

III & IV Semester Mathematics Syllabus for Three Major B. Sc. Programme

In accordance with

State Education Policy (SEP) Scheme

(Effective from 2024-25 Batch Onward)

III Semester BSCMTCS301	Number Theory and Higher Order Differential Equations	3 Credits	(48 Hours, 4 Hrs/week)
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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} , $\cos ax$, $\sin ax$, xm $e^{ax}V(x)$, where $V(x)$ is $\sin ax$, $\cos ax$ or xm . 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 Theory*, 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.

BSCMTPS301	Practicals on Number Theory and Higher Order Differential Equations	2 Credits	(4 hours/ week)
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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 equation.
- 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).

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

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, 5th Edition, 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, 2nd Edition, 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 BSCMTCS401	Group Theory, Sequences and Series	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 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.

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 \mathbb{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.

BSCMTPS401	Practicals on Group Theory, Sequences and Series	2 Credits	(4 hours/ week)
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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.

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).

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.

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.