Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar (Autonomous)

(Affiliated to Savitribai Phule Pune University, Pune)

Choice Based Credit System (CBCS)

Proposal to Introduce New Academic Programe

In

M.SC. II Mathematics

Implemented from

Academic Year 2022 - 23

Program Structure and Course Titles: (All academic years)

Sr. No.	Class	Semester	Course Code	Course Title	Credits
1.	M. Sc.	I	MSC-MT 111 T	Linear Algebra	04
2.	M. Sc.	I	MSC-MT 112 T	Real Analysis	04
3.	M. Sc.	I	MSC-MT 113 T	Group Theory	04
4.	M. Sc.	I	MSC-MT 114 T (A)	Advanced Calculus	04
5.	M. Sc.	I	MSC-MT 114 T (B)	Combinatorics	04
6.	M. Sc.	I	MSC-MT 115 T (A)	Ordinary Differential equations	04
7.	M. Sc.	I	MSC-MT 115 T (B)	Theory of Wavelets	04
8.	M. Sc.	I	MSC-MT 116 P	Practical: Advance LaTeX	02
9.	M. Sc.	II	MSC-MT 211 T	Complex Analysis	04
10.	M. Sc.	II	MSC-MT 212 T	General Topology	04
11.	M. Sc.	II	MSC-MT 213 T	Ring Theory	04
12.	M. Sc.	II	MSC-MT 214 T (A)	Numerical Analysis	04
13.	M. Sc.	II	MSC-MT 214 T (B)	Operations Research I	04
14.	M. Sc.	II	MSC-MT 215 T (A)	Partial Differential Equations	04
15.	M. Sc.	II	MSC-MT 215 T (B)	Graph Theory	04
16.	M. Sc.	II	MSC-MT 216 T	Probability and Statistical Techniques	02
17.	M. Sc.	III	MSC-MT 311 T	Functional Analysis	04
18.	M. Sc.	III	MSC-MT 312 T	Field Theory	04
19.	M. Sc.	III	MSC-MT 313 T+P	Mathematics and Python Programming	02+02
20.	M. Sc.	III	MSC-MT 314 T (A)	Mechanics	04
21.	M. Sc.	III	MSC-MT 314 T (B)	Integral transforms	04
22.	M. Sc.	III	MSC-MT 315 T (A)	Integral Equations	04
23.	M. Sc.	III	MSC-MT 315 T (B)	Lattice Theory	04
24.	M. Sc.	III	MSC-MT 316 T	Fractional Calculus	02
25.	M. Sc.	IV	MSC-MT 411 T	Fourier Series and Boundary Value Problems	04
26.	M. Sc.	IV	MSC-MT 412 T	Differential Geometry	04
27.	M. Sc.	IV	MSC-MT 413 T+P	Introduction to Data Science	02+02

28.	M. Sc.	IV	MSC-MT 414 T (A)	Number Theory	04
29.	M. Sc.	IV	MSC-MT 414 T (B)	Optimization Techniques	04
30.	M. Sc.	IV	MSC-MT 415 T (A)	Coding Theory	04
31.	M. Sc.	IV	MSC-MT 415 T (B)	Fuzzy Set Theory	04
32.	M. Sc.	IV	MSC-MT 419 P	Practical: Mathematica(Wolfram Cloud)	02

9. Detail Syllabus:

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's
New Arts, Commerce and Science College, Ahmednagar(Autonomous)
Syllabus of M. Sc. Mathematics
under
Faculty of Science

Semester – III	Paper – I
Course Code: MSC-MT-311T	Title of the Course:Functional Analysis
Credits: 4	Total Lectures: 60 Hrs.

Course Outcomes (COs):

a. On the completion of course students will identify Hilbert space and Banach space example.
b. Students can apply Gram-Schmidt orthogonalization process to examples.
c.Students understand the relation between Operators.
d. Students understand spectrum of an operator and spectral resolution.

Detailed Syllabus:

Unit I: Banach Spaces **[20 Hours]**

1.1 The definition and some examples
1.2 Continuous linear transformations
1.3 The Hahn-Banach theorem
1.4 The natural imbedding of N in N**
1.5 The Open mapping theorem
1.6 The conjugate of an operator

Unit II: Hilbert Spaces [18 Hours]

1.1 The definition and some simple properties
1.2 Schwar'z inequality
1.3 Parallelogram law
1.4 Polarization identity
1.5 Orthogonal complements
1.6 Orthonormal set
1.7 Bessel's inequality
1.8 Complete orthonormal set
1.9 Gram-Schmidt orthogonalization process

Unit III: Operators on a Hilbert Space **[12 Hours]**

3.1 The conjugate space H**
3.2 Ries'z Representation Theorem
3.3 The adjoint of an operator
3.4 Self adjoint operator

3.5 Positive operator
3.6 Normal operator
3.7 Unitary operator
3.8 Projections
3.9 Invariance and reducibility

Unit IV: Finite-Dimensional Spectral Theory [10 Hours]

4.1 Matrices
4.2 Determinants and the spectrum of an operator
4.3 The Spectral Theorem
4.4 The Spectral Resolution
4.5 A Survey of the situation

Suggested Readings:

1. G.F. Simmons, Introduction to Topology and Modern Analysis, Tata-McGraw Hill,1925
2. B.V. Limaye, Functional Analysis, Wiley Eastern Ltd,Second Edition,1996.
3. George Bachman, Lawrence Narici, Functionl Analysis, Dover Publications,1968
4. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley Edition, 1989

Semester-III	Paper-II
CourseCode: MSC-MT 312T	TitleoftheCourse: Field Theory
Credits:4	TotalLectures: 60Hrs

Course Outcomes(COs):

a. Student will understand how to construct field containing all roots of given polynomial equation and applications in Galois theory.
b. To understand concept of reducibility and irreducibility of a polynomial.
c. To construct the splitting field for a given polynomial and normal extension for given field.
d. Student can solve many ancient geometric problems by the theory of fields.

Details of Syllabus:

Unit I. Algebraic Extension of fields [15 **Hours**]

1.1 Irreducible polynomials
1.2 Eisenstein criterion, Rational root test
1.3 Adjunction of roots, Degree of extension Kronecker theorem
1.4 Algebraic extensions, finite extensions
1.5 Algebraically closed field, Algebraic Closure

Unit II. Normal and Separable extensions [15 **Hours**]

2.1 Splitting fields,
2.2 Normal extensions
2.3 Multiple roots,Simple roots
2.4 Finite fields, Automorphism of field
2.5 Separable extensions,Simple extension

Unit III. Galois Theory [20 **Hours**]

3.1 Automorphism groups
3.2 Fixed fields, Dedekind Lemma
3.3 Fundamental theorem of Galois theory
3.4 Fundamental theorem of algebra

Unit IV. Applications of Galois theory to classical problems [10 **Hours**]

1.1.Roots of unity
1.2.Cyclotomic polynomials
1.3.Cyclic extensions
1.4.Polynomials solvable by radicals
1.5.Symmetric functions
1.6.Ruler and compass constructions

Suggested Readings

1. P. B. Bhattacharyya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, Second Edition.(1995)
2. D. Dummit and R.M.Foote, Abstract Algebra, Wiley Eastern Ltd., Third Edition(2004)
3. J. B. Fraleigh, A First Course in Abstract Algebra, 7^{th} Edition, Pearson Edition Ltd, Seventh Edition(2002)
4. I. S. Luthar, I. B. S. Passi, Algebra, Vol. 4, Field Theory, Narosa Publishing House(2004)

Semester – III	**Paper – III**
Course Code: MSC-MT-313 T+P	**Title of the Course:** Mathematics and Python Programming
Credits: 2+2	**Total Lectures: 60 Hrs.**

Course Outcomes (COs):

a. Acquire proficiency in using different functions of Python to compute solutions of basic mathematical problems and solutions of system of equations.
b. Demonstrate the use of Python to solve differential equations along with visualize the solutions.
c. Be familiar with the built-in functions to deal with numerical methods.
d. Explain basic principles of Python programming in Mathematics.

Detailed Syllabus:

Unit I: Introduction to Python [2 Hours]

1.1 Python Packages
1.2 Anaconda
1.3 Python Editors
1.4 Resources
1.5 Installing Python
  1.6.1 Python Windows 10 Store App
  1.6.2 Installing Anaconda

Unit II: Start using Python [4 Hours]

2.1 Python IDE
2.2 My first Python program
2.3 Python Shell
  2.3.1 Running Python from the Console
  2.3.2 Opening the Console on Windows
  2.3.3 Add Python to Path
2.4 Scripting Mode
  2.4.1 Run Python Scripts from the Python IDLE
  2.4.2 Run Python Scripts from the Command Prompt in Windows

Unit III: Basic Python Programming [8 Hours]

3.1 Basic Python Program
3.2 Variables (Numbers, Strings, String Input)
3.3 Built-in Functions
3.4 Python Standard Library
3.5 Using Python Libraries, Packages and Modules

Unit IV: Python Programming [8 Hours]

4.1 If ... Else
4.2 Arrays
4.3 For Loops
4.4 While Loops
4.5 Exercises

Unit V: Creating Functions, Classes and Python Modules [8 Hours]

5.1 Introduction of Functions
5.2 Functions with multiple return values
5.3 Exercises
5.4 Introduction of classes
5.5 The init () Function
5.6 Exercises
5.7 Python Modules
5.8 Exercises

Unit VI: File Handling in Python [6 Hours]

6.1 Introduction
6.2 Write Data to a File
6.3 Read Data from a File
6.4 Logging Data to File
6.5 Web Resources
6.6 Exercises
6.7 Error Handling in Python
6.8 Debugging in Python
6.9 Installing and using Python Packages

Unit VII: Symbolic computation: SymPy [6 Hours]

7.1 Output
7.2 Symbols
7.3 isympy
7.4 Numeric types
7.5 Differentiation and Integration
7.6 Ordinary differential equations
7.7 Series expansions and plotting
7.8 Linear equations and matrix inversion
7.9 Nonlinear equations
7.10Numerical Computation: Numbers and numbers
7.11 Exercises

Unit VIII: Numerical Python (numpy): arrays [6 Hours]

8.1 Numpy introduction
8.2 History
8.3 Arrays
8.4 Convert from array to list or tuple
8.5 Standard Linear Algebra operations
8.6 More numpy examples

Unit IX: Visualising Data: Matplotlib (Pylab) [6 Hours]

9.1 Matplotlib and Pylab
9.2 First example
9.3 How to import matplotlib, pylab, pyplot, numpy and all that
9.4 IPython's inline mode
9.5 Saving the figure to a file
9.6 Interactive mode
9.7 Fine tuning your plot
9.8 Plotting more than one curve
9.9 Histograms
9.10Visualizing matrix data
9.11Plots of z = f (x, y) and other features of Matplotlib
9.12Visual Python

9.13Basics, rotating and zooming
9.14Setting the frame rate for animations
9.15Tracking trajectories
9.16Connecting objects (Cylinders, springs, . . .)
9.173d vision
9.18 visualizing higher dimensional data

Unit X: Numerical Methods using Python (scipy) [6 Hours]

10.1SciPy
10.2Numerical integration
10.3Exercise: integrate a function ,plot before you integrate
10.4Solving ordinary differential equations
10.5Exercise: using odeint
10.6Root finding, Interpolation, Curve fitting
10.7Fourier transforms
10.8Optimization
10.9Other numerical methods

Suggested Readings:

1.Hans-Petter Halvorsen, Python for Science and Engineering, ISBN:978-82-691106-5-4,2020
2. Hans Fangohr, Introduction to Python for Computational Science and Engineering (A beginner's guide), University of Southampton, 2016.
3. J.C. Bautista, Mathematics and Python Programming, Edition: illustrated, Publisher: Lulu.com, 2014
4. J. Kiusalaas, Numerical methods in engineering with Python 3. Cambridge University Press, 2013.

Semester – III	**Paper – IV**
Course Code:MSC- MT 314 T(A)	**Title of the Course:Mechanics**
Credits: 4	**Total Lectures: 60 Hrs.**

Course Outcomes (COs):

a. Familiarize with subject matter which has been the equation of motion, degree of freedom, and constraints of motion, generalized co-ordinates, and Lagrange's equations.

b. Understand the concept of Variational Principles, Brachistochrone problem, Isoperimetric problems, extreme values.

c. Determine the Hamiltonian Formulation, Lagrange's Equations of Motion from Hamilton's
Principle, Routh's Procedure, and Principle of Least Action.

d. Learn that a particle moving under a central force describes a plane curve and know the Kepler's Laws of Planetary Motions, which were deduced by him long before the mathematical theory given by Newton.

Detailed Syllabus:

Unit I: Lagrange's Formulation **[20 Hours]**

1.1 Equation of Motion and conservation Theorems, Equation of Motion of a Particle, Equation of Motion of a System of Particle.

1.2 Conservation Theorem of Linear Momentum of the system of particles, Angular Momentum of the system of Particle, Constraint Motion, Examples of motion under constraints, Holonomic and Non – Holonomic Constraints, Scleronomic and Rheonomic Constraints, Degrees of Freedom and Generalized Co – ordinates.

1.3 Transformation Relations, Virtual work, Principle of Virtual Work, D ' Alembert's Principle, Conservation of Energy, Kinetic Energy as a Homogeneous quadratic function of generalized velocities, another way of proving conservation Theorem for Energy, Lagrange's Equations for Non – holonomic Constraints.

Unit II: Variational Principles **[10 Hours]**

2.1 Generalization of Theorem, Minimum surface of revolution, Brachistochrone Problem, A case of variable end points along vertical lines $x = a$ and $x = b$, Integrand as a function of more than two dependent variables.

2.2 Isoperimetric problems, variational problems with moving boundaries.

2.3 Functional dependent on functions of two dependent variables.

Unit III: Hamilton's Principle **[20 Hours]**

3.1 Hamilton's Principle for Non – Conservative and Conservative Systems, Configuration Space and Phase Space, Lagrange's Equations of Motion from Hamilton's Principle, Hamiltonian Formulation, Hamiltonian Function, Hamilton's Canonical Equations of Motion for partially.

3.2 Conservative and Partially Non – Conservative System, Derivation of Hamilton's Equations of Motion from Hamilton's Principle, Physical Meaning of the Hamiltonian.
3.3 Conservative and Scleronomic system, Non–conservative and Rheonomic system, partially conservative, Partially Non –conservative system, Cyclic co – ordinates in Hamiltonian, Routh's Procedure, Principle of Least Action.

Unit IV: Two Body Central Force Motion **[10 Hours]**

4.1 Reduction of Two body problem to an equivalent one Body problem, Equation of Motion and the First Integral.
4.2 Kepler's Laws of Planetary Motion, Kepler's First second and Third Law, Deduction of Kepler's Laws, Escape velocity.
4.3 Newton's law of Gravitation from Kepler's Laws of Planetary Motion, Differential Equation of the orbit of a Particle, Virial Theorem.

Suggested Readings:

1. L. N. Katkar: Problems in Classical Mechanics, Narosa Publication House Pvt. LtD (2014).
2. Herbert Goldstein, Charles Poole, John Safko: Classical Mechanics (3rd Edition.), Addison-Wesley,(2001).
3. Gupta, Kumar and Sharma: Classical Mechanics, Pragati Prakashan, (2012).
4. N.C.Rana, P.S. Joag: Classical Mechanics,(2nd Edition) McGraw Hill India, (2021).

Semester – III	Paper – IV
Course Code: MSC-MT 314 T (B)	Title of the Course: Integral Transforms
Credits: 04	Total Lectures: 60 Hrs.

Course Outcomes (COs):

a. Students will be able to recognize the different methods of finding Laplace transforms and Fourier transforms of different functions.

b. Students will be able to find Inverse of both Laplace and Fourier Transforms.

c. Use Laplace Transforms in finding the solutions of differential equations, initial value problems and boundary value problems.

d. Students will have the knowledge of Fourier Transforms and Finite Fourier transforms in finding the solutions of differential equations, initial value problems and boundary value problems.

Detailed Syllabus:

Unit I: Laplace Transform and Inverse Laplace Transform [15 Hours]

1.1 Definition of Laplace Transform, Properties of Laplace Transform, Laplace Transform of the derivatives of function.

1.2 Inverse Laplace transform, Properties of inverse Laplace transform.

1.3 Inverse Laplace transform of derivatives, convolution theorem, Heaviside's expansion theorem.

Unit II: Application of Laplace Transform [20 Hours]

2.1 Application of Laplace Transform to solution of differential equations; solutions of initial Value problems, Solution of differential equations with constant coefficients.

2.2 Solution of system of two simultaneous differential equations, Application of Laplace Transform to the solution of integral equations with convolution type kernel.

2.3 Applications of Laplace Transform to the solution of initial-boundary value problems like Solution of Heat equation, Solution of wave equation, Solution of Laplace equation.

Unit III: Fourier Transforms [15 Hours]

3.1 Fourier Transforms, Fourier sine transform, Fourier cosine transform.

3.2 Inverse Fourier Transform, Inverse Fourier sine Transform, Inverse Fourier cosine Transform, Properties of Fourier Transforms.

3.3 Modulation theorem, Convolution theorem, Fourier Transform of the derivatives of functions, Parseval's identity.

Unit IV: Application of Fourier Transforms [10 Hours]

4.1 Application of Fourier Transforms to the solution of initial-boundary value problems like Solution of Heat equation, Solution of diffusion equation, Solution of wave equation, Solution of Laplace equation.

Suggested Readings:

1.A.R.Vashista, Dr. R.K.Gupta, Integral transforms - Krishna Prakasham Mandir.
2. Murray R.Spiegel, Theory and problems of Laplace transforms - Schaums Outline Series Tata Mac Grawhill
3. Goyal and Gupta, Integral Transforms - Pragati Prakashan.
4.I.N.Sneddon, Use of Integral Transforms, Tata-McGraw Hill, 1972.
5.Bracemell R., Fourier Transform and its Applications, MacDraw hill, 1965.
6. Brian Davies, Integral transforms and their Applications, Springer, 1978.

Semester – III	**Paper – V**
Course Code: MSC-MT-315T (A)	**Title of the Course:** Integral Equations
Credits: 4	**Total Lectures: 60 Hrs.**

Course Outcomes (COs):

a. Acquire knowledge of different types of Integral equations: Fredholm and Volterra integral equations.

b. Obtain integral equation from ODE and PDE arising in applied mathematics and different engineering branches and solve accordingly using various method of solving integral equation.

c. To understand and techniques for solving the Volterra and Fredholm Integro-differential equations.

d. Categorise and solve different integral equations using various techniques

Detailed Syllabus:

Unit-I Introductory Concepts **[12Hours]**

1.1 Definitions
1.2 Classification of Linear Integral Equations
1.3 Solution of an Integral Equation
1.4 Converting Volterra Equation to ODE
1.5 Converting IVP to Volterra Equation
1.6 Converting BVP to Fredholm Equation

Unit-II Fredholm Integral Equations **[14 Hours]**

2.1 Introduction
2.2 The Decomposition Method
2.3 The Direct Computation Method
2.4 The Successive Approximation Method
2.5 The Method of Successive Substitutions
2.6 Comparison between Alternative Methods
2.7 Homogeneous Fredholm Equations

Unit-III Volterra Integral Equations **[14 Hours]**

3.1 Introduction
3.2 The Decomposition Method
3.3 The Series Solution Method
3.4 Converting Volterra Equation to IVP

3.5 The Successive Approximation Method
3.6 The Method of Successive Substitutions
3.7 Comparison between Alternative Methods
3.8 Volterra Equation of the First Kind

Unit-IV Fredholm Integro-Differential Equations **[10 Hours]**

4.1 Introduction
4.2 Fredholm Integro-Differential Equations
4.3 The Direct Computation Method
4.4 The AdomianDecomposition Method
4.5 Converting to Fredhlom integral equations

Unit-V Volterra Integro-Differential Equations **[10 Hours]**

5.1 Introduction
5.2 Volterra Integro-Differential Equations
5.3 The series solution method
5.4 The AdomianDecomposition Method
5.5 Converting to Volterra integral equations

Suggested Readings:

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

2. Kanwal Ram P., Linear Integral Equations, Birkhauser publication 1997.

3. Abdul J. Jerri, Introduction to Integral Equations with Applications, Wiley-Interscience, 2ndedition (September 3, 1999)

4.A. J. Jerri, Introduction to integral equations with applications. Sampling Publishing, 2007.

Semester – III	Paper – V
Course Code: MSC-MT 315 T(B)	Title of the Course: Lattice Theory
Credits: 04	Total Lectures: 60 Hrs.

Course Outcomes (COs):

a. Understand the fundamental concepts of Lattice Theory and Lattice-ordered Groups.
b. To learn Stones Theorem, Modular and Distributive Lattice.
c. Explain the relation between Graph Theory and Lattice Theory
d. Learn the beauty of Lattice-ordered Groups and related concepts.

Detailed Syllabus:

Unit I: Introductory Concepts of Lattices **[20 Hours]**

1.1 Introduction to Posets, Semi-lattice, Two definitions of lattices, Hasse Diagrams.

1.2 Homomorphism, Isotone maps, Ideals, Congruence relations, Congruence lattice, Convex Lattice.

1.3 The homomorphism theorem, Product of lattices, Complete lattices, Ideal lattice, Distributive and Modular Inequalities and Identities, Complements.

Unit II: Distributive Lattices **[20 Hours]**

2.1 Characterization theorem for modular and distributive lattice, Dedekind's characterization of modular lattice, Birkhoff's characterization of distributive lattices.

2.2 Representation of distributive lattices, Stone's theorem, Nabchin theorem, Statement of Hashimoto's theorem.

Unit III: Elements of Lattice **[08 Hours]**

3.1 Distributive, Standard and Neutral elements.

Unit IV: Lattice-Ordered Groups **[12 Hours]**

4.1 Introduction to Lattice-ordered groups.

4.2 Definition of the l-group, Calculations in l-group, Riesz Decomposition Theorem, Basic facts, Definition of Convex l-subgroup, Prime Subgroup, Polar.

Suggested Readings:

1.George Grätzer , General Lattice Theory, Birkhäuser Verlag (Second Edition).
2.G. Birkhoff, Lattice Theory, Amer. Math. Soc. Coll. Publications, Third Edition 1973
3.Davey B. A. and Priestly H. A. (2002), Introduction to Lattices and Order, Cambridge University Press .
4.Kopytov V. M. and Medvedev N. Y. (1994), The Theory of Lattice-Ordered Groups, Springer-Science.

Semester – III	**Paper – VI**
Course Code: MSC-MT-316 T	**Title of the Course:** Fractional Calculus
Credits: 2	**Total Lectures: 30 Hrs.**

Course Outcomes (COs):

a. Compare Grünwald-Letnikov,Riemann-Liouville,and Caputo fractional derivative.
b. Evaluate fractional derivatives and fractional integral of power function and trigonometric functions.
c. To understand Linear Fractional Differential Equations and Laplace Transform.
d. To understand and solve Fractional Differential Equations.

Detailed Syllabus:

UNIT I: Introduction of Fractional Calculus. [07 Hours]

1.1 Gamma function and its properties, Beta function, Contour integral representation. Fractional derivatives
1.2 Grunwald-Letnikov, Riemann-Liouville and Caputo's fractional derivative, Leibniz rulefor fractional.
1.3 Derivatives, Geometric and physical interpretation of fractional integration and fractional differentiation.

UNIT II: Integral Transforms [07 Hours]

2.1 Sequential fractional derivatives. Left and right fractional derivatives. Properties of fractional derivatives.
2.2 Laplace transforms of fractional derivatives. Fourier transforms and Mellin transforms of fractional derivatives.

UNIT III: The Laplace transform method [08 Hours]

3.1 Linear Fractional Differential Equations: Fractional differential equation of a general form.
3.2 Existence anduniqueness theorem as a method of solution. Dependence of a solution on initial conditions.
3.3 The Laplacetransform method. Standard fractional differential equations. Sequential

fractional differential equations.

UNIT IV: Fractional Differential equations **[08 Hours]**

4.1Fractional Differential Equations: Introduction, linearly independent solutions, Solutions of the homogeneousand non-homogeneous fractional differential equations,

4.2 Reduction of fractional partial differential equations toordinary differential equations.

Suggested Readings:

1. Oldham K. B. and Spanier J., The Fractional Calculus: Theory and Applications of Differentiation andIntegration to Arbitrary Order, Dover Publications Inc, 2006.
2. Miller K. S. & Ross. B., An Introduction to the Fractional Calculus and Fractional Differential EquationsHardcover, Wiley Blackwell, 1993.
3. Podlubny I., Fractional Differential Equations, Academic Press, 1998.
4. A. AnatoliiAleksandrovichKilbas, Hari Mohan Srivastava, Juan J. Trujillo, Theory And Applications of Fractional Differential Equations,Elsevier, 2006

Semester – IV	**Paper – I**
Course Code: MSC-MT 411 T	**Title of the Course:** Fourier Series and Boundary Value Problems
Credits: 04	**Total Lectures: 60 Hrs.**

Course Outcomes (COs):

a.Students will learn the basics of Fourier series.
b.Students will learn the separation of variable technique for solving linear secondorder PDEs (heat equation, Laplace's equation, wave equation).
c. Students will learn the basic properties of and how to solve regular SturmLiouville eigenvalue problems.
d.Acquire knowledge about the notion ofconvergence of numerical sequences and series and learn ways of testing convergence

Detailed Syllabus:

Unit I: Fourier Series **[10 Hours]**
1.1 Piecewise Continuous Functions, Fourier Cosine Series, Examples.
1.2 Fourier Sine Series, Examples.
1.3 Fourier Series, Examples.
1.4 Adaptations to other Intervals.
Unit II: Convergence of Fourier Series **[10 Hours]**
2.1 One-Sided Derivatives, Property of Fourier Coefficients.
2.2 Two Lemmas, Fourier Theorem, Discussion of the theorem and its Corollary, Convergence on other intervals, Lemma.
2.3 Absolute and uniform convergence of Fourier series, Differentiation of Fourier series, Integration of Fourier series.
Unit III: The Fourier Method **[08 Hours]**
3.1 Linear Operators, Principle of Superposition.
3.2 A Temperature Problem, A Vibrating String Problem.
Unit IV: Boundary Value Problems **[12 Hours]**
4.1 A Slab with Faces at Prescribed Temperatures, Related Problems, A Slab with Internally Generated Heat, Steady Temperatures in a Rectangular Plate.
4.2 Cylindrical Coordinates, String with Prescribed Initial Conditions, Resonance, Elastic Bar.
4.3 Double Fourier Series, Periodic Boundary Conditions.
Unit V: Orthonormal Sets **[12 Hours]**
5.1 Inner Products and Orthonormal Sets, Examples.
5.2 Generalized Fourier series, Examples.

5.3 Best approximation in the Mean, Bessel's Inequality and Parseval's Equation.
5.4 Application to Fourier series.

Unit VI: Sturm-Liouville's Problems and Applications **[08 Hours]**

6.1 Regular Sturm-Liouville Problems, Modifications, Orthogonality of Eigen functions, Real-Valued Eigen functions and Non-negative Eigen Values, Methods of solution.
6.2 Examples of Eigen functions Expansions, A Temperature Problem in Rectangular Coordinates, Another Problem, Other Coordinates.
6.3 Modification of the Method, Another Modification.

Suggested Readings:

1.J.W.Brown and R.V.Churchill: Fourier Series and Boundary Value Problems. 8th Edition, McGraw Hill Education (India) Private Limited,New Delhi.
2.Murray Spiegel, Fourier Analysis with Applications to Boundary Value Problems, Schaum's Outline Series, McGraw Hill.
3.W. E. Boyce and R. C. DiPrima, "Elementary Differential Equations and Boundary ValueProblems", John Wiley and Sons.(7th Edition)
4. Walter Rudin, Fourier Analysis on Groups, Dover Publications, 2017

Semester-IV	Paper-II
CourseCode: MSC-MT 412 T	TitleoftheCourse: Differential Geometry
Credits:4	TotalLectures: 60 Hrs.

Course Outcomes(COs):

- **a.** Students are able to understand the concept of Graphs and Level sets.
- **b.** To find and sketch the gradient vector field for a given function.
- **c.** To study concept of vector fields on surfaces and Orientation.
- **d.** To understand the concepts of Parallel transport, Weingarten map and curvature of plane curve.

Details of Syllabus:

Unit I. Graphs and Vector fields [15 Hours]

1.1 Graphs
1.2 Level Sets
1.3 Vector Fields
1.4 The Tangent Space
1.5 Surfaces

Unit II. Surfaces and Orientation [15 Hours]

2.1 Vector Fields on Surfaces
2.2 Orientation
2.3 The Gauss Map
2.4 Geodesics
2.5 Results on geodesics
2.6 Parallel Transform.

Unit III. Plane Curves [20 Hourrs]

3.1 The Weingarten Map, winding number
3.2 Shape operator
3.3 Normal component of acceleration
3.4 Curvature of Plane Curves, Global parametrization, Examples
3.5 Frenet Formula

Unit IV Line Integral [10 Hours]

4.1. Arc Length
4.2.Line Integrals
4.3.Differential 1-form, Results on 1-form
4.4.Curvature of Surfaces
4.5.Normal curvature
4.6.Quadratic form

Suggested Readings

1. J.A. Thorpe, Elementary Topics in Differential Geometry, First Indian Reprint, Springer (2004)

2. Andrew Pressley Elementary Differential Geometry, Springer International Edition UTM, Indian Reprint (2004).

3. Struik, D.T. Lectures on Classical Differential Geometry, Addison - Wesley, Mass (1950).
4. Kobayashi. S. and Nomizu. K. Foundations of Differential Geometry, Interscience Publishers, (1963)

5. Wilhelm Klingenberg: A course in Differential Geometry, Graduate Texts in Mathematics, Springer-Verlag (1978).

Semester – IV	**Paper – III**
Course Code: MSC-MT 413 T+P	**Title of the Course: Introduction to Data Science**
Credits: 2+2	**Total Lectures: 60 Hrs.**

Course Outcomes (COs):

- **a.** Explore the fundamental concepts of data science.
- **b.** Understand data analysis techniques for applications handling large data.
- **c.** Understand various machine learning algorithms used in data science process.
- **d.** Visualize and present the inference using various tools and learn to think through the ethics surrounding privacy, data sharing and algorithmic decision making.

Detailed Syllabus:

UNIT I: Data **[10 Hours]**

1.1 Introduction
1.2 Data Types
1.3 Data Collections
1.4 Data Pre-processing

UNIT II: Data Techniques **[15 Hours]**

2.1 Introduction
2.2 Data Analysis and Data Analytics
2.3 Descriptive Analysis
2.4 Diagnostic Analytics
2.5 Predictive Analytics
2.6 Prescriptive Analytics
2.7 Exploratory Analysis
2.8 Mechanistic Analysis

UNIT III:Machine Learning Introduction and Regression **[18 Hours]**

3.1 Introduction
3.2 What is Machine Learning?
3.3 Regression
3.4 Gradient Descent

UNIT IV:Supervised Learning **[17 Hours]**

4.1 Introduction
4.2 Logistic Regression
4.3 Softmax Regression
4.4 Classification with ( )kNN
4.5 Decision Tree
4.6 Random Forest
4.7 Naïve Bayes

4.8 Support Vector Machine (SVM)

Suggested books:

1. Chirag Shah, A Hands-on Introduction to Data Science, Cambridge University Press, (2020)
2. Davy Cielen, Arni D.B. Mesman, Mohamed Ali, Introducing data science, Manning Publications Co., 1st edition, 2016
3. Joel Grus, Data Science from Scratch: First Principles with Python, O'Reilly, 1st edition, 2015
4. Cathy O'Neil, Doing data Science, Straight Talk from frontline, Rachel Schutt, O'Reilly, 1st edition, 2013

Semester – IV	Paper – IV
Course Code: MSC-MT 414 T (A)	**Title of the Course:Number Theory**
Credits: 4	**Total Lectures: 60 Hrs.**

Course Outcomes (COs):

- **a.** This course will enable students to learn some of the open problems related to prime numbers.
- **b.** This course enables student to learn about number theoretic functions and modular arithmetic.
- **c.** Students are able to apply Euclidean algorithm to integers.
- **d.** Students are able to determine multiplicative inverses, modulo n and use to solve linear congruences.
- **e.** Students can understand how to apply De'Polignac formula

Detailed Syllabus:

Unit I: Integers **[10 Hours]**

1.1 Divisibility in integers

1.2 Division algorithm

1.3 G.C.D., L.C.M.

1.4 Fundamental theorem of arithmetic and the number of primes

Unit II: Congruences **[18 Hours]**

2.1 Properties of congruence relation

2.2 Residue classes their properties

2.3 Fermat's and Euler's theorems

2.4 Wilson's Theorem.

2.5 Linear congruence's of degree one

2.6 Chinese remainder Theorem

Unit III: Quadratic Reciprocity **[16 Hours]**

3.1 Quadratic residue

3.2 Quadratic reciprocity law

3.3 Jacobi symbol and its properties

3.4 Sums of Two Squares

Unit IV: Some Functions of Number Theory **[08 Hours]**

4.1 Greatest integer function

4.2 Arithmetic Function

4.3 Mobius Inversion formula

Unit V: Diophantine Equations [08 Hours]

5.1 The equation ax + by = c

5.2 Simultaneous linear equations

Suggested Readings:

1. Ivan Niven and H.S. Zuckerman, An Introduction to Number Theory, (Wiley Eastern Limited), (Fifth edition), 1991
2. T.M. Apostol, An Introduction to Analytical Number Theory, (Springer International Student's Edition), 1998
3. David M Burton, Elementary Number Theory (Universal Book Stall, New Delhi), (Second edition), 1994
4. S. G. Telang, Number Theory (Tata McGraw Hill), 1996
5. G. H. Hardy and E. M. Wright, An Introduction to Theory of Numbers,(The English language book society and oxford university press),(Sixth Edition), 2008

Semester – IV	Paper – IV
Course Code: MSC-MT 414 T (B)	Title of the Course:Optimization Techniques
Credits: 4	Total Lectures: 60 Hrs.

Course Outcomes (COs):

a. Students are able to solve multi-objective optimization problems, using goal programming allows to stay within efficient linear programming computational environment.
b. Students understands how to solve Integer linear programming using algorithms.
c. Students are able to identify when a model as a dynamic program and understand the various algorithms for solving a dynamic program.
d. Students understands that Decision analysis gives approach for making optimal choices under conditions of uncertainty and learn how to take decisions to solve the problems.

Detailed Syllabus:

Unit I: GOAL PROGRAMMING [14 hours]

1.1 Difference between LP and GP Approach

1.2 Concept of Goal Programming

1.3 A Goal Programming Formulation

1.4 Goal Programming Algorithms (The Weights Method and The Pre-emptive Method)

1.5 Graphical Solution Method for Goal Programming

1.6 Modified Simplex Method for Goal Programming

Unit II: INTEGER LINEAR PROGRAMMING [12 hours]

2.1 Applications- Capital Budgeting, Set-Covering Problem, Fixed-Charge Problem, Either-Or and If-Then Constraints

2.2 Integer Programming Algorithms (Branch-and-Bounded(B&B) Algorithm, Cutting- Plane Algorithm)

Unit III: DYNAMIC PROGRAMMING [16 hours]

3.1 Dynamic Programming Terminology

3.2 Developing Optimal Decision Policy (The General Algorithm)

3.3 Deterministic Dynamic Programming

3.4 Recursive Nature of Computations in DP

3.5 Forward and Backward Recursion

3.6Dynamic Programming under Certainty involving additive and multiplicative separable returns for objective as well as constraint function

3.7 Problem of dimensionality

Unit IV: DECISION THEORY [18 hours]

4.1 Steps of Decision-Making Process

4.2 Types of Decision Making Environments

4.3 Decision-Making Under Uncertainty- Criterion of Optimism, Criterion of Pessimism, Equal Probabilities (Laplace) Criterion, Coefficient of Optimism (Hurwicz) Criterion , Regret (Savage) Criterion

4.4 Decision-Making Under Risk

4.5 Posterior Probabilities and Bayesian Analysis

4.6 Decision Trees Analysis

Suggested Readings:

1. Hamdy A. Taha , Operation Research-An Introduction , Pearson Education, 10th Ed. 2017.
2. J. K. Sharma, Operations Research (Theory and Applications) , Macmillan India, 4th Ed. 2009.
3. Er.Prem Kumar Gupta and Dr. D.S.Hira, Operation Research, S chand& Company Ltd ,Revised Ed. 2017
4. S.Chandra, Jayadeva, Aparna Mehra, Numerical Optimization with Application, Narosa Publishing House, 2009.

Semester – IV	Paper – V
Course Code: MSC-MT-415T(A)	Title of the Course: Coding Theory
Credits: 4	Total Lectures: 60 Hrs.

Course Outcomes (COs):

a. Learn about input and output of a signal via transmission channel
b. Learn about Minimal polynomial
c. Study detection and correction of errors during transmission
d. Represent a linear code by matrices – encoding and decoding

Detailed Syllabus:

Unit I:Error Detection, Correction and Decoding: **[14 Hours]**

1.1 Communication channels, q-ary symmetric channel, Binarysymmetric channel
1.2 Maximum likelihood decoding
1.3 Hamming distance
1.4 Nearest neighbour/minimum distance decoding
1.5 Distance of a code

Unit II: Finite Fields

2.1 Introduction of Finite Field **[06 Hours]**
2.2 Primitive element of finite field
2.3 Minimal polynomials
2.4 Cyclotomic cosets
2.5 Factorization of $x^n - 1$

Unit III: Linear Codes **[18 Hours]**

3.1 Vector spaces over finite fields
3.2 Linear codes, Dimension of linear code, Dual code,Self-Orthogonal and self-dual code
3.3 Hamming weight
3.4 Bases for linear codes
3.5 Generator matrix and parity-check matrix
3.6 Equivalence of linear codes
3.7 Encoding with a linear code
3.8 Decoding of linear codes
3.9 Cosets, Coset leader
3.10 Nearest neighbour decoding for linear codes
3.11 Syndrome decoding

Unit-IV:Bounds in coding theory **[10 Hours]**

4.1 The main coding theory problem
4.2 Lower bounds
4.3 Sphere-covering bound
4.4 Gilbert–Varshamov bound
4.5 Hamming bound and perfect codes
4.6 Binary Hamming codes
4.7 q-ary Hamming codes

Unit-V: Cyclic Codes **[12 Hours]**

5.1 Cyclic codes, Ideal, Principal ideal

5.2 Generator polynomials

5.3 Generator and parity-check matrices

5.4 Reciprocal Polynomial

5.5 Decoding of cyclic codes, Decoding algorithm

Suggested Readings:

1. San Ling, Chaoping Xing, Coding Theory- A First Course,First Edition**(**Cambridge University Press 2004)

2. Raymod Hill, A First Course in Coding Theory,First Edition (Oxford University Press 2001)

3. Lid and Pilz, Applied Abstract Algebra, Second Edition (Springer Publication 2010)

4. J. H. van Lint, Introduction to Coding Theory,Third Edition (Springer Publication 1999)

Semester – IV	Paper – V
Course Code: MSC-MT 415 T (B)	Title of the Course: Fuzzy Set Theory
Credits: 4	Total Lectures: 60 Hrs.

Course Outcomes (COs):

- **a.** Provides knowledge on the basic definitions and fundamentals of Fuzzy set theory.
- **b.** Able to understand idea on Fuzzy graphs and its properties.
- **c.** Improves their ability in the concept of Fuzzy relations in real life situations
- **d.** Attains knowledge of the Fuzzy Sets in different forms

Detailed Syllabus:

UNIT I: FUZZY SETS **[10 Hours]**

1.1 Sets
1.2 Operation of sets
1.3 Characteristics of Crisp Set
1.4 Definition of Fuzzy Set
1.5 Expanding Concepts of Fuzzy Set
1.6 Standard Operation on Fuzzy Sets

UNIT II: THE OPERATIONS ON FUZZY SETS **[10 Hours]**

2.1 Standard Operations on Fuzzy Sets
2.2 Fuzzy Complement
2.3 Fuzzy Union
2.4 Fuzzy Intersection
2.5 Other Operations in Fuzzy Set
2.6 T-norms and T-conorms

UNIT III: FUZZY RELATION AND COMPOSITION **[10 Hours]**

3.1 Crisp Relation
3.2 Properties of Relation on a Single Set
3.3 Fuzzy Relation
3.4 Extension of Fuzzy Set

UNIT IV: FUZZY GRAPH AND RELATION **[15 Hours]**

4.1 Fuzzy Graph
4.2 Characteristics of Fuzzy Relation
4.3 Classification of Fuzzy Relation
4.4 Other Fuzzy Relations

UNIT V: FUZZY NUMBER **[15 Hours]**

5.1 Concept of a fuzzy number
5.2 Operation of fuzzy number
5.3 Triangular fuzzy number
5.4 Other types of fuzzy number

Suggested Readings:

1. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005

2. ChanderMohan , An Introduction to Fuzzy Set Theory and Fuzzy Logic, Anshan Publishers, 2015
3. H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 1991.
4. John Yen, Reza Langari, Fuzzy Logic - Intelligence, Control and Information, Pearson Education, 1998

Semester-IV	Paper-VI
CourseCode:MSC-MT 416 P	**TitleoftheCourse:**Practical: Mathematica (Wolfram Cloud)
Credits:2	**TotalLectures: 60 Hrs.**

Course Outcomes (COs):

a. Handling the Mathematica (Wolfram Cloud) software.

b. Acquire proficiency in using different commands of Mathematica to compute solutions of basic mathematical functions and solutions of system of equations.

c. Demonstrate the use of Mathematica to solve differential equations and Integration along with visualize the solutions.

d. Create 2D, 3D and interactive graphics with controls to dynamically change the parameters.

Detailed Syllabus:

Unit I:Working with Mathematica [10 Hours]

1.1 Introduction Mathematica
1.2 The Basic Technique for Using Mathematica
1.3 The First Computation
1.4 Commands for Basic Arithmetic
1.5 Input and Output
1.6 The Basic Math
1.7 Decimal In, Decimal Out
1.8 Three Well-Known Constants
1.9 Typing Commands in Mathematica

Unit II:Functions and Their Graphs [10 Hours]

2.1 Defining a Function
2.2 Plotting a Function
2.3 Using Mathematica's Plot Options
2.4 Investigating Functions with Manipulate
2.5 Producing a Table of Values
2.6 Combining Graphics

Unit III:Fun with Algebra in Mathematica [20 Hours]

3.1 Factoring and Expanding Polynomials
3.2 Finding Roots of Polynomials with Solve and NSolve
3.3 Solving Equations and Inequalities with Reduce
3.4 Working with Rational Functions
3.5 Working with Other Expressions
3.6 Solving General Equations
3.7 Solving Difference Equations
3.8 Solving Systems of Equations

Unit IV:Visualization: Calculus [20 Hours]

4.1 Computing Limits
4.2 Working with Difference Quotients
4.3 The Derivative
4.4 Visualizing Derivatives
4.5 Higher Order Derivatives
4.6 Implicit Differentiation
4.7 Differential Equations
4.8 Integration
4.9 Definite and Improper Integrals
4.10 Numerical Integration
4.11 Surfaces of Revolution
4.12 Sequences and Series

Suggested Readings:

1. Bruce F. Torrence, Eve A. Torrence , The Student's Introduction to Mathematica: A Handbook for Precalculus, Calculus, and Linear Algebra, CAMBRIDGE UNIVERSITY PRESS, Second edition,2009
2. Stephen Wolfram,The Mathematica Book, 5th ed. (Wolfram Media, 2003)
3. Cliff Hastings, Kelvin Mischo, Hands-on Start to Wolfram|Alpha Notebook Edition, Wolfram Media,Year: 2020
4. Edward B. Magrab , Advanced Engineering Mathematics with Mathematica, CRC Press, 2020