SIDDHARTH UNIVERSITY, KAPILVASTU

SIDDHARTHNAGAR-272202, UTTAR PRADESH

Department of Mathematics

SYLLABUS

Integrated Bachelor of Science (B.Sc) - Master of Science (M.Sc.) Programme

in

Mathematics

(I-X Semester)

With effect from the Academic Year 2025-26 onwards

Approved in BOS dated on 22/08/2025

Board of Studies (BoS)

S. No.	Name of the BoS Member	Designation	Department	College/University
1.	Prof. Prakriti Rai	Professor & Convenor	Mathematics	Siddharth University, Kapilvastu
2.	Prof. Veena Singh	Professor & Member	Mathematics	M. L. K. PG College, Balrampur
3.	Prof. Sudhir Kumar Srivastava	Professor & Expert	Mathematics	D. D. U. Gorakhpur University, Gorakhpur
4.	Prof. Vijay Shanker Verma	Professor & Expert	Mathematics	D. D. U. Gorakhpur University, Gorakhpur
5.	Prof. Arvind Kumar Singh	Professor & Expert	Mathematics	St. Andrews College, Gorakhpur
6.	Dr. Jitendra Kumar Singh	Assoc. Professor & Member	Mathematics	Siddharth University, Kapilvastu
7.	Dr. Anuj Kumar	Asst. Professor & Member	Mathematics	Siddharth University, Kapilvastu
8.	Dr. Vineesh Kumar	Asst. Professor & Member	Mathematics	University of Lucknow
9.	Shri Lavkush Pandey	Asst. Professor & Member	Mathematics	M. L. K. PG College, Balrampur
10.	Shri Bhanu Pratap Singh	Asst. Professor & Member	Mathematics	M. L. K. PG College, Balrampur

Faculty Members Designed/Re-structured the Syllabus

S. No.	Name of the Faculty	Designation	Name of Course (s)
1.	Prof. Prakriti Rai	Professor	1. Discrete Mathematics 2. Number Theory 3. Operations Research 4. Special Functions
2.	Dr. Jitendra Kumar Singh	Associate Professor & Head	1. Group and Ring Theory 2. Vector Calculus and Analytical Geometry 3. Ordinary Differential Equations 4. Numerical Analysis 5. Mathematical Methods 6. Complex Analysis 7. Partial Differential Equations 8. Mechanics 9. Abstract Algebra

			10. Advanced Numerical Analysis 11. Analytical Dynamics 12. Hydrodynamics 13. Mathematical Modeling 14. Continuum Mechanics 15. Fluid Mechanics 16. Practical (Calculus, Algebra, and Geometry) 17. Practical (Numerical Analysis) 18. Practical (Advanced Numerical Analysis) 19. Lab (R-Programming) 20. Mathematical Aptitude and Reasoning-I, II & III 21. MS Word Processing 22. LaTeX for Typesetting 23. Fundamentals of MATLAB 24. Vedic Mathematics
3.	Dr. Anuj Kumar	Assistant Professor	1. Calculus 2. Linear Algebra 3. Real Analysis 4. Multivariable Calculus 5. Metric Spaces 6. Topology 7. Advanced Linear Algebra 8. Functional Analysis 9. Probability Theory 10. Fourier Analysis 11. Measure Theory 12. Wavelet Analysis 13. Fractal Geometry 14. Mathematical Statistics

Compiled by: Dr. Jitendra Kumar Singh, Associate Professor & Head, Department of Mathematics, Siddharth University, Kapilvastu, Siddharth Nagar-272202.

Department of Mathematics

Programme: Integrated Bachelor of Science (B.Sc.)-Master of Science (M.Sc.)

Duration: 5 Years (10 Semesters)

Programme Overview:

The Integrated Bachelor of Science (B.Sc.) - Master of Science (M.Sc.) programme is designed as per Uttar Pradesh NEP 2020 UG-PG course structure aligned with FYUGP of University Grant Commission (UGC), New Delhi. The Integrated Bachelor of Science (B.Sc.) - Master of Science (M.Sc.) programme is designed to meet the Academia-Industry demand, where students get a deeper knowledge of Advanced Mathematics through a vast range of subjects such as Geometry, Calculus, Algebra, Numerical Analysis, Linear Algebra, Differential Equations, Mathematical Analysis, Mathematical Modelling, etc. Students become more skilled and specialized in Mathematics after this programme. Students learn problem-solving and reasoning skills, which help them to solve real-life problems. In this program, students learn to collect large datasets and analyze them using various tools and methods.

Programme Educational Objectives (PEOs):

After completion of the Integrated Bachelor of Science (B.Sc.) - Master of Science (M.Sc.) programme:

1. Students are equipped with knowledge, skills, and insight in Mathematics and related fields.
2. Students can work as a Mathematical Professional or as a Scientific Researcher.
3. Students develop the ability to utilize the Mathematical problem-solving methods, such as analysis, modelling, programming, and mathematical software applications, in addressing the global issues.
4. Students can recognize the need to develop the ability to engage in lifelong learning.

Programme Outcomes (POs):

After completion of the Integrated Bachelor of Science (B.Sc.) - Master of Science (M.Sc.) programme, the students will be able to:

1. Acquire in-depth knowledge of topics in the diverse areas of Mathematical Sciences, such as Mathematical Analysis, Algebra, Numerical Methods, Differential Equations, and Mathematical Methods etc.
2. Evaluate their capability of finding and evaluating new sources to further Mathematical Science, renew and develop their academic skills, combine insight from multiple disciplines, and contribute to multidisciplinary collaboration.
3. Develop logical reasoning techniques and techniques for analyzing the situation.
4. Read, analyze, and write logical arguments to prove Mathematical concepts.
5. Communicate Mathematical ideas with clarity and coherence, both written and verbally.
6. Acquire the capability to evaluate hypotheses, methods, and evidence within their proper contexts in any situation.
7. Demonstrate the ability to conduct research independently and pursue higher studies toward a Doctoral Degree in Mathematics.

Nomenclature of the UG-PG Course Structure Aligned with FYUGP

The following is the nomenclature of courses to be used for the UG-PG course structure, aligned with FYUGP.

1. The Course Code shall consist of 11 characters: the first two (02) characters for Undergraduate/Postgraduate.
2. The next two (02) characters for Discipline Specific Course (DSC), Skill Enhancement Course (SEC)/Co-Curricular Ability/Enhancement Course (AEC).
3. The next two (2) characters for Subject Code.
4. The next character for the nature of the course (T: Theory cum Practical cum Tutorial, P: Research Project/Dissertation).
5. The next two characters (02) for the semester.
6. The last two (02) characters for the course number.

Illustration:

BSDSMAT0101

BS→ Bachelor of Science, DS→ Discipline Specific Course, MA→ Mathematics, T→ Theory, 01→ Semester-I, 01 → Course 1

For examination marks:

2/3 Credits = 25 Marks; 4/5/6 Credits = 75 Marks

Internal Assessment Test = 25 Marks

Syllabus of Integrated B.Sc. - M.Sc. Programme
(Academic Year 2025-26)

I & II Semester

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC[*]/SEC[†]/AEC[‡]/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
Certificate in Science	I	Calculus	BSDSMAT0101	DSC	6-0-0	6
		Mathematical Aptitude and Reasoning-I	BSSEMAT0102	SEC	3-0-0	3
		MS Word Processing	BSAEMAT0103	AEC	1-0-1	2
	II	Group and Ring Theory	BSDSMAT0201	DSC	6-0-0	6
		Mathematical Aptitude and Reasoning-II	BSSEMAT0202	SEC	3-0-0	3
		Fundamentals of MATLAB	BSAEMAT0203	AEC	1-0-1	2

III & IV Semester

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC/SEC/AEC/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
Diploma in Science	III	Vector Calculus and Analytical Geometry	BSDSMAT0301	DSC	6-0-0	6
		Mathematical Aptitude and Reasoning-III	BSSEMAT0302	SEC	3-0-0	3
		LaTeX for Typesetting	BSAEMAT0303	AEC	1-0-1	2
	IV	Linear Algebra	BSDSMAT0401	DSC	4-0-0	4
		Practical (Calculus, Algebra, and Geometry)	BSDSMAT0402	DSC	0-0-2	2
		Vedic Mathematics	BSAEMAT0403	AEC	2-0-0	2
		Project	BSDSMAP0404	DSC	3-0-0	3

[*] DSC-Discipline Specific Course
[†] SEC-Vocational Skill Enhancement Course
[‡] AEC-Co-Curricular Ability/Enhancement course

V & VI Semester

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC/SEC/AEC/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
B.Sc. Degree	V	Real Analysis	BSDSMAT0501	DSC	5-0-0	5
		Ordinary Differential Equations	BSDSMAT0502	DSC	5-0-0	5
	VI	Complex Analysis	BSDSMAT0601	DSC	4-0-0	4
		Numerical Analysis	BSDSMAT0602	DSC	4-0-0	4
		Practical (Numerical Analysis)	BSDSMAT0603	DSC	0-0-2	2

VII & VIII Semester (Honours)

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC/SEC/AEC/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
B.Sc. Honours in Mathematics	VII	Multivariable Calculus	BSDSMAT0701	DSC	4-0-0	4
		Mathematical Methods	BSDSMAT0702	DSC	4-0-0	4
		Metric Spaces	BSDSMAT0703	DSC	4-0-0	4
		Partial Differential Equations	BSDSMAT0704	DSC	4-0-0	4
		Mechanics	BSDSMAT0705	DSC	4-0-0	4
	VIII	Topology	BSDSMAT0801	DSC	4-0-0	4
		Advanced Algebra	BSDSMAT0802	DSC	4-0-0	4
		Advanced Linear Algebra	BSDSMAT0803	DSC	4-0-0	4
		Advanced Numerical Analysis	BSDSMAT0804	DSC	4-0-0	4
		Practical (Advanced Numerical Analysis)	BSDSMAT0805	DSC	0-0-4	4

VII & VIII Semester (Honours with Research)

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC/SEC/AEC/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
B.Sc. Honours with Research in Mathematics	VII	Multivariable Calculus	BSDSMAT0701	DSC	4-0-0	4
		Mathematical Methods	BSDSMAT0702	DSC	4-0-0	4
		Metric Spaces	BSDSMAT0703	DSC	4-0-0	4
		Partial Differential Equations	BSDSMAT0704	DSC	4-0-0	4
		Research Project	BSDSMAT0706	DSC	4-0-0	4
	VIII	Topology	BSDSMAT0801	DSC	4-0-0	4
		Advanced Algebra	BSDSMAT0802	DSC	4-0-0	4
		Advanced Linear Algebra	BSDSMAT0803	DSC	4-0-0	4
		Advanced Numerical Analysis	BSDSMAT0804	DSC	4-0-0	4
		Research Project	BSDSMAT0806	DSC	4-0-0	4

IX & X Semester

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC/SEC/AEC/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
M.Sc. in Mathematics	IX	Functional Analysis	MSDSMAT0901	DSC	4-0-0	4
		Analytical Dynamics	MSDSMAT0902	DSC	4-0-0	4
		Probability Theory	MSDSMAT0903	DSC	4-0-0	4
		Optional (any one of the following) A. Hydrodynamics B. Mathematical Modeling C. Discrete Mathematics D. Continuum Mechanics E. Fourier Analysis F. Number Theory	MSDSMAT0904 (A-F)	DSC	4-0-0	4
		Research Project	MSDSMAP0904	Research Project	4-0-0	4
	X	Measure Theory	MSDSMAT1001	DSC	4-0-0	4
		Mathematical Statistics	MSDSMAT1002	DSC	4-0-0	4
		Optional (any one of the following) A. Special Functions B. Wavelet Analysis C. Fluid Mechanics D. Fractal Geometry E. Operations Research	MSDSMAT1003 (A-E)	DSC	4-0-0	4
		Lab (R-Programming)	MSDSMAT1004	DSC	0-0-4	4
		Research Project	MSDSMAT1005	Research Project	4-0-0	4

Syllabus of Integrated B.Sc. - M.Sc. Programme
(Academic Year 2025-26)

I & II Semester

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC/SEC/AEC/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
Certificate in Science	I	Calculus	BSDSMAT0101	DSC	6-0-0	6
		Mathematical Aptitude and Reasoning-I	BSSEMAT0102	SEC	3-0-0	3
		MS Word Processing	BSAEMAT0103	AEC	1-0-1	2
	II	Group and Ring Theory	BSDSMAT0201	DSC	6-0-0	6
		Mathematical Aptitude and Reasoning-II	BSSEMAT0202	SEC	3-0-0	3
		Fundamentals of MATLAB	BSAEMAT0203	AEC	1-0-1	2

CALCULUS

Course code: BSDSMAT0101	Course Title: Calculus
Semester-I	Course Credits: 06
Contact Hours per Week (L-T-P): 6-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objectives

By the end of this course, students will:

1. Develop a deep and rigorous understanding of the **structure of the real number line** $\mathbb{R}$, including its **algebraic**, **order**, and **completeness** properties.
2. Apply these foundational properties to **prove results related to the convergence and divergence** of sequences and series of real numbers.
3. Understand and use the **fundamental tools of calculus,** including **limits**, **derivatives**.

Units	Topics	Number of Lectures
I	Algebraic and order properties of $\mathbb{R}$, Absolute value of a real number, Bounded above and bounded below sets, Supremum and infimum of a non-empty subset of $\mathbb{R}$, The completeness property of $\mathbb{R}$, Archimedean property, Density of rational numbers in $\mathbb{R}$.	15
II	Sequences and their limits, Convergent sequence, Limit theorems, Monotone sequences, Monotone convergence theorem, Subsequences, Bolzano-Weierstrass theorem for sequences, Limit superior and limit inferior for bounded sequence, Cauchy sequence, Cauchy's convergence criterion.	15
III	Convergence and divergence of infinite series of real numbers, Necessary condition for convergence, Cauchy criterion for convergence, Tests for convergence of positive term series, Integral test, Basic comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy's nth root test, Raabe's test, Alternating series, Leibniz test, Absolute and conditional convergence.	15
IV	Limits of functions (ε - δ and sequential approach), Algebra of limits, Squeeze theorem, One-sided limits, Infinite limits and limits at infinity; Continuous functions and their properties on closed and bounded intervals, Intermediate Value Theorem; Uniform continuity.	15
V	Differentiability of a real-valued function, Algebra of differentiable functions, Chain rule, Relative extrema, Interior extremum theorem, Rolle's theorem, Mean-value theorems and their applications, Intermediate value theorem for derivatives.	15

VI	Higher order derivatives and calculation of the *n*th derivative, Leibnitz's theorem; Taylor's theorem, Taylor's series expansions of e^x, $\sin x$, $\cos x$. Indeterminate forms, L'Hôpital's rule; Concavity and inflexion points; Singular points, Asymptotes, Curvature and Envelope. Tracing graphs of rational functions and polar equations.	15

Course outcomes

This course will enable students to:

- **CO1.** Understand the **fundamental properties of the real numbers**, including the **completeness property**, the **Archimedean property**, and the **density of rational numbers** in $\mathbb{R}$.
- **CO2.** Define **sequences** as functions from $\mathbb{N}$ **to a subset of** $\mathbb{R}$, and determine their **limits**.
- **CO3.** Identify and analyze **bounded**, **convergent**, **divergent**, **Cauchy**, and **monotonic sequences**, and compute the **limit superior** and **limit inferior** of bounded sequences.
- **CO4.** Apply various convergence tests—including the **limit comparison test**, **ratio test**, **root test**, and **alternating series test**—to determine the **convergence** or **absolute convergence** of infinite series of real numbers.
- **CO5.** Understand the notions of limits, continuity, and uniform continuity of functions.
- **CO6.** Analyze the geometrical properties of continuous functions on closed and bounded intervals.
- **CO7.** Applications of the derivative, relative extrema, and mean value theorems.
- **CO8.** Work with higher-order derivatives, apply Taylor's Theorem, evaluate indeterminate forms, and perform curve tracing.

Suggested Readings

1. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). *Calculus* (10th ed.). John Wiley & Sons Singapore Pvt. Ltd. Reprinted (2016) by Wiley India Pvt. Ltd., Delhi.
2. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2002). *Calculus* (3rd ed.). Prentice Hall.
3. Ross, Kenneth A. (2013). *Elementary Analysis: The Theory of Calculus* (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian reprint.
4. Bartle, Robert G. & Sherbert, Donald R. (2011). *Introduction to Real Analysis* (4th ed.). John Wiley & Sons. Wiley India edition, reprint.
5. Prasad, Gorakh (2016). *Differential Calculus* (19th ed.). Pothishala Pvt. Ltd., Allahabad.
6. Denlinger, Charles G. (2011). *Elements of Real Analysis*. Jones and Bartlett India Pvt. Ltd., Student Edition. Reprinted 2015.
7. Ghorpade, Sudhir R. & Limaye, B. V. (2006). A Course in Calculus and Real Analysis. Undergraduate Texts in Mathematics, Springer (SIE). Indian reprint.

MATHEMATICAL APTITUDE AND REASONING-I

Course code: BSSEMAT0102	Course Title: Mathematical Aptitude and Reasoning-I
Semester-I	Course Credits: 03
Contact Hours per Week (L-T-P): 3-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 2 Hours	Semester Examination: 25 Marks

Course objective

1. The key objective of this course is to develop an understanding of various concepts of mathematical aptitude and logical reasoning.
2. This course develops problem-solving ability among students in diverse areas like number systems, number series, percentages, etc.
3. This course is developed for students preparing for the various competitive examinations.

Units	Topics	Number of Lectures
I	**Number System:** Simplification, Speed Math, Squaring and Cubing Techniques, Multiplication Tricks, Divisibility Rules, HCF of numbers, LCM of numbers, Factors/Divisors of a Given Composite Number, Number of Divisors, Number of Even & Odd Divisors, Sum of Divisors, Product of Divisors, Number of ways of expressing a given number as a product of two factors, Number of ways of expressing a given number as a product of two Co-Primes, Number of sets of factors which are Co-Prime to each other.	15
II	**Number Series:** Series, Types of Series, Number Series, Missing numbers, incomplete series - odd-even series, primes, Fibonacci series, arithmetic progression, geometric progression, harmonic progression, squares and cubes, and operations on them, operations on digits, exponential series, increasing multiplication, hybrid series. Alphabetical Series- Missing alphabets, incomplete letter series - series of words, series of letters, arrangement of words/letters, letters marked with corresponding numbers sequence, positions of letters, ranking of the word in the dictionary; Mixed Series - Missing numbers and words/letters, complete the series.	15
III	**Percentage:** Concept Explanation, Quick Calculation of Percentages, Conversion of Fraction to Percentage Table, Successive Percentage, Concept of ‘By’ & ‘To’, Percentage Change, Percentage Point Change, Product Constancy, Increased Value & Increase in Value, Percentage Changes in Numerator & Denominator, Successive Percentage.	15

Course outcomes

After the completion of the course, the students will have:

CO1. Strong foundation in the number system and number series.
CO2. Skills in solving problems related to percentages.
CO3. Skills for solving logical reasoning problems and analytical skills.

Suggested Readings

1. R.S. Aggarwal, Quantitative Aptitude for Competitive Examinations, S. Chand Publishing, 2017.
2. R.S. Aggarwal, A Modern Approach to Logical Reasoning, S. Chand Publishing, 2006.
3. Arun Sharma, How to Prepare for Logical Reasoning for CAT, McGraw-Hill Edition, 2014.
4. M. Tyra and K. Kundan, Magical Book on Quicker Maths, BSC Publishing Co. Pvt. Ltd., 2018.

MS WORD PROCESSING

Course code: BSAEMAT0103	Course Title: MS Word Processing
Semester-I	Course Credits: 02
Contact Hours per Week (L-T-P): 2-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 2 Hours	Semester Examination: 25 Marks

Course objective

1. The main objective of this course is to introduce MS Word processing and MS Excel.
2. The goal in this paper is to enable users to prepare documents, edit documents, and the insertion and editing of tables, and send emails to various recipients using Mail Merge.
3. Enable the user to handle a huge amount of data in Excel format, tabulation, and graphical representation of data.

Units	**Topics**	**Number of Lectures**
I	**MS Word:** Word Processing Basics, Opening Word Processing Package, Title Bar, Menu Bar, Toolbars & Sidebar, creating a New Document, Opening and Closing Documents, Save and Save As, Using the Help, Page Setup, Print Preview, Printing of Document, PDF file, and Saving a Document as PDF file, Editing Text, Text Selection, Cut, Copy, and Paste, Font, Color, Style and Size selection, Alignment of Text, Undo & Redo, AutoCorrect, Spelling & Grammar, Find and Replace, Formatting the Text, Paragraph Indentation, Bullets and Numbering, Change case, Header & Footer, Table Manipulation, Insert & Draw Table, Changing cell width and height, Alignment of Text in a cell, Delete / Insertion of Row, Column and Merging & Splitting of Cells, Border and Shading, Mail Merge **MS PowerPoint:** Preparation of PPT	8
II	**MS Excel:** Elements of Spread Sheet, Creating of Spread Sheet, Concept of Cell Address and selecting a Cell, Entering Data in Cells, Page Setup, Printing of Sheet, Saving Spreadsheet, Opening and Closing, Manipulation of Cells & Sheet, Editing Cell Content, Formatting Cell, Cut, Copy, Paste & Paste Special, Changing Cell Height and Width, Inserting and Deleting Rows, Column, AutoFill, Sorting & Filtering, Formulas, Functions and Charts, Using Formulas for Numbers (Addition, Subtraction, Multiplication & Division), AutoSum, Functions (Sum, Count, MAX, MIN, AVERAGE), Charts (Bar, Pie, Line)	7

Course outcomes

After the completion of the course, the students will have:

CO1. In-depth Knowledge of Word Processing, its usage, and details of Word Processing.
CO2. Able to do Document creation, formatting of text, paragraphs, and whole documents.
CO3. Basic Knowledge of Spreadsheet Processing, its usage, and details of the Spreadsheet screen.
CO4. Knowledge of applying basic formulas and functions. Preparation of a chart to represent the information in a sheet.

Suggested Readings

1. P. K. Sinha and P. Sinha, Computer fundamentals, BPB publications, 2004.
2. S.K. Gunter, Word 2013 Absolute Beginner's Guide, Que Publishing, 2013.
3. D.J. Clark, The Unofficial Guide to Microsoft Office Word 2007. John Wiley & Sons, 2007.
4. E. Hossain, Introduction to Microsoft Excel. In Excel Crash Course for Engineers (pp. 1-18). Cham: Springer International Publishing, 2021.

GROUP AND RING THEORY

Course code: BSDSMAT0201	Course Title: Group and Ring Theory
Semester-II	Course Credits: 06
Contact Hours per Week (L-T-P): 6-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. The objective of the course is to enlighten students with the basic operations of integers and group theory, which is an essential tool of modern mathematics.
2. This course enables students to study the properties of a permutation group, normal subgroup, quotient group, and group homomorphism.
3. This course introduces the ring and field theory, which is the foundation of modern linear algebra.

Units	Topics	Number of Lectures
I	Properties of Integers, Divisors, and Division Algorithm. Greatest Common Divisor, Euclidean algorithm, Fundamental theorem of arithmetic, Congruences and residue classes. Euler ϕ-function and its properties, Euler's, Fermat's, and Wilson's theorems.	15
II	Recapitulation of Set, Relation and Function, Algebraic Structure, Definition of a group with examples, Subgroups, Generators of a group, Cyclic groups, Order of an element of a group, Centre of a group. Coset decomposition, Lagrange's theorem, and its consequences.	15
III	Normal subgroups, Simple group, Quotient groups. Homomorphism and isomorphism, Kernel of homomorphism, Fundamental theorem of group homomorphism, Theorems on isomorphism, Group automorphism.	15
IV	Introduction to Ring, Ring with and without zero divisors, integral domains and fields, Subring, Subfield, Characteristic of a Ring, Ideals, Ideals generated by a subset of a Ring	15
V	Ring homomorphism, Kernel of a ring homomorphism, Isomorphism and Quotient Rings, Isomorphism theorems, Field of quotients	15
VI	Principal ideal domain, Principal ideal rings, Units and Associates, Prime Ideals, Maximal Ideals, Embedding of rings, Divisibility in Ring, Prime and Irreducible Elements, Euclidean Ring,	15

Course outcomes

After the completion of the course, the students will be able to:

CO1. Knowing the basic operations on a set of integers is related to group and ring theory. Analyze the basic properties of groups and rings.

CO2. Acquire knowledge of algebra, which prepares the groundwork for advanced courses on algebra and research.

Suggested Readings

1. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd, New Delhi, 1975.
2. Joseph A. Gallian, Contemporary Abstract Algebra, Cengage Learning India Private Limited, New Delhi., Fourth impression, 2015.
3. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, First Course in Linear Algebra, Wiley Eastern Ltd., New Delhi, 1983.
4. S. Singh and Q. Zameeruddin, Modern Algebra, Vikas Publication House, India.
5. David M. Burton, Elementary Number Theory, Wm. C. Brown Publishers, Dubuque, Iowa, 1989.

MATHEMATICAL APTITUDE AND REASONING-II

Course code: BSSEMAT0202	Course Title: Mathematical Aptitude and Reasoning-II
Semester-II	Course Credits: 03
Contact Hours per Week (L-T-P): 3-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 2 Hours	Semester Examination: 25 Marks

Course objective

1. The objective of this course is to provide the students with a solid foundation of quantitative aptitude and logical reasoning concepts.
2. This covers various topics such as commercial mathematics, set theory and Venn diagrams, odd one out, arrangements, input-output, and direction sense.
3. This course helps students develop their analytical and problem-solving skills, which are essential for success in various competitive exams and real-life applications.

Units	Topics	Number of Lectures
I	**Commercial Mathematics:** Profit, Loss, Cost Price, Selling Price, Marked Price, Formula, Examples. Simple Interest, Compound Interest, basic formulas, equal annual installment, Difference between simple interest & compound interest, Application of digital sum in SI & CI, Successive percentages in SI & CI, Population formula, growth rate, Offering Loan on a Discount, Shortcut methods.	15
II	**Set Theory & Venn Diagram:** Sets, Set notations, Cardinality of a set, Types of sets, Operations on sets, Venn Diagrams, Universal Set, Relationships using Venn Diagrams - Union of sets using Venn diagram, Difference of sets using Venn diagram, Disjoint Sets, Intersection of sets using Venn diagram, Venn diagram in case of two elements, Venn diagrams in case of three elements, Venn Diagrams in case of four elements, Problem Solving using Venn Diagrams.	15
III	**Odd One Out:** Odd number/Even number/Prime numbers, Perfect squares/Cubes, Numbers in A.P./G.P., Difference or sum of numbers, Cumulative series, Power series. Alphabet Classification, Word Classification, Number Classification. **Direction Sense:** Four Main Directions, Four Cardinal Directions, Distance, displacement, Starting and ending points, Referential directions, Directions of shadows, Actual and conditional directions.	15

Course outcomes

After the completion of the course, the students may be able to:

CO1. Apply quantitative techniques in solving real-world problems related to profit & loss, SI & CI, etc.

CO2. Solve problems related to set theory and Venn diagrams.

CO3. Identify the odd one out from a given set of objects. Solve problems related to direction sense.

Suggested Readings

1. R.S. Aggarwal, Quantitative Aptitude for Competitive Examinations, S. Chand Publishing, 2017.
2. R.S. Aggarwal, A Modern Approach to Logical Reasoning, S. Chand Publishing, 2006.
3. Arun Sharma, How to Prepare for Logical Reasoning for CAT, McGraw-Hill Edition, 2014.
4. M. Tyra and K. Kundan, Magical Book on Quicker Maths, BSC Publishing Co. Pvt. Ltd., 2018.

FUNDAMENTALS OF MATLAB

Course code: BSAEMAT0203	Course Title: Fundamentals of MATLAB
Semester-II	Course Credits: 02
Contact Hours per Week (L-T-P): 2-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 2 Hours	Semester Examination: 25 Marks

Course objective

1. The main objective of this course is to introduce MATLAB as a programming and scientific computing tool.
2. This course enables the students to solve basic problems and matrix operations using MATLAB.
3. The course objective is to familiarize the students with basic plotting tools available in MATLAB.

Units	Topics	Number of Lectures
I	**Introduction:** Starting MATLAB, working in the command window, arithmetic operations, display formats, elementary maths built-in functions, defining scalar variables, useful commands for managing variables, and script files. 1 and 2-dimensional arrays, addition and subtraction, array multiplication and division, element-by-element operations, generation of random numbers, and analyzing arrays using built-in maths functions. Basic plot commands, plot, fplot, formatting a plot, subplots, basic 2D and 3D plots: Line plots, mesh and surface plots, contour, view command.	15
II	**Practical:** **1.** Understanding the MATLAB Workspace (i) Start MATLAB (ii) type commands in the main window (iii) change current directory **2.** Use of MATLAB as a calculator: (i) perform some arithmetic calculations (ii) understand the importance of operators and functions (iii) use MATLAB's help files (iv) use functions like $\sin x$, $\cos x$, $\lvert x \rvert$ to solve problems **3.** Understanding the purpose of variables and how to create variables. **4.** Write a script M-File (a list of MATLAB commands, saved in a file) with an emphasis on using appropriate comments	30

	5. Create 1 and 2-D arrays, understand the advantages of the different ways of creating arrays, including the standard format and the linespace command. **6.** Access specific numbers in arrays using their position. **7.** Use array commands to perform different arithmetic operations on arrays. **8.** Using basic commands to plot 2D and 3D plots. **9.** Different ways of formatting the plots using basic commands like xlabel, ylabel, axis, etc. **10.** Plotting of multiple graphs on the same figure using hold on/off commands	

Course outcomes

After the completion of the course, the students will have:

CO1. A general understanding of the purpose of MATLAB.
CO2. Knowledge to use MATLAB effectively to analyze and visualize data.
CO3. An in-depth understanding and use of MATLAB fundamental data structures.
CO4. Hands-on experience to create and control simple plots and user interface graphics, objects in MATLAB.

Suggested Readings

1. Brian R. Hunt, Ronald L. Lipsman and Jonathan M. Rosenberg, A Guide to MATLAB - for Beginners and Experienced Users", 2nd Ed., Cambridge University Press, 2006.
2. Rudra Pratap, Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers, Oxford University Press, 2010.
3. S. Wolfram, The Mathematica, Cambridge University Press, 2003.

Syllabus of Integrated B.Sc. - M.Sc. Programme
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<u>III & IV Semester</u>

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC/SEC/AEC/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
Diploma in Science	III	Vector Calculus and Analytical Geometry	BSDSMAT0301	DSC	6-0-0	6
		Mathematical Aptitude and Reasoning-III	BSSEMAT0302	SEC	3-0-0	3
		LaTeX for Typesetting	BSAEMAT0303	AEC	1-0-1	2
	IV	Linear Algebra	BSDSMAT0401	DSC	4-0-0	4
		Practical (Calculus, Algebra, and Geometry)	BSDSMAT0402	DSC	0-0-2	2
		Vedic Mathematics	BSAEMAT0403	AEC	2-0-0	2
		Project	BSDSMAP0404	DSC	3-0-0	3

VECTOR CALCULUS AND ANALYTICAL GEOMETRY

Course code: BSDSMAT0301	Course Title: Vector Calculus and Analytical Geometry
Semester-III	Course Credits: 6
Contact Hours per Week (L-T-P): 6-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. This course enables the basic idea of vector differentiation and integration, and their uses in physical problems.
2. This course introduces the fundamentals of analytical geometry and visualizes the three-dimensional geometrical figures and their properties.
3. This course enlightens the three-dimensional solid geometries like sphere, cone, and cylinder, and their properties.

Units	Topics	Number of Lectures
I	**Vector Calculus:** Vector functions and space curves, derivatives of vector functions, Gradient, Divergence and Curl, Normal on a surface, Directional Derivative, Double integrals over rectangles, iterated integrals, double integrals over general regions, change of order of integration; double integrals in polar coordinates, applications, surface area, triple integrals, triple integrals in cylindrical and spherical coordinates, change of variables.	15
II	**Vector Integral Theorems:** Vector fields, line integrals, fundamental theorem for line integrals, Green's theorem, curl and divergence, parametric surfaces and their areas, surface integrals, Stokes' theorem, Divergence theorem	15
III	**Conics:** General equation of second degree, System of conics, Tracing of conics, Confocal conics, Polar equation of conics and its properties.	15
IV	**Straight line and plane:** Three-dimensional coordinates in space, Distance between two points, Direction cosines, Projection of a segment on a straight line, Projection of the join of two points on a straight line, Angle between two lines, Distance of a point from a line. Plane, General equation of a plane, Equation of a plane through given points, Straight line in three dimensions, Coplanar lines, The image of a point in a plane, shortest distance between two lines.	15

V	**Sphere, Cylinder, and Cone:** Sphere, Equation of a sphere whose centre is given, Intersection of two spheres, Intersection of sphere and a straight line, Cone, Equation of cone, Equation of right circular cone, enveloping cone. Cylinder, right circular cylinder, Enveloping cylinder,	15
VI	**Conicoid:** Central conicoid, properties of the central conicoid in standard form, the ellipsoid, the hyperboloid of one sheet, the hyperboloid of two sheets, intersection of a line and a central conicoid, tangent plane, condition of tangency, director sphere, normal to a conicoid, polar plane, diametral plane.	15

Course outcomes

After the completion of the course, the students will be able to:

CO1. Apply the vector calculus in solving the physical problems of interest.
CO2. Analyze the three-dimensional geometrical shapes and their properties.
CO3. Learn about the three-dimensional solid shapes and their geometrical applications.

Suggested Readings

1. Shanti Narayan, A Text Book of Vector Calculus, S. Chand Pub., New Delhi, 2003.
2. P. R. Vittal, Analytical Geometry, Pearson Pub., 2013.
3. S. L. Loney, The Elements of Coordinate Geometry, Arihant Pub., 2016.
4. Robert J.T. Bell, Elementary Treatise on Coordinate Geometry of three dimensions, Forgotten Books Pub., 2018.
5. S. R. K. Iyenger and R. K. Jain, Advanced Engineering Mathematics, Narosa Publishing House, 2019.

MATHEMATICAL APTITUDE AND REASONING-III

Course code: BSSEMAT0302	Course Title: Mathematical Aptitude and Reasoning-III
Semester-III	Course Credits: 3
Contact Hours per Week (L-T-P): 3-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 2 Hours	Semester Examination: 25 Marks

Course objective

1. This course is designed to improve the quantitative aptitude and logical reasoning skills of the students.
2. Students will have a solid grasp of various topics such as combinatorics, theory of equations, geometry, mensuration, data interpretation, and reasoning.
3. Students will be equipped with the skills necessary to apply the concepts of combinatorics, theory of equations, geometry, mensuration, and data interpretation in their personal and professional lives.

Units	Topics	Number of Lectures
I	**Combinatorics:** Counting Technique, Factorial, Permutations, Combinations, Stocks and Shares. Experiments, Events, and sample space, Independent Events, Conditional Probability, Problems on dice and cards.	15
II	**Theory of Equations:** Linear equations in one, two, and three variables, Methods of solving linear equations. Methods of solving quadratic equations. **Geometry:** Concepts of Angles, Different polygons like triangles, rectangles, squares, right-angle triangles, Pythagorean Theorem, Perimeter and Area of Triangle, Rectangle, and circles.	15
III	**Mensuration:** Area, Volume, and Surface Area, Pipe and Cisterns. **Data Interpretation and Reasoning:** Raw and group data, Tabulation, Bar Graphs, Pie Charts, Mean, Median and Mode, Analytical reasoning, Mirror Images.	15

Course outcomes

After the completion of the course, the students will be able to:

CO1. Understand and apply the concepts of combinatorics in problem-solving.
CO2. Solve problems related to the theory of equations and geometry.
CO3. Calculate the area and volume of various geometrical figures in mensuration.
CO4. Develop logical reasoning skills for solving problems in various competitive exams.

Suggested Readings

1. R.S. Aggarwal, Quantitative Aptitude for Competitive Examinations, S. Chand Publishing, 2017.
2. R.S. Aggarwal, A Modern Approach to Logical Reasoning, S. Chand Publishing, 2006.
3. Arun Sharma, How to Prepare for Logical Reasoning for CAT, McGraw-Hill Edition, 2014.
4. M. Tyra and K. Kundan, Magical Book on Quicker Maths, BSC Publishing Co. Pvt. Ltd., 2018.

LaTeX FOR TYPESETTING

Course code: BSAEMAT0303	Course Title: LaTeX for Typesetting
Semester-III	Course Credits: 2
Contact Hours per Week (L-T-P): 2-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 2 Hours	Semester Examination: 25 Marks

Course objective

1. This course introduces the LaTeX typesetting and formatting software for the preparation of documents, articles, and dissertations.
2. The course objective is to enable the reader to use the LaTeX software and prepare Books and chapters containing mathematical equations with hyperlinks and bibliography.

Units	Topics	Number of Lectures
I	Installing and using LaTeX for creating a first LaTeX document, formatting text and understanding LaTeX commands and environments, designing pages, typing a book with chapters and a table of contents, creating and customizing lists, including images, and creating tables with captions.	15
II	Setting labels and references, Hyperlinks, customizing the table of contents, generating an index, creating a bibliography, writing basic math formulas and equations, and developing large documents by splitting the input and creating front/back matter.	15

Course outcomes

After the completion of the course, the students will be able to:

CO1. Prepare the documents and presentation, which include the mathematical equations, tables, and figures.

CO2. Type their dissertation and reports with a bibliography.

Suggested Readings

1. Firuza Karmali Aibara, A Short Introduction to LaTeX: A Book for Beginners, 2019.
2. Stefan Kottwitz, LaTeX Beginner's Guide: Create visually appealing texts, articles, and books for business and science using LaTeX, Packt Publishing Limited, 2021.

LINEAR ALGEBRA

Course code: BSDSMAT0401	Course Title: Linear Algebra
Semester-IV	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 4 Hours	Semester Examination: 75 Marks

Course objectives

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

1. Understand the fundamental structures of fields and vector spaces, including subspaces and their algebraic properties.
2. Develop a solid grasp of linear transformations, their algebra, and the related concepts such as rank, nullity, and isomorphisms.
3. Understand matrix representations of linear transformations and perform operations including basis change, matrix inversion, and solving systems of equations.
4. Understand eigenvalues, eigenvectors, and utilize the minimal polynomial in determining diagonalizability and triangularizability of matrices.

Units	Topics	Number of Lectures
I	Definition of field: The fields $\mathbb{R}$, $\mathbb{C}$, $\mathbb{Q}$, and $\mathbb{Z}_p$. Vector spaces, Subspaces, Algebra of subspaces, Linear combination of vectors, Linear span, Linear independence, Bases and dimension, Dimension of subspaces, Sum and direct sum of subspaces, Quotient spaces.	15
II	Linear transformations, Null space, Range space, Rank and nullity of a linear transformation, Rank-Nullity theorem, Algebra of linear transformations, Fundamental theorem of vector space homomorphism, Invertibility of Linear transformation, Isomorphisms and related theorems.	15
III	Matrix representation of a linear transformation, effect of change of basis on matrix representation, non-singular linear transformations and matrices, equivalent and similar matrices, rank of a matrix, elementary row and column operations, inverse of an invertible linear transformation and matrix, reduction of a matrix into echelon form, row reduced echelon form and normal form, Solving linear system of equations.	15
IV	Characteristic and Minimal polynomial polynomials of a matrix, Cayley-Hamilton theorem and its applications, Eigenvalues, Eigenvectors of a linear transformation and matrix, Eigenspace, Diagonalization, Triangularization.	15

Course Outcomes

Upon successful completion of the course, students will be able to:

- **CO1.** Define and give examples of fields such as $\mathbb{R}$, $\mathbb{C}$, $\mathbb{Q}$, and $\mathbb{Z}_p$, and describe properties of vector spaces.
- **CO2.** Construct subspaces, determine linear independence, basis, and dimension of vector spaces.
- **CO3.** Compute the kernel and image of linear transformations, and verify the Rank-Nullity theorem.
- **CO4.** Obtain matrix representations of linear transformations and analyze the effect of changes of basis.
- **CO5.** Solve systems of linear equations.
- **CO6.** Compute eigenvalues, eigenvectors, and verify the Cayley-Hamilton theorem.
- **CO7.** Determine conditions for diagonalization and triangularization of matrices using minimal polynomials.

Suggested Readings

1. Friedberg, Stephen H., Insel, Arnold J., & Spence, Lawrence E. (2003). Linear Algebra (4th ed.). Prentice-Hall of India Pvt. Ltd., New Delhi.
2. Andrilli, S., & Hecker, D. (2016). Elementary Linear Algebra (5th ed.). Elsevier India.
3. Lay, David C., Lay, Steven R., & McDonald, Judi J. (2016). Linear Algebra and its Applications (5th ed.). Pearson Education.
4. Kolman, Bernard, & Hill, David R. (2001). Introductory Linear Algebra with Applications (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.
5. Hoffman, Kenneth, & Kunze, Ray Alden (1978). Linear Algebra (2nd ed.). Prentice Hall of India Pvt. Limited. Delhi. Pearson Education India Reprint, 2015.
6. Lang, Serge (1987). Linear Algebra (3rd ed.). Springer.

PRACTICAL (CALCULUS, ALGEBRA & GEOMETRY)

Course code: BSDSMAT0402	Course Title: Practical (Calculus, Algebra & Geometry)
Semester-IV	Course Credits: 2
Contact Hours per Week (L-T-P): 0-0-2	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 2 Hours	Semester Examination: 25 Marks

Course objective

1. The main objective of the course is to equip the student to plot the different graphs using different computer software such as SageMath/Mathematica/MATLAB/Scilab//C-Programming, etc.
2. This course aims to enable students to test the convergence of sequences and series using different testing approaches.
3. The course is designed to enable students to perform various operations related to matrices, such as addition, multiplication, finding the inverse, and finding eigenvalues and eigenvectors.

Units	Topics	Number of Hours
I	**Calculus:** **1.** By plotting the graph, find the solution of the equation: $x = e^x$, $x^2+1 = e^x$, $1-x^2 = e^x$, $x = \log_{10} x$, $x = \cos x$. **2.** Sketching parametric curves, e.g., Trochoid, Cycloid, Epicycloid, and Hypocycloid, etc. **3.** Obtaining the surface of revolution of curves. **4.** Study the convergence of sequences through plotting. **5.** Verify the Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot. **6.** Study the convergence/divergence of infinite series by plotting their sequences of partial sums. **7.** Shortening the numbers. **8.** Cauchy's root test by plotting nth roots. **9.** Ratio test by plotting the ratio of the n^{th} and $(n+1)^{th}$ term.	30
II	**Algebra & Geometry:** **10.** Graph of Circular trigonometric functions, Inverse trigonometric functions. **11.** Matrix Operations: Addition, Multiplication, Inverse, Transpose, Adjoint, Determinant, Rank. **12.** For square matrices, finding the characteristic equation, Eigenvalues, and Eigenvectors.	30

	13. Verification of the Cayley-Hamilton theorem and solving the systems of linear equations. **14.** Tracing of Sphere, Cone, Cylinder, Ellipsoid, Hyperboloid of one and two sheets, Elliptic cone, Elliptic paraboloid, and Hyperbolic paraboloid using Cartesian coordinates.	

Course outcomes

After the completion of the course, the students will be able to:

CO1. Check the convergence of sequences through the plotting of graphs.

CO2. Verify the Bolzano-Weierstrass theorem through plotting the sequence.

CO3. Verify Cauchy's root test by plotting nth roots and the Ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ term.

CO4. Perform various operations related to matrices, such as addition, multiplication, finding the inverse, and finding Eigenvalues and eigenvectors.

CO5. Trace complex numbers, trigonometric functions, conics, and conicoid.

VEDIC MATHEMATICS

Course code: BSAEMAT0403	Course Title: Vedic Mathematics
Semester-IV	Course Credits: 2
Contact Hours per Week (L-T-P): 2-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 2 Hours	Semester Examination: 25 Marks

Course objective

1. This course introduces the Indian Knowledge System (IKS) of Mathematics and the contributions of Indian Mathematicians.
2. The course objective is to enable the reader to learn basic Vedic Mathematics methods for multiplication and division.

Units	Topics	Number of Lectures
I	Introduction of Basic Vedic Mathematics, Techniques in Multiplication, Tables, etc., Comparison of Standard Methods with Vedic Methods of Multiplication and Division.	15
II	Contribution of Indian Mathematicians, Aryabhatt, Brahmagupt, Mahaveeracharya, Bharti Krishna Tirtha	15

Course outcomes

After the completion of the course, the students will be able to:

CO1. Learn the Vedic Indian Knowledge System (IKS) of Mathematics and know the contribution of Indian Mathematicians.

CO2. Understand how the Vedic Mathematics techniques are effective for mathematical calculations.

Suggested Readings

1. Vedic Mathematics, Motilal Banarsi Das, New Delhi.
2. Vedic Ganita: Vihangama Drishti-1, Siksha Sanskriti Uthana Nyasa, New Delhi. 3
3. Vedic Ganita Praneta, Siksha Sanskriti Uthana Nyasa, New Delhi.
4. Vedic Mathematics: Past, Present and Future, Siksha Sanskriti Uthana Nyasa, New Delhi.
5. Leelavati, Chokhambba Vidya Bhavan, Varanasi.
6. Bharatiya Mathematicians, Sharda Sanskrit Sansthan, Varanasi.

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V & VI Semester

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC/SEC/AEC/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
B.Sc. Degree	V	Real Analysis	BSDSMAT0501	DSC	5-0-0	5
		Ordinary Differential Equations	BSDSMAT0502	DSC	5-0-0	5
	VI	Complex Analysis	BSDSMAT0601	DSC	4-0-0	4
		Numerical Analysis	BSDSMAT0602	DSC	4-0-0	4
		Practical (Numerical Analysis)	BSDSMAT0603	DSC	0-0-2	2

REAL ANALYSIS

Course code: BSDSMAT0501	Course Title: Real Analysis
Semester-V	Course Credits: 5
Contact Hours per Week (L-T-P): 5-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objectives

The primary objectives of this course are to:

1. Develop a rigorous understanding of **pointwise** and **uniform convergence** of sequences and series of functions.
2. Explore conditions under which the **limit** of a sequence or series of functions can be **interchanged** with differentiation and integration.
3. Introduce and analyze **power series**, including their convergence properties and role in representing elementary functions.
4. Understand the **integration of bounded functions** over a closed and bounded interval using the Riemann approach.
5. Understand the **application of fundamental theorems** of integral calculus.

Units	Topics	Number of Lectures
I	Pointwise and uniform convergence of a sequence of functions, the uniform norm, Cauchy criterion for uniform convergence, M_n-test, Continuity of the limit function of a sequence of functions, Interchange of the limit and derivative, interchange of the limit and integral of a sequence of functions, Bounded convergence theorem.	15
II	Pointwise and uniform convergence of series of functions, Theorems on the continuity, differentiability, and integrability of the sum function of a series of functions, Cauchy criterion, and the Weierstrass M-test for uniform convergence.	15
III	Definition of a power series, Radius of convergence, Absolute convergence (Cauchy-Hadamard theorem), Differentiation and integration of power series, Abel's theorem, Weierstrass's approximation theorem; The exponential, logarithmic, and trigonometric functions: Definitions and their basic properties.	15
IV	Definition of upper and lower Darboux sums, Darboux integral, Inequalities for upper and lower Darboux sums, Necessary and sufficient conditions for the Darboux integrability; Riemann's definition of integrability by Riemann sum and the equivalence of Riemann's and Darboux's definitions of integrability; Definition and examples of the Riemann-Stieltjes integral.	15
V	Riemann integrability of monotone functions and continuous functions, Properties of Riemann integrable functions; Definitions of piecewise	15

	continuous and piecewise monotone functions and their Riemann integrability; Functions of bounded variation and their properties, Intermediate value theorem for integrals, Fundamental Theorems of Calculus (I and II).	

Course outcomes

Upon successful completion of this course, students will be able to:

- **CO1.** **Differentiate** between pointwise and uniform convergence and determine convergence using tools like the **uniform norm**, **Cauchy criterion**, and **Weierstrass M-test**.
- **CO2.** **Analyze** the continuity, differentiability, and integrability of the **limit function** of a sequence or series of functions.
- **CO3.** **Apply** results that justify the **interchange** of limit operations with integration and differentiation under certain convergence conditions.
- **CO4.** **Understand** the structure and behavior of **power series**, including determining their **radius of convergence** and applying the **Cauchy-Hadamard theorem**, **Abel's theorem**, and **Weierstrass's approximation theorem**.
- **CO5.** **Compute and interpret** Darboux sums and apply necessary and sufficient conditions for **Darboux integrability**.
- **CO6.** **Understand** and demonstrate the **equivalence** between Darboux and Riemann integrals using formal definitions and examples.
- **CO7.** **Define and evaluate** the **Riemann-Stieltjes integral** for appropriate function pairs and understand its properties.
- **CO8.** **Classify** and prove the **Riemann integrability** of different classes of functions such as monotone, continuous, piecewise continuous, and piecewise monotone functions.
- **CO9.** **State and apply** the **Intermediate Value Theorem for integrals** and both **Fundamental Theorems of Calculus** in solving problems involving integration.

Suggested Readings

1. **Ross, Kenneth A.** (2013). *Elementary Analysis: The Theory of Calculus* (2nd ed.). Undergraduate Texts in Mathematics, Springer.
2. **Anton, Howard**, **Bivens, Irl**, and **Davis, Stephen** (2012). *Calculus* (10th ed.). John Wiley & Sons, Inc.
3. **Denlinger, Charles G.** (2011). *Elements of Real Analysis*. Jones & Bartlett India Pvt. Ltd., Indian Reprint.
4. **Ghorpade, Sudhir R.** and **Limaye, B. V.** (2006). *A Course in Calculus and Real Analysis*. Undergraduate Texts in Mathematics, Springer (SIE), Indian Reprint.
5. **Bartle, Robert G.** & **Sherbert, Donald R.** (2015). *Introduction to Real Analysis* (4th ed.). Wiley, Indian Edition.
6. **Kumar, Ajit** and **Kumaresan, S.** (2014). *A Basic Course in Real Analysis*. CRC Press, Taylor & Francis Group, Special Indian Edition.

ORDINARY DIFFERENTIAL EQUATIONS

Course code: BSDSMAT0502	Course Title: Ordinary Differential Equations
Semester-V	Course Credits: 5
Contact Hours per Week (L-T-P): 5-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. The course objective is to develop analytical skills for solving first-order and first-degree differential equations using various methods.
2. The course aimed to develop the skill of solving linear differential equations of higher order, both homogeneous and non-homogeneous, with constant and variable coefficients, with the assistance of various methods.
3. The course includes the classical power series and Frobenius method to solve second-order linear ordinary differential equations near ordinary and singular points.
4. The course objective is to explore boundary value problems via Green's functions and Sturm-Liouville theory.

Units	Topics	Number of Lectures
I	**First order differential equations:** Solution of ordinary differential equations, order and degree, linear and non-linear differential equations, Formation of ordinary differential equation, Differential equation of first order and first degree, Bernoulli's and Riccati's equations, Exact differential equations, Differential equations of first order but not of first degree, Lagrange's equation, Clairaut's form, Singular solution, Geometrical Interpretation, Orthogonal trajectories.	15
II	**Second-order linear differential equations:** General solution for homogeneous equations, superposition of solutions, methods of solution for non-homogeneous problems, undetermined coefficients, normal form, change of independent variable, variation of parameters.	15
III	**Theory of linear differential equations:** Linear differential equation of order n, Basic theory of homogeneous linear differential equations, Wronskian, necessary and sufficient condition for linear dependence and linear independence of solutions of homogeneous linear equations, Abel's Identity, Fundamental sets of solutions, non-homogeneous linear differential equation of order n: Method of variations of parameters. Exact differential equations and adjoint equations, Lagrange's Identity, Green's formula, and the Self-adjoint equation of second order.	15

IV	**Existence and Uniqueness of Solutions:** Lipschitz continuity, Existence and Uniqueness problem, Gronwall's inequality, Peano existence theorem, Picard existence and uniqueness theorem, and interval of definition. **Theory of two-point BVP:** Green's functions, properties of Green's functions, Sturm-Liouville's problem, orthogonal functions, eigenvalues and eigenfunctions, completeness of the eigenfunctions.	15
V	**Power Series Solution:** Power series, Radius of convergence, and interval of convergence, examples and theorems. Ordinary and singular points, Power series solution about an ordinary point. The working rule of the solution by the Frobenius method. The series solution about a regular singular point at infinity, examples.	15

Course outcomes

After successful completion of the course, the student will be able to:

CO1. Understand the Ordinary Differential Equations (ODEs), their solutions, and various analytical approaches to solve them.

CO2. Understand the geometrical meaning of different kinds of solutions of first-order ODEs and apply them in orthogonal trajectories for given families of curves.

CO3. Formulate and solve boundary value problems using Green's functions and Sturm-Liouville theory.

CO4. Analyze eigenvalues and eigenfunctions in boundary value problems and apply the concept of orthogonality and completeness of eigenfunctions.

CO5. Apply the power series solutions method to find the solution of second-order linear differential equations around ordinary and singular points using various methods.

Suggested Readings

1. W. E. Boyce and R. C. Di Prima, Elementary Differential Equations and Boundary Value Problems, 7th Edition, John Wiley & Sons (Asia), 2001.
2. S. L. Ross, Differential Equations, 3rd Edition, Wiley, 1984.
3. G. F. Simmons, Differential Equations with Applications and Historical Notes, McGraw-Hill, 1991.
4. E. A. Codington, An Introduction to Ordinary Differential Equations, Prentice-Hall, 1974.
5. S. J. Farlow, An Introduction to Differential Equations and Their Applications, McGraw-Hill International Editions, 1994.
6. A. R. Forsyth, A Treatise on Differential Equations, CBS Pub, 2005.

COMPLEX ANALYSIS

Course code: BSDSMAT0601	Course Title: Complex Analysis
Semester-VI	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. The objective of this course is to introduce the theory of analytic functions and harmonic conjugates.
2. The key objective is to understand theorems in complex analysis, including Cauchy's theorem, Morera's theorem, and Liouville's theorem, and their implications for analytic functions.
3. This Course familiarizes with power series, their convergence, and the relationship with Taylor and Laurent series.
4. This course explores rational functions, singularities, and residues, applying these concepts to evaluate integrals and analyze analytic functions at singular points.

Units	**Topics**	**Number of Lectures**
I	**Set of Complex Numbers & Analytic Functions**: Complex numbers, their representation, and the algebra of complex numbers, the complex plane and open set, domain, and region in a complex plane, Stereographic projection. Complex functions and their limits, continuity, differentiability, and analyticity, the C-R equations and sufficient conditions for differentiability and analyticity, Harmonic functions, Mobius transformation.	15
II	**Complex integration:** Line integration, path independence, Green's theorem, anti-derivative theorem, Cauchy-Goursat theorem, Cauchy's integral formula, Cauchy's inequality, derivative of analytic functions, Liouville theorem, fundamental theorem of algebra, maximum modulus theorem.	15
III	**Sequence and Series:** Sequence and Series and their convergence, Power series, Radius of convergence, Power series representation of Analytic function, Relation between Power series and Analytic function, Taylor's series, Laurent's series.	15
IV	**Singularities:** Rational Functions, Singularities, Poles, Classification of Singularities, Characterization of removable Singularities, poles, Behavior of an Analytic function at an essential singular point. Entire and Meromorphic functions. The Residue Theorem. Evaluation of Definite integrals, Argument principle, Rouche's theorem, Schwarz Lemma, and Conformal mapping.	15

Course outcomes

After successful completion of the course, the student will be able to:

- **CO1.** Identify and analyse analytic functions and harmonic conjugates.
- **CO2.** Demonstrate an understanding of fundamental theorems in complex analysis, including Cauchy's theorem and Liouville's theorem, to study properties of analytic functions and their zeros.
- **CO3.** Utilize power series expansions to represent analytic functions, determine their radius of convergence, and apply Taylor and Laurent series effectively.
- **CO4.** Classify singularities, apply the residue theorem for evaluating definite integrals, and utilize key results like Rouche's theorem and the maximum modulus theorem in complex analysis.

Suggested Readings

1. J. B. Conway, Functions of one Complex Variable, Narosa Publication,1987 2
2. L. V. Ahlfors, Complex Analysis, McGraw-Hill,1986.
3. J. W. Brown & R. V. Churchill. Complex Variables and Applications, McGraw-Hill,2017.
4. H. S. Kasana. Complex Variables, Prentice Hall, 2015.
5. S. Ponnaswamy, Foundations of Complex Analysis, Narosa Publications, 2011.
6. S. Kumarasan, A Pathway to Complex Analysis, Techno World, 2021.

NUMERICAL ANALYSIS

Course code: BSDSMAT0602	Course Title: Numerical Analysis
Semester-VI	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. This course introduces how to estimate the roots of the nonlinear equations, algebraic or transcendental equations.
2. The solution of system equations by iterative methods is another key feature of the course.
3. This course enables interpolation of the polynomials and numerical integration methods and their error analysis.

Units	Topics	Number of Lectures
I	**Floating-Point Numbers:** Floating-point representation, rounding, chopping, error analysis, conditioning, and stability. Non-Linear Equations: Bisection, secant, fixed-point iteration, Secant Method, Regula-Falsi method, Newton-Raphson method for simple and multiple roots, their convergence analysis, and order of convergence.	15
II	**Linear Systems and Eigenvalues:** Gauss elimination method using pivoting strategies, LU decomposition, Gauss-Seidel and successive-over-relaxation (SOR) iteration methods, and their convergence. Ill-conditioned systems, Rayleigh's power method for eigenvalues.	15
III	**Interpolation and Approximations:** Finite differences, Newton's forward and backward interpolation, Gauss's forward and backward formulas, Stirling formula, Lagrange and Newton's divided difference interpolation formulas with error analysis, and least square approximations.	15
IV	**Numerical Differentiation and Integration**: Methods of numerical differentiation, Error in differentiation, Newton-Cotes quadrature formulae (Trapezoidal and Simpson's rules) and their error analysis, Gauss-Legendre quadrature formulae.	15

Course outcomes

After the completion of the course, the students will be able to:

CO1. Understand the errors, source of error, and their effect on any numerical computations, and also analyze the efficiency of any numerical algorithms.

CO2. Learn how to obtain numerical solutions of nonlinear equations using different methods and their error analysis.

CO3. Solve a system of linear equations numerically using direct and iterative methods.

CO4. Understand how to approximate the functions using interpolating polynomials.

CO5. Learn how to solve definite integrals and initial value problems numerically.

Suggested Readings

1. R. S. Gupta, Elements of Numerical Analysis, Cambridge University Press, 2015.
2. R. L. Burden, J. D. Faires, Numerical Analysis, 9th Edition, Cengage Publisher, 2011.
3. K. Sankara Rao, Numerical Methods for Scientists and Engineers, PHI Publishers, 2007.
4. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publishers, 2014.
5. J. B. Scarborough, Numerical Mathematical Analysis, 6th Edition, Oxford and IBH Publisher, 1984.
6. B. S. Grewal, Numerical Methods in Engineering and Science, Khanna Publishers, 2013.

PRACTICAL (NUMERICAL ANALYSIS)

Course code: BSDSMAT0603	Course Title: Practical (Numerical Analysis)
Semester-VI	Course Credits: 2
Contact Hours per Week (L-T-P): 0-0-2	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 2 Hours	Semester Examination: 25 Marks

Course objective

1. This course is designed to handle numerical problems efficiently with the assistance of Mathematica/MATLAB/Python/C-Programming.
2. This course aims to enable students to execute appropriate numerical methods to solve algebraic and transcendental equations correctly up to a certain level of significance.
3. The course objective is to develop the computational approach to solve linear systems of homogeneous and non-homogeneous equations.
4. The course aimed to approximate a function by a polynomial using various interpolation techniques. Students will learn the numerical integrations in this course.

Units	Topics	Number of Hours
I	**Algebraic & Transcendental Equations:** **1.** Find a simple root of $f(x)=0$ using the bisection method. Read the endpoints of the interval in which the root lies, the maximum number of iterations, and the error tolerance eps. **2.** Find a simple root of $f(x)=0$ using the Regula-Falsi method. Read the endpoints of the interval in which the root lies, the maximum number of iterations, and the error tolerance eps. **3.** Find a simple root of $f(x)=0$ using the Secant method. Read the endpoints of the interval in which the root lies, the maximum number of iterations, and the error tolerance eps. **4.** Find a simple root of $f(x)=0$ using Newton Raphson method. Read any initial approximation, maximum number of iterations, and error tolerance eps.	15
II	**Linear System of Equations:** **5.** Solution of a system of linear equations using the Gauss elimination method. **6.** Matrix inversion and solution of a system of linear equations using the Gauss-Jordan method. **7.** Program to solve a system of linear equations using the Jacobi iteration method. **8.** Program to solve a system of linear equations using the Gauss-Seidel method.	15

III	**Interpolating Polynomials:** **9.** Program for Newton's forward and backward interpolation. **10.** Program for Lagrange interpolation. **11.** Program for Newton's divided difference.	15
IV	**Numerical Integration:** **12.** Program to evaluate the integral using the Trapezoidal rule. **13.** Program to evaluate the integral using Simpson's one-third and three-eighths rules. **14.** Program to evaluate the approximate value of finite integrals using Gaussian/Romberg integration.	15

Course outcomes

After the completion of the course, the students will be able to:

CO1. Solve algebraic and transcendental equations using an appropriate numerical method arising in various engineering problems efficiently

CO2. Solve linear systems of equations using an appropriate numerical method arising in computer programming, chemical engineering problems, etc, efficiently

CO3. Approximate a function using an appropriate numerical method in various research problems up to the desired level of accuracy

CO4. Evaluate definite integrals using an appropriate numerical method in various practical problems

Suggested Readings

1. M. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publication, 2022.
2. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
3. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw-Hill, 2014.
4. R. W. Hamming, Numerical Methods for Scientists and Engineers, Dover Publications, 1987.
5. B. S. Grewal, Numerical Methods in Engineering & Science with Programs in C, C++ and MATLAB, Khanna Pub., 2013.
6. Allen Downey, Jeff Elkner, and Chris Meyers -Learning with Python, 2015.
7. Hans-Petter Halvorsen, Python for Science and Engineering, 2019.
8. John C. Polking, Ordinary Differential Equations Using MATLAB, Pearson Education, 2009.
9. Alexander Stanoyevitch, Introduction to Numerical Ordinary and Partial Differential Equations Using MATLAB, Wiley, 2011.

Syllabus of Integrated B.Sc. - M.Sc. Programme
(Academic Year 2025-26)

VII & VIII Semester (Honours)

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC/SEC/AEC/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
B.Sc. Honours in Mathematics	VII	Multivariable Calculus	BSDSMAT0701	DSC	4-0-0	4
		Mathematical Methods	BSDSMAT0702	DSC	4-0-0	4
		Metric Spaces	BSDSMAT0703	DSC	4-0-0	4
		Partial Differential Equations	BSDSMAT0704	DSC	4-0-0	4
		Mechanics	BSDSMAT0705	DSC	4-0-0	4
	VIII	Topology	BSDSMAT0801	DSC	4-0-0	4
		Advanced Algebra	BSDSMAT0802	DSC	4-0-0	4
		Advanced Linear Algebra	BSDSMAT0803	DSC	4-0-0	4
		Advanced Numerical Analysis	BSDSMAT0804	DSC	4-0-0	4
		Practical (Advanced Numerical Analysis)	BSDSMAT0805	DSC	0-0-4	4

VII & VIII Semester (Honours with Research)

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC/SEC/AEC/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
B.Sc. Honours with Research in Mathematics	VII	Multivariable Calculus	BSDSMAT0701	DSC	4-0-0	4
		Mathematical Methods	BSDSMAT0702	DSC	4-0-0	4
		Metric Spaces	BSDSMAT0703	DSC	4-0-0	4
		Partial Differential Equations	BSDSMAT0704	DSC	4-0-0	4
		Research Project	BSDSMAP0706	DSC	4-0-0	4
	VIII	Topology	BSDSMAT0801	DSC	4-0-0	4
		Abstract Algebra	BSDSMAT0802	DSC	4-0-0	4
		Advanced Linear Algebra	BSDSMAT0803	DSC	4-0-0	4
		Advanced Numerical Analysis	BSDSMAT0804	DSC	4-0-0	4
		Research Project	BSDSMAP0806	DSC	4-0-0	4

MULTIVARIABLE CALCULUS

Course code: BSDSMAT0701	Course Title: Multivariable Calculus
Semester-VII	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course Objectives:

The primary objectives of this course are:

1. To develop the concept of improper integrals and analyze their convergence using standard techniques.
2. To provide a foundation in multivariable calculus, including functions of two and three variables.
3. To explore methods for finding local and constrained extrema using Lagrange multipliers.
4. To grasp the knowledge of functions of bounded variation.
5. To build analytical problem-solving skills applicable to real-world problems in science and engineering.

Units	Topics	Number of Lectures
I	**Improper Integrals:** Integration by substitution and integration by parts; Volume by slicing and cylindrical shells, Length of a curve in the plane, and the area of surfaces of revolution. Improper integrals of Type-I, Type-II, and mixed type, Convergence of improper integrals, The beta and gamma functions and their properties.	15
II	**Function of Several Variables:** Basic concepts of functions of several variables, Limits and continuity of functions of two variables, Partial derivatives, Euler's theorem, Tangent planes, Total differential, Differentiability of functions of two variables, Chain rules, Directional derivatives, and the gradient.	15
III	**Extremum of Functions of Several Variables:** Composite functions, Mean value theorem, and Taylor's theorem for functions of two variables, Schwarz's theorem, Invertible function, Inverse function theorem, Implicit function theorem, Maxima and minima of functions of two and three variables, Lagrange's method of undetermined multipliers. Optimization problems of two variables using the graphical method.	15
IV	**Absolute Continuity:** Absolutely continuous functions and their properties, the relation between absolute continuity and functions of bounded variation. **Double and triple integrals:** Double integration over rectangular and nonrectangular regions, Change of variables in double integrals. Triple integrals over a parallelopiped and a solid region, Triple integrals using change of variables.	15

Course Outcomes:

Upon successful completion of this course, students will be able to:

- **CO1.** **Evaluate improper integrals** of Type I, Type II, and mixed types, and determine their convergence using appropriate tests.
- **CO2.** **Analyze functions of two variables**, including limits, continuity, partial derivatives, and differentiability.
- **CO3.** Ap**ply multivariable calculus concepts** to solve real-world problems in physics, engineering, and related fields.
- **CO4.** Analyze the functions of bounded variation and their properties.

Suggested Readings

1. **Ross, Kenneth A.** (2013). *Elementary Analysis: The Theory of Calculus* (2nd ed.). Undergraduate Texts in Mathematics, Springer.
2. **Anton, Howard**, **Bivens, Irl**, and **Davis, Stephen** (2012). *Calculus* (10th ed.). John Wiley & Sons, Inc.
3. **Denlinger, Charles G.** (2011). *Elements of Real Analysis*. Jones & Bartlett India Pvt. Ltd., Indian Reprint.
4. **Ghorpade, Sudhir R.** and **Limaye, B. V.** (2006). *A Course in Calculus and Real Analysis*. Undergraduate Texts in Mathematics, Springer (SIE), Indian Reprint.
5. **Bartle, Robert G.** & **Sherbert, Donald R.** (2015). *Introduction to Real Analysis* (4th ed.). Wiley, Indian Edition.
6. **Kumar, Ajit** and **Kumaresan, S.** (2014). *A Basic Course in Real Analysis*. CRC Press, Taylor & Francis Group, Special Indian Edition.

MATHEMATICAL METHODS

Course code: BSDSMAT0702	Course Title: Mathematical Methods
Semester-VII	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. Gain the key concept of popular and useful transformation techniques like the Fourier and Laplace transform.
2. Introduce the basic concepts and knowledge about different types of integral equations and their applications.
3. To lay a broad foundation for an understanding of the problems of the calculus of variations and its various methods and techniques.

Units	Topics	Number of Lectures
I	**Integral Transforms:** Fourier transforms, Fourier series, Fourier integral formula, definition of Fourier transforms, properties, convolution theorem, Fourier transform as a limit of Fourier series, applications to differential equations. Laplace transforms-Definitions, properties, convolution theorem, inverse Laplace transformation, applications to differential equations.	15
II	**Integral Equations:** Volterra integral equations, relationship between linear differential equations and Volterra integral equations, resolvent kernel of Volterra integral equations, solution of integral equations by resolvent kernel, the method of successive approximations, convolution type equations, solution of integro-differential equations with the aid of Laplace transformation.	15
III	**Fredholm integral equations:** Fredholm equations of the second kind, fundamentals, iterated kernels, constructing the resolvent kernel with the aid of iterated kernels, integral equations with degenerate kernels, characteristic numbers and eigenfunctions, solution of homogeneous integral equations with degenerate kernel, nonhomogeneous symmetric equations, Fredholm alternative. Reduction of IVPs, BVPs, and eigenvalue problems to integral equations. Hilbert-Schmidt theorem.	15
IV	**Calculus of variations**: Variation of a functional, extremum of a functional, variational problems, Euler's equation, standard variational problems including geodesics, minimal surface of revolution, hanging chain problems.	15

Course outcomes

CO1. Students apply techniques of the Integral transform to formulate and solve complex problems of differential equations.

CO2. The student understands the Volterra and Fredholm integral equations and their solutions using various methods.

CO3. Students apply various mathematical techniques in solving engineering and science problems.

Suggested Readings

1. C M Bender, S. A. Orszag, Advanced Mathematical Methods for Scientists and Engineers, Springer Publishers, 1999. 2.
2. L Debnath and D Bhatta, Integral Transforms and their Applications, Taylor and Francis, 2007.
3. R. P. Kanwal, Linear Integral Equations Theory and Techniques, Academic Press, New York, 1971.
4. I. N. Sneddon, The use of Integral Transforms, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1974.
5. Shanti Swaroop and S. R. Singh, Integral Equations, Krishna Publications, 2014.
6. F. G. Tricomi, Integral Equations, Dover Publications Inc., New York, 1985.

METRIC SPACES

Course code: BSDSMAT0703	Course Title: Metric Spaces
Semester-VII	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objectives

The objective of this course is to:

1. Introduce the concept of **distance in an abstract setting**, generalizing the familiar notion from Euclidean spaces to more abstract sets, while preserving its essential properties.
2. Explore two fundamental **topological properties** of metric spaces—**connectedness** and **compactness**—along with their characterizations and implications.

Units	Topics	Number of Lectures
I	Definition and examples of metric spaces, Open and closed balls, sequences and Cauchy sequences in a metric space, Complete metric space; Neighborhood, Interior of a set, Exterior of a set, Boundary of a set, Open set.	15
II	Limit point of a set, Derived set, Closed set, Closure of a set, Diameter of a set, Cantor's theorem, Subspaces, Dense sets, nowhere dense sets, Compact sets, locally compact, Category I and category II sets, Baire's Category Theorem, Totally bounded sets and their connection with completeness and compactness.	15
III	Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity; Homeomorphism, Isometry and equivalent metrics, Contraction mapping, Banach fixed point theorem.	15
IV	Connectedness, Connected subsets of $\mathbb{R}$, path connected, locally connected, Connectedness and continuous mappings, Compactness and boundedness, finite intersection property, compactness via finite intersection property, Characterizations of compactness, Continuous functions on compact spaces.	15

Course outcomes

Upon successful completion of this course, students will be able to:

CO1. Understand and apply **various formulations of distance** on sets.

CO2. Analyze the process by which **mathematical theories generalize** from specific, concrete examples to abstract frameworks.

CO3. Develop a deeper **mathematical appreciation of geometric concepts**—such as open balls, connected sets, and compact sets—within an abstract context.

Suggested Reading

1. **Shirali, Satish** & **Vasudeva, H. L.** (2009). *Metric Spaces*. Springer. Indian Reprint, 2019.
2. **Kumaresan, S.** (2014). *Topology of Metric Spaces* (2nd ed.). Narosa Publishing House, New Delhi.
3. **Rudin, Walter.** *Principles of Mathematical Analysis* (3rd ed.).
4. **Simmons, George F.** (2004). *Introduction to Topology and Modern Analysis*. McGraw-Hill Education, New Delhi.
5. **Aliprantis, C. D.**, & **Burkinshaw, O.** (1998). *Principles of Real Analysis* (3rd ed.). Academic Press.

PARTIAL DIFFERENTIAL EQUATIONS

Course code: BSDSMAT0704	Course Title: Partial Differential Equations
Semester-VII	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. The course objective is to introduce the classification and solution methods for linear and nonlinear first-order Partial Differential Equations (PDEs).
2. This course is designed to develop an understanding of second-order PDEs, focusing on their origin, classification, and reduction to canonical forms.
3. This course equips students with methods to solve elliptic, parabolic, and hyperbolic PDEs using separation of variables.
4. This course explores advanced techniques for non-linear second-order PDEs, focusing on Monge's method and its different solution cases.

Units	Topics	Number of Lectures
I	**First Order Partial Differential Equations:** Solution of Partial Differential Equations (PDEs), Formation of PDEs, Classification of first order PDEs, Solution of first order PDEs: Lagrange's method, Integral surfaces passing through a given curve, surfaces orthogonal to a given system of surfaces. Non-linear PDE of first order: Compatible system of first order PDE, and their condition, Charpit's method. Cauchy Problem, Method of characteristics for first-order PDE.	15
II	**Second Order Partial Differential Equations:** Introduction, Origin of Second Order Equations, Equations with Variable Coefficients, and their different types, Classification of second-order PDE in two independent variables, Reduction to its canonical form: method for reducing Parabolic, elliptic, and Hyperbolic equations to their Canonical Forms.	15
III	**Solutions of Elliptic, Parabolic, and Hyperbolic PDEs:** Solutions of Elliptic, Parabolic, and Hyperbolic PDEs by the methods of Separation of Variables, Solution of Elliptic, Parabolic, and Hyperbolic equations in cylindrical and spherical polar coordinates.	15
IV	**PDEs with constant coefficients:** Solution of homogeneous and non-homogeneous PDEs with constant coefficients. **Non-Linear PDE of second order:** Introduction, Monge's method of integrating $Rr + Ss + Tt = V$ by different types, (i) leads to two distinct	15

	intermediate integrals and both of them are used to get the desired solution (ii) leads to two distinct intermediate integrals and only one is employed to get the desired solution (iii) leads to two identical intermediate integrals, and (iv) fails to yield two identical intermediate integrals, illustrative through examples	

Course outcomes

After successful completion of the course, the student will be able to:

CO1. Classify and solve first-order PDEs, apply Lagrange's and Charpit's methods, and handle initial value problems.

CO2. Students will effectively classify and reduce second-order PDEs to their canonical forms and identify parabolic, elliptic, and hyperbolic types.

CO3. Demonstrate proficiency in solving elliptic, parabolic, and hyperbolic PDEs, including applications in cylindrical and spherical coordinates.

CO4. Apply Mange's method to solve non-linear second-order PDEs and differentiate solution cases using intermediate integrals.

Suggested Readings

1. N. Sneddon, Elements of Partial Differential Equations, Dover Publications, 2006.
2. R. McOwen, Partial Differential Equations: Methods and Applications, Pearson, 2002.
3. Phoolan Prasad and R. Ravindran, Partial Differential Equations, New Age International, 2011.
4. Qing Han, A Basic Course in Partial Differential Equations, AMS, 2011.
5. L. C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, American Mathematical Society, 1998.
6. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, Birkhäuser, 2007.
7. K Sankar Rao, Introduction to Partial Differential Equations, PHI Publications, 3rd Edition, 2017.
8. Stanley J. Farlow, Partial Differential Equations for Scientists and Engineers: Dover Publications, 1993.
9. T. Amaranath, An elementary course in Partial Differential Equations, 2nd Edition, Narosa Publishers, 2013.

MECHANICS

Course code: BSDSMAT0705	Course Title: Mechanics
Semester-VII	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. The course objective is to introduce the students to the imbalance of forces acting on a rigid body and its equilibrium.
2. The course is designed to explain the various physical phenomena that arise in natural systems.
3. The course aimed to enable the students to apply Mathematics in analyzing physical phenomena.

Units	Topics	Number of Lectures
I	Forces in three dimensions, Poinsot's central axis, Wrenches, Null lines, and null planes, Conjugate lines and conjugate forces.	15
II	Analytical conditions of equilibrium of coplanar forces, Virtual work, Stable and unstable equilibrium, Catenary, Catenary of uniform strength.	15
III	Motion in a straight line, velocity and acceleration, accelerations in terms of different coordinate systems, Elastic and inelastic collisions between two objects, the coefficient of restitution, motion in a plane, velocity and acceleration along radial and transverse directions, velocity and acceleration along tangential and normal directions, Elastic strings.	15
IV	Motion in a resisting medium, Projectile motion in a resisting medium, Moments and products of inertia, The momental ellipsoid, Equimomental systems, Principal axes, Central orbits, Apses and apsidal distances, Kepler's laws of planetary motion, Motion of a particle in three dimensions.	15

Course outcomes

After the completion of the course, the students will be able to:

CO1. Understand the significance of mathematics in the study of physical problems, particularly in Mechanics.

CO2. Discuss various physical concepts like simple harmonic motion, motion under other laws, and forces.

CO3. Explain the various physical phenomena and their application in real life.

Suggested Readings

1. R. C. Hibbeler, Engineering Mechanics-Statistics, Macmillan Pub, 1994.
2. A. Nelson, Engineering Mechanics- Dynamics, McGraw-Hill, 2017.
3. J. L. Synge and B.A. Griffith, Principles of Mechanics, McGraw-Hill, 1959
4. S. L. Loney, The Elements of Statistics & Dynamics Part I: Statics, Arihant Publications, 2016.
5. S. L. Loney, The Elements of Statistics & Dynamics Part I: Dynamics, Arihant Publications, 2025.

TOPOLOGY

Course code: BSDSMAT0801	Course Title: Topology
Semester-VIII	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objectives:

The objective of this course is:

1. To introduce the basic definitions and examples of topological spaces.
2. To develop an understanding of neighbourhoods and neighbourhood systems of a point and their properties.
3. To explain the concepts of interior points and interiors of sets, and understand interior as an operator with its properties.
4. To define closed sets as complements of open sets.
5. To study the concepts of limit points, derived sets in topological spaces.
6. To understand closure points and the closure of a set, and explore closure as an operator with its properties.
7. To examine the ideas of dense subsets and separable topological spaces, connectedness, compactness, continuity, **countability axioms** and **separation axioms** in topological spaces.

Units	Topics	Number of Lectures
I	Definition and examples of topological spaces, neighbourhoods, neighbourhood system of a point and its properties, interior point and interior of a set, interior as an operator and its properties, closed sets, limit point (accumulation point) of a set, derived set of a set, adherent point (closure point) of a set, closure of a set, closure as an operator and its properties, dense sets and separable spaces, Connectedness.	15
II	Base for a topology and its characterization, base for neighbourhood system, sub-base for a topology, product topology, relative (induced) topology and subspace of a topological space, Alternate methods of defining a topology using properties of neighbourhood system, interior operator, closed sets, Kuratowski closure operator, comparison of topologies on a set, about intersection and union of topologies.	15
III	First countable, second countable, their relationships and hereditary property, Lindelöf theorem. Definition, examples and characterisations of continuous functions, composition of continuous functions, open and closed functions, homeomorphism, and Topological invariant property.	15

IV	Compactness: Definition and examples of compact spaces, compactness in terms of finite intersection property, continuity and compact sets. Separation Axioms: T0, T1 and Hausdorff spaces, completely regular and normal spaces, Urysohn's lemma; Tietze extension theorem.	15

Course outcomes:

After successful completion of this course, students will be able to:

- **CO1.** **Define and explain** the structure of a topological space and distinguish between different types of topologies.
- **CO2.** **Understand and apply** the concepts of neighborhood, interior point, interior, and their properties in the context of topological spaces.
- **CO3.** **Describe** open and closed sets, and their role in the structure of a topology.
- **CO4.** **Distinguish** between interior points, limit points, and derived sets.
- **CO5.** **Compute** the closure and interior of a set, and verify the properties of closure and interior as operators.

Suggested Readings

1. **Munkres, James R.** (2002). *Topology* (2nd ed.). Prentice Hall of India Pvt. Ltd.
2. **Simmons, G. F.** (2017). *Introduction to Topology and Modern Analysis*. McGraw-Hill Education, Delhi.
3. **Patty, C. W.** (2009). *Foundations of Topology* (2nd ed.). Jones & Bartlett Learning.
4. **Joshi, K. D.** (1983). *Introduction to General Topology*. Wiley Eastern Limited.
5. **J. B. Conway** (2014), A Course in Point Set Topology, Springer.

ABSTRACT ALGEBRA

Course code: BSDSMAT0802	Course Title: Abstract Algebra
Semester-VIII	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. This course introduces the relation of conjugacy on the groups, the partition of a group into equivalence classes, Sylow's theorem, and subnormal series of groups.
2. The objective of the course is to extend the Ring and Field algebraic structures to an extensive theory dealing mainly with polynomials.
3. Factorization of polynomials and the irreducibility test are other objectives of the course.

Units	Topics	Number of Lectures
I	Recapitulation of group, Permutation groups, Cyclic permutation, Transposition, Even and odd permutations, The alternating group, Cayley's theorem, Relation of conjugacy, conjugate classes of a group, number of elements in a conjugate class of a component of a finite group, class equation in a finite group, and related results, Sylow's theorems	15
II	Maximal normal subgroup, Subnormal series of a group, refinement of a subnormal series, solvable groups and related results, nilpotent groups, relation between solvable and nilpotent groups, composition series of a group, Zassenhaus theorem, Jordan-Holder theorem for finite groups.	15
III	Recapitulation of Definitions and Examples of Rings, Polynomial rings over commutative rings. Degree of Polynomials, Primitive polynomials, Division algorithm and consequences, Principal ideal domains.	15
IV	Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein criterion, Unique factorization in Z[x]. Divisibility in Integral Domains, Irreducible, Primes, Unique Factorization Domain, Euclidean Domain.	15

Course outcomes

After the completion of the course, the students will be able to:

CO1. Understand how to divide the group into equivalent classes based on a relation of conjugacy.

CO2. Explain the subnormal series, solvable groups, and composition series with examples.

CO3. Perform the factorization of polynomials and do the irreducibility test over the polynomial rings.

Suggested Readings

1. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd, New Delhi, 1975.
2. Joseph A. Gallian, Contemporary Abstract Algebra, Cengage Learning India Private Limited, New Delhi., Fourth impression, 2015.
3. S. Singh and Q. Zameeruddin, Modern Algebra, Vikas Publication House, India.
4. David M. Burton, Elementary Number Theory, Wm. C. Brown Publishers, Dubuque, Iowa, 1989.
5. D. S. Dummit and R.M. Foote, Abstract Algebra, John Wiley, N.Y., 2003.
6. J. B. Fraleigh, A first course in Abstract algebra, Narosa, 2003.

ADVANCED LINEAR ALGEBRA

Course code: BSDSMAT0803	Course Title: Advanced Linear Algebra
Semester-VIII	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objectives:

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

1. Revisit and deepen understanding of linear transformations and their matrix representations.
2. Explore the structure of the space of linear maps, including the dual and double dual spaces.
3. Understand the concept of annihilators, transpose of linear transformations, and their representation in dual bases.
4. Explore invariant subspaces and study nilpotent transformations, including the primary decomposition theorem and Jordan canonical forms.
5. Introduce inner product spaces and develop techniques for orthogonalization.
6. Study the classification and properties of important linear operators (normal, self-adjoint, unitary, orthogonal).
7. Understand orthogonal projections and the spectral theorem.
8. Explore the theory of bilinear forms, including symmetric, alternating, and quadratic forms, along with their matrix representations.

Units	Topics	Number of Lectures
I.	Recapitulation of linear transformations and their matrix representations, Class of all linear transformations as a vector space, Dual spaces, Double dual, Dual basis, Transpose of a linear transformation and its matrix in the dual basis.	15
II.	Annihilators, Invariant subspaces, Nilpotent transformations, Index of nilpotency, The primary decomposition theorem, Jordan blocks and Jordan forms.	15
III.	Inner products and norms, Orthonormal basis, Gram-Schmidt orthogonalization process, Orthogonal complements, Bessel's inequality; Adjoint of a linear operator with applications to least squares approximation and minimal solutions to systems of linear equations.	15

IV.	Normal, self-adjoint, unitary, and orthogonal operators and their properties; Orthogonal projections and the spectral theorem; Bilinear forms, Bilinear forms and matrices, alternating bilinear forms, symmetric bilinear forms, Quadratic forms, Real Symmetric Bilinear forms.	15

Course outcomes:

After successful completion of the course, students will be able to:

- **CO1.** Represent linear transformations as matrices and understand the structure of the set of all linear transformations as a vector space.
- **CO2.** Apply concepts of dual spaces, dual basis, and compute the transpose of a linear transformation.
- **CO3.** Analyze and determine invariant subspaces, classify nilpotent transformations, and compute the index of nilpotency.
- **CO4.** Apply the primary decomposition theorem.
- **CO5.** Define and utilize inner products, norms, orthonormal bases, and perform Gram-Schmidt orthogonalization.
- **CO6.** Use orthogonal projections, adjoint operators, and understand applications in least squares approximation and minimal norm solutions.
- **CO7.** Classify linear operators as normal, self-adjoint, unitary, or orthogonal, and understand their properties.
- **CO8.** Understand bilinear forms, including symmetric and alternating types, and analyze quadratic forms through matrix representation.

Suggested Readings

1. Friedberg, Stephen H., Insel, Arnold J., & Spence, Lawrence E. (2003). Linear Algebra (4th ed.). Prentice-Hall of India Pvt. Ltd., New Delhi.
2. Andrilli, S., & Hecker, D. (2016). Elementary Linear Algebra (5th ed.). Elsevier India.
3. Lay, David C., Lay, Steven R., & McDonald, Judi J. (2016). Linear Algebra and its Applications (5th ed.). Pearson Education.
4. Kolman, Bernard, & Hill, David R. (2001). Introductory Linear Algebra with Applications (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.
5. Hoffman, Kenneth, & Kunze, Ray Alden (1978). Linear Algebra (2nd ed.). Prentice Hall of India Pvt. Limited. Delhi. Pearson Education India Reprint, 2015.
6. Lang, Serge (1987). Linear Algebra (3rd ed.). Springer.

ADVANCED NUMERICAL ANALYSIS

Course code: BSDSMAT0804	Course Title: Advanced Linear Algebra
Semester-VIII	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. This course introduces the numerical techniques to solve the IVPs and BVPs.
2. The solution of Ordinary and Partial Differential Equations by the finite difference method is another key feature of the course.
3. This course enables the solution of parabolic, elliptic, and hyperbolic partial differential equations by numerical methods.
4. This course introduces the finite element method for solving Partial Differential Equations.

Units	Topics	Number of Lectures
I	**Numerical Solution of Ordinary Differential Equations:** Estimation of local truncation error of Euler and single-step methods, Taylor Series, Runge-Kutta method. Bounds of local truncation error and convergence analysis of multistep methods, Predictor-Corrector methods, Adams-Bashforth methods, Adams-Moulton formula, Milne-Simpson method, System of Differential Equations.	15
II	**Finite Difference Method for Ordinary Differential Equations:** Finite difference method for solving second-order IVPs and BVPs, the Shooting method for boundary value problems.	15
III	**Finite Difference Method for Partial Differential Equations:** Finite difference approximations to partial derivatives, solving parabolic equations using implicit and explicit formulae, C-N scheme and ADI methods; solving elliptic equations using Gauss-elimination, Gauss-Seidel method, SOR method, and ADI method, solving hyperbolic equations using method of characteristics, explicit and implicit methods.	15
IV	**Finite Element Method:** Weighted residual method, Galerkin's method, least square method, collocation method, variational method, Rayleigh-Ritz method.	15

Course outcomes

After the completion of the course, the students will be able to:

CO1. Apply the numerical methods to solve the ordinary and partial differential equations.
CO2. Solve the second-order IVP and BVPs with the help of the finite element method.
CO3. Learn how to solve partial differential equations using finite element method.
CO4. Evaluate the convergence and accuracy of various numerical methods and choose appropriate techniques for specific applications.

Suggested Readings

1. R. S. Gupta, Elements of Numerical Analysis, Cambridge University Press, 2015.
2. R. L. Burden, J. D. Faires, Numerical Analysis, 9^{th} Edition, Cengage Publisher, 2011.
3. K. Sankara Rao, Numerical Methods for Scientists and Engineers, PHI Publishers, 2007.
4. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publishers, 2014.
5. J. B. Scarborough, Numerical Mathematical Analysis, 6th Edition, Oxford and IBH Publisher, 1984.
6. B. S. Grewal, Numerical methods in Engineering and Science, Khanna Publishers, 2013.
7. Joe D. Hoffman, Numerical methods for Engineers and Scientist, McGrow-Hill, 1993.
8. A. Quarteroni and A. Valli, Numerical Approximation of Partial Differential Equations, Springer, 1994.
9. K. Atkinson and W. Han, Theoretical Numerical Analysis: A Functional Analysis Framework, Springer-Verlag, New York, 2001.
10. P. G. Ciarlet, The Finite Element Method for Elliptic Problems, North-Holland, Amsterdam, 1978.
11. S. C. Brenner and L. R. Scott, The Mathematical Theory of Finite Element Methods, Springer-Verlag, New York, 1994.

PRACTICAL (ADVANCED NUMERICAL ANALYSIS)

Course code: BSDSMAT0805	Course Title: Advanced Numerical Analysis
Semester-VIII	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. This course is designed to handle Differential Equations problems efficiently with the assistance of Mathematica/MATLAB/Python/C-Programming.
2. This course aims to equip students with the computational skills to solve first and second-order ordinary differential equations using various numerical methods.
3. This course visualizes solutions to differential equations through graphical representation and enhances students' understanding of the behaviour of solutions of differential equations.
4. The objective of the course is to foster critical thinking and problem-solving abilities by engaging students in programming exercises that require the application of theoretical concepts to practical scenarios in differential equations.

Units	Topics	Number of Hours
I	**Ordinary Differential Equations:** **1.** Write a program to solve the first-order ordinary differential equations. **2.** Write a program to solve the first-order initial value problem and use the plot command for plotting the solution. **3.** Write a program to solve the second-order ordinary differential equation. **4.** Write a program to solve the second-order initial value problem and use the plot command for plotting the solution. **5.** Write a program to solve the higher-order initial value problem and use the plot command for plotting the solution.	30
II	**First Order IVP:** **6.** Program to find an approximate solution of a differential equation with initial condition by Picard’s method of successive approximation. **7.** Program to find the approximate solution of a differential equation with initial condition by Taylor's series method. **8.** Program to solve the initial value problem using the Euler Method. **9.** Program to solve the initial value problem using the Modified Euler Method.	60

	10. Program to find the solution of the initial value problem using the Runge-Kutta II order Method. **11.** Program to find the solution of the initial value problem using the Runge-Kutta IV order Method. **12.** Program to find the solution of the initial value problem using the Predictor-Corrector method. **13.** Program to find the solution of the initial value problem using Milne's Method.	
III	**Boundary Value Problems (BVPs):** **14.** Program to find the solution of ODE by the finite difference method. **15.** Program to find the solution of ODE by the Shooting method. **16.** Program to find the numerical solution of the Laplace equation by the method. **17.** Program to find the numerical solution of the wave equation using the Finite difference method **18.** Program to find the solution of ODE by Galerkin's method.	30

Course outcomes

After the completion of the course, the students will be able to:

CO1. Solve initial IVPs using multiple numerical methods such as Taylor's series method, Euler method, and Runge-Kutta method.

CO2. Implement advanced numerical techniques, such as the Predictor-Corrector method and Milne's Method, to obtain solutions for differential equations.

CO3. Get hands-on experience in solving boundary value problems using different methods, including the finite difference method, shooting method, and Galerkin's method.

CO4. Equipped with essential skills for solving differential equations arising from real-world mathematical modelling problems.

Suggested Readings

1. M. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publication, 2022.
2. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
3. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw-Hill, 2014.
4. R. W. Hamming, Numerical Methods for Scientists and Engineers, Dover Publications, 1987.
5. B. S. Grewal, Numerical Methods in Engineering & Science with Programs in C, C++ and MATLAB, Khanna Pub., 2013.
6. Allen Downey, Jeff Elkner, and Chris Meyers -Learning with Python, 2015.
7. Hans-Petter Halvorsen, Python for Science and Engineering, 2019.

8. John C. Polking, Ordinary Differential Equations Using MATLAB, Pearson Education, 2009.
9. Alexander Stanoyevitch, Introduction to Numerical Ordinary and Partial Differential Equations Using MATLAB, Wiley, 2011.

Syllabus of Integrated B.Sc. - M.Sc. Programme
(Academic Year 2025-26)

<u>IX & X Semester</u>

Award/ Certificate/ Diploma/ Degree	Semester	Course Name	Course Code	DSC/SEC/AEC/ Research Project/ Dissertation	Lectures per Week (L-T-P)	Credit
M.Sc. in Mathematics	IX	Functional Analysis	MSDSMAT0901	DSC	4-0-0	4
		Analytical Dynamics	MSDSMAT0902	DSC	4-0-0	4
		Probability Theory	MSDSMAT0903	DSC	4-0-0	4
		Optional (any one of the following) A. Hydrodynamics B. Mathematical Modeling C. Discrete Mathematics D. Continuum Mechanics E. Fourier Analysis F. Number Theory	MSDSMAT0904 (A-F)	DSC	4-0-0	4
		Research Project	MSDSMAP0904	Research Project	4-0-0	4
	X	Measure Theory	MSDSMAT1001	DSC	4-0-0	4
		Mathematical Statistics	MSDSMAT1002	DSC	4-0-0	4
		Optional (any one of the following) A. Special Function B. Wavelet Analysis C. Fluid Mechanics D. Fractal Geometry E. Operations Research	MSDSMAT1003 (A-E)	DSC	4-0-0	4
		Lab (R-Programming)	MSDSMAT1004	DSC	0-0-4	4
		Research Project	MSDSMAT1005	Research Project	4-0-0	4

FUNCTIONAL ANALYSIS

Course code: MSDSMAT0901	Course Title: Functional Analysis
Semester-IX	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objectives

The course aims to introduce students to:

1. Understanding norms, normed spaces, Banach spaces, and Hilbert spaces as complete normed spaces, along with their key properties.
2. Studying various forms of norms through definitions and examples.
3. Exploring the structure and properties of bounded linear operators on normed and Hilbert spaces.
4. Learning the following four fundamental theorems: Hahn-Banach Theorem, Uniform Boundedness Principle, Open Mapping Theorem, and Closed Graph Theorem.

Units	Topics	Number of Lectures
I	Normed spaces, Banach spaces and their examples, Subspaces, Quotient spaces of normed linear space and their completeness, Compactness and finite dimension; Continuous and bounded linear operators and their basic properties, Normed linear space of bounded linear operators and its completeness, Various forms of an operator norm.	15
II	Equivalent norms, Bounded linear functionals, Dual spaces with examples, Hahn Banach theorems for real and complex vector spaces, Hahn Banach theorem for normed spaces; Reflexive spaces; Uniform boundedness theorem, Open mapping theorem, Closed graph theorem.	15
III	Overview of inner product spaces and their properties, Schwartz inequality, Norm induced by inner product, Continuity of inner product, Parallelogram equality, polarization identity, Hilbert spaces, Orthogonal complements and direct sums, Orthonormal sets and sequences, Bessel inequality, Riesz representations theorem.	15
IV	Hilbert-adjoint operators, Shift operators, Self-adjoint operators, Positive operators, Normal operators, Unitary operators, Orthogonal projection operators, Eigenvalues and Eigen Vectors of an Operator, Spectrum of an operator, The Spectral Theorem on a Finite-Dimensional Hilbert Space.	15

Course Outcomes

Upon successful completion of this course, students will be able to:

- **CO1.** Demonstrate knowledge of normed linear spaces, including examples and key properties.
- **CO2.** Identify and characterize bounded linear operators on normed spaces and recognize them as continuous mappings.
- **CO3.** **Apply** Schwarz (Cauchy-Schwarz) Inequality, Bessel's Inequality.
- **CO4.** Understand and illustrate linear operators, including **self-adjoint**, **unitary**, and **normal** operators on Hilbert spaces.
- **CO5.** Prove and effectively apply the Hahn-Banach theorem, Uniform Boundedness Principle, Open Mapping Theorem, and Closed Graph Theorem.

Suggested Readings

1. **E. Kreyszig** (1978). *Introductory Functional Analysis with Applications*. John Wiley & Sons, New York.
2. **W. Rudin** (1977). *Functional Analysis*. Tata McGraw-Hill, New Delhi.
3. **P.K. Jain, O.P. Ahuja, and K. Ahmad** (1997). *Functional Analysis*. New Age International (P) Ltd. & Wiley Eastern Ltd., New Delhi.
4. **F. B. Choudhary & S. Nanda** (1989). *Functional Analysis with Applications*. Wiley Eastern Ltd.
5. **I.J. Maddox** (1970). *Functional Analysis*. Cambridge University Press.
6. **K. Chandrashekhara Rao**. *Functional Analysis*. Narosa Publishing House, New Delhi.
7. **Béla Bollobás** (1999). *Linear Analysis: An Introductory Course* (2nd ed.). Cambridge University Press.
8. **Bryan P. Rynne and Martin A. Youngson** (2008). *Linear Functional Analysis* (2nd ed.). Springer-Verlag London Limited.
9. **B.V. Limaye** (2014/2017). *Functional Analysis*. New Age International.
10. **M. Thamban Nair** (2021). *Functional Analysis: A First Course* (2nd ed.), PHI Learning / Prentice-Hall of India, New Delhi

ANALYTICAL DYNAMICS

Course code: MSDSMAT0902	Course Title: Analytical Dynamics
Semester-IX	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. Analytical Dynamics is one of the essential and fundamental courses that establishes the links between body motion and its causes, specifically the forces acting on the bodies and their properties, particularly mass and moment of inertia.
2. The main objective of the course is to explore the dynamics of bodies in depth in this study.

Units	Topics	Number of Lectures
I	Work function and energy, virtual work, and D'Alembert's principle, Classification of dynamical systems, Constraints, generalized coordinates, Holonomic and non-holonomic systems, Lagrange's equation of motion, Kinetic energy, generalized forces and generalized momentum, and generalized components of the effective and applied forces, Lagrange's equation for impulsive motion.	15
II	Hamilton's variables, Donkin's theorem, Hamilton's canonical equation, reciprocal relations, Ignoration of coordinates, Routhian function, Poisson bracket, Jacobi-Poisson theorem. Application of Hamiltonian methods to natural motions.	15
III	Hamilton's variational principle, principle of least action, Canonical transformations, generating function. Hamilton-Jacobi equation, Hamilton characteristic function.	15
IV	Lagrange brackets, invariance of Lagrange brackets, and Poisson brackets under canonical transformations. Small oscillations, Normal modes, normal coordinates, and their stationary properties.	15

Course outcomes

CO1. The students will be able to classify dynamical systems and define generalized coordinates, generalized components of momentum, and effective applied forces.

CO2. The students will be able to use Lagrange's and Hamilton's equations to solve dynamical problems.

CO3. Students will be able to solve the small oscillations problems with the help of Lagrange's and Hamilton's equations

Suggested Readings

1. S. L. Loney, An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies, Macmillan, India, Ltd., 1982.
2. A. S. Ramsey, Dynamics Part II, Cambridge University Press,1972.
3. J. L. Synge and B. A. Griffith, Principles of Mechanics, McGraw-Hill International Book Company, 1982.
4. L. N. Hand and J. D. Finch, Analytical Mechanics, Cambridge University Press, 1998.
5. Naveen Kumar, Generalized Motion of Rigid Body, Narosa, 2004.

PROBABILITY THEORY

Course code: MSDSMAT0903	Course Title: Probability Theory
Semester-IX	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course Objectives

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

1. **Understand the fundamentals of probability theory**, including the various interpretations of probability (classical, statistical, and axiomatic).
2. **Model and analyze random experiments**, define sample spaces and events, and apply set-theoretic operations in probability.
3. **Apply core probability theorems**, including laws of addition and multiplication, conditional probability, independence, the law of total probability, and Bayes' theorem.
4. **Define and work with random variables**, both discrete and continuous, and interpret their pmf, pdf, and cdf.
5. **Analyze functions of random variables** and perform transformations, especially in univariate and bivariate settings.
6. **Compute expectations, variances, and higher moments**, and understand the use of generating functions (MGF, CGF, characteristic functions) in probability theory.
7. **Work with important discrete and continuous probability distributions**, understanding their properties, applications, and approximations.
8. **Handle problems involving joint, marginal, and conditional distributions**, as well as independence between random variables.
9. **Develop a foundation for further study** in statistical inference, stochastic processes, and applied probability.

Units	Topics	Number of Lectures
I	**Probability:** Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem, and its applications.	15
II	**Random variables:** Discrete and continuous random variables, probability mass function (pmf), probability density function(pdf), and Cumulative distribution function (cdf), illustrative examples and properties of random variables, univariate transformations with illustrations. Two-dimensional random variables: discrete and continuous type, joint, marginal, and conditional pmf, pdf, and cdf, and independence of variables.	15

III	**Mathematical Expectation and Generating Functions:** Expectation of single and bivariate random variables and their properties. Moments and Cumulants, moment generating function, cumulant generating function, and characteristic function. Uniqueness and inversion theorems. Conditional expectations.	15
IV	**Standard probability distributions:** Uniform, Binomial, Poisson, geometric, along with their properties and limiting/approximation cases. Standard continuous probability distributions: uniform, normal, exponential, beta, and gamma, along with their properties and limiting/approximation cases.	15

Course Outcomes

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

- **CO1.** Understand the fundamental concepts of probability, including sample space, events, and classical, statistical, and axiomatic definitions.
- **CO2.** Apply the laws of probability, such as addition, multiplication, conditional probability, and Bayes' theorem, to solve problems.
- **CO3.** Define and analyze discrete and continuous random variables using pmf, pdf, and cdf.
- **CO4.** Analyze bivariate random variables and determine joint, marginal, and conditional distributions, as well as independence.
- **CO5.** Compute expectations, moments, and cumulants of random variables and utilize generating functions (MGF, CGF, characteristic functions).
- **CO6.** Identify and apply standard discrete distributions (Uniform, Binomial, Poisson, Geometric) and continuous distributions (Uniform, Normal, Exponential, Beta, Gamma).
- **CO7.** Apply probability concepts and distributions to real-life and theoretical problems, including conditional expectations and distribution approximations.

Suggested Readings

1. Rohatgi, V. K., & Saleh, A. K. Md. E. (2001). *An Introduction to Probability and Statistics* (2nd ed.). Wiley.
2. Gupta, S. C., & Kapoor, V. K. (2008). *Fundamentals of Mathematical Statistics* (4th ed., Reprint). Sultan Chand & Sons.
3. Jacod, J., & Protter, P. (2004). *Probability Essentials*. Springer.
4. Ross, S. (2002). *A First Course in Probability* (6th ed.). Pearson.
5. Grimmett, G. R., & Stirzaker, D. R. (2001). *Probability and Random Processes* (3rd ed.). Oxford University Press.
6. Rosenthal, J. (2006). *A First Look at Rigorous Probability Theory* (2nd ed.). World Scientific.
7. Feller, W. (1968). *An Introduction to Probability Theory and Its Applications* (Vol. 1, 3rd ed.). Wiley.

HYDRODYNAMICS

Course code: MSDSMAT0904 (A)	Course Title: Hydrodynamics
Semester-IX	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. The objective of this course is to provide a treatment of topics in Hydrodynamics to a standard where the student will be able to apply the techniques used in deriving a range of important results and in research problems.
2. The objective is to provide the student with knowledge of the fundamentals of Hydrodynamics and an appreciation of their application to real-world problems.

Units	Topics	Number of Lectures
I	Some basic properties of fluid, viscous and inviscid fluids, Newton's Law of Viscosity, Newtonian and non-Newtonian fluids, real and ideal fluids, and some important types of flows. Kinematics of fluid motion: Lagrangian and Eulerian methods to describe the fluid motion, velocity, acceleration of a fluid particle, material, local and convective derivatives, and illustrative examples. The equation of continuity in different coordinates, symmetrical forms of the equation of continuity, and boundary conditions.	15
II	Streamline, path line, streak line, velocity potential, vortex line, vortex tube, vortex filament, angular velocity, and illustrative examples. Euler's equation of motion, equation of motion under impulsive forces, and illustration through applications.	15
III	The energy equation and illustration through applications, Lagrange's hydrodynamical equations, Cauchy's integrals, and Helmholtz's vorticity equations. Bernoulli's equation and theorem: illustration through applications.	15
IV	Motion in Two dimensions: Stream function and the physical significance, complex potential, Cauchy-Reimann equation in polar form, complex potential for uniform flows, illustration through examples. Source and sinks in two dimensions, complex potential due to a source, sink and doublet in two dimensions, and illustration through examples. Images and their advantages, Image of a source, sink, and doublet with regard to a line and circle, Blasius theorem.	15

Course outcomes

CO1. The students will be able to state Newton's law of viscosity and explain the mechanics of fluids at rest and in motion by observing the fluid phenomena.

CO2. The students will be able to identify the fundamental concepts of hydrodynamics and their role in modern mathematics and applied contexts.

CO3. The students will be able to apply the Hydrodynamics concepts to diverse situations in Physics, engineering, and other mathematical contexts.

Suggested Readings

1. F. Charlton, Textbook on Fluid Dynamics, CBS Publishers, 2018.
2. W. Kaufmann, Fluid Mechanics, McGraw-Hill Book Company, 1958.
3. G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press, 2009.
4. M. D. Raisinghania, Fluid Dynamics, S Chand Publisher, 2nd Edition, 2020.
5. R. K. Bansal, A Textbook of Fluid Mechanics and Hydraulic Mechanics, Laxmi Publications,2018.

MATHEMATICAL MODELLING

Course code: MSDSMAT0904 (B)	Course Title: Mathematical Modelling
Semester-IX	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. The objective of the course is to understand the mathematical model of ODE of first order & second order, Population dynamics, genetics, and to be familiar with mathematical models of graphs.
2. Enable learners to use mathematical models in Medicine, Arms Race, Battles, and International Trade Dynamics, etc.

Units	Topics	Number of Lectures
I	Mathematical modeling: need, techniques, classification, and illustrative example. Mathematical Modeling through Ordinary Differential Equations of First Order: Linear Growth and Decay Models, Non-Linear Growth and Decay Models, Compartment Models, Dynamics problems – Geometrical problems.	15
II	Mathematical Modeling through Systems of Ordinary Differential Equations of First Order: Population Dynamics, Epidemics, Compartment Models, Economics, Medicine, Arms Race, Battles, and International Trade Dynamics.	15
III	Mathematical Modeling through Ordinary Differential Equations of Second Order: Planetary Motions, Circular Motion and Motion of Satellites, Mathematical Modeling through Linear Differential Equations of Second Order, Miscellaneous Mathematical Models.	15
IV	Mathematical modeling through partial differential equations: simple models, mass-balance equations, variational principles, probability generating function, traffic flow problems, initial & boundary conditions.	15

Course outcomes

CO1. After completing this course, the student gains knowledge about various aspects of Mathematical modeling, which is a motivating tool in areas such as applied mathematics, engineering, etc.

CO2. Students understand applications of differential equations, difference equations, and graph theory in Mathematical modeling.

Suggested Readings

1. J. N. Kapur, Mathematical Modeling, Wiley Eastern Limited, New Age International Pvt. Ltd., Reprint 2013.
2. J. N. Kapur, Mathematical Models in Biology and Medicine, Affiliated East-West Press, New Delhi, 1985.
3. R. Olink, Mathematical Models in Social and Life Sciences, 1978.

DISCRETE MATHEMATICS

Course code: MSDSMAT0904 (C)	Course Title: Discrete Mathematics
Semester-IX	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. The Objective of this course is to provide the fundamentals and the concepts of Discrete Mathematical Structures with Applications to Computer Sciences, including Mathematical Logic, Boolean Algebra and its Applications, Graphs and Trees.
2. The Objective of this course is to help the students understand the computational and algorithmic aspects of Sets, Relations, Mathematical Logic, Boolean algebra, Graphs, Trees, and Algebraic Structure in the field of Computer science and its applications.

Units	Topics	Number of Lectures
I	**Set Theory and Mathematical Logic:** Sets and Subsets, Venn Diagrams, Operations on sets, Laws of set theory, power sets and product of sets, principle of inclusion-exclusion. Proposition, Propositional Calculus-Propositional Variables and Compound propositions, Basic Logical Operations: Conjunction, Disjunction, Negation, Conditional, Biconditional. Compound Statements, Equivalence, Duality, Algebra of Statements, Valid and Invalid, Arguments, Tautologies, Contradiction, Contingency.	15
II	**Relations, digraphs and lattices:** Definition and Properties of relation, types of relation, digraph representation of relation, equivalence and partially ordered relation, transitive closure and Warshall's algorithm, posets and Hasse diagrams, Introduction to Lattice.	15
III	**Boolean Algebra and Applications:** Definition of Boolean Algebra, Laws of Boolean Algebra, Basic Theorems, Boolean Functions – Disjunctive Normal Form, Conjunctive Normal Form, Duality Principle. Boolean Expression – Sum of Products, Product of Sums, Minterm and Maxterm, Applications of Boolean Algebra.	15
IV	**Graph:** Finite graph, Infinite graph, Connected graph, Disconnected graph, Null graph. Subgraph, Incidence, Adjacency, Degree, Directed Graph, Walk, Path, Circuit, Wheel, Eulerian graph, Hamiltonian graph, Planar graph, Isomorphism of Graph, coloring of Graph. **Tree:** Properties of Tree, weighted tree, rooted tree, binary tree, Spanning Tree, Incidence Matrix, Adjacency Matrix.	15

Course outcomes

CO1. Demonstrate knowledge of how Sets and Relations are defined.
CO2. Explain Boolean algebra and circuit design.
CO3. Describe Lattices and Posets and their use.
CO4. Apply Graph theory and trees in Computer Science.

Suggested Readings

1. J. P. Tremblay, & R. Manohar, Discrete mathematical structures with applications to computer science. McGraw-Hill Inc., 1975.
2. Colmun, Busby, and Ross, Discrete Mathematical Structure, Prentice Hall India, 6th Edition, 2015.
3. C. L. Liu, Elements of Discrete Mathematics. (No Title), 1985.
4. K. H. Rosen, J. P. Tremblay, & R. Manohar, Discrete Mathematics and its Applications, Tata McGraw-Hill Pub. Co. Ltd., 2015.

CONTINUUM MECHANICS

Course code: MSDSMAT0904 (D)	Course Title: Continuum Mechanics
Semester-IX	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. The course of continuum mechanics aims to develop an understanding of the common mathematical foundation to describe the behavior of matter.
2. The course introduces the continuum hypothesis, deformation, stress, and strain tensors, and fundamental physical laws.
3. This course aims to discuss some applications of continuum mechanics to solid and fluid mechanics.

Units	Topics	Number of Lectures
I	Summation convention and indicial notation, coordinate transformation, contravariant, covariant, and mixed tensors, Algebra of tensors, Contraction theorem, Quotient law, Isotropic tensors, Tensor as operator, Symmetric and skew-symmetric tensors. Scalar, vector, and tensor functions, comma notation, Gradient of vector functions, Divergence and Curl of tensor functions, Laplacian operator in tensor form, Integral theorems for tensors.	15
II	Continuum Hypothesis, Configuration of a continuum, Mass and density, Description of motion, Material and spatial coordinates, Translation, Rotation, Deformation of a surface element, Deformation of a volume element, Isochoric deformation, Stretch and Rotation, Decomposition of a deformation, Deformation gradient, Strain tensors, Infinitesimal strain, Compatibility relations, Principal strains.	15
III	Material and Local time derivatives, Strain, rate tensor, Transport formulas, Streamlines, Path lines, vorticity and circulation, stress components, and Stress tensors, Normal and shear stresses, principal stresses.	15
IV	Law of conservation of mass, Law of conservation of linear and angular momentum, Law of conservation of energy, and their representing equations in material and spatial forms.	15

Course outcomes

CO1. The students will be able to apply the transformation of the rectangular coordinate system to physical problems.

CO2. Students derive the fundamental physical conservative laws and their governing equations.

CO3. Students may be able to develop mathematical models of various solid and fluid mechanics problems arising in natural and technological systems.

Suggested Readings

1. D. S. Chandrasekharaiah and L. Debnath, “Continuum Mechanics”, Academic Press, (1994).
2. A. J. M. Spencer, “Continuum Mechanics”, Dover Publications Inc., New York, (1980).
3. Y. C. Fung, “A First Course in Continuum Mechanics”, Prentice Hall (1977).
4. P. Chadwick, “Continuum Mechanics”, Dover Publications Inc., New York, (1976).
5. A. I. Borisenko, “Vector and Tensor Analysis with Applications”, Dover Publications, (2003).
6. P. Grinfeld, “Introduction to Tensor Analysis and the Calculus of Moving Surfaces”, Springer, (2013)

FOURIER ANALYSIS

Course code: MSDSMAT0904 (E)	Course Title: Fourier Analysis
Semester-IX	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective:

The objective of this course is:

1. To introduce the fundamental concepts and rigorous theory of Fourier series and Fourier transforms.
2. To develop skills in analyzing convergence, uniqueness, and summability of Fourier series.
3. To explore important theorems related to Fourier analysis and their applications.
4. To understand the applications of Fourier analysis in signal processing and harmonic analysis.

Units	Topics	Number of Lectures
I	**Fourier Series**–Definition, uniqueness, convolution, summability, convergence of Fourier series, Fourier series for square integrable functions, Plancherel theorem, Riesz-Fischer theorem, Gibbs phenomenon.	15
II	Riemann-Lebesgue lemma, A continuous function with a divergent Fourier series, Parseval's identity, Isoperimetric inequality, Weierstrass approximation theorem, Weyl’s equidistribution theorem.	15
III	Schwartz space on R, Fourier transform on the Schwartz space, Fourier transform of integrable and square-integrable functions, Poisson summation formula.	15
IV	Applications–Uncertainty principle, Paley-Wiener theorem, Wiener’s theorem, Shannon sampling theorem, multiplier theorem for integrable functions.	15

Course Outcomes:

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

CO1. Define and explain Fourier series and their key properties, such as uniqueness, convolution, and summability.

CO2. Analyze convergence criteria and behavior of the Fourier series for square integrable functions.

CO3. Understand the Plancherel theorem, Riesz-Fischer theorem, and Parseval's identity.

CO4. Describe the Gibbs phenomenon and the implications of the Riemann-Lebesgue lemma.

CO5. Explain the Schwartz space and compute Fourier transforms on this space.

CO6. Interpret and apply the Weierstrass approximation theorem, isoperimetric inequality, and Weyl's equidistribution theorem.

CO7. Demonstrate knowledge of key applications such as the uncertainty principle, Paley-Wiener theorem, Wiener's theorem, and Shannon sampling theorem.

Suggested Readings

1. **Stein E., Shakarchi R.**, Fourier Analysis. An Introduction: Princeton Lectures in Analysis, Princeton University Press.
2. **Stein, E.M. and Weiss, G**., Introduction to Fourier Analysis on Euclidean Spaces, Princeton University Press.
3. **Christensen, O.,** Functions, Spaces and Expansions, Springer, 2010.

NUMBER THEORY

Course code: MSDSMAT0904 (F)	Course Title: Number Theory
Semester-IX	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

Number theory is an important area of study in Mathematics. Without the knowledge of the behavior of various numbers and their properties, the study of Mathematics is, in a way is meaningless. After completing this course, students learn various concepts that have been used to study and apply in coding theory, cryptology besides in algebra and analysis.

Units	Topics	Number of Lectures
I	Euclid's division lemma and Divisibility. The Linear Diophantine Equation. The fundamental theorem of Arithmetic. Fermat's Little theorem, Wilson's Theorem, Generating functions, and Basic Properties of Congruence. Residue Systems, Linear Congruence. The Theorems of Fermat and Wilson Revisited. The Chinese Remainder Theorem. Polynomial Congruence.	15
II	Combinatorial Study of $\varphi(n)$, Formulae for d(n) and $\sigma(n)$, Multiplicative Arithmetic Functions. The Mobius Inversion Formula. Properties of Reduced Residue Systems. Primitive Roots Modulo p. Elementary properties of $\Pi(x)$. Tchebychev's Theorem.	15
III	Euler's Criterion. The Legendre Symbol. The Quadratic Reciprocity Law. Applications of the Quadratic Reciprocity Law. Consecutive Residues and Non-residues consecutive Triples of Quadratic Residues.	15
IV	Sum of Two Squares, Sum of Four Squares, Euler's Partition Theorem, Dirichlet's Divisor Problem.	15

Course outcomes

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

CO1. They can understand the number system.
CO2. They learn how to apply various concepts in coding theory, cryptology, besides in algebra and analysis.
CO3. They learn how to solve problems based on Residue Systems, Linear Congruence and Polynomial Congruence.
CO4. They learn to differentiate between Residues and Non-residues.

Suggested Readings

1. Andrews, George E. Number theory. Courier Corporation, 1994.
2. Niven, Ivan, Herbert S. Zuckerman, and Hugh L. Montgomery. An introduction to the theory of numbers. John Wiley & Sons, 1991.
3. Flath, Daniel E. Introduction to number theory. American Mathematical Soc., 2018.
4. Ireland, Kenneth, and Michael Ira Rosen. A classical introduction to modern number theory. Vol. 84. Springer Science & Business Media, 1990.
5. Fröhlich, Albrecht, and Martin J. Taylor. Algebraic number theory. No. 27. Cambridge University Press, 1991.

MEASURE THEORY

Course code: MSDSMAT1001	Course Title: Measure Theory
Semester-X	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objectives

This course aims to:

1. Introduce the foundational concepts of σ-algebras and measures, with a focus on Lebesgue measure and integration.
2. Develop the theory of measurable functions and the Lebesgue integral.
3. Explore key convergence theorems (Monotone Convergence Theorem, Fatou's Lemma, Dominated Convergence Theorem) and their applications.
4. Examine signed measures, decompositions, and the Lebesgue-Radon-Nikodym theorem.
5. Analyze functions of bounded variation, absolute continuity, and differentiation of measures and integrals.

Units	Topics	Number of Lectures
I	Algebras and σ-algebras, Lebesgue Measure, Outer measures, Borel measure on the real line, Measurable functions, simple functions.	15
II	Integration of nonnegative functions, monotone convergence theorem, Integration of complex functions, Fatou's Lemma, Dominated convergence theorem.	15
III	Modes of convergence, Egoroff's theorem, Lusin's Theorem, the Lp-spaces, completeness of Lp-spaces, approximation by continuous functions.	15
IV	Signed measures, Hahn and Jordan decomposition theorems, the Lebesgue-Radon-Nikodym theorem, Functions of bounded variation, Differentiation of monotone functions, differentiation of an integral, and absolute continuity.	15

Course outcomes

Upon successful completion of this course, students will be able to:

CO1. Define and construct σ-algebras, measures, and measurable spaces, and describe properties of Lebesgue and Borel measures on $\mathbb{R}$.

CO2. Identify and work with measurable functions, simple functions, and understand their role in Lebesgue integration.

CO3. Apply and prove the Monotone Convergence Theorem, Fatou's Lemma, and the Dominated Convergence Theorem in integration theory.

CO4. Analyze different modes of convergence of measurable functions and apply Egoroff's and Lusin's theorems.

CO5. Define L^p-spaces, prove their completeness, and approximate functions in L^p-spaces using continuous functions.

CO6. Work with signed measures, understand Hahn and Jordan decompositions, and apply the Radon-Nikodym theorem.

CO7. Understand the concepts of bounded variation and absolute continuity, and apply theorems on differentiation of measures and integrals.

Suggested Readings

1. **H. L. Royden and P. M. Fitzpatrick**, *Real Analysis*, 4th Edition, Prentice Hall of India.
2. **Sheldon Axler**, *Measure, Integration & Real Analysis*, Springer, 2022.

MATHEMATICAL STATISTICS

Course code: MSDSMAT1002	Course Title: Mathematical Statistics
Semester-X	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objectives

The main objective of this course is to introduce:

1. The joint behavior of several random variables theoretically and through illustrative practical examples.
2. The theory underlying modern statistics is to give the student a solid grounding in (mathematical) statistics and the principles of statistical inference.
3. The application of the theory to the statistical modeling of data from real applications, including model identification, estimation, and interpretation.
4. The idea of Fisher information to find the minimum possible variance for an unbiased estimator, and to show that the MLE is asymptotically unbiased and normal.

Units	Topics	Number of Lectures
I	Random variables: discrete and continuous random variables, probability mass function (pmf), probability density function(pdf) and Cumulative distribution function (cdf), Joint probability mass function for two discrete random variables, Marginal probability mass function, Joint probability density function for two continuous random variables, Marginal probability density function, Independent random variables; Expected values, covariance, and correlation.	15
II	Linear combination of random variables and their moment generating functions; Conditional distributions and conditional expectation, Laws of total expectation and variance; Bivariate normal distribution, Distribution of important statistics such as the sample totals, sample means, and sample proportions, Central limit theorem, Law of large numbers.	15
III	Chi-squared, t, and F distributions; Distributions based on normal random samples; Concepts and criteria for point estimation, methods of moments and maximum likelihood estimation (MLE); Assessing estimators: Accuracy and precision, Unbiased estimation, Consistency and sufficiency, The Neyman factorization theorem, Rao-Blackwell theorem, Fisher Information, The Cramér-Rao inequality, Efficiency.	15

IV	Interval estimation and basic properties of confidence intervals, One-sample t confidence interval, Confidence intervals for a population proportion and population variance. Statistical hypotheses and test procedures, One-sample tests about a population mean and a population proportion, P-values for tests; The simple linear regression model and its estimating parameters; Chi-squared goodness-of-fit tests, Two-way contingency tables.	15

Course outcomes

The course will enable the students to:

CO1. Understand joint distributions of random variables, including the bivariate normal distribution.
CO2. Estimate model parameters through statistical inference based on point estimation and hypothesis testing.
CO3. Apply the Rao-Blackwell theorem to improve estimators and use the Cramér-Rao inequality to determine the lower bound on the variance of unbiased estimators.
CO4. Understand the theory and application of linear regression models and contingency tables.

Suggested Readings

1. Rohatgi, V. K., & Saleh, A. K. Md. E. (2001). *An Introduction to Probability and Statistics* (2nd ed.). Wiley.
2. Gupta, S. C., & Kapoor, V. K. (2008). *Fundamentals of Mathematical Statistics* (4th ed., Reprint). Sultan Chand & Sons.
3. Devore, J. L., Berk, K. N., & Carlton, M. A. (2021). *Modern Mathematical Statistics with Applications* (3rd ed.). Springer.
4. Devore, J. L. (2016). *Probability and Statistics for Engineering and the Sciences* (9th ed.). Cengage Learning India Private Limited, Delhi. Fourth impression 2022.
5. Hogg, R. V., McKean, J. W., & Craig, A. T. (2019). *Introduction to Mathematical Statistics* (8th ed.). Pearson. Indian Reprint 2020.
6. Mood, A. M., Graybill, F. A., & Boes, D. C. (1974). *Introduction to the Theory of Statistics* (3rd ed.). Tata McGraw-Hill Publishing Co. Ltd. Reprinted 2017.
7. Wackerly, D. D., Mendenhall III, W., & Scheaffer, R. L. (2008). *Mathematical Statistics with Applications* (7th ed.). Cengage Learning.

SPECIAL FUNCTIONS

Course code: MSDSMAT1003 (A)	Course Title: Special Functions
Semester-X	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. The objective in this course is to introduce the special functions like Gauss hypergeometric, Legendre functions, with their integral representations.
2. The objective is to enlighten the students with the Bessel's function, Hermite function, etc, with its properties like recurrence relations, orthogonal properties, generating functions, etc.
3. This course develops the understanding of how special functions are useful in differential equations.

Units	Topics	Number of Lectures
I	**The Gamma And Beta Functions:** The Gamma function, a series for $\Gamma'(z)/\Gamma(z)$, Evaluation of $\Gamma(1)$ and $\Gamma'(1)$, the Euler product for $\Gamma(z)$, The difference equation $\Gamma(z+1) = z\Gamma(z)$, the order symbols o and O, Evaluation of certain infinite products, Euler's integral for $\Gamma(z)$, The Beta function, the value of $\Gamma(z)\Gamma(1-z)$, the factorial function, Legendre's duplication formula, Gauss' multiplication theorem.	15
II	**Hypergeometric Functions:** Solution of a homogeneous linear differential equation of order two. Second-order differential equation with three regular singularities. Hypergeometric equation and its properties. Confluent hypergeometric equation. The contiguous function relations. A simple integral, the function pFq with unit argument, Saalschutz theorem, Whipple's theorem, Dixon's theorem, Contour integrals of Barnes type. The Barnes integrals and the function pFq.	15
III	**Legendre polynomials:** Properties of Legendre polynomials. Complete solution of Legendre's differential equation. Recurrence formulae for $Q_n(z)$. Rodrigue's formula. Generating functions. Orthogonal properties. Hypergeometric forms of $P_n(z)$.	15
IV	**Bessel Functions:** Properties of Bessel Functions. Generating functions. Recurrence relations. Orthogonal properties.	15

Course outcomes

- **CO1.** The students will be able to explain the applications and the usefulness of special functions.
- **CO2.** The students will be able to analyze properties of special functions.
- **CO3.** The students will be able to understand Hypergeometric Functions and its properties.
- **CO4.** The students will be able to understand Legendre polynomials and its properties.
- **CO5.** The students will be able to understand the Bessel Function and its properties.

Suggested Readings

1. W. W. Bell, Special functions for scientists and engineers. Courier Corporation, 2004.
2. E.D. Rainville's, Special Functions, Chelsea Publishing Company, 1971.
3. P. W. Karlsson, H. M. Srivastava, and H. L. Manocha, A treatise on generating functions, 1988.
4. L. J. Slater, Generalised hypergeometric series, Cambridge Univ. Press Cambridge, 1966.
5. G. E. Andrews, R. Askey, R. Roy, R. Roy & R. Askey, Special functions, Cambridge: Cambridge University Press, 1999.

WAVELET ANALYSIS

Course code: MSDSMAT1003 (B)	Course Title: Wavelet Analysis
Semester-X	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course Objective

The objective of this course is:

1. To introduce fundamental concepts of Fourier analysis and wavelet theory.
2. To develop an understanding of key theorems such as Plancherel formula, Poisson summation, and Shannon sampling.
3. To explore continuous and discrete wavelet transforms and their applications.
4. To study frames, Riesz systems, and multi-resolution analysis for constructing orthogonal wavelet bases.
5. To analyze properties of wavelets, including smoothness, support, and construction of compactly supported wavelets.
6. To familiarize students with spline and Franklin wavelets and their applications in signal processing.

Units	Topics	Number of Lectures
I	Basic Fourier Analysis: Fourier transform of square integrable functions, Plancheral formula, Poisson Summation formula, Shannon sampling theorem, Heisenberg Uncertainty principle.	15
II	Continuous Wavelet transform, Plancherel formula, Inversion formulas. Frames, Riesz Systems, Discrete wavelet transform.	15
III	Orthogonal bases of wavelets, Multi-resolution analysis (MRA), Smoothness of wavelets, Compactly supported wavelets, Construction of compactly supported wavelets.	15
IV	Franklin wavelets and Spline wavelets on the Real line, Orthonormal bases of periodic splines, Characterization of MRA wavelets, low-pass filters, and scaling functions.	15

Course Outcomes

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

CO1. Understand and apply the Fourier transform to square-integrable functions.

CO2. Use the Plancherel formula and Poisson summation formula in Fourier analysis.
CO3. Explain the Shannon sampling theorem and the Heisenberg uncertainty principle.
CO4. Perform continuous wavelet transform and apply Plancherel and inversion formulas.
CO5. Understand and utilize frames and Riesz systems in wavelet theory.
CO6. Conduct discrete wavelet transforms and construct orthogonal wavelet bases.
CO7. Explain multi-resolution analysis (MRA) and its role in wavelet construction.
CO8. Analyze smoothness and compact support properties of wavelets.
CO9. Construct compactly supported wavelets.
CO10. Describe the Franklin wavelets and the spline wavelets on the real line.
CO11. Understand orthonormal bases of periodic splines.
CO12. Characterize MRA wavelets through low-pass filters and scaling functions

Suggested Readings

1. **E. Hernández and G. Weiss**, *A First Course on Wavelets*, CRC Press, New York, 1996.
2. **C. K. Chui**, *An Introduction to Wavelets*, Academic Press, 1992.
3. **I. Daubechies**, *Ten Lectures on Wavelets*, CBMS-NSF Regional Conference Series in Applied Mathematics, Vol. 61, SIAM, 1992.
4. **Christensen, O.,** Functions, Spaces and Expansions, Springer, 2010.

FLUID MECHANICS

Course code: MSDSMAT1003 (C)	Course Title: Fluid Mechanics
Semester-X	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. Prepare a foundation to understand the motion of fluid, which enables solving the problems of fluid flow and helps in advanced studies and research in Fluid Mechanics.
2. Introduce the Navier-Stokes equation.
3. Introduce the dynamical similarity between the prototype and the actual model and its significance.

Units	Topics	Number of Lectures
I	General theory of Stress and Rate of strain: Newton's law of viscosity, body and surface forces, Definitions of stress, stress vector and components of stress tensor, state of stress at a point, transformation of stress components, plane stress, principal stress and principal directions of the stress tensor, nature of strain, transformation of the rate of strain components, Stokes law of viscosity, The rate of strain quadric translation, rotation and rate of deformation, and illustrative examples.	15
II	The Navier-Stokes equations of motion of a viscous fluid, the energy equation, the equation of state for a perfect fluid, diffusion of vorticity, equations of vorticity and circulation, dissipation of energy in Cartesian form, and illustrative examples. Vorticity transport equation, Diffusion of a vertex filament.	15
III	Dynamical similarity, Reynolds principle of similarity, and its significance, inspection analysis in the case of the flow of viscous compressible fluid. Physical significances of non-dimensional numbers, some dimensionless coefficients: Local skin friction, Lift and drag coefficient, Nusselt number, temperature recovery factor, and illustration through applications. Buckingham's pi-theorem & its applications.	15
IV	Some exact solutions of Navier-Stokes equations: Determination of velocity distribution in steady laminar flow of viscous incompressible fluid: Plane Couette flow, generalized plane Couette flow, plane Poiseuille flow, the Hagen Poiseuille flow, and flow between two coaxial circular cylinders.	15

Course outcomes

CO1. Students will understand the relation between stress and the rate of strain.

CO2. Students will know the formation of the Navier-Stokes equation.

CO3. Students will be able to illustrate Buckingham's pi-theorem & its applications.

CO4. Students can determine the velocity distribution in steady laminar flow of viscous incompressible fluid in diverse geometrical setups.

Suggested Readings

1. F. Chorlton, Textbook on Fluid Dynamics, CBS Publishers, 2018.
2. W. Kaufmann, Fluid Mechanics, McGraw-Hill Book Company, 1958.
3. G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press, 2009.
4. M. D. Raisinghania, Fluid Dynamics, S Chand Publisher, 2nd Edition, 2020.
5. R. Aris, Vectors, Tensors and the Basic equations of Fluid Mechanics, Dover Publishers, 1990.

FRACTAL GEOMETRY

Course code: MSDSMAT1003 (D)	Course Title: Fractal Geometry
Semester-X	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course Objectives

By the end of the course, students will:

1. Understand foundational concepts in set theory, metric spaces, and functions relevant to the study of fractals.
2. Explore the structure and properties of fractals through iterated function systems.
3. Analyze the dimensional properties of fractals using Hausdorff and box-counting dimensions.
4. Study interpolation techniques leading to fractal interpolation functions and their applications.
5. Examine the use of classical calculus tools in the context of non-differentiable fractal functions.

Units	Topics	Number of Lectures
I	Basic set theory, functions and limits, Euclidean distance, Complete metric spaces, Compact sets, Hausdorff metric, Place where fractals live, Completeness of the space of fractals, Contraction mapping theorem, Definition and examples of iterated function systems, Contraction mappings on the space of fractals.	15
II	Fractals constructed by iteration, self-similar sets, self-affine sets, continued fraction examples, dimensions of graphs, the Weierstrass function, and self-affine graphs.	15
III	Measures and mass distributions, Hausdorff measure, Hausdorff dimension, Basic methods of calculating dimensions, Box-counting dimensions, Properties of box-counting dimension.	15
IV	Interpolation functions, Fractal interpolation function and its properties, Fractal dimension of fractal interpolation functions, Hidden variable fractal interpolation function, Classical calculus on fractal interpolation functions.	15

Course outcomes

After successful completion of the course, students will be able to:

CO1. Apply concepts of metric spaces, compactness, and completeness to describe and analyze fractal structures.
CO2. Demonstrate understanding of the contraction mapping theorem and use it to prove the existence of fixed points in the space of fractals.
CO3. Construct and analyze fractals using iterated function systems.
CO4. Compute and interpret various types of fractal dimensions for different sets.
CO5. Formulate and analyze fractal interpolation functions, including their properties and dimensions.

Suggested Readings

1. **Michael F. Barnsley**, *Fractals Everywhere*, Academic Press, 1988.
2. **Kenneth Falconer**, *Fractal Geometry: Mathematical Foundations and Applications*, 2nd Edition, Wiley, 2004.
3. **Gerald Edgar**, *Measure, Topology, and Fractal Geometry*, 2nd Edition, Springer, 2008.

OPERATIONS RESEARCH

Course code: MSDSMAT1003 (E)	Course Title: Operations Research
Semester-X	Course Credits: 4
Contact Hours per Week (L-T-P): 4-0-0	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. The objective of this course is to develop those parts of the optimization theory that apply to linear and Network models. Students will learn the tools and techniques of quantitative analysis outlined in the schedule, how and when to apply them, and practice the application of those tools. Students completing this goal will be prepared to quantify a variety of policy problems for analysis and decision-making. The syllabus includes Linear, Non-linear Programming, Transportation, Decision Theory, and Project Management.
2. The objective of this course is intended for students using concepts of optimization in Engineering and Information technology.

Units	Topics	Number of Lectures
I	**Introduction & Linear Programming:** Basic Definition, Nature and Significance of OR, Features of OR Approach, Application and Scope of OR, General Methods for Solving OR Models. General Structure of Linear Programming, Advantages and Limitations of Linear Programming, Application Areas of Linear Programming. Multiple Solutions, Unbounded Solutions, Infeasible Solution	15
II	**Simplex Method & Duality in LPP:** Maximization and Minimization Problem, Two-Phase Method, Big M Method. Dual Linear Programming Problem, Rules for Constructing the Dual from Primal, Feature of Duality.	15
III	**Transportation Problem:** Mathematical Model of Transportation Problem, Transportation Method, North West Corner Method, Linear Cost Method, Vogel's Approximation Method, Unbalanced Supply and Demand, Degeneracy Problem, Alternative Optional Solution, Maximization Transportation Problem, Trans-Shipment Problem.	15
IV	**Decision Theory & Decision Tree, Theory of Games:** Steps in DT Approach, types of Decision Making Environments, Criterion of Optimism and Pessimism, Equally Likely Decision Criterion, Decision Making under Risk, Decision Tree Analysis. Two Person Zero-Sum Games, Pure Strategies, Game with Saddle Point, Games without Saddle Point, Rule of Dominance, Methods for Solving Problems without Saddle.	15

Course outcomes

CO1. Identify the real-life problem for which a linear and dynamic optimization model is developed.

CO2. Define an accurate linear model and IPP.

CO3. Understand the mathematics of optimization techniques used for linear and network models.

CO4. Apply optimization techniques in the areas of linear programming and network models.

Suggested Readings

1. G. Hadley, Linear Programming, Addison-Wesley, Mass, 2002.
2. H. A. Taha, Operations research: an introduction. Pearson Education India, 2013.
3. F. S. Hillier, & G. J. Liebermann, Operations Research: Einführung, Walter de Gruyter GmbH & Co KG, 2014.
4. K. Swarup, P. K. Gupta, & M. Mohan, Operations Research, 247-293. S Chand & Sons, New Delhi.

PRACTICAL (R-Programming)

Course code: MSDSMAT1004	Course Title: Practical (R-Programming)
Semester-X	Course Credits: 4
Contact Hours per Week (L-T-P): 0-0-4	Continuous Internal Assessment: 25 Marks
Semester Examination Duration: 3 Hours	Semester Examination: 75 Marks

Course objective

1. This course is designed to build the foundation of R-Programming among the students.
2. Course introduces fundamentals of R programming, including installation, variable creation, and basic data structures like vectors, matrices, and data frames.
3. The course aims to develop abilities among students in data import/export and control flow commands, such as loops and conditional statements in R.
4. This course equips students with skills in data visualization using R, covering histograms, bar plots, box plots, and pie diagrams with customization options.
5. The course objective is to provide hands-on practice with R functions through practical exercises, including matrix operations, vector manipulation, and constructing informative plots.

Units	Topics	Number of Hours
I	Fundamentals, installation and use of R software, Creation of new variables, vectors, matrices, data frames, lists, accessing elements of a vector or matrix, import and export of files, for loop, repeat loop, while loop, if command, if else command, R-functions.	8
II	The plot command, histogram, bar plot, box plot, pie diagram, inserting mathematical symbols in a plot, adding text/legend to a plot, and other customizations of a plot.	7
III	**Programs:** **1.** Find the addition and subtraction of two matrices. **2.** Find the product of two matrices. **3.** Find the inverse of the matrix. **4.** Check whether the given number is prime or not. **5.** Print the Fibonacci sequence. **6.** Find the sum of two vectors. **7.** Find the scalar and vector product of two vectors. **8.** Write R code to find all possible roots of the quadratic equation. **9.** From the pre-summarized data, note column and row names. Make the columns of the object available by name. Construct plots. Add axes labels and legends. **10.** From the pre-summarized data in a table, draw a bar plot and a histogram plot. Add axes labels and legends. **11.** R Program to create a Histogram. **12.** R Program to create a bar plot.	90

	13. R Program to create a box plot. 1 **14.** R Program to insert mathematical symbols in a plot. **15.** R Program to create a pie diagram.	

Course outcomes

After the completion of the course, the students will be able to:

CO1. Perform different operations on R software, create and manipulate variables, vectors, matrices, data frames, and lists.

CO2. Demonstrate proficiency in implementing loops, conditional statements, and custom functions for solving basic computational problems in R.

CO3. Create customized visualizations, including histograms, bar plots, and pie diagrams, effectively adding labels, legends, and mathematical symbols.

CO4. Apply R programming techniques to solve practical problems, perform matrix and vector calculations, and visualize data with appropriate plots.

Suggested Readings

1. Mark Gardener, Beginning R – The Statistical Programming Language, Wiley, 2013.
2. The Book of R: A First Course in Programming and Statistics, Tilman M. Davies, No Starch Press, Inc. https://web.itu.edu.tr/~tokerem/The_Book_of_R.pdf
3. Using R for Numerical Analysis in Science and Engineering, Victor A. Bloomfield, A Chapman & Hall Book. http://hsrm-mathematik.de/SS2020 /semester4 / Datenanalyse-und-Scientific Computing-mit-R/book.pdf
4. Robert Knell, Introductory R: A Beginner's Guide to Data Visualisation, Statistical Analysis and Programming in R, Amazon Digital South Asia Services Inc, 2013
5. The R Software-Fundamentals of Programming and Statistical Analysis -Pierre Lafaye de Micheaux, Rémy Drouilhet, Benoit Liquet, Springer 2013.