Maharashtra Education Society's

MES Abasaheb Garware College (Autonomous)

Karve Road, Pune-411004

(Affiliated to Savitribai Phule Pune University)

Three-year B.Sc. Degree Program in Mathematics

(Faculty of Science and Technology)

Syllabi under NEP 2020

T.Y.B.Sc. (Mathematics)

(Level 5.5) (NEP 2024 Pattern) (NEP 2.0)

To be implemented from Academic Year 2026-2027

Title of the Course: B.Sc. (Mathematics)

Preamble:

Taking into consideration the rapid changes in science and technology and new approaches in different areas of Mathematics and related subjects, the board of studies in Mathematics, with the concern of teachers of Mathematics and industry, has prepared the syllabus of T.Y.B.Sc. Mathematics. To develop the syllabus, the UGC Model curriculum is followed.

Summary of the Program

- **Title of the Program**: Bachelor of Science (B.Sc.) Program in Mathematics.
- **Degree Offered**: Bachelor of Science (B.Sc.) in Mathematics.
- **Board of Studies**: Mathematics.
- **Mode of operation**: Full Time.
- **Duration**: 3 years.
- **Credits and breakup**: 132 credits with 1 credit = 15 contact hours.
- **Medium of Instruction**: English.

Eligibility:

Passed with 44 credits in F.Y.B.Sc. and at least 22 credits in S.Y.B.Sc.

Program Outcomes:

1) To give knowledge of fundamental principles, methods, Mathematical ideas, and tools.
2) Reflecting the broad nature of the subject and developing Mathematical tools for continuing further study in various fields of science and technology.
3) Enhancing students' overall development and equipping them with Mathematical abilities and problem-solving skills.
4) Enabling students to develop a positive attitude towards Mathematics as an interesting and valuable subject of study.

Examinations:

There shall be two types of examinations, internal examinations and end-semester examinations (ESE). Internal examinations will be conducted at the department level, whereas ESE will be conducted by the college. The internal examination and ESE are respectively given 50 % and 50% weightages. A student should score 40% marks in Continuous Assessment (CA) and 40% marks in Practical/Oral End Semester Examination (ESE), and 40% marks in Theory End Semester Examination (ESE) to pass in that course.

Credit Framework for T.Y.B.Sc. Mathematics (NEP 2024 pattern)
(To be implemented from 2026-2027)

Year	Level/ Difficulty	Semester	Course Type	Course Code	Course Title	Remark	Credit	No. of hours to be conducted
3	5.5/300	V	Major	MTS-309-MJ	Introduction to Real Analysis	Theory	2	30
				MTS-302-MJ	Group Theory	Theory	2	30
				MTS-310-MJ	Complex Analysis	Theory	2	30
				MTS-304-MJ	Ordinary Differential Equations	Theory	2	30
				MTS-307-MJP	Mathematics Practical Based on Introduction to Real Analysis and Group Theory	Practical	2	60
				MTS-308-MJP	Mathematics Practical based on Complex Analysis and Ordinary Differential Equations	Practical	2	60
			Major Elective	MTS-314-MJE	Operations Research	Theory	2	30
				MTS-315-MJEP	Mathematics Practical based on Operations Research	Practical	2	60
				OR				
				MTS-316-MJE	Number Theory	Theory	2	30
				MTS-318-MJEP	Mathematics Practical based on Number Theory	Practical	2	60
			VSC	MTS-321-VSC	Data Analytics Using Python	Practical	2	60
			Minor	MTS-343-MN	Laplace Transform	Theory	2	30
			FP/CEP	MTS-331-FP	Field Project	Practical	2	60
			Major	MTS-359-MJ	Advanced Real Analysis	Theory	2	30
				MTS-352-MJ	Ring Theory	Theory	2	30

		VI		MTS-354-MJ	Topology of Metric Spaces	Theory	2	30
				MTS-357-MJ	Partial Differential Equations	Theory	2	30
				MTS-355-MJP	Mathematics Practical Based on Advanced Real Analysis and Ring Theory	Practical	2	60
				MTS-358-MJP	Mathematics Practical based on Topology of Metric Spaces and Partial Differential Equations	Practical	2	60
			Major Elective	MTS-364-MJE	Graph Theory and Combinatorics	Theory	2	30
				MTS-365-MJEP	Mathematics Practical based on Graph Theory and Combinatorics	Practical	2	60
				OR				
				MTS-367-MJE	Financial Mathematics	Theory	2	30
				MTS-369-MJEP	Mathematics Practical based on Financial Mathematics	Practical	2	60
			VSC	MTS-371-VSC	Computational Geometry using Python	Practical	2	60
			OJT	MTS-381-OJT	OJT	Practical	4	120

Note:

1) Practical on Mathematical software can be performed on a computer.
2) A study tour / Field visit may be organised at some places.

SEMESTER-V
Major
Course Code: MTS-309-MJ
Course Title: Introduction to Real Analysis

(Credits-2) **No. of contact Hours: 30**

Course Outcomes:

1. Develop a rigorous understanding of the real number system.
2. Introduce formal proof techniques in analysis.
3. Study convergence of sequences and series.
4. Understand compactness and continuity in $\mathbb{R}$.

Unit 1: Foundations of Real Numbers **[05 Hours]**

1.1 Some Preliminaries (Logic and proof techniques, Mathematical induction)
1.2 Completeness axiom
1.3 Density of rational and irrational numbers
1.4 Cardinality
1.5 Cantor's theorem

Unit 2: Sequences of real numbers **[12 Hours]**

2.1 Discussion: rearrangement of infinite series.
2.2 Limit of a sequence
2.3 Algebraic and order limit theorems
2.4 Monotone convergence theorem
2.5 Series of nonnegative terms
2.6 Calculating square roots, Arithmetic -Geometric mean sequence
2.7 Limit superior and limit inferior
2.8 Subsequences and Bolzano Weierstrass Theorem

Unit 3: Series of real numbers **[08 Hours]**

3.1 Cauchy sequences and completeness of real numbers
3.2 Algebra of series, Cauchy criterion of series
3.3 Geometric Series
3.4 Absolute convergence of series, Alternating series test, Rearrangement
3.5 Ratio test
3.6 Summation by parts, Abel's test, Dirichlet's test
3.7 Double summations and product of infinite series

Unit 4: Continuity **[05 Hours]**

4.1 ε–δ definition of continuity

4.2 Sequential characterization
4.3 Algebra of continuous functions
4.4 Intermediate Value Theorem
4.5 Extreme Value Theorem
4.6 Uniform continuity
4.7 Continuity of functions on metric spaces, Connectedness and compactness as topological property, path connectedness

Recommended Book:

Stephen Abbott, Understanding Analysis, Springer.

Reference Books:

1. Robert G. Bartle and Donald R. Sherbert, Introduction to Real Analysis, Wiley.
2. Walter Rudin, Principles of Mathematical Analysis, McGraw-Hill.
3. Kenneth A. Ross, Elementary Analysis: The Theory of Calculus, Springer.
4. Tom M. Apostol, Mathematical Analysis, Addison-Wesley.
5. Charles C. Pugh, Real Mathematical Analysis, Springer.
6. Richard R. Goldberg, Methods of Real Analysis, Wiley.

Course Code: MTS-302-MJ
Course Title: Group Theory

(Credits-2) **No. of contact Hours: 30**

Course Outcomes:

The course will enable the students to:

1) Recognise the mathematical objects that are groups, and classify them as abelian, cyclic, and permutation groups, etc.
2) Analyse the consequences of Lagrange's theorem.
3) To learn about structure-preserving maps between groups and their consequences.
4) Explain the significance of the notion of cosets, normal subgroups, and factor groups.

Unit 1. Groups **[05 Hours]**

1.1 Binary Operation
1.2 Isomorphic Binary Structures
1.3 Groups

Unit 2. Subgroups **[05 Hours]**

2.1 Subgroups
2.2 Cyclic Groups

Unit 3. Permutations **[10 Hours]**

3.1 Groups of Permutations
3.2 Orbits
3.3 Cycles
3.4 Alternating Groups
3.5 Cosets and the Theorem of Lagrange
3.6 Direct Products

Unit 4. Homomorphisms and Factor Group [10 Hours]

4.1 Homomorphisms: Kernel of a homomorphism
4.2 Factor Groups: Normal subgroups, Fundamental Theorem of Homomorphism
4.3 Factor Group Computations and Simple Groups
4.4 Group Actions

Recommended Book:

John B. Fraleigh, A First Course in Abstract Algebra, Seventh Edition, Pearson.

Reference Books:

1. I. N. Herstein, Topics in Algebra, John Wiley and Sons.
2. N.S. Gopalakrishnan, University Algebra, Second Edition, New Age International, New Delhi, 1986.
3. Joseph A. Gallian, Contemporary Abstract Algebra (4th Edition), Narosa Publishing House.

Course Code: MTS-310-MJ
Course Title: Complex Analysis

(Credits-2) No. of contact Hours: 30

Course Learning Outcomes: The completion of the course will enable the students to:

1) Students able to understand complex numbers and regions in complex plane.
2) Understand the significance of the differentiability of complex functions leading to the understanding of the Cauchy-Riemann equations.
3) Evaluate the contour integrals and understand the role of Cauchy-Goursat theorem and the Cauchy integral formula.

Unit 1: Complex numbers [06 Hours]

1.1 Sums and Products
1.2 Basic Algebraic properties
1.3 Further Properties
1.4 Vectors and Moduli
1.5 Complex Conjugates
1.6 Exponential Form
1.7 Products and Powers in Exponential Form

1.8 Arguments of Products and Quotients
1.9 Roots of Complex Numbers

Unit 2: Analytic functions [07 Hours]

2.1 Functions of a Complex Variables
2.2 Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulas
2.3 Cauchy- Riemann Equations, Sufficient Conditions for differentiability
2.4 Polar coordinates, Analytic functions, Harmonic functions.

Unit 3: Elementary Functions [04 Hours]

3.1 The Exponential functions
3.2 The Logarithmic function, Branches and derivatives of logarithms, Some identities Involving logarithms
3.3 Complex exponents, Trigonometric functions.

Unit 4. Integrals [07 Hours]

4.1 Derivatives of functions, Definite integrals of functions
4.2 Contours, Contour integral, Examples
4.3 Upper bounds for Moduli of contour integrals, Anti-derivatives
4.4 Cauchy-Goursat Theorem, Simply and multiply Connected domains, Cauchy integral formula, Derivatives of analytic functions. Liouville's Theorem and Fundamental Theorem of Algebra.

Unit 5. Series [03 Hours]

5.1 Taylor's series, Laurent series (without proof), examples only.

Unit 6. Residues and Poles [03 Hours]

6.1 Isolated singular points, Residues
6.2 Cauchy residue theorem, residue at infinity, types of isolated singular points, residues at poles

Recommended Book:

J.W. Brown and R.V. Churchill, Complex Variables and Applications, International Student Edition, 2009. (Eighth Edition).

Reference Books:

1. S. Ponnusamy, Complex Analysis, Second Edition (Narosa).
2. S. Lang, Complex Analysis, (Springer Verlag).
3. A.R. Shastri, An Introduction to Complex Analysis, (MacMillan).
4. L.V.Ahlfors, Complex Analysis, 3rd edition, McGraw Hill, 2000.

Course Code: MTS-304-MJ
Course Title: Ordinary Differential Equations

(Credits-2) **No. of contact Hours: 30**

Course Outcomes: The course will enable the students to:

1) Find the solution of the differential equations
2) To learn linear differential equations
3) Study applications of differential equations

Unit 1. Differential Equations of first order and first degree: [10 Hours]

Differential equations, Elimination of arbitrary constants, General solution of Differential equations, Methods of finding solution of Differential Equations of first order and first degree, Variable separable form, Homogeneous Differential equations, Exact Differential equations, The Linear Differential equations, The general linear equation, Orthogonal Trajectories, Integrating factor, Bernoulli's Differential equations.

Unit 2. Linear Differential equations with constant coefficients: [10 Hours]

Existence and uniqueness of solution, linear independence, The Wronskian, the general solution of homogeneous equation, The general solution of non-homogeneous equation,
The auxiliary equations, Distinct roots, Repeated roots, Complex roots, and particular solution. The operator 1/F(D) and its evaluation for the functions x^m, e^{ax}, $e^{ax}v$, xv and the operator $1/D^2+a^2$ and its evaluation for the functions acting as sin ax and cos ax.

Unit 3. Non-Homogeneous Differential Equations: [05 Hours]

Method of undetermined coefficients, Method of variation of parameters, Method of reduction of order, and the use of a known solution to find another.

Unit 4: Linear Systems of Equations [05 Hours]

First-order systems with constant coefficients, Solution of a first-order system, First-order systems revisited, Complex eigenvalues, Repeated eigenvalues

Recommended Book:

Elementary Differential Equations (7^{th} edition), Rainville and Bedient, Macmillan Publication Sections: 1 to 12, 17 to 21, 24 to 37, 39 to 50, 76 to 81

Reference Books:

1. Differential Equations by George F. Simmons, Steve G. Krantz, Tata McGraw-Hill
2. A First Course in Differential Equations with applications by W.R. Derrick and Grossman, CBS Publishers and distributors, Delhi.
3. Ordinary and Partial Differential Equations, by M.F. Raisinghania, S. Chand and Company LTD.

Course Code: MTS-307-MJP
Course Title: Mathematics Practical Based on Introduction to Real Analysis and Group Theory

(Credits-2) **No. of Contact Hours: 60**

Course Code: MTS-308-MJP
Course Title: Mathematics Practical Based on Complex Analysis and Ordinary Differential Equations

(Credits-2) **No. of Contact Hours: 60**

Major Elective
Course Code: MTS-314-MJE
Course Title: Operations Research

(Credits-2) **No. of contact Hours: 30**

Course Outcomes:

This course will enable the students to learn:

1) Analyze and solve linear programming models of real-life situations.
2) The graphical solution of LPP with only two variables, and illustrate the concept of
3) Convex set and extreme points. The theory of the simplex method is developed.
4) The relationships between the primal and dual problems and their solutions with applications to transportation and the assignment problem.
5) PERT and CPM

Unit 1. Modelling with Linear Programming **[05 Hours]**

1.1Two variable LP Model
1.2 Solution of LP Model by Graphical Method

Unit 2. The Simplex Method and Duality **[10 Hours]**

2.1 LP Model in equation form
2.2 The Simplex method.
2.3 Definition of the dual problem
2.4 Primal dual relationship

Unit 3. Transportation Model **[08 Hours]**

3.1 Definition of the Transportation Model
3.2 The Transportation algorithm.

3.3 Assignment Problem

Unit 4. CPM and PERT **[07 Hours]**

4.1 CPM, Network representation, Critical path computations

4.2 PERT networks

Recommended Book:

Hamdy A. Taha, Operations Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operations Research (Eighth Edition) Tata McGraw-Hill.

2. J K Sharma, Operations Research (Theory and Applications, second edition, 2006), Macmillan India Ltd.

Course Code: MTS-315-MJEP

Course Title: Mathematics Practical based on Operations Research

(Credits-2) **No. of Contact Hours:60**

Course Code: MTS-316-MJE

Course Title: Number Theory

(Credits-2) **No. of contact Hours: 30**

Course Outcomes: This course will enable the students to learn:

1) Some of the open problems related to prime numbers.
2) About number theoretic functions and modular arithmetic.
3) The Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues.
4) Students will be able to solve Diophantine equations and able to find Pythagorean triplets.

Unit 1. Divisibility **[06 Hours]**

1.1 Divisibility: GCD, Euclidean Algorithm, LCM

1.2 Prime: Fundamental theorem of arithmetic, primes are infinite

Unit 2. Congruences **[06 Hours]**

2.1 Congruences

2.2 Solution of Congruences

2.3 The Chinese Remainder Theorem

2.4 Techniques of Numerical Calculation

2.5 Public key cryptography

Unit 3. Some functions of number theory **[06 Hours]**

3.1 Greatest integer function
3.2 Arithmetic functions
3.3 The Mobius Inversion formula

Unit 4. Quadratic Reciprocity **[06 Hours]**

4.1 Quadratic residues
4.2 Quadratic reciprocity
4.3 The Jacobi symbol

Unit 5. Diophantine Equations **[06 Hours]**

5.1 Diophantine equations ax + by = c
5.2 Pythagorean triplets.

Recommended Book: I. Niven, H. Zuckerman and H.L. Montgomery, An Introduction to Theory of Numbers, 5th Edition, John Wiley and Sons.
Reference Book: Elementary Number Theory, David M. Burton Seventh Edition.

Course Code: MTS-318-MJEP
Course Title: Mathematics Practical based on MTS-316-MJE

(Credits-2) **No. of Contact Hours: 60**

VSC
Course Code: MTS-321-VSC
Course Title: Data Analytics Using Python

(Credits-2) **No. of Contact Hours:60**

Practicals based on the following syllabus shall be conducted .

Course Outcomes:

1) Students will be able to understand and explain fundamental concepts of machine learning such as classification, regression, overfitting, and model evaluation.
2) Students will be able to build, train, and evaluate machine learning models using various supervised learning algorithms.
3) Students will be able to preprocess data and apply unsupervised learning techniques such as clustering and dimensionality reduction.

Unit 1: Introduction

1.1 Why Machine Learning?,

Problems Machine Learning Can Solve
Knowing Your Task and Knowing Your Data

1.2 Why Python?
scikit-learn, Installing scikit-learn

1.3 Essential Libraries and Tools
Jupyter Notebook, NumPy, SciPy, matplotlib, pandas, mglearn

1.4 A First Application: Classifying Iris Species
Meet the Data, Measuring Success: Training and Testing Data, First Things First: Look at Your Data, Building Your First Model: k-Nearest Neighbors, Making Predictions, Evaluating the Model

Unit 2: Supervised Learning

2.1 Classification and Regression

2.2 Generalization, Overfitting, and Underfitting
Relation of Model Complexity to Dataset Size

2.3 Supervised Machine Learning Algorithms
Some Sample Dataset, k-Nearest Neighbors, Linear Models, Naive Bayes Classifiers Decision Trees, Ensembles of Decision Trees, Kernelized Support Vector Machines Neural Networks (Deep Learning)

2.4 Uncertainty Estimates from Classifiers
The Decision Function, Predicting Probabilities, Uncertainty in Multiclass Classification

Unit 3: Unsupervised Learning and Preprocessing

3.1 Types of Unsupervised Learning

3.2 Challenges in Unsupervised Learning

3.3 Preprocessing and Scaling
Different Kinds of Preprocessing, Applying Data Transformations, Scaling Training and Test Data the Same Way, The Effect of Preprocessing on Supervised Learning, Dimensionality Reduction, Feature Extraction, and Manifold Learning, Principal Component Analysis (PCA), Non-Negative Matrix Factorization (NMF)

3.4 Clustering
k- Means Clustering, Agglomerative clustering, DBSCAN, Comparing and Evaluating Clustering Algorithms

Recommended Books:

Introduction to Machine Learning with Python, a Guide for Data Scientists, Andreas C. Muller and Sarah Guido, O'Reilly

Reference books:

1) Data Science and analytics with python, Dr Jesús Rogel-Salazar, CRC Press, Taylor and

Fransis group.
2) Python for Data Analysis, Wes McKinney, O'Reilly second edition.
3) Practical Linear Algebra for Data Science, From Core Concepts to Applications Using Python, Mike X Cohen, O'Reilly

Minor

Course Code: MTS-343-MN
Course Title: Laplace Transform

(Credits-2) **No. of contact Hours: 30**

Course Outcomes: This course will enable the students to learn:

1) Laplace transform and inverse Laplace transform of elementary functions.
2) About properties of the Laplace transform and the inverse Laplace transform.
3) To find the Fourier series of the functions.

Unit 1. The Laplace Transform: **[12 Hours]**

1.1 Definition, Laplace Transform of some elementary functions.
1.2 Some important properties of Laplace Transform.
1.3 Laplace Transform of derivatives, Laplace Transform of Integrals.
1.4 Methods of finding Laplace Transform, Evaluation of Integrals.
1.5 The Gamma function, Unit step function and Dirac delta function.

Unit 2. The Inverse Laplace Transform: **[12 Hours]**

2.1 Definition, Some inverse Laplace Transform.
2.2 Some important properties of Inverse Laplace Transform.
2.3 Inverse Laplace Transform of derivative, Inverse Laplace Transform of integrals.
2.4 Convolution Theorem, Evaluation of Integrals.

Unit 3. Fourier series **[6 Hours]**

3.1 Definition and examples of Fourier Series.

Recommended Books:

1. Schaum's Outline Series - Theory and Problems of Laplace Transform by Murray R. Spiegel.
2. Richard R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd. (1970).

Reference Books:

1. Joel L. Schiff: The Laplace Transforms - Theory and Applications, Springer-Verlag New York 1999.
2. Dyke: An Introduction to Laplace Transforms and Fourier Series, Springer

International Edition, Indian Reprint 2005.

FP/CEP
Course Code: MTS-331-FP
Course Title: Field Project

(Credits-2) **No. of contact hours: 30**

Topics for the field project:

1. Graph theory
    - Social network analysis using graphs
    - Shortest path problems (transport/navigation systems)
    - Planarity and network design
    - Minimum spanning tree in real-life networks (electric grids, roads)
    - Graph theory model of your college network
    - Study of planar and non-planar graphs with examples
2. A project exploring how natural phenomena follow mathematical rules, including the Fibonacci sequence, fractals, symmetry, and geometric shapes.
3. Examining the causes of mathematics anxiety in students and identifying strategies for reducing math anxiety in the classroom.
4. Test mathematical games or puzzles designed to improve students' problem-solving abilities and mathematical understanding.
5. Operations Research
    - Linear programming models (maximize profit/minimize cost)
    - Transportation and assignment problems
    - Project scheduling (PERT/CPM)
    - Game theory in decision making
6. Mathematical Modelling of Real-Life Situations
    - Population growth modelling using exponential functions
    - Spread of a rumour/disease (basic modelling)
    - Traffic flow analysis near the college
7. Financial Mathematics Projects
    - EMI calculation for loans (home, vehicle, education)
    - Study of bank interest systems (simple vs compound interest)
    - Savings and investment planning using mathematics
8. Least Squares Method for Data Fitting:
    - Collect real data (height vs weight, study hours vs marks)
    - Fit a line using least squares
    - Compare predicted vs actual values

9. Modelling Natural Shapes (Leaves, Flowers, Shells)
    - Collect samples (leaves, flowers, shells)
    - Identify symmetry, spirals, Fibonacci patterns
    - Model shapes using equations or sequences
    - Measure angles, ratios (e.g., golden ratio)
10. Study of Geometric Shapes in Architecture
    - Visit local buildings/temples
    - Identify shapes: triangles, arches, domes
    - Study symmetry and tessellations
    - Measure dimensions and proportions
11. Voting systems and fairness
12. Survey analysis
13. Study habits vs academic performance

SEMESTER-VI
Major
Course Code: MTS-359-MJ
Course Title: Advanced Real Analysis

(Credits-2) **No. of contact Hours: 30**

Course Outcomes:

1. Develop Riemann integration theory.
2. Understand uniform convergence of function sequences.
3. Introduce metric space theory.

Unit 1: Sequences and Series of Functions **[15 Hours]**

1.1 Pointwise convergence
1.2 Uniform convergence
1.3 Cauchy criterion for uniform convergence
1.4 Dini's theorem
1.5 Arzela- Ascoli Theorem
1.6 Interchange of limit and derivative
1.7 Series of functions
1.8 Term by term differentiation of series of functions
1.9 Weierstrass M test
1.10 Power series
1.11 Abel's Theorem
1.12 Term by term antiderivative of series
1.13 Taylor series with Lagrange's form of remainder.
1.14 Weierstrass Approximation theorem

Unit 2: Riemann Integration **[15 Hours]**

2.1 Partitions, Upper and lower Riemann sums
2.2 Riemann integrability criterion
2.3 Integrability of monotone and continuous functions
2.4 Integrating functions with discontinuities
2.5 Properties of Integral
2.6 Uniform convergence and integral
2.7 Fundamental Theorem of calculus I
2.8 Fundamental Theorem of Calculus II
2.9 Lebesgue's Criterion of Integrability
2.10 Nonintegrable differentiable function
2.11 Improper Riemann integrals, Gamma function, Cauchy principal value of an

improper integral.

Recommended Book:

Stephen Abbott, Understanding Analysis, Springer.

Reference Books: -

1. Robert G. Bartle and Donald R. Sherbert, Introduction to Real Analysis, Wiley.
2. Walter Rudin, Principles of Mathematical Analysis, McGraw-Hill.
3. Kenneth A. Ross, Elementary Analysis: The Theory of Calculus, Springer.
4. Terence Tao, Analysis I & II, Hindustan Book Agency.
5. Tom M. Apostol, Mathematical Analysis, Addison-Wesley.
6. Charles C. Pugh, Real Mathematical Analysis, Springer.
7. Richard R. Goldberg, Methods of Real Analysis, Wiley.
8. Frank Morgan, Real Analysis, American Mathematical Society.
9. H. L. Royden and P. M. Fitzpatrick, Real Analysis, Pearson

Course Code: MTS-352-MJ
Course Title: Ring Theory

(Credits-2) **No. of contact Hours: 30**

Course Outcomes:

The course will enable the students to learn about:

1) The fundamental concept of Rings, Fields, subrings, integral domains.
2) Students learn irreducibility criterion for polynomials.
3) Learn in detail about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields.
4) Appreciate the significance of unique factorization in rings and integral domains.

Unit 1: Rings and Fields **[06 Hours]**

1.1 Ring, Subring, Fields.
1.2 Divisors of zero, Integral Domain, The Characteristics of a Ring.
1.3 The Field of Quotients of an Integral Domain.

Unit 2: Rings of Polynomials & Factorization **[06 Hours]**

2.1 Polynomials in an determinate,
2.2 The Evaluation Homomorphism Zeros.
2.3 Factorization of a Polynomial over a Field: The Division Algorithm in F[x]
2.4 Irreducible Polynomials, Uniqueness of Factorization in F[x].

Unit 3: Ideals and Factor Rings **[06 Hours]**

3.1 Homomorphism, Properties of Homomorphism
3.2 Ideals, Factor Ring, Fundamental Homomorphism Theorem.
3.3 Maximal Ideal, Prime Ideal, Ideal Structure in F[x].

Unit 4: Factorization [12 Hours]

4.1 Unique Factorization Domain, Principal Ideal Domain, Gauss Lemma, D[x] is a UFD.
4.2 Euclidean Norm, Euclidean Domain, Euclidean Algorithm (Without Proof).
4.3 Gaussian Integers, Multiplicative Norm.

Recommended Book:

John B. Fraleigh, A First Course In Abstract Algebra, 7th Edition, Pearson.

Reference Books:

1. Josheph A. Gallian, Contemporary Abstract Algebra, 7th Edition, Narosa Publishing House.
2. David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Edition, Jonh Wiley and Sons, Inc.
3. N. Herstein, Abstract Algebra, 3rd Edition, Prentice Hall of India.

Course Code: MTS-354-MJ
Course Title: Topology of Metric Spaces

(Credits-2) No. of contact Hours: 30

Course Outcomes: The course will enable the students to:

1) understand the introductory concepts of metric spaces;
2) correlate these concepts to their counter parts in modern analysis by studying examples;
3) learn to analyse mappings between spaces.
4) attain background for advanced courses in real analysis, functional analysis, and topology.
5) appreciate the abstractness of the concepts such as open balls, closed balls, compactness, connectedness etc. beyond their geometrical imaginations.

Unit 1: Basic Notions [08 Hours]

1.1 Definition and examples
1.2 Open Balls and Open Sets

Unit 2: Convergence [08 Hours]

2.1 Convergent Sequences
2.2 Limit and Cluster points
2.3 Cauchy Sequences and Completeness
2.4 Bounded Sets

2.5 Dense Sets
2.6 Boundary of a set

Unit 3: Continuity **[06 Hours]**

3.1 Continuous Functions
3.2 Equivalent Definitions of Continuity
3.3 Topological Property
3.4 Uniform Continuity
3.5 Limit of a Function

Unit 4: Compactness and Connected **[08 Hours]**

4.1 Compact Spaces and their Properties
4.2 Connected Spaces

Recommended Book:

Topology of Metric Spaces, S. Kumaresan, Narosa Publishing House (2nd edition), 2011.

Reference Books:

1 Methods of Real Analysis, Richard R. Goldberg
2 Real Analysis by S.C. Malik and Savita Arora

Course Code: MTS-357-MJ
Course Title: Partial Differential Equations

(Credits-2) **No. of contact Hours: 30**

Course Outcomes:

The course will enable the students to:

1) Formulate, classify and transform partial differential equations into canonical form.
2) Solve linear partial differential equations using various methods and apply these methods in solving some physical problems.
3) Solve partial differential equations using separation of variables methods.
4) Students understand the various canonical forms of partial differential equations.

Unit 1: Introduction to Ordinary and Partial Differential Equations **[08 Hours]**

1.1 Surfaces and Curves in Three Dimensions
1.2 Simultaneous Differential Equations of the First Order and the First Degree in Three Variables.
1.3 Methods of solution of $dx\ /P = dy/\ Q = dz\ /R$
1.4 Pfaffian Differential Forms and Equations.
1.5 Solution of Pfaffian Differential Equations in Three Variables

Unit 2: Partial Differential Equations [08 Hours]

2.1 Introduction to Partial Differential Equations
2.2 Origin of first order Partial Differential Equations
2.3 Linear Equations of First order equations
2.4 Integral surfaces passing through given curve

Unit 3: Second Order Partial Differential Equations [08 Hours]

3.1 The Origin of Second Order Partial Differential Equations.
3.2 Linear Partial Differential Equations with constant coefficients.
3.3 Methods of solving Linear Partial Differential Equations
3.4 Solution of reducible equations
3.5 Solution of irreducible equations with constant coefficients
3.6 Rules of finding complementary functions
3.7 Rule of finding particular integrals

Unit 4: Classification of Partial Differential Equations [06 Hours]

4.1 Classification of second order partial differential equations, canonical forms
4.2 Solution of Laplace equations by separation variables methods
4.3 Solution of periodic differential equations by separation variables method
4.4 Solution of wave equation by separation variables method.

Recommended Books:

1. Ian Sneddon, Element of Partial Differential Equations, McGraw-Hill Book Company, McGraw-Hill Book Company.
2. J.N. Sharma, Kehar Singh, Partial Differential equations for Engineers and Scientists, second Edition, Narasa Publications.

Reference Books:

1. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa Publishing House 2nd Edition, 2003 (Reprint, 2006).
2. K. Sankara Rao, Introduction to Partial Differential Equations, Third Edition, PHI.

Course Code: MTS-355-MJP
Course Title: Mathematics Practical based on Advanced Real Analysis and Ring Theory

(Credits-2) **No. of Contact Hours: 60**

Course Code: MTS-358-MJP
Course Title: Mathematics Practical based on Topology of Metric Spaces and Partial Differential Equations

(Credits-2) **No. of Contact Hours: 60**

Major Elective
Course Code: MTS-364-MJE
Course Title: Graph Theory and Combinatorics

(Credits-2) **No. of contact Hours:30**

Course Learning Outcomes: The completion of the course will enable the students to:

1) understand graphs and its applications
2) to prove well known results about graphs
3) to solve a variety of problems in graph theory and combinatorics
4) aware of various counting techniques
5) know how to use generating functions in computations and proofs.

Unit 1: Topics in Graph Theory **[06 Hours]**

1.1 Graphs, Graphs as Models, Matrices and Isomorphism; decomposition and Special Graphs, Degree of a vertex.

1.2 Paths, Cycles, Trails, Connection in Graphs, Bipartite Graphs, Eulerian Circuits, Hamiltonian Cycles

Unit 2: Trees **[06 Hours]**

2.1 Trees, Properties of Trees; Distance in Trees and Graphs Further Properties

2.2 Enumeration of Trees, Spanning Trees in Graphs, Minimum Spanning Trees, Shortest Paths, Connectivity, Edge Connectivity.

Unit 3: Basic Counting Principles **[06 Hours]**

3.1 Two Basic Counting Principles.

3.2 Simple Arrangements and Selections.

3.3 Arrangements and Selections with Repetitions. Distributions.; Binomial Identities

Unit 4: Generating Functions **[06 Hours]**

4.1 Generating Functions Models.

4.2 Calculating Coefficients of Generating Functions.

4.3 Partitions; Exponential Generating Functions.

Unit 5: Recurrence Relations **[06 Hours]**

5.1 Generating Functions Models.

5.2 Solutions of Linear Recurrence Relations.

5.3 Counting with Venn Diagrams

5.4 Inclusion-Exclusion Formula.

Recommended Books:

1) Douglas B. West: Introduction to Graph Theory; 2nd Edn; PHI Learning Pvt. Ltd.
2) Alan Tucker: Applied Combinatorics 6th Edn; Wiley India.

Reference Books:

1) Robin Wilson: Introduction to Graph Theory, 5th Edn, Pearson Publication
2) Sebastian M. Cioabă and M. Ram Murty: A first course in Graph Theory and Combinatorics, 2nd Edition, Trim Series

Course Code: MTS-365-MJEP
Course Title: Mathematics Practical based on Graph Theory and Combinatorics

(Credits-2) **No. of Contact Hours: 60**

Course Code: MTS-367-MJE
Course Title: Financial Mathematics

(Credits-2) **No. of contact Hours: 30**

Course Outcomes:

The course will enable the students to:

1) Describe and explain the fundamental features of a financial instruments.
2) Demonstrate a clear understanding of financial research planning, methodology and implementation.
3) Demonstrate understanding of basic concepts in linear algebra, relating to linear equations, matrices, and optimization.
4) Demonstrate understanding of concepts relating to functions and annuities.

Unit 1: Mathematical models in economics, recurrences, and the elements of finance **[07 Hours]**

1.1 Introduction, a model of the market, market equilibrium and excise tax.
1.2 The first-order recurrence, limits, special cases, continuous compounding of interest.
1.3 Interest and capital growth, income generation, the interval of compounding.

Unit 2: The Cobweb model, and Introduction to optimization **[08 Hours]**

2.1 Stability of market equilibrium, the general linear case and economic interpretation
2.2 Marginal cost as a derivative, Profit maximization, critical points, optimization in an interval and infinite intervals.

Unit 3: The derivative in economics **[08 Hours]**

3.1 Elasticity of demand, profit maximization again.

3.2 Competition versus monopoly, the efficient small firm, startup and break-even points.

Unit 4: Linear equations and the input-output model [07 Hours]

4.1 Making money with matrices, a two-industry 'economy', arbitrage portfolios and state prices and IS-LM analysis.

4.2 An economy with many industries and the technology matrix.

Recommended Book:

Martin Anthony and Norman Biggs, Mathematics for Economics and Finance Methods and Modeling, Cambridge University Press, Reprint 2012.

Reference Books:

1. Edward T. Dowling, Mathematical Economics, Second Edition, Schaum's Outline Series, McGraw Hill International Edition.
2. Aswath Damodaran, Corporate Finance- Theory and Practice, John Wiley and Sons, Inc.
3. Sheldon M. Ross, An Introduction to Mathematical Finance, Cambridge University Press.

Course Code: MTS-369-MJEP

Course Title: Mathematics Practical based on Financial Mathematics

(Credits-2) **No. of Contact Hours: 60**

VSC

Course Code: MTS-371-VSC

Course Title: Computational Geometry using Python

(Credits-2) **No. of Contact Hours: 60**

Practicals based on the following syllabus shall be conducted.

Course Outcomes:

1) Students will learn computer graphics and transformations using python.
2) Students will be able to understand affine spaces.
3) Students able to construct various projections in 3D objects.
4) Students able to construct the curves using interpolations.

Unit 1: Geometric objects and transformations

Vector spaces, Affine spaces, Lines, Planes, Affine sums, Convexity, Dot and cross products, Coordinate systems, change of coordinate systems, Homogeneous coordinates, Affine transformations, Transformations in Homogeneous coordinates. Concatenation of transformations, Transformation Matrices.

Unit 2: Projections

Orthographic projections, Axonometric Projections, oblique projections, Parallel projections, Perspective projections, Matrices of Projections.

Unit 3: Curves

Interpolation, Blending functions, Bezier curves

Sample Programs (for reference)

1. Sierpinski Gasket
2. Recursive generation of Sierpinski Gasket
3. Rotation of a cube
4. Axonometric view of a cube
5. Perspective views of a cube
6. Pre-Fragment Lighting of sphere Model
7. Rotating Cube with texture
8. Uniformly spaced points on a circle
9. Uniformly spaced points on an ellipse
10. Uniformly spaced points on a parabola
11. Bezier curve
12. Stereographic Projection

Recommended Book:

Interactive Computer Graphics by Edward Angel and Dave Shreiner, Addison -Wesley.

On Job Training
Course Code: MTS-381-OJT
Course Title: On Job Training

(Credits-4) **Total contact Hours: 120**

1) Teaching to school students
2) Visits to Mathematical institutes
3) Workshop/training programs
4) Training of online teaching from organisations
5) Summer programmes
6) Mathematical Models
7) Conducting workshops
8) Organizing events/competitions
9) Content writing in different languages
10) Content creation
11) Writing articles

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