. To develop analytical and problem-solving skills by integrating mathematical modeling, computation, and logical reasoning in practical applications.

**Course Outcomes (COs):**

1. Students will be able to formulate and implement mathematical models to analyze and solve application-based problems in various domains.
2. Students will demonstrate proficiency in presenting mathematical findings through structured reports and effective communication of results.

# Question Paper Patterns for Semester Exams

**B.Sc. Mathematics (Three Major Scheme)**

**Theory (3 credit core courses)**

**For I/ II / III/ IV/ V/ VI Semesters**

Duration: 3 hours Max. Marks: 80

| PART -A | |
|---|---|
| I. Answer any 10 questions out of 14 questions ($10 \times 2 = 20$) | |
| Question Number | Unit 1 to 4 |
| 1 to 14 | At least 3 questions from each unit |
| PART -B | |
| II. Answer 12 questions by choosing any three from each unit ($12 \times 5 = 60$) | |
| *Question Number* | *Units* |
| 1 to 5 | Unit - 1 |
| 6 to 10 | Unit - 2 |
| 11 to 15 | Unit - 3 |
| 16 to 20 | Unit - 4 |

**Theory (2 credit core courses)**

**For III/ IV Semesters**

Duration: 2 hours Max. Marks: 40

| PART -A | |
|---|---|
| I. Answer any 5 questions out of 8 questions ($5 \times 2 = 10$) | |
| Question Number | Unit Number |
| 1 to 4 | Unit - 1 |
| 5 to 8 | Unit - 2 |
| PART -B | |
| II. Answer 6 questions by choosing any three from each unit ($6 \times 5 = 30$) | |
| Question Number | Units |
| 1 to 5 | Unit - 1 |
| 6 to 10 | Unit - 2 |

**Practicals (2 credit courses)**

**For Semesters I to VI**

Semester Practical Exam 40 marks + Lab Internal Assessment 10 marks = 50 marks

**Semester Practical Exam:**

| Components | Marks |
|---|---|
| Record and Viva | 10 |
| Program (writing and execution) | 30 |
| **Total** | **40** |

**Lab internal assessment:** Lab internal assessment marks should be based on two lab tests.

**For Compulsory Skill/Practicals Course**

**<u>Mini Project in Applications of Mathematics (to be carried in either IV, V or VI Semester)</u>**

| **Components** | **Marks** |
|---|---|
| Project | 40 |
| Presentation | 5 |
| Viva | 5 |
| **Total** | **50** |