M. C. E. Society's
Abeda Inamdar Senior College
Of Arts, Science and Commerce, Camp, Pune-1
(Autonomous) Affiliated to SavitribaiPhule Pune University
NAAC accredited 'A' Grade

Two Year M.Sc. Degree Program in Mathematics
(Faculty of Science & Technology)

Syllabus for

M.Sc.-I (Mathematics)

Choice Based Credit System Syllabus
To be implemented from the academic year 2023-2024

Title of the Course: M.Sc (Mathematics)

Aims and Objectives of the Course

Sr. No.	Objectives
1.	To maintain an updated curriculum.
2.	To take care of fast development in the knowledge of mathematics
3.	To enhance the quality and standards of Mathematics Education.
4.	To provide a broad common framework, for exchange, mobility, and free dialogue across theIndian Mathematical and associated community.

Expected Course Specific Learning Outcome

Sr. No.	Objectives
1.	Students will have an aptitude to Study higher Mathematics and creative work in Mathematics.
2.	Students will equipped themselves with that part of Mathematics which is needed for various branches of Sciences or Humanities in which they have an aptitude for higher studies and original work.

Structure of M.Sc-I Mathematics Course

Sr. No.	Major Mandatory		Continuous Internal Evaluation (CIE) (Internal Marks)	End Semester Exam (External Marks)	Total Marks	Credits
	Semester-I	Semester-II				
1.	23SMMT11MM: Linear Algebra	23SMMT21MM: Advanced Calculus	50	50	100	04
2.	23SMMT12MM: Real Analysis	23SMMT22MM: General Topology	50	50	100	04

3.	23SMMT13MM: GroupTheory	23SMMT23MM: Rings and Modules	50	50	100	04
4.	23SMMT14MM: Ordinary Differential Equations	23SMMT24MM: Partial Differential Equations	25	25	50	02
5.	23SMMT11RM: Research Methodology	23SMMT21OJ: OJT/FP			100	04
Major Electives (Any One)						
6.	23SMMT11MEA: Discrete Mathematics	23SMMT21MEA: Coding Theory	50	50	100	04
7.	23SMMT11MEB: Advanced Numerical Analysis	23SMMT21MEB: Integral Equations	50	50	100	04
8.	23SMMT11MEC: course from Swayam /NPTEL / E-Pathashala etc.	23SMMT21MEC: course from Swayam /NPTEL / E-Pathashala etc.			100	04

Structure of M.Sc-II Mathematics Course

Sr. No.	**Major Mandatory**		**Continuous Internal Evaluation (CIE) (Internal Marks)**	**End Semester Exam (External Marks)**	**Total Marks**	**Credits**
	Semester-III	**Semester-IV**				
1.	23SMMT31MM: Complex Analysis	23SMMT41MM: Functional Analysis	50	50	100	04
2.	23SMMT32MM: FieldTheory	23SMMT42MM: Differential Geometry	50	50	100	04
3.	23SMMT33TMM: Programming withPython (Theory)	23SMMT43TMM: Introduction to Data Science (Theory)	25	25	50	02

4.	23SMMT33PMM: Programming with Python (Practical)	23SMMT43PMM: Introduction to Data Science (Practical)	25	25	50	02
5.	23SMMT34MM: Fourier Series and Boundary Value Problems	-	25	25	50	02
6.	23SMMT31RP: Research Project	-			100	04
	-	23SMMT41RP: Research Project			150	06
Major Electives (Any One)						
6.	23SMMT31MEA: Probability and Stochastic Process	23SMMT41MEA: Number Theory	50	50	100	04
7.	23SMMT31MEB: Mechanics	23SMMT41MEB: Statistical Inference	50	50	100	04
8.	23SMMT31MEC: course from Swayam /NPTEL / E-Pathashala etc.	23SMMT41MEC: course from Swayam /NPTEL / E-Pathashala etc.			100	04

For Continuous Internal Evaluation (CIE), evaluation of theory courses will be done continuously throughout the semester. CIE will be of 50% marks for CGPA papers.

CIE for 4 credits theory paper: It will be divided as follows:

SR. NO.	COMPONENTS		MARKS
1.	CIE I	Mid Semester examination	15
2.	CIE II	Two Class Test of 15 marks each (Best of 2)	15
3.	CIE III	One Presentation/Seminar/ MCQ Test	10
4.	CIE IV	Class Assignments / One group discussion / Open Book Test	10
		TOTAL	**50**

CIE for 4 credits Practical paper: It will be divided as follows:

SR. NO.	COMPONENTS		MARKS
1.	CIE I	Mock Practical Examination	30
2.	CIE II	Viva Voce	10
3.	CIE III	Journal / project report/ dissertation report completion and certification on time.	10
		TOTAL	**50**

Above components will also be followed for 2 credit theory and practical paper.

Syllabus:

Course/ Paper Title	**Linear Algebra**
Course Code	**23SMMT11MM**
Semester	**I**
No. of Credits	**04**

Unit No	Title with Contents	No. of Lectures
Unit I	**Vector Spaces:**	**16**
	1. Definition and examples.	1
	2. Subspaces.	1
	3. Basis and dimension.	2
	4. Linear transformations.	2
	5. Quotient spaces.	2
	6. Direct sum.	3
	7. The matrix of a linear transformation.	3
	8. Duality	2
Unit II	**Canonical Forms:**	**16**
	1. Eigenvalues and eigenvectors.	3
	2. The minimal polynomial.	3
	3. Diagonalizable and triangulable operators.	4
	4. The Jordan form.	3
	5. The rational form.	3
Unit III	**Inner Product Spaces:**	**16**
	1. Inner products.	2
	2. Orthogonality.	2
	3. The adjoint of a linear transformation.	3
	4. Unitary operators.	3

	5. Self-adjoint and normal operators. 6. Polar and singular value decompositions.	3 3
Unit IV	**Bilinear Forms:**	**12**
	1. Definition and examples. 2. The matrix of a bilinear form. 3. Orthogonality. 4. Classification of bilinear forms.	1 3 4 4

Textbook:

Vivek Sahai, Vikas Bist, Linear Algebra, Narosa Publishing House.

ISBN 978-88-7319-392-7.

Unit I: Chapter 2.

Unit II: Chapter 3.

Unit III: Chapter 4.

Unit IV: Chapter 5.

References:

1. Books:

1. P. B. Bhattacharya, S. R. Nagpaul, S. K. Jain, First Course in Linear Algebra, 2nd Edition, New Age International Publishers.

2. S. Kumaresan, Linear Algebra A Geometric Approach, PHI Learning Private Ltd.

3. Charles W. Curtis, Linear Algebra An Introductory Approach, Springer.

4. Michael Artin, Algebra, Pearson India Education Services Pvt. Limited.

2. Website:

1. http://math.mit.edu/~gs/linearalgebra/

2. MIT 18.06 Linear Algebra, Spring 2005. Instructor: Gilbert Strang
https://www.youtube.com/results?search_query=linear+algebra+gilbert+strang+

Course/ Paper Title	Real Analysis
Course Code	23SMMT12MM
Semester	I
No. of Credits	04

Unit No	Title with Contents	No. of Lectures
Unit I	**The Real Numbers: Sets, Sequences, and Functions:**	10
	1. Countable and Uncountable Sets. 2. Open Sets; Closed Sets; and Borel Sets of Real Numbers. 3. Sequences of Real Numbers. 4. Continuous Real-Valued Functions of a Real Variable.	2 3 2 3
Unit II	**Lebesgue Measure:**	20
	1. Introduction. 2. Lebesgue Outer Measure. 3. The σ- Algebra of Lebesgue Measurable Sets. 4. Outer and Inner Approximation of Lebesgue Measurable Sets. 5. Countable Additivity; Continuity; Borel-Cantelli Lemma. 6. Non-measurable Set. 7. Cantor Set and the Cantor-Lebesgue Function.	1 3 3 3 4 3 3
Unit III	**Lebesgue Measurable Functions:**	10
	1. Sums; Products and Compositions. 2. Sequential Pointwise Limits and Simple Approximation. 3. Littlewood's Three Principles; Egoroff's Theorem; and Lusin's Theorem.	2 4 4
Unit IV	**Lebesgue Integration:**	20

	1. The Riemann Integral.	2
	2. The Lebesgue Integral of a Bounded Measurable Function over a Set of Finite measure.	4
	3. The Lebesgue Integral of a Measurable Nonnegative Function.	4
	4. The General Lebesgue Integral.	3
	5. Countable Additivity and Connuity of Integration.	3
	6. Uniform Integrability: The Vitali Convergence Theorem.	4

Textbook:

H. L. Royden, P. M Fitzpatrick, Real Analysis, Fourth Edition, PHI.

Unit I: Chapter 1: Sec. 1.3 - 1.6.

Unit II: Chapter 2: Sec. 2.1 - 2.7.

Unit III: Chapter 3: Sec. 3.1 - 3.3.

Unit IV: Chapter 4: Sec. 4.1 - 4.6.

Reference:

1. Books:

1. N. L. Carothers, Real Analysis, Cambridge University Press, ISBN: 9781139643160.
2. Elias M. Stein and Rami Shakarchi, Real Analysis: Measure Theory, Integration, and Hilbert Spaces, Princeton University Press.

2. Website:

1. Measure Theory Instructor: Prof. Inder Kumar Rana IIT Bombay.
https://www.youtube.com/results?search_query=measure+therory+inder+kumar+rana

Course/ Paper Title	**Group Theory**
Course Code	**23SMMT13MM**
Semester	**I**
No. of Credits	**04**

Unit No	Title with Contents	No. of Lectures
Unit I	**Groups, Subgroups, and Cyclic Groups:**	**08**
	1. Definition and Examples of Groups; Properties of Groups; Order of a finite group; Order of an element in a group; Subgroups;Subgroup Tests. 2. Cyclic Groups; Properties of Cyclic Groups; Classification of Subgroups of Cyclic Groups	4 4
Unit II	**Permutation Groups- Isomorphism:**	**12**
	1. Permutations Groups; Definition and notation; Cycles; Properties of Permutations; Even and odd permutations; Alternating Group of degree n. 2. Isomorphism of Group; Properties of Isomorphisms; Cayley's Theorem; Automorphisms	6 6
Unit III	**Cosets, Lagrange's Theorem, External Direct Product:**	**12**
	1. Cosets; Lagrange's Theorem and consequences; Stabilizer and orbit;Orbit stabilizer theorem. 2. External Direct Products; Properties of External Direct Products;Group of units modulo n as an external direct product.	6 6
Unit IV	**Normal Subgroups, Homomorphisms:**	**12**
	1. Normal Subgroups; Factor Groups; Application of Factor Groups;Internal Direct Products. 2. Group Homomorphisms; Definition and examples; Properties of Homomorphisms;First Isomorphism Theorem.	6 6
Unit V	**Sylow Theorems:**	**12**
	1. Fundamental Theorem of Finite Abelian Groups; Isomorphism Classesof Abelian Groups; Proof of the Fundamental Theorem. 2. Conjugacy Classes; Class Equation; The Sylow Theorems; Applications of Sylow's Theorems.	6 6

Unit VI	**Group Actions:**	**04**
	1. Group Actions; Definition and examples; Permutation representation associated with a given action; Faithful action; Kernel; Left regular action.	4

Textbooks:

1. Joseph Gallian, Contemporary Abstract Algebra, 9th Edition, Cengage Learning India Pvt. Ltd. ISBN-10 9353502527

Unit I: Chapters: 2, 3, 4.

Unit II: Chapters: 5 (except last article: A check Digit Scheme based on D_5), 6.

Unit III: Chapters: 7 (except: Rotations of a cube and Soccer Ball and subsequent Article), 8 (except: Applications).

Unit IV: Chapters: 9, 10.

Unit V: Chapters: 11, 24.

2. David S. Dummit, Richard M. Foote, Abstract Algebra, 2nd Edition, John Wiley and Sons (Indian Edition)

Unit VI: Chapter: 1 only Article 1.7.

Reference:

1. Books:

1. I. S. Luthar, I. B. S. Passi, Algebra (Vol 1), Groups; Narosa Publication House.
2. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd.
3. M. Artin, Algebra, Prentice Hall.
4. N. S. Gopalkrishnan, University Algebra, Wiley Eastern Ltd.
5. J. B. Fraleigh, A First Course in Abstract Algebra, 7th Edition, Pearson Edition Ltd.
6. P.B.Bhattacharya, S.K. Jain, S.R. Nagpaul, Basic Abstract Algebra Second Edition, Cambridge University Press.

2. Website:

1. Introduction to Abstract Group Theory - Krishna Hanumanthu | CMI - NPTEL
https://www.youtube.com/results?search_query=introduction+to+abstract+group+theory+krishna+hanumanthu

Course/ Paper Title	**Ordinary Differential Equations**
Course Code	**23SMMT14MM**
Semester	**I**
No. of Credits	**02**

Unit No.	Title with Contents	No. of Lectures
Unit I	**Linear Equations with Constant Coefficients:**	**8**
	1. Revision: Linear equations of the first order, the equation $y' + ay = 0$, the equation $y' + ay = b(x)$, the general linear equations of first order.	1
	2. Second order homogeneous equation.	1
	3. Initial value problems for second order equations.	1
	4. Linear dependence and independence.	1
	5. A formula for the Wronskian.	1
	6. The non-homogeneous equation of order two.	1
	7. The homogeneous equation of order n.	1
	8. The non-homogeneous equation of order n.	1
Unit II	**Linear Equations with Variable Coefficients:**	**7**
	1. Initial value problems for the homogeneous equation.	1
	2. Solutions of the homogeneous equation.	1
	3. The Wronskian and linear independence.	1
	4. Reduction of the order of a homogeneous equation.	1
	5. The non-homogeneous equation.	1
	6. Homogeneous equations with analytic coefficient.	1
	7. The Legendre equation.	1
Unit III	**Linear Equations with Regular Singular Points:**	**4**
	1. Introduction.	1
	2. Euler equation.	1

	3. Second order equation with regular singular points- an example. 4. The Bessel equation.	1 1
Unit IV	**Existence and uniqueness of solutions to first order equations:**	**7**
	1. Introduction. 2. Equations with variables separated. 3. Exact equations. 4. The method of successive approximations. 5. The Lipschitz condition. 6. Approximation to, and uniqueness of, solutions.	1 1 1 1 1 2
Unit V	**Existence and Uniqueness of solutions to Systems and n-th Order Equations:**	**4**
	1. System as vector equations. 2. Existence and uniqueness of solutions to systems. 3. Existence and uniqueness for linear systems.	1 1 2

Textbook:

E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall.
Unit I: Chapter 1: Sections 4, 5, 6, 7. Chapter 2: Sections 1, 2, 3, 4, 5, 6, 7, 10.
Unit II: Chapter 3: Sections 1, 2, 3, 4, 5, 6, 7, 8.
Unit III: Chapter 4: Sections 1, 2, 3, 4, 6, 7, 8.
Unit IV: Chapter 5: Sections 1, 2, 3, 4, 5, 8.
Unit V: Chapter 6: Sections 5, 6, 7.

Reference:

1. Books:

1. G. F. Simmons, S. G. Krantz, Differential Equations (Tata McGraw-Hill).

2. Lawrence Perko, Differential Equations and Dynamical Systems Third Edition, Springer.

2. Website:

http://gibbs.if.usp.br/~marchett/fismat2/linear-ode_coddington-carlson.pdf

Course/ Paper Title	**Research Methodology**
Course Code	**23SMMT11RM**
Semester	**I**
No. of Credits	**4**

Syllabus

Unit No	Title with Contents	No. of Lectures
Unit I	**Scientific Research and Literature Survey**	**10**
	1. Finding and solving research problems,	1
	2. Role of a supervisor.	1
	3. Survey of a research topic.	1
	4. Publishing a paper.	1
	5. Reviewing a paper.	1
	6. Funding agencies.	1
	7. Research grant proposal writing.	1
	8. Copyright issues, Ethics and plagiarism.	1
	9. MathSciNet, ZMATH, Scopus, ISI Web of Science, Impact factor, h-index.	1
	10. Google Scholar, ORCID, JStor, Online and open access journals.	1
Unit II	**Introduction to LaTeX**	**02**
	1.1 Definition and application of LaTeX, Preparation and Compilation of LaTeX input file	01
	1.2 LaTeX Syntax and Keyboard Characters in LaTeX	01
Unit III	**Formatting Words, Lines, and Paragraphs**	**04**

	2.1 Text and Math Mode Fonts, Emphasized and Colored Fonts.	01
	2.2. Labeling and Referring Numbered Items.	01
	2.3. Texts Alignment and Quoted text.	01
	2.4. New Lines and Paragraphs.	01
Unit IV	**Listing and Table Preparation**	**06**
	3.1 Listing Texts.	02
	3.2 Table Through the tabular Environment and tabularx Enviroment.	01
	3.3 Vertical Positioning of Tables, Sideways (Rotated) Texts in Tables.	01
	3.4 Merging Rows and Columns of Tables.	02
Unit V	**Equation Writing**	**03**
	4.1 Basic Mathematical Notations and Delimiters.	01
	4.2 Mathematical Operators, Mathematical Expression in Text- mode.	01
	4.3 Simple Equations and Array of Equations.	01
Unit VI	**Figure Insertion and Figure Drawing**	**03**
	5.1 Commands and Environment for Inserting Figures.	01
	5.2 Inserting a simple figure.	01
	5.3 tikz package for drawing figures.	01
Unit VII	**Presentation Using Beamer**	**04**
	6.1 Frames and Sectional Units in Presentation.	02
	6.2 Presentation Structure.	01
	6.3 Appearance of a Presentation (Beamer Themes).	01
Unit VIII	**Getting Started with SageMath**	**03**
	7.1 Introduction and Installation of SageMath.	01
	7.2 Exploring integers, solving equations in SageMath.	01

	7.3 2D and 3D plotting in SageMath.	01
Unit IX	**Calculus with SageMath**	**08**
	8.1 Calculus of one variable with SageMath.	01
	8.2 Applications of derivatives.	01
	8.3 Applications of Integrals.	01
	8.4 Partial Derivatives and gradients, jacobians.	02
	8.5 Local maximum-minimum.	01
	8.6 Application of local maximum and minimum	02
Unit X	**Linear Algebra with SageMath**	**07**
	9.1 RREF and Solving system of linear Equations.	01
	9.2 Vector spaces in SageMath.	01
	9.3 Linear Transformations with SageMath.	01
	9.4 Eigenvalues and Eigenvectors with SageMath.	01
	9.3 Inner Product Spaces in SageMath.	01
	9.4 Gram-Schmidt Process.	02
Unit XI	**Numerical Analysis with SageMath**	**10**
	10.1 QR- Factorization, Singular Value Decomposition (SVD).	03
	10.2 Numerical Solution of algebraic equations.	02
	10.3 Numerical Solutions of system linear equations.	01
	10.4 Interpolations.	02
	10.5 Numerical Integration.	02

Text book: **LaTeX**

1. Dilip Datta, LaTeX in 24 Hours, A Practical Guide for Scientific Writing, Springer

Unit II: Chapter-1.

Unit III: Chapter-2, Chapter-3 : 3.1, 3.2, 3.3, 3.4, 3.5.

Unit IV: Chapter -6: 6.1, Chapter-7: 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7.

Unit V: Chapter-11: 11.1,11.2, 11.3, 11.4 ,11.5.

Unit VI: Chapter-9: 9.1, 9.2.

Unit VII: Chapter 21: 21.1, 21.2, 21.3, 21.4.

2. Zofia Walczak, Graphics in LATEX using TikZ.

Reference Books: SageMath

1. Mathematical Computation with Sage by Paul Zimmermann available from on http://www.sagemath.org.

2. An Introduction to SAGE Programming: With Applications to SAGE Interacts for Numerical Methods by Razvan A Mezei, Springer.

3. Sage for Undergraduates, Gregory V. Bard.

Course/ Paper Title	**Discrete Mathematics**
Course Code	**23SMMT11MEA**
Semester	**I**
No. of Credits	**04**

Unit No	Title with Contents	No. of Lectures
	A] Graph Theory	
Unit I	**Topics in Graph Theory**	**15**
	1. Graphs; Graphs as Models; Matrices and Isomorphism; Decomposition and Special Graphs; Degree of a vertex; Counting and Bijections. 2. Paths, Cycles, Trails: Connection in Graphs; Bipartite Graphs; Eulerian Circuits; Hamiltonian Cycles. 3. Directed Graphs: Definition and Examples; Vertex Degrees; Eulerian Digraphs.	5 5 5
Unit II	**Trees**	**12**
	1. Trees: Properties of Trees; Distance in Trees and Graphs. 2. Enumeration of Trees: Spanning Trees in Graphs; Minimum Spanning Trees; Shortest Paths; Connectivity; Edge Connectivity. 3. Trees in Computer Science.	5 5 2
Unit III	**Matchings**	**3**
	1. Maximum Matchings; Hall's Matching Condition.	3
	B] Combinatorics	
Unit IV	**Basic Counting Principles**	**10**

	1. Two Basic Counting Principles. 2. Simple Arrangements and Selections. 3. Arrangements and Selections with Repetitions. 4. Distributions. 5. Binomial Identities.	2 2 2 2 2
Unit V	**Generating Functions**	**10**
	1. Generating Functions Models. 2. Calculating Coefficients of Generating Functions. 3. Partitions. 4. Exponential Generating Functions.	3 3 2 2
Unit VI	**Recurrence Relations**	**10**
	1. Recurrence Relations Models. 2. Solutions of Linear Recurrence Relations. 3. Counting with Venn Diagrams. 4. Inclusion-Exclusion Formula	3 3 2 2

Textbooks:

1. Douglas B. West: Introduction to Graph Theory; 2nd Edn; PHI Learning Pvt. Ltd.

   Unit I: Chapter 1: Sections 1.1, 1.2, 1.3 (Counting and Bijections), 1.4 (Definitions, Vertex Degrees, Eulerian Digraphs). Chapter 7: Section 7.2 (Hamiltonian Cycles).

   Unit II: Chapter 2: Section 2.1 (Properties of Trees; Distance), 2.2 (Enumeration of Trees; Spanning Trees), 2.3. Chapter 4: Sections 1.1 (Connectivity, Edge Connectivity).

   Unit III: Chapter 3: Section 3.1 (Maximum Matchings; Hall's Matching Condition).

2. Alan Tucker: Applied Combinatorics 6th Edn; Wiley India.

   Unit IV: Chapter 5: Sections 5.1 to 5.5.

   Unit V: Chapter 6: Sections 6.1 to 6.4.

   Unit VI: Chapter 7: Sections 7.1, 7.3. Chapter 8: Sections 8.1, 8.2.

References:

1. Books:

1. B. Kolman, R. Busby, S.C. Ross: Discrete Mathematical Structures, 6th Edn, Pearson Edn.

2. John Clark, D. A. Holton: A First Look at Graph Theory, World Scientific, 1991.

2. Website:

1.https://www.youtube.com/watch?v=E40r8DWgG40&list=PLEAYkSg4uSQ2fXcfrTGZdPuTmv98bnFY5

2. https://nptel.ac.in/courses/111/106/111106155/

Course/ Paper Title	**Advanced Numerical Analysis**
Course Code	**23SMMT11MEB**
Semester	**I**
No. of Credits	**04**

Unit No	Title with Contents	No. of Lectures
Unit I	**Root Finding Methods:**	**08**
	1. Convergence; Floating Point Number Systems; Floating Point Arithmetic.	3
	2. Fixed Point Interaction Schemes; Newton's Method; Secant Method; AcceleratingConvergence	5
Unit II	**System of Equations:**	**14**
	1. Gaussian Elimination; Pivoting Strategies.	3
	2. Error Estimates and Condition Number; LU decomposition; Direct Factorization.	4
	3. Iterative Techniques for Linear Systems: Basic Concepts and Methods.	4
	4. Nonlinear Systems of Equations.	3
Unit III	**Eigenvalues and Eigenvectors:**	**05**
	1. The Power Method.	2
	2. The Inverse Power Method.	1
	3. Reduction to Symmetric Tridiagonal Form.	1
	4. Eigenvalues of Symmetric Tridiagonal Matrices.	1

Unit IV	**Interpolation (and Curve Fitting):**	**09**
	1. Lagrange Form of Interpolating Polynomial. 2. Neville's Algorithm. 3. The Newton Form of Interpolating Polynomial. 4. Optimal Points for Interpolation. 5. Piecewise Linear Interpolation. 6. Cubic Spline Interpolation.	1 1 1 2 2 2
Unit V	**Differentiation and Integration:**	**12**
	1. Numerical Differentiation, Part II. 2. Numerical Integration – The Basics and Newton-Cotes Quadrature; Composite Newton-Cotes Quadrature.	6 6
Unit VI	**Initial Value Problems of Ordinary Differential Equations:**	**12**
	1. Euler's Method; Higher-Order One-Step Methods: Taylor Methods. 2. Runge-Kutta Methods. 3. Multistep Methods (Adams-Bashforth Methods, The Two Step Adams-Bashforth Method, Milnes's Method). 4. Convergence and Stability Analysis.	3 3 3 3

Textbook:

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Prentice Hall 2007, ISBN 978-81-317-0942-9.

Unit I: Chapter 1: Sec. 1.2, 1.3, 1.4, Chapter 2: Sec. 2.3, 2.4, 2.5, 2.6.

Unit II: Chapter 3: Sec.3.1, 3.2, 3.4, 3.5, 3.6, 3.8, 3.10.

Unit III: Chapter 4: Sec. 4.1, 4.2, 4.4, 4.5.

Unit IV: Chapter 5: 5.1, 5.2, 5.3, 5.4, 5.5, 5.6.

Unit V: Chapter 6: Sec. 6.2, 6.4, 6.5.

Unit VI: Chapter 7: Sec. 7.2, 7.3, 7.4, 7.5 (Adams-Bashforth Methods, Example 7.16 and Example 7.17), 7.6.

2. John H. Mathews, Kurtis D. Fink, Numerical Methods Using Matlab, 4th Edition,

Pearson Education (Singapore) Pte. Ltd., Indian Branch, Delhi 2005.

(SciLab commands similar to MatLab commands can be used for problems)

Reference:

1. Books:

1. K .E. Atkinson, An Introduction to Numerical Analysis, Second Edition, John Wiley & Sons.

2. J. L. Buchaman, P. R. Turner, Numerical Methods and Analysis, McGraw Hill, 1992.

3. M.K. Jain, S.R.K. Iyengar, R.K. Jain, Numerical Methods for Scientific & Engineering Computation, 5th Edition, New Age International Publication

Engineering Computation, 5th Edition, New Age International Publication.

4. Numerical Method Kit: For matlab, Scilab and Octave Users by Rohan Verma University of Delhi Independently published in 2020.

5. G Shanker Rao, Numerical Analysis, New Age International, 2006.

6. S.S.Sastry, Sastry Introductory Methods of Numerical Analysis Fifth Edition, PHI Learning Private Limited.

2. Website:

Numerical Analysis Instructor: Prof Usha Department Of Mathematics IIT Madras

https://www.youtube.com/results?search_query=numerical+analysis+nptel

Course/ Paper Title	**Advanced Calculus**
Course Code	**23SMMT21MM**
Semester	**II**
No. of Credits	**04**

Unit No	Title with Contents	No. of Lectures
Unit I	**Differential Calculus of Scalar and Vector Fields:**	**20**
	1. Functions from R^n to R^m. Scalar and vector fields; Open balls and open sets; Limits and continuity. 2. The derivative of a scalar field with respect to a vector; Directional derivatives and partial derivatives; Partial derivatives of higher order; Inverse function theorem and ImplicitFunction theorem. (Statement only without proof) 3. Directional derivatives and continuity; The total derivatives; The gradient of a scalar field; A sufficient condition for differentiability. 4. A chain rule for derivatives of scalar fields; Applications to geometry. Level sets. Tangent planes; Derivatives of vector fields; Differentiability implies continuity; The chain rule for derivatives of vector fields; Matrix form of the chain rule	4 6 4 6
Unit II	**Line Integrals:**	**10**
	1. Paths and line integrals; Other notations for line integrals; Basic properties of line integrals. 2. The concept of work as a line integral; Line integrals with respect to arc length; Further applications of line integrals. 3. Open connected sets. Independence of the path; The first and second fundamental theorem of calculus for line integrals; Necessary and sufficient conditions for a vector field to be a gradient; Necessary conditions for a vector field to be a gradient.	2 2 6
Unit III	**Multiple Integrals:**	**15**

	1. Partitions of rectangles. Step functions; The double integral of a step function; The definition of the double integral of a function defined and bounded on a rectangle; Upper and lower double integrals; Evaluation of double integral by repeated one-dimensional integration; Geometric interpretation of the double integral as a volume; Worked examples. 2. Integrability of continuous functions; Integrability of bounded functions with discontinuities ; Double integrals extended over more general regions; Applications to area and volume;Worked examples. 3. Green's theorem in the plane; Some applications of Green's theorem; A necessary andsufficient condition for a two dimensional vector field to be a gradient. 4. Change of variables in a double integral; Special cases of the transformation formula withproof; General case of the transformation formula with proof; Extensions to higher dimensions; Change of variables in an n-fold integral; Worked examples.	3 2 5 5
Unit IV	**Surface Integrals:**	**15**
	1. Parametric representation of a surface; The fundamental vector product; The fundamentalvector product as a normal to the surface; Area of a parametric surface. 2. Surface integrals; Change of parametric representation; Other notations for surface integrals. 3. The theorem of Stokes; Curl and divergence of a vector field; Properties of curl and divergence;the divergence theorem (Gauss' theorem) and applications of the divergence theorem.	5 5 5

Textbooks:

1.Tom M. Apostol, Calculus Volume II (Second Edition) Indian Reprint 2016 (John Wiley & Sons, Inc) ISBN: 978-81-265-1520-2.

Unit I: Chapter 8: Sections 8.1 to 8.22.

Unit II: Chapter 10: Sections 10.1 to 10.11, 10.14 to 10.16.

Unit III: Chapter 11: Sections 11.1 to 11.15; 11.19 to 11.22, 11.26 to 11.34.

Unit IV: Chapter 12: Sections 12.1 to 12.15, 12.19 and 12.21.

2. For " Inverse Function Theorem" and "Implicit Function Theorem", use

Tom M. Apostol, Mathematical Analysis 2nd Edition Narosa Publication 20th Reprint 2002. ISBN 978-81-85015-66-8.

Unit I: Chapter 13: Sections 13.3, 13.4.

Reference:

1. Books:

1. Gerald B. Folland, Advanced Calculus, Pearson Edn 2012.

2. A Devinatz, Advanced Calculus, Holt, Rnehart and Winston Inc., New York, 1968.

2. Website

1. Multivariable Calculus Intructor: Dr. S.K.Gupta IIT Roorkee

https://www.youtube.com/results?search_query=multi+variable+calculus+nptel

Course/ Paper Title	**General Topology**
Course Code	**23SMMT22MM**
Semester	**II**
No. of Credits	**04**

Unit No	Title with Contents	No. of Lectures
Unit I	**Prerequisites:**	**10**
	1. Cartesian Products.	1
	2. Finite Sets.	2
	3. Countable and Uncountable Sets.	3
	4. Infinite Sets and The Axiom of Choice.	2
	5. Well-Ordered Sets.	2
Unit II	**Topological Spaces and Continuous Functions:**	**20**
	1. Topological Spaces.	2
	2. Basis for a Topology.	2
	3. The Order Topology.	2
	4. The Product Topology on X x Y.	2

	5. The Subspace Topology. 6. Closed Sets and Limit Points. 7. Continuous Functions. 8. The Product Topology. 9. The Metric Topology. 10. The Quotient Topology	2 2 2 2 2 2
Unit III	**Connectedness and Compactness:**	**15**
	1. Connected Spaces. 2. Connected Subspaces of the Real Line. 3. Components and Local Connectedness. 4. Compact Spaces. 5. Compact Subspaces of the Real Line. 6. Limit Point Compactness. 7. Local Compactness.	2 2 3 2 2 2 2
Unit IV	**Countability and Separation Axioms:**	**15**
	1. The Countability Axioms. 2. The Separation Axioms. 3. Normal Spaces. 4. The Urysohn Lemma (only statement). 5. The Urysohn Metrization Theorem (only statement). 6. The Tietze Extension Theorem (only statement). 7. The Tychonoff's Theorem (only statement).	2 3 2 2 2 2 2

Textbook:

J. R. Munkres, Topology, A First Course, (Prentice Hall, Second Edition), 2000.

Unit I: Chapter 1: Sec. 5 to 7, Sec. 9, 10.

Unit II: Chapter 2: Sec.12 to 22.

Unit III: Chapter 3: Sec. 23 to 29.

Unit IV: Chapter 4: Sec. 30 to 35, Chapter 5: Sec. 37.

Reference:

1. Books:

1. K. Janich, Topology, Springer, 1984.

2. M. A. Armstrong, Basic Topology, Springer, 1983.

3. K. D. Joshi, Introduction to General Topology, John Wiley &Sons.

2. Website:

Topology by Prof. P. Veeramani, Department of Mathematics, IIT Madras

https://www.youtube.com/results?search_query=general+topology+ntptl

Course/ Paper Title	**Rings and Modules**
Course Code	**23SMMT23MM**
Semester	**II**
No. of Credits	**04**

Unit No	Title with Contents	No. of Lectures
Unit I	**Rings:**	**16**
	1. Terminologies.	1
	2. Rings of Continuous Functions.	1
	3. Matrix Rings.	1
	4. Polynomial Rings.	1
	5. Power Series Rings.	1
	6. Laurent Rings.	1
	7. Boolean Rings.	2
	8. Some Special Rings.	2
	9. Direct Products.	2
	10. Several Variables.	2
	11. Opposite Rings.	1
	12. Characteristic of a Ring.	1
Unit II	**Ideals:**	**12**
	1. Definitions.	1
	2. Maximal Ideals.	1
	3. Generators.	1
	4. Basic Properties of Ideals.	1
	5. Algebra of Ideals.	2

	6. Quotient Rings. 7. Ideals in Quotient Rings. 8. Local Rings	2 2 2
Unit III	**Homomorphisms of Rings:**	**10**
	1. Definitions and Basic Properties. 2. Fundamental Theorems. 3. Endomorphism Rings. 4. Field of fractions. 5. Prime fields.	2 2 2 2 2
Unit IV	**Factorization in Domains:**	**12**
	1. Division in Domains. 2. Euclidean Domains. 3. Principal Ideal Domains. 4. Factorisation Domains. 5. Unique Factorisation Domains. 6. Eisenstein's Criterion.	2 2 2 2 2 2
Unit V	**Modules:**	**10**
	1. Definitions and Examples. 2. Direct Sums. 3. Free Modules. 4. Quotient Modules. 5. Homomorphisms. 6. Simple Modules. 7. Modules over P I D's.	1 1 1 1 2 2 2

Textbook:

C. Musili, Rings and Modules, 2nd Revised Edition, Narosa Publishing House.

Unit I: Chapter 1.

Unit II: Chapter 2.

Unit III: Chapter 3.

Unit IV: Chapter 4.

Unit V: Chapter 5(except 5.4 and 5.5).

Reference:

1 Books:

1. Dummit and Foote, Abstract Algebra, Second Edition (Wiley India).

2. Luther and Passi, Algebra Vol. 2: Rings, Narosa Publishing House.

3. Jain and Bhattacharya, Basic Abstract Algebra, 2nd Edition, Cambridge University Press.

4. Joseph Gallian, Contemporary Algebra, 7th Edition, Narosa Publishing House.

2. Website:

Introduction to Rings and Fields - Krishna Hanumanthu | CMI - NPTEL

https://www.youtube.com/results?search_query=introduction+to+ring+theory+nptel

Course/ Paper Title	**Partial Differential Equations**
Course Code	**23SMMT24MM**
Semester	**II**
No. of Credits	**02**

Unit No	**Title with Contents**	**No. of Lectures**
Unit I	**First Order P.D.E.:**	**9**
	1. Revision: Genesis of First Order P.D. E, Classification of Integral, Linear Equations of First the First Order, Pfaffian Differential Equations, Compatible Systems, Charpit's Method, Jacobi's Method. 2. Integral Surfaces Through a Given Curve. 3. Quasi-Linear Equations. 4.Non-Linear First Order P.D.E	4 2 1 2
Unit II	**Second Order P.D.E.:**	**21**
	1. Genesis of Second Order P.D. E.	1

	2. Classification of Second Order P. D. E.	2
	3. One Dimensional Wave Equation.	
	i. Vibrations of an Infinite String.	4
	ii. Vibrations of a Semi-infinite String.	
	iii. Vibrations of a String of Finite Length.	
	iv. Vibrations of a String of Finite Length (Method of Separation of Variables).	
	4. Laplace's Equation.	
	i. Boundary Value Problems.	5
	ii. Maximum and Minimum Principles.	
	iii. The Cauchy Problem.	
	iv. The Dirichlet Problem for the Upper Half Plane.	
	v. The Neumann Problem for the Upper Half Plane.	
	vi. The Dirichlet Problem for a Circle.	
	vii. The Dirichlet Exterior Problem for a Circle.	
	viii. The Neumann Problem for a Circle.	
	ix. The Dirichlet Problem for a Rectangle.	
	x. Harnack's Theorem.	
	5. Heat Conduction Problem.	
	i. Heat Conduction - Infinite Rod Case.	3
	ii. Heat Conduction - Finite Rod Case.	
	6. Duhamel's Principle.	
	i. Wave Equation.	3
	ii. Heat Conduction Equation.	
	7. Classification in the Case of n-Variables.	
	8. Families of Equipotential Surfaces.	1
	9. Kelvin's Inversion Theorem.	1
		1

Textbook:

T. Amarnath : An Elementary Course in Partial Differential Equations (2nd edition) (Narosa Publishing House Pvt. Ltd.).

Unit I: Chapter 1: Sec. 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11.

Unit II: Chapter 2: Sec. 2.1, 2.2, 2.3(2.3.1, 2.3.2, 2.3.3, 2.3.5), 2.4(2.4.1 - 2.4.10), 2.5(2.5.1, 2.5.2), 2.6(2.6.1, 2.6.2), 2.7, 2.8, 2.9.

Reference:

1. Books:

1. K. Sankara Rao: Introduction to partial differential equation, third edition.

2. W. E. Williams: Partial Differential equations (Clarendon press-oxford).

3. E. T. Copson : Partial differential equations (Cambridge university press).

4. I.N. Sneddon: Elements of partial differential equations (Mc-Graw Hill Book Company).

2. Website:

Partial Differential Equations Instructor: Prof. Sirshendu De IIT Khargpur

https://www.youtube.com/results?search_query=partial+differential+equations+nptel

Course/ Paper Title	**Coding Theory**
Course Code	**23SMMT21MEA**
Semester	**II**
No. of Credits	**04**

Unit No	Title with Contents	No. of Lectures
Unit I	**Error detection, correction and decoding**	**12**
	1. Introduction. 2. Communication channels. 3. Maximum likelihood decoding. 4. Hamming distance. 5. Nearest neighbour / minimum distance decoding. 6. Distance of a code.	2 2 2 2 2 2
Unit II	**Finite fields**	**12**
	1. Fields. 2. Polynomial rings. 3. Structure of finite fields. 4. Minimal polynomials**.**	3 3 3 3
Unit III	**Linear Codes**	**16**

	1. Vector spaces over finite fields. 2. Linear codes. 3. Hamming weight. 4. Bases for linear codes. 5. Generator matrix and parity–check matrix. 6. Equivalence of linear codes. 7. Encoding with a linear code. 8. Decoding of linear codes: Cosets; Nearest neighbour decoding for linear codes; Syndrome decoding.	2 2 2 2 2 2 2 2
Unit IV	**Bounds in coding theory**	**08**
	1. The main coding theory problem. 2. Lower bounds: Sphere–covering bound; Gilbert–Varshamov bound. 3. Hamming bound and perfect codes: Binary Hamming codes; Golay codes. 4. Singleton bound and MDS codes.	2 2 2 2
Unit V	**Cyclic codes**	**08**
	1. Definitions. 2. Generator polynomials. 3. Generator and parity–check matrices. 4. Decoding of cyclic codes.	2 2 2 2
Unit VI	**Some special cyclic codes**	**04**
	1. BCH codes: Definitions; Parameters of BCH codes.	4

Textbook:

San Ling, Chaoping Xing, Coding Theory, A First Course; Cambridge University Press, 2004.Chap 2: Sections 2.1 to 2.5

Chap 3: Sections 3.1, 3.2, 3.3, 3.4

Chap 4: Sections 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7,4.8

Chap 5: Sections 5.1, 5.2, 5.3, 5.4

Chap 7: Sections 7.1 to 7.4

Chap 8: Sections 8.1, 8.1.1, 8.1.2

References:

1. Books:

1. Raymod Hill, A First Course in Coding Theory, Oxford University Press.
2. Rudolf Lidl, Günther Pilz, Applied Abstract Algebra, Second Edition, Springer, Reprint 2004.

2. Website:

1. https://nptel.ac.in/courses/117/106/117106031/
2. https://nptel.ac.in/courses/108/104/108104092/

Course/ Paper Title	**Integral Equations**
Course Code	**23SMMT21MEB**
Semester	**II**
No. of Credits	**04**

Unit No.	Title with Contents	No. of Lectures
Unit I	**Introductory Concepts**	**12**
	1. Definitions.	2
	2. Classification of Linear Integral Equations.	2
	3. Solution of an Integral Equation.	2
	4. Converting Volterra Equation to ODE.	2
	5. Converting IVP to Volterra Equation.	2
	6. Converting BVP to Fredholm Equation.	2
Unit II	**Fredholm Integral Equations**	**12**

	1. Introduction. 2. The Decomposition Method. 3. The Direct Computation Method. 4. The Successive Approximation Method. 5. The Method of Successive Substitutions. 6. Comparison between Alternative Methods. 7. Homogeneous Fredholm Equations.	1 2 2 2 2 1 2
Unit III	**Volterra Integral Equations**	**14**
	1. Introduction. 2. The Decomposition Method. 3. The Series Solution Method. 4. Converting Volterra Equation to IVP. 5. The Successive Approximation Method. 6. The Method of Successive Substitutions. 7. Comparison between Alternative Methods. 8. Volterra Equation of the First Kind.	1 2 2 2 2 2 1 2
Unit IV	**Integro-Differential Equations**	**10**
	1. Fredholm Integro-Differential Equations. 2. Volterra Integro-Differential Equations.	5 5
Unit V	**Singular Integral Equations**	**06**
	1. Definitions. 2. Abel's Problem. 3. The Weakly-Singular Volterra Equations.	2 2 2
Unit VI	**Integral Transform Methods**	**06**
	1. Introduction. 2. Fourier Transform 3. Laplace Transform. 4. Applications to Volterra Integral Equations with Convolution-Type Kernels. 5. Examples.	1 1 1 1 2

Textbook:

1. Abul-Majid Wazwaz, A First Course In Integral Equations, World Scientific Publications, 1997.

Unit I: Chapter 1.

Unit II: Chapter 2.

Unit III: Chapter 3.

Unit IV: Chapter 4 and 5.

Unit V: Chapter 6: Sections 6.1, 6.2, 6.3, 6.4.

2. Ram P. Kanwal, Linear Integral Equations, 2nd Edition, Springer Science+Business Media, LLC.

Unit VI: Chapter 9: Sections 9.1, 9.2, 9.3, 9.4, 9.5.

References:

1. Books:

1. Rainer Kress, Linear Integral Equations, 3rd Edition, Springer.
2. Abdul J. Jerri, Introduction to Integral Equations with Applications, Wiley-Interscience; 2nd Edition (September 3, 1999).

2. Website:

1. https://www.youtube.com/watch?v=GiPOQC5nYMs&list=PL521C2DFD15FF56
2. https://nptel.ac.in/courses/111/107/111107