DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY

CIRCULAR NO.SU/Sci./M.Sc.Mathematics/06/2022

It is hereby inform to all concerned that, the syllabus prepared by the Board of Studies in Mathematics and recommended by the Dean, Faculty of Science & Technology the Hon'ble Vice-Chancellor has accepted the **Syllabus of M.A/M.Sc. Mathematics Second Year (IIIrd & IVth semester) for affiliated Colleges and University Department** in his emergency powers under section 12(7) of the Maharashtra Public Universities Act, 2016 on behalf of the Academic Council as appended herewith.

This shall be effective from the Academic Year 2022-23 and onwards.

All concerned are requested to note the contents of this circular and bring notice to the students, teachers and staff for their information and necessary action.

University Campus,
Aurangabad-431 004.
REF.NO. SU/SCI/2022/5304-5310
Date:- 02.08.2022

Deputy Registrar,
Academic Section.

Copy forwarded with compliments to :-

1] **The Principal of all concerned Colleges,**
Dr. Babasaheb Ambedkar Marathwada University,
2] **Head of the Department, Department of Mathematics,**
Dr.Babasaheb Ambedkar Marathwada University, Aurangabad.
3] **The Director, University Network & Information Centre, UNIC, with a request to upload this Circular on University Website.**

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1] The Director, Board of Examinations & Evaluation,Dr.BAMU,A'bad.
2] The Section Officer,[M.Sc.Unit] Examination Branch,Dr.BAMU,A'bad.
3] The Programmer [Computer Unit-1] Examinations, Dr.BAMU,A'bad.
4] The Programmer [Computer Unit-2] Examinations, Dr.BAMU,A'bad.
5] The In-charge,[E-Suvidha Kendra], Rajarshi Shahu Maharaj Pariksha Bhavan, Dr.BAMU,A'bad.
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7] The Record Keeper, Dr.BAMU,A'bad.

DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD.

CURRICULUM UNDER CHOICE BASED CREDIT

&

GRADING SYSTEM

MATHEMATICS

M.A/M.Sc. SECOND YEAR

SEMESTER – III AND IV

RUN AT UNIVERSITY DEPARTMENT AND AFFILIATED COLLEGES.

W.E.F 2022-2023

Dean
Faculty of Science & Technology
Dr. Babasaheb Ambedkar Marathwada
University, Aurangabad

Dr. Bhausaheb R. Sontakke
Chairman,
Board of Studies in Mathematics,
Dr. Babasaheb Ambedkar Marathwada
University, Aurangabad (M.S.)

DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD

Curriculum under Choice Based Credit and Grading System

M.A/M.Sc. Second Year Mathematics

Semester III

Courses	Course Code	Title of the Courses	No of periods per week	University Assessment (Theory)	Continuous Internal Assessment	Total Marks	Credits
Core Courses	MAT 501	Functional Analysis	06	80	20	100	6
	MAT 502	Partial Differential Equations	06	80	20	100	6
Elective Courses (Choose any THREE Courses)	MAT 521	MATLAB Programming	06	80	20	100	6
	MAT 522	Fluid Mechanics-I	06	80	20	100	6
	MAT 523	Numerical Analysis	06	80	20	100	6
	MAT 524	Lattice Theory	06	80	20	100	6
	MAT 525	Operation Research – I	06	80	20	100	6
	MAT 526	Fourier Analysis and Applications	06	80	20	100	6
	MAT 527	Fractional Differential Equations-I	06	80	20	100	6
	MAT 528	Reaction Diffusion Theory	06	80	20	100	6
Total Credits							30

30/7/22
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University, Aurangabad (M.S.)

Semester- IV

Courses	Course Code	Title of the Courses	No of periods per week	University Assessment (Theory)	Continuous Internal Assessment	Total Marks	Credits
Core Courses	MAT 511	Linear Integral Equations	06	80	20	100	6
	MAT 512	Mechanics	06	80	20	100	6
Elective Courses (Choose any THREE Courses)	MAT 531	Difference Equations	06	80	20	100	6
	MAT 532	Fluid Mechanics-II	06	80	20	100	6
	MAT 533	Fuzzy Mathematics	06	80	20	100	6
	MAT 534	Analytic Number Theory	06	80	20	100	6
	MAT 535	Operations Research – II	06	80	20	100	6
	MAT 536	Wavelet Analysis	06	80	20	100	6
	MAT 537	Fractional Differential Equations-II	06	80	20	100	6
	MAT 538	Coding Theory	06	80	20	100	6
Total Credits							30

Total No. of Credits for III and IV Semester = 60

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Semester-III

Course Number.: MAT 501 **Credits: 06**

Functional Analysis

Learning Objectives: To introduce the Banach spaces, Hilbert spaces and spectral theory.

Learning Outcomes: The students will be able to study various fixed point theorems, spectrum of normal and self-adjoint operators which will be useful to them in the existence and uniqueness results of differential equations.

Unit I:

Banach Spaces: Definition and Examples, Continuous linear transformations, The Hahn Banach Theorem

Unit II:

Natural embedding of N in N^{**}, The open mapping Theorem, The conjugate of an operator.

Unit III:

Hilbert Spaces: Definition and simple properties, Orthogonal compliments, Orthonormal sets, The conjugate space of H^*.

Unit IV:

The adjoint operator, Self-adjoint operators, Normal and Unitary operators, Projections.

Unit V:

Finite-dimensional Spectral Theory: Matrices, Determinants and spectrum of an operator, The spectrum theorem, Fixed point theorems.

Text Book:

G. F. Simmons: ***Introduction to Topology and Modern Analysis***: McGraw Hill Book Company (1963)

Scope:

Chapter 9: Articles 46, 47, 48, 49, 50, 51.

Chapter 10: Articles 52, 53, 54, 55, 56, 57, 58, 59.

Chapter 11: Articles 60, 61, 62.

Appendix One

Reference Books:

1) Angus E. Taylor, *Introduction to Functional Analysis*: John Wiley & Sons (1958)

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2) B. Choudhary, Sudarshan Nanda: *Functional Analysis with Applications*: Wiley Eastern Ltd. New Delhi (1989)

3) D. Somsundarm: *A First Course in Functional Analysis*: Narosa Publishing House New Delhi (2006)

4) Erwin Kreyszig: *Introduction to Functional Analysis with Application*: John Wiley and Sons New York (1966)

5) J. B. Conway, *A Course in Functional Analysis*: Springer-Verlag (1985)

6) S. Kesavan, *Topics in Functional Analysis and Applications*: Wiley Eastern New Delhi Ltd. New Delhi (1989)

7) B. V. Limaye: *Functional Analysis*: Wiley Eastern New Delhi Ltd. New Delhi (1981)

8) L. J. Maddox: *Elements of Functional Analysis*: Cambridge University Press (1970)

9) Martin Schechter: *Principles of Functional Analysis*: American Mathematical Society (2002).

10) S. Kumaresan, D. Sukmar: *Functional Analysis*: *A first Course*: Narosa Publishing House.

Semester – III

Course No.: MAT-502 **Credits: 06**

Partial Differential Equations

Learning Objectives: Students who take this course can expect to:

- Fundamentals of DE and PDE.
- General analysis of PDE.
- Fundamentals Linear and Nonlinear PDE.
- Fundamentals Jacobi's method, Charpit's Method

Learning Outcomes:

- Student will become familiar with DE and PDE to find the solutions.
- Student will be able to analysis to classify the second order PDE.
- Student will become familiar with how to find the general solution of PDE by using Jacobi's method, Charpit's Method.
- Student will be able to handle to solve any type of PDE.
- Students will be able to handle to solve boundary value problem.

Unit-I:

First order partial differential equation, linear equations of the first order, Pfaffian differential equation, integral surface passing through a curve, surfaces orthogonal to a given system of surfaces.

Unit-II:

Non-linear partial differential equations of the first order, Cauchy's method of characteristics, compatible system of first order equations (condition of compability), Charpit's method.

Unit-III:

Special types of first order equations, solutions satisfying given conditions,

a) Integral surface through a curve.
b) Derivation of one complete integral from another.
c) Integral surfaces circumscribing a given surfaces.

Jocobi's method for solving $F(x, y, z, p, q) = 0$

Unit-IV:

The origin of second order equations, linear partial differential equations with constant coefficients, Vibration of an infinite string, vibration of semi-infinite string, vibration of a string of finite length, classification of second order partial differential equation (Canonical form).

Unit-V:

Boundary value problem, maximum and minimum principles, the Cauchy problem, the Dirichlets problem, Neumann problem, heat conduction problem, characteristic curves of second order equation, the solution of hyperbolic equations, separation of variables, the method of integral transform.

Text books:

1. **Ian Sneddon:** Elements of Partial Differential Equation, Dover Publication, McGraw – Hill Book Company, New York, 1957. (Chapter 2, Chapter 3, Chapter 5 and Chapter 6).

2. **T. Amarnath**: An Elementary Course in Partial Differential Equation (2nd Edition) – Narosa Publishing House 2003. (Chapter 1.5, 1.7, 1.8, 2.2, 2.3, 2.4, 2.5).

Reference book:

1. **M.D. Raisighania**: Ordinary and Partial Differential Equation, S. Chand & Company Ltd, New Delhi.

Semester – III

Course No.: MAT 521 **Credits 06**

MATLAB Programming

Learning Objective: The main objective of the paper is to study the MATLAB programming language to solve numerical problems

Learning Outcome: After learning this paper student will be able to write the mathematical programs in MATLAB.

Unit – I:

Introduction: Input / output of Data from MATLAB Command, file Types, Creating saving and, Executing the Script file, Creating and executing functions file, working with files and directories.

Unit – II:

Matrices: Matrix manipulation, creating vectors. Arithmetic operations. Relational operations, Logical operations, matrix functions, Determinant of matrix, Eigen values and Eigen vectors.

Unit – III:

Programming in Matlab: function files, sub functions, Global Variables, Loops, branches and control flow, Interactive input, Recursion, Publishing a report, Controlling Command Windows, Command line Editing.

Unit – IV:

Linear algebra and Interpolation: solving a linear system, Gaussian elimination, Matrix factorizations, Curve fitting, Polynomial curve fitting, Least squares curve fitting, General nonlinear fits, Interpolation.

Unit – V

Differential equations & Graphics: First order linear ODE, Second order ODE, Double integration, Roots of Polynomial, 2-d plots, 3-D plots, Matlab Plotting tools, Mesh and Surface Plots.

Text Books:

1. Applied Numerical Methods Using MATLAB, Won Young Yang, Tae-Sang chung, John Morris, A John Wiley and Sons. Inc. Publication.
2. Solving ODE's with Maltab, L.F. Shampine, I Gladwell, S. Thompson, Cambridge University Press

3. Getting Started with MATLAB 7, Rudra Pratap. OXFORD Press.

Reference Books:

1. Brain D. Hahn Dan: essential MATLAB for engineers and Scientists, 3rd Edition Valentine.
2. Gunnar Backstrom: Practical Mathematics Using Matlab.

Semester – III

Course No: MAT-522 **Credits: 06**

Fluid Mechanics-I

Learning Objectives: Students who take this course can expect to:

- Fundamentals of fluids.
- General Analysis of fluid motions, fluid pressure.
- Fundamentals of motion.
- Fundamentals of two dimensional flows

Learning Outcomes:

- Student will become familiar with real and ideal fluids, also able to find velocity at a point, stream lines, path lines etc.
- Student will be able to analysis fluid motion, also able to find fluid pressure at rest and moving fluid.
- Student will become familiar with motion. i.e. two dimensional motion, Impulsive motion, vortex motion etc.
- Student will be able to handle 2-D irrotational, incompressible flow.

Unit – I :
Review of vector Analysis, Kinematics: Lagrangian and Eulerian methods (Rathy) Real and ideal fluids, velocity at a point, streamlines, path lines, streak lines, velocity potential, irrotational and rotational motions (Rathy), vorticity and circulation, Local and particle rates of change, The equation of continuity.

Unit – II:
Acceleration of a Fluid. Conditions at rigid boundary, General analysis of fluid motion. Pressure at a point in a fluid at rest and moving fluid, conditions at a boundary of two inviscid immiscible fluids, Euler's equation of motion, Bernoulli's equation.

Unit – III:

Steady motion under conservative body forces, Potential Theorems, Axial symmetric flows, some two dimensional flows, Impulsive motion, some aspects of vortex motion, sources, sinks, doublets and their images.

Unit – IV:

Some two dimensional flows: Meaning of two dimensional flow, use of cylindrical polar coordinates, The stream function, The complex potential for two dimensional irrotational, incompressible flow, complex velocity potentials for standard two dimensional flows

Unit – V:

Examples, two dimensional image systems, Milne-Thomson circle theorem, applications and extension of circle theorem, the theorem of Blasius, conformal Transformation.

Text Books:

1. R. K. Rathy, An Introduction to Fluid Dynamics, IBH, New Delhi, 1976

   Chapter – III: Article 3.1, 3.5, 3.6

2. F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers and Distributors, Delhi, 1985.

   Chapter – 2: Article 2.1 to 2.10, Chapter – 3 Article 3.1 to 3.12

   Chapter – 4: Article 4.1 to 4.3, Chapter – 5: Article 5.1 to 5.10

Reference Books:

1. S. W. Yuan Foundations of Fluid Mechanics, Prentic Hall of India Pvt. Ltd, New Deli, 1976.
2. W. H. Besaint and A. S. Ramsey, A Treatise on Hydromechanics, Part- II CBS Publishers, Delhi, 1988.
3. J. Chorin and A. Marsden, A Mathematical Introduction to Fluid Dynamics, Springer-verlag, New York, 1993.

Semester-III

Course No.: MAT 523 **Credits: 06**

Numerical Analysis

Learning Objectives: To become familiar with Director Method and iterative method.

Learning Outcomes: The students will able to distinguish between classical or direct methods and iterative methods.

Unit – I: Solution of algebraic and transcendental equations: Introduction; Bisection method; Iteration methods based on first degree equation: Newton Raphson method; Secant and Regula-falsi methods, Rate of convergence for secant method and Newton Raphson method; General iteration methods.

Unit –II: System of linear Algebraic equations: Introduction; Linear system of equations: Direct methods; Gauss Elimination method; Gauss – Jordan Elimination method; Triangularization method; Iteration methods; Jacobi iteration method; Gauss – Seidal iteration method; successive over Relaxation (SOR) method.

Unit- III: Interpolation and approximation: Introduction; Lagrange and Newton Interpolation; Finite difference operators; Interpolating polynomial using finite difference; Hermite interpolation; piecewise and spline interpolation.

Unit –IV: Differentiation and integration: Introduction; Numerical Differentiate; Numerical Integration; Methods based on interpolation; Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpson's $3/8^{th}$ rule; Composite Integration methods; Gauss quadrature methods; Gauss-Legendre Integration methods; Gauss-Legendre Formulas.

Unit – V: Ordinary Differential Equations: Initial Value Problems: Introduction, Difference Equations, Numerical methods, Single step Methods, Runge-Kutta methods.

Text Book: -

1. Jain, lyenger and Jain, Numerical Methods for Scientific and Engineering Computation, Fifth Edition:2007, New Age International Publication, New Delhi.

Reference Books:

1. S. S. Sastry, Introduction to methods of Numerical Analysis, 4th edition, Prentice Hall Publication of India.
2. J. I. Buchaman and P.R. Turner, Numerical Methods and Analysis, Prentice Hall Publication of Indi

Semester -III

Course No.: MAT 524 **Credits: 06**

Lattice Theory

Learning Objectives: To introduce lattice structure, Modularity and Distributivity in lattice, Boolean algebra

Learning Outcomes: Students should acquire thorough knowledge of fundamental notions from Lattice theory and properties of Lattices, Modular and Distributive Lattice, Boolean algebra. Students should develop ability to solve individually and creatively advanced problems of Lattice theory and also problems connected with its applications to mathematics, describe Lattices and Posets and their use

Unit - I:
Two definitions of Lattices, How to describe Lattices

Unit - II:
Some algebraic concepts, Polynomials, identities and inequalities

Unit - III:
Some special elements, Characterization theorems and representation theorems

Unit - IV:
Congruence relations, Topological representation

Unit -V:
Introduction to Stone algebra, identities and congruences

Text Book:
George Grätzer: ***Lattice Theory*: *First Concept and Distributive Lattices***: Dover Publications, Inc. Mincola, New York (1999)

Scope:
Chapter 1: Articles 1, 2, 3, 4, 5.
Chapter 2: Articles 7, 9, 11 (Upto theorem 5).
Chapter 3: Articles 14, 15 (Upto Lemma 6).
Appendix One

Reference Books:

1. George Grätzer: *The Congruences of A Finite Lattice*: Birkhäuser, Boston (2006)
2. George Grätzer: *Lattice Theory*: *Foundation*: Birkhäuser, Boston (2011)
3. George Grätzer: *General Lattice Theory*: Academic Press New York (1978)
4. T. Y. Blyth: *Lattices and Ordered Algebraic structures*: Springer- Verlag (2005)

5. Steven Roman: *Lattices and Ordered Sets*: Springer- Verlag (2008)
6. Garrett Birkhoff: *Lattice Theory*: American Mathematical Society, Providence, Rhode Island (1973)
7. L. A. Skornjakov: *Elements of Lattice Theory*: Hindustan Publishing Corporation New Delhi (1977)
8. D. E.Rutherford :*Introduction to Lattice Theory* : Oliver and Boyd, London (1965)
9. Raymond Bables and Philip Dwinger: Distributive *Lattices*: University of Missouri Press, Coumbia, Missouri (1974)
10. F. Maeda and S. Maeda: *Theory of Symmetric Lattices*: Springer- Verlag (1970)

Semester – III

Course No: MAT-525 **Credits: 06**

Operation Research - I

Learning Objectives: Students who take this course can expect to:

- Fundamentals of Linear Programming Problems.
- Graphical solution of L.P.P. Simplex method to solve L.P.P
- Duality in L.P.P.
- Transportation and assignment problems.

Learning Outcomes:

- The Student will become familiar with Linear Programming Problem and will able to find solution, feasible solution, and optimal solution.
- The Student will able to find optimal solution of L.P.P. using graphical method and simplex method.
- The Student will able to find primal and duality in L.P.P. also able to solve dual simplex method.
- Students will be able to handle Industrial Problem like – Transportation Problem, and Assignment Problem using various given methods.

Unit – I:

Operations research and its scope, Necessity of operations research in industry, Linear programming problems, convex sets, feasible solutions, formulation of L.P.P. method for solution of LPP.

Unit – II:

Graphical solution of L.P.P, Simplex method; theory and problems. Computational procedure, artificial variables inverse of a matrix using simplex method.

Unit – III:

Duality in L.P.P., Concept of duality, properties, dual simplex method, its algorithm. parametric linear programming.

Unit – IV:

Transportation and Assignment problems, various methods.

Unit – V:

Game theory two person zero sum games, saddle point mixed strategies, graphical solution, by L.P.P., dominance.

Text Books:

1. Kanti Swarup, P.K. Gupta and Man Mohan: Operations Research,

   S. Chand; & Sons, New Delhi.

   Chapter- 0 (Related concepts) Chapter 1, 2, 3, 4, 5, 10, 11.

2. Mittal, K. V.: Optimization Methods, Wiley, New Delhi.

Reference Books:

1. H. A. Taha: Operations Research- An introduction, Macmillan, New York,

2. N. S. Kambo, Mathematical-programming Techniques. Affiliated East- West Press, New Delhi.

Semester – III

Course No: MAT- 526 **Credits: 06**

Fourier Analysis and Applications

Learning Objectives: To introduce the mathematical technique of Fourier analysis.

Learning Outcomes:

1. The student can represent functions in the form of Fourier series.
2. The student can apply Fourier transform technique to obtain solutions of various problems in applied mathematics, physics, engineering, etc.

Unit – I : Fourier Series- I :- Definition of Fourier Series, Periodic functions, Euler's formulae, Fourier Series representation, Fourier Series of functions with arbitrary periods, Even and odd functions, Half range Expansions, Mean square Approximation and Parseval's Identity.
Unit – II: Fourier Series- II: - Complex form of Fourier Series, forced oscillations, Fourier Series Representation Theorem, Uniform Convergence and Dirichlet test for convergence of Fourier Series.

Unit – III: Fourier Transform-I: - Introduction, Fourier Integral Formulas, Definition of Fourier Transform and Examples, Fourier Transform of Generalized Functions, Basic properties of Fourier Transform.

Unit – IV: Fourier Transform-II: - Poisson Summation Formula, Shannon Sampling Theorem, Gibbs' Phenomenon, Heisenberg's Uncertainty Principle. Applications of Fourier Transform to Ordinary Differential Equations and Integral Equations.

Unit – V: Fourier Transform-III: - Solution of Partial Differential Equations, Fourier Cosine and Sine transforms, Examples, Properties and application to Partial Differential Equations and evaluation of Definite integrals.

Text Books: -

1. *Nakhle'H. Asmar,* Parctial Differential Equations with Fourier Series and Boundary Value Problems (2nd Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education in South Asia) (2012). ISBN: - 978-81-317-8819-6. **[Unit –I & Unit -II]**

2. *Lokenath Debnath & Damba Bhatta*, Integral Transforms and their application (2ndEd), Chapman& Hall/CRC (2007). ISBN-10:- 1-58488-575-0
[Unit–III to Unit -V]

Semester-III

Course No.: MAT 527 **Credits: 06**

Fractional Differential Equations-I

Learning Objectives: The course introduces some special functions of the fractional calculus, Riemann-Liouville fractional derivative, Caputo's fractional derivative, Laplace, Fourier and Mellin transforms of fractional derivatives, Existence and uniqueness theorem as a method of solution.

Learning Course Outcomes: After completing this course, the student will be able to:

CO1: Understand the Gamma, Mittag-Leffler, Wright functions.
CO2: Study Riemann-Liouville and Caputo fractional derivative.
CO3: Analyze the integral transform methods of solution of fractional differential equations.
CO4: Study existence and uniqueness theorem of fractional differential equations and Cauchy.

Unit-I: Special Functions:
Definition of Gamma function and Beta function, Some properties of Gamma and Beta functions, Relation between Gamma and Beta functions, Definition of Mittag-Leffler functions of one and two parameters, Relations of Mittag-Leffler function in two parameters, Wright function, Definition of Wright function, Integral relation and relation to other functions.

Unit-II: Fractional Integrals and Derivatives:
Grunwald-Letnikov fractional derivatives, Riemann-Liouville fractional derivative, some other approaches-Caputo's fractional derivative, generalized functions approach, Sequential fractional derivatives, Left and right fractional derivatives.

Unit-III: Integral transforms of Fractional Derivatives:
Laplace transform of fractional derivatives; Fourier transform of fractional derivative and Mellin transform of fractional derivative.

Unit-IV: Linear Fractional differential equations:
Linear Fractional differential equations, fractional differential equations of a general form, Existence and uniqueness theorem as a method of solution, dependence of a solution on initial conditions.

Unit-V: Riemann-Liouville Fractional Differential Equations in Space of summable functions:
Introduction and brief overview of results, equations with the Riemann-Liouville fractional derivative in the space of summable functions.

Text Books:

1. **Igor Podlubny**: Fractional Differential Equations, Academic Press, San Diego, California, 92101-4495, USA

   Scope: Unit I - Chapter 1.
   Unit II - Chapter 2- Art 2.1 to 2.6.
   Unit III - Chapter 2- Art 2.7 to 2.10.19
   Unit IV - Chapter 3.

2. **Anatoly A. Kilbas, Hari M. Srivastav, Juan J. Trujillo**: Theory and Applications of Fractional Differential Equations, Elesvier, New York 2006.

Scope: Unit-V – Chapter 3- Art 3.1, 3.2

Reference Books:

1. Miller K.S. and Ross B.: An Introduction to Fractional Calculus and Fractional Differential Equations, New York, John Wiley, 1993.
2. Oldham K.B. and Spanier J.: The Fractional Calculus, New York, Academic Press, 1974.
3. Shantanu Das: Functional Fractional Calculus, Berlin, Springer, 2011
4. Abdul-Majid Wazwaz: Partial Differential Equations and Solitary Waves Theory, Springer-Verlag Berlin Heidelberg 2009
5. Mainardi Francesco: Fractional Calculus and Waves in Linear Viscoelasticity, Imperial College Press,2010.

Semester- III

Course No: MAT 528 **Credits: 06**

Reaction Diffusion Theory

Learning Objectives: The course introduces Reaction Diffusion equations, monotone method for time dependent problems and parabolic boundary value problems, Existence and uniqueness theorems.

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

- Derive Reaction Diffusion equations and apply maximum principle and Positivity lemma.
- Develop monotone method for steady state problem.
- Analyze Positivity lemma and construct upper and lower sequences.
- Solve elliptic boundary value problems using upper and lower solutions.
- Analyze Enzyme- kinetics model, Chemical reactor model

Unit – I:

Reaction Diffusion Equations. Derivation of Reaction Diffusion Equations. Boundary Conditions. Derivation of Some Specific Models. Linear Reaction diffusion Equations. Maximum Principles [2] Positivity Lemmas.

Unit – II:

Monotone Method for Time Dependent Problems. Non uniqueness of Time Dependent Solutions. Monotone Method for Steady-State Problems. Applications to Specific Models.

Unit – III:

Parabolic Boundary value Problems. A Review of the Linear Parabolic Problem. (Theorem 1.2, and Theorem 1.3, statements only) Lemma 1.1, 1.2, 1.3 and Theorem 1.1, 1.2, 1.3 only statements. A Positivity Lemma. Upper and Lower Sequences. Positivity Lemma, Maximum Principles. [2]

Unit – IV:

Existence- Comparison Theorems. Elliptic Boundary Value Problems. The Linear Boundary Value Problem (Lemma 1.1, Lemma 1.2, Lemma 1.3, Theorem 1.3, Theorem 1.4, and Theorem 1.5, Statements only). The Method of Upper and Lower Solutions.

Unit – V:

The Uniqueness Problem. Positive Steady-State Solutions. Applications – (1) the Enzyme-Kinetics Model with Inhibition. (2) Chemical Reactor Model (3) the Thermal Ignition Problems (a) and (b).

Text Books:

[1] C. V. Pao; Nonlinear Parabolic and Elliptic Equations; Plenum Press, New York and London, 1992.

Chapter 1: Article 1.1-1.8,

Chapter 2: Article 2.1-2.4,

Chapter 3: Article 3.1-3.4 and 3.8.

[2]. M. H. Potter and H.F. Weinberger; Maximum Principles in Differential Equations. Springer-Verlag, New York, 1984.

Chapter 2: Article 3,

Chapter 3: Article 2, 3.

Reference Books:

[1] A Friedman; Partial Differential equations of Parabolic Type, Prentice Hall, Englewood cliffs, N. J. 1964.

[2] G. S. Ladde; V. Lakshmikantham, and A. S. Vatsala, Monotone; Iterative Techniques for Nonlinear Differential Equations, Pittman, Boston 1985.

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Semester -IV

Course No.: MAT 511 **Credits: 06**

Integral Equations

Learning Objective: To know the techniques of solving various integral equations.

Learning Outcome: The students will come to know various types of integral equations and techniques to solve them.

Contents:

Unit I : Definition of Integral Equations and Linear Integral Equations, Types of Linear Integral Equations, Special kinds of Kernels: Separable or degenerate kernel, symmetric kernel, convolution-type kernels, Eigenvalues and eigenfunctions of kernels/integral equations, Resolvent kernel of integral equation, Solution of linear integral equations, Verification of solution of linear integral equations, Conversion of Initial Value Problems to integral equations and vice-versa, Conversion of Boundary Value Problem to integral equations and vice-versa, Eigenvalues and eigenfunctions of homogeneous Fredholm integral equation by converting it into BVP.

Unit II: Methods of obtaining solution for Fredholm integral equations, Eigenvalues and eigenfunctions of homogeneous Fredholm integral equation with separable kernel, Solution of Fredholm integral equations of second kind with separable kernels, Method of successive approximation/Iterated kernel method for Fredholm integral equations, Resolvent kernels and their properties.

Unit III: Methods of solutions for Volterra integral equations, Volterra type kernel, Method of differentiation, Method of successive approximations, Method of iterative kernels, Resolvent kernels and its use to solve Volterra integral equations, Direct differentiation method, Solution of Volterra integral equations if kernel is a polynomial in x-t or t-x.

Unit IV: Integral Transform Methods, Recall of Laplace and Fourier Transforms, Application of Laplace transform to Volterra integral equations with convolution-type kernel and examples, Application of Fourier transform to some singular integral equations and examples.
Unit V: Solution of singular integral equations of some kind namely Abel's integral equations and generalized form of Abel's integral equations.

Recommended Books:

1. Linear Integral Equations: Theory and Applications, R. P. Kanwal (Academic Press, 1971)

Scope: Articles 1.1 to 1.7, 2.1 to 2.4, 2.6, 3.1 to 3.5, 5.1 to 5.3, 8.1, 8.2, 9.1 to 9.5

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Reference Books:

1. A First course in Integral Equations, Abdul-Majid Wazwaz (World Scintific)
2. Integral Equations, Shanti Swarup (Krishna Prakashan Media P. Ltd., Meeruat)
3. Integral Equations and Boundary Value Problems, M. D. Raisinghania (S. Chand &Company Pvt. Ltd. 2007)

Semester – IV

Course No.: MAT-512 **Credits: 06**

Mechanics

Learning Objectives: Students who take this course can expect to:

- Fundamentals of equation of motion.
- General analysis Lagrange's equation.
- Fundamentals and applications of Hamilton's equation.
- Fundamentals of calculus of variations.
- Fundamentals of Euler's theorem &Caley-Klein theorem.

Learning Outcomes:

- Student will become familiar with equation of motions.
- Student will be able to analysis of Lagrange's formulation.
- Student will become familiar with Hamilton's equations from variational principal and principle of least action
- Student will be able to handle to solve to extremals of the functional by using Euler's equation.
- Student will become familiar with Euler angles and dynamical equation for motion.

Unit – I:

Mechanics of system of particles, generalized coordinates, Holonomic & nonholonimic system, Scleronomic & Rheonomic system, D' Alemberts's principle and Lagrange's equation of motion, different forms of Lagrange's equation, Generalized potential, conservative fields and its energy equation, Application of Lagrange's formulation.

Unit – II:

Functionals, Linear functionals, Fundamental lemma of Calculus of Variations simple variational problems, The variation of functional, the extermum of functional, necessary condition for extreme, Euler's equation, Euler's equation of several variables, invariance of Euler's equation, Motivating problems of calculus of variation, Shortest distance, Minimum surface of revolution, Brachistochrone Problem, Isoperimetric problem, Geodesic.

Unit – III

The fixed end point problem for 'n' unknown functions, variational problems in parametric form, Generalization of Euler's equation to (i) 'n' dependent functions (ii) higher order derivatives. Variational problems with subsidiary conditions.

Unit – IV:

Hamilton's principle, Hamilton's canonical equations, Lagrange's equation from Hamilton's principle Extension of Hamilton's Principle to nonholonomic systems, Application of Hamilton's formulation (Hamiltonian) cyclic coordinates & conservation theorems, Routh's procedure, Hamilton's equations from variational principle, The principle of least action.

Unit – V:

Euler's theorems, finite rotation, infinitesimal rotation, rotations in the plane, rotations in 3-space, scalar product of two vectors under rotation, the Euler angles, Cayle-Klein parameters and rotational quantities, Euler's dynamical equation for motion of rigid body.

Text Books:

1. H. Goldstein, Charles Poole, John Safko: Classical Mechanics, Pearson 3rd Education, 2002.

   Chapter–1, Chapter– 2 (2.1 to 2.4), Chapter-8 (8.2 to 8.6) Chapter 4 (4.1 to 4.6)

2. I. M. Gelfand& S. V. Fomin: Calculus of Variations, Prentice-Hall.

   Chapter -1 (1, 2, 3, 4, 5, 6) Chapter –2 (9,10,11,12)

Reference Books:

1. L. D. Landau & E. M. Lifshitz: Mechanics, Pergamon Press, 1976.
2. J. L. Synge & B. A. Griffith: Principles of Mechanics, McGraw Hill, 1959.
3. A. S. Ramsey, Dynamics Part II, The English Language book Society and Cambridge University Press 1972.

Semester – IV

Course No.: MAT 531 **Credits: 06**

Difference Equations

Learning Objectives: The main objective of the paper is to study various Difference equations methods to solve problems. Study the linear and nonlinear difference equations and its stability.

Learning Outcomes: After learning this paper student will be able to solve the mathematical problem using difference equation.

Unit – I:

Introduction, Difference Calculus-The Difference Operator summation, Generating functions and approximate summation,

Unit- II:

Linear difference Equations- first order equations, General results for linear equations. Equations with constant coefficients

Unit- III:

Application, Equations with variable coefficients nonlinear equations, which can be linearized, The Z transforms

Unit- IV:

Stability Theory- Initial value problems for linear systems. Stability of linear systems Stability of nonlinear systems chaotic behaviours

Unit- V:

Asymptotic Methods-Introduction Asymptotic analysis of sums. Linear equations nonlinear equations.

Text Book:

1. Walter G. Kelley and Allan C. Peterson: difference Equations – An Introduction with applications. Academic Press, Harcourt Brace Jouranovich Pub. 1991.

Reference book:

1. Calvin Ahlbrandt and Allan C. Peterson: Discrete Hamiltonian systems Difference equations, continued fractions and riccati Equations, Kulwer, Boston 1996.

Semester – IV

Course No.: MAT-532 **Credits:06**

Fluid Mechanics-II

Learning Objectives: Students who take this course can expect to:

- Fundamentals of viscous flow, stress and strain.
- Basics of viscosity and laminar flow, viscous incompressible fluid.
- Solvable Problems in viscous flow with heat transfer.
- Applications of flow.

Learning Outcomes:

- Student will become familiar with viscous flow, stress and strain.
- Student will able to find viscosity and laminar flow, Navier Stock's equations, [1]: The energy equation, [2], [3], and Equations in cartesian, cylindrical or spherical polar coordinates for a viscous incompressible fluid.
- Student will able to calculate solvable problems in viscous flow with heat transfer like flow between parallel plates velocity and temperature distribution [2], [3], steady flow through a tube of uniform circular cross section etc.
- Students will be able to handle Flow between two porous plates, plane Couett flow, plane Poisseuille flow – velocity and temperature distribution, [2] etc.

Unit – I:

Viscous flows, stress components in a real fluid, Relation between Cartesian components of stress, translational motion of a fluid element, rate of strain quadric and principal stresses, properties of the rate of strain quadric, [1].

Unit – II:

Stress Analysis in Fluid Motion, relation between stress and rate of strain, the coefficient of viscosity and laminar flow, the Navier Stock's equations, [1]: The energy equation, [2], [3], Equations in Cartesian, cylindrical or spherical polar coordinates for a viscous incompressible fluid: - Statements only without proof; [2] [3], Diffusion of velocity and dissipation of energy due to viscosity, [1].

Unit – III:

Some Solvable Problems in viscous flow with heat transfer: - Flow between parallel Plates velocity and temperature distribution [2], [3] steady flow through a tube of uniform circular cross section, Velocity and Temperature Distribution, [2], [3], Distribution, [2], steady flow between concentric rotating cylinders, velocity and temperature distribution, [2], [3], Flow in tubes of arbitrary but uniform cross section, equations for velocity and Temperature in a steady flow, [1], [2], [3] Uniqueness Theorem for the velocity and Temperature, [1], Velocity distribution for tubes having equilateral triangular or elliptic cross section, [1], Velocity distribution for the flow through a tube of rectangular cross section [2], [3].

Unit – IV:

Flow between two porous Plates, plane Couett of plane poisseuille flow – velocity and temperature distribution, [2], Flow through a convergent or divergent channel, [2], [3], [4], Flow of two immiscible fluids between parallel Plates, [2], Flow due to a Plane wall suddenly set in motion or due to an oscillating plane wall, [3], [4].

Unit – V:

Element of Thermodynamics: The equation of e of a substance, the first law of thermodynamics, internal energy of a gas, specific heat of gas, Function of State; Entropy, Maxwell's thermodynamic relations, isothermal, adiabatic and isentropic processes, one dimensional wave equation, spherical wave, progressive and stationary wave, the speed of sound in gas, equation of motion of a gas [1].

Text Books:

1. F. Chorlton: Textbook of Fluid Dynamics, C.B.S. Pub. Delhi, 1976,

   Chapter 8: Article 6.1 to 6.7, Article 7.2 to 7.4 & Article 8.1 to 8.5

2. R. K. Rathy: An Introduction to Fluid dynamics, I.B.H. Pub. Co, New Delhi 1976,

   (§ 6.5, 6.6a to 6.6c, 8.2 to 8.2c, 8.2e, 8.3 to 8.5b, 8.10a, 11.1,

   11.2, 11.4, 11.6, 11.9, 11.9a, 119b, 11.10, 11.10a, 12.2, 12.3d,).

3. J. L. Bansal: Viscous Fluid Dynamics, Oxford and IBH Pub. Co. 1977.

   (§ 2.5, 2.6, Tables 2.2, 2.4, 2.6, § 4.2 to 4.7, 4.12, 4.13, 5.1 to 5.3, 5.6, 6.1, 6.2.

4. M. D. Raisinghania: Fluid Dynamics, S. Chand & Company Ltd. First Edition 1982.

Reference Books:

1. S. W. Yuan: Foundations of Fluid Mechanics Prentice Hall, of India, New Dehli, 1976.
2. W. H. Besaut and A. S. Ramsay: A Treatise on Hydrowecouies part II, CBS Pub. Delhi 1988.
3. A. J. Chorian and A Marsdeu: A Mathematical Introduction to Fluid Dynamics, Springer Verlag New York 1993.
4. L. D. Landau and E. M. Lipschitz: Fluid Mechanics, Press London 1985.
5. H. Schlicating: Boundary layer Tehory McGraw Hill New York, 1979.
6. A. D. Young: Boundary Layer AIAA Education Series, Washington, 1989

Semester-IV

Course No.: MAT-533 **Credits: 06**

Fuzzy Mathematics

Learning Objectives: To introduce the theory of Fuzzy sets and Fuzzy relations as a measure of uncertainty and an ambiguity. And also, to study different operations on them.

Learning Outcomes: The students will become familiar with the classical set theory versus fuzzy set theory with their practical application.

Unit-I: From classical (crisp) sets to fuzzy sets: Introduction, crisp sets: An overview, fuzzy sets: Basic types, Fuzzy sets: Basic concepts, Convex fuzzy sets (Theorems and Exercises).

Unit-II: Fuzzy sets Vs classical (crisp) sets: Additional properties of $\alpha - cuts$, Representation of Fuzzy sets, Decomposition Theorems, Extension Principle for Fuzzy sets.

Unit-III: Operations on fuzzy sets: Types of operations, Fuzzy complements, Fuzzy intersections: t-norms, Fuzzy unions: t-conorms, Combinations of operations, Aggregation operations.

Unit-IV: Fuzzy Arithmetic: Fuzzy Numbers, Arithmetic operations on intervals, Arithmetic operations on fuzzy numbers, Fuzzy numbers and extension principle: Extension Principle, Fuzzy numbers and Operations.

Unit-V: Fuzzy Relations: Introduction, Fuzzy relations, Operations on Fuzzy Relations, $\alpha - cuts$ of fuzzy relations, Composition of fuzzy relations, Projections of Fuzzy relations, Cylindric Extensions, Fuzzy relations on a domain.

Text Books:

1. George J. Klir and Yuan Bo, Fuzzy Sets and Fuzzy Logic, Theory and Applications, Printice Hall of India Pvt. Ltd., New Delhi, 2007.
2. M. Ganesh, Introduction to Fuzzy sets and Fuzzy Logic, Printice Hall of India Pvt. Ltd., New Delhi, 2007.

Reference Books:

1. Kazuo Tanaka, An Introduction to Fuzzy Logic Fuzzy Logic for Practical Applications, Springer Verlag, New York,1997.
2. Zimmermann H. J., Fuzzy Set Theory and its Applications, 1997.

Semester – IV

Course No.: MAT 534 **Credits: 06**

Analytic Number Theory

Learning objectives: The objectives of this course are:

- To introduce the concept of arithmetic's, congruence's, arithmetical functions
- To make aware about quadratic laws of reciprocity, Legendre and Jacobi symbols
- To explain modular arithmetic, primitive roots, existence of primitive roots, their relation with quadratic reciprocity and calculus of indices.

Learning Outcomes: After completing this course, the students will able to:

- Explain divisibility and its properties, use of divisibility to calculate gcd of numbers and prove fundamental theorem of arithmetic's.
- Examine properties of congruence's and their use in finding residue and complete systems. Also, use them to prove Euler-Fermat, Fermat last theorems, Lagrange's theorem, Chinese remainder theorem
- Illustrate properties of Legendre and Jacobi symbols and their use in reciprocity laws,

Unit I: The fundamental theorem of arithmetic:
Divisibility, Greatest common divisor, Prime numbers, The fundamental theorem of arithmetic, The Euclidean algorithm, The gcd of more than two elements.

Unit II: Arithmetic functions and Dirichlet multiplication:
The Mobious function$\mu(n)$, The Euler totient function $\emptyset(n)$,, A relation connecting, $\emptyset, n$, A product $\emptyset(n)$, Dirichlet product of arithmetic functions, Dirichlet inversion and Mobious inversion formula, The Mangoldt function $\Lambda(n)$, Multiplicativefunctions and Dirichlet multiplication, The inverse of completely multiplicativefunction, Liouville function, The divisor function, Generalized convolution.

Unit III: Congruences:
Definition and basic properties of congruences, Residue classes and complete residue system, Linear congruences, Reduced residue system and Euler-Fermat theorem, Polynomial congruences modulo p, Lagrange theorem, Application of Lagrange's theorem: Simultaneous linear equations, The Chinese remainder theorem and its applications, Polynomial congruences and prime power modulli.

Unit IV: Quadratic residues and Quadratic reciprocity law:
Quadratic residue, Legendre's symbol and its properties, Evaluation of$\left(-\frac{1}{p}\right)$ *and* $\left(\frac{2}{p}\right)$,

Gauss lemma, The quadratic reciprocity law, Application of reciprocity law, The Jacobi symbol.

Unit V: Primitive roots:

The exponent of a number modulo m, Primitive roots, Primitive roots and reduced residue system, The non-existence of primitive roots and mod 2α for $\alpha \geq 3$, The existence of primitive roots mod p, The non-existence of primitive roots mod m, The primitive roots and quadratic residues, The index calculus.

Text Book:

[1] T. M. Apostol, Introduction to Analytic Number Theory, Narosa Publishing House (1980).

Reference Books:

[1] Ivan Niven and H. S. Zuckerman, An Introduction to the Theory of Numbers, Wiley East (2001).

[2] D.M. Burton, Elementary Number Theory, Tata McGraw Hill Education Private Limited (2009).

Semester – IV

Course No.: MAT-535 **Credits: 06**

Operations Research – II

Learning Objectives: Students who take this course can expect to:

- Fundamentals of Dynamic programming.
- Fundamentals of Nonlinear Programming
- Replacement problems.
- Network scheduling and PERT CPM.

Learning Outcomes:

- The student will become familiar with Dynamic Programming which is used to find solutions of L.P.P.
- The Student will be able to solve Nonlinear Programming problem.
- The Student will able to handle Industrial Problem and its applications using Replacement Problem.
- Students will be able to find out Shortest Path and Critical Path for given problem

Unit – I:

Sequencing, problems with n jobs and two machines, problems with n jobs and two machines, graphical method, n- jobs and m machines.

Unit – II:

Dynamic programming, Applications of dynamic programming, computational procedure, solution of LPP by dynamic programming.

Unit – III:

Nonlinear Programming introduction, general nonlinear programming problems, problem of constrained maxima and minima, graphical solution Kuhn-Tucker conditions, Quadratic programming. Wolf's modified simplex method.

Unit – IV:

Replacement problems, Applications to industrial problems.

Unit – V:

Network scheduling by PERT/PM.

Text book:

1. Kanti Swarup, P. K. Gupta and Man Mohan: Operations Research, S. Chand and Son's, New Delhi.(Fourteenth Edition 2008)

Chapter -12, 13, 18, 25, 27.

Reference Books:

1. H. A. Taha: Operations Research- An introduction, Macmillan, New York,
2. S. S. Rao: Optimization Theory and Applications, Wiley, New Delhi.
3. N. S. Kambo, Mathematical-programming Techniques. Affiliated East- West Press, New Delhi.

Semester – IV

Course No.: MAT 536 **Credits: 06**

Wavelet Analysis

Learning Objectives: To introduce the latest mathematical technique of wavelet analysis.

Learning Outcomes: The student can use the analysis and synthesis of signal in orthogonal And biorthogonal wavelet system and construct certain wavelet systems.

Unit -I: - Vector spaces, Function spaces, continuous time-frequency representation of signals, Windowed Fourier Transform (STFT), Continuous Wavelet Transform, admissibility condition, Fourier transform of wavelet transform, Parseval's relation for wavelet transform, Properties.

Unit - II: - Discrete Wavelet Transform: - Harr Scaling Functions, Nested Spaces, Harr Wavelet Function, Orthogonality, Normalization at different Scales, Refinement Relation, Support of a Wavelet System, Daubechies Wavelets. Designing Orthogonal Wavelet System: -Refinement relations for orthogonal wavelet systems, Restrictions on filter coefficients.

Unit-III: - Filter Banks: - Signal Decomposition, Relation with filter Banks, signal Reconstruction, Up sampling and Filtering. Biorthogonality in Vector Space, Biorthogonal Wavelet Systems and Signal representation, Biorthogonal Analysis, Biorthogonal Synthesis-From Coarse Scale to Fine Scale, Construction of Biorthogonal Wavelet System.

Unit-IV: - Generating and Plotting of Parametric Wavelets: Orthogonality Conditions and Parameterization, Poly phase Matrix and Recurrence Relation, Numerical Evaluation of ϕ and ψ by various Methods.

Unit-V:- Wavelet Packet Analysis, Haar wavelet packet. Mathematical Preliminaries for B-splines, B-splines scaling function, orthogonalization of Causal /B-splines scaling function, Anti Causal B-splines, Symmetric splines, Differentiation of B-splines, Fractional Splines, Orthogonal Fractional B-Splines.

Text Books:

1. *Lokenath Debnath & Damba Bhatta*, Integral Transforms and their application (2^{nd} Ed), Chapman & Hall/CRC (2007). ISBN-10:- 1-58488-575-0 **[Unit–I]**

2. *Soman K. P. and Ramachandran K. I. and Resmi N. G.*, Insight in to Wavelets – Form Theory to Practice, (3^{rd} Ed.) P.H.I. Pvt. Ltd, New Delhi, 2010. **[Unit–I to Unit -V]**

Semester-IV

Course No.: MAT 537 **Credits: 06**

Fractional Differential Equations-II

Course Objectives: The course introduces the concept of fractional green's functions, other methods for the solution of fractional order equations, numerical approximations of fractional derivatives, numerical solution of fractional differential equations.

Course Outcomes: After completing this course, the student will be able to:

- Study the solution of the initial value problem for the ordinary fractional linear differential equation with constant coefficients using Green's function.
- Understand different methods for the solution of fractional order equations.
- Analyze the numerical approximations of fractional derivatives.
- Study the numerical solution of fractional differential equations.

Unit-I: Green's Function Method:
Definition and some properties, one term equation, Two term equation, Three term equation, Four term equation, general Case:n-term equation.

Unit-II: Methods of Solution of Fractional Differential Equations:
The Mellin transform method, Power series method, Babenko's symbolic calculus method, Method of orthogonal polynomials.

Unit-III: Numerical Approximations:
Riemann-Liouville and Grunwald-Letnikov definitions of the fractional order derivatives, approximation of fractional derivatives, the short memory principle, order of approximation, computation of coefficients, higher order approximations calculations of heat load intensity, finite part integrals and fractional derivatives.

Unit-IV: Numerical Solution of Fractional Differential Equations:
Initial conditions: Which problem to solve?, Numerical solution, examples of numerical solutions, the short memory principle in initial value problems for fractional differential equations.

Unit-V: Fractional Diffusion-Wave Equations:
Solution of Cauchy Type Problems for Fractional Diffusion-Wave Equations, Solution of Cauchy Problems for Fractional Diffusion-Wave Equations,

Text Book:

1. **Igor Podlubny**: Fractional Differential Equations, Academic Press, San Diego, California, 92101-4495, USA

Scope: Unit I - Chapter 5.
Unit II - Chapter 6.
Unit III - Chapter 7.
Unit IV - Chapter 8.

2. **Anatoly A. Kilbas, Hari M. Srivastav, Juan J. Trujillo**: Theory and Applications of Fractional Differential Equations, Elesvier, New York 2006.

Scope: Unit-V – Chapter 6- Art 6.2, 6.3

Reference Books:

1. Miller K.S. and Ross B.: An Introduction to Fractional Calculus and Fractional Differential Equations, New York, John Wiley, 1993.
2. Oldham K.B. and Spanier J.: The Fractional Calculus, New York, Academic Press, 1974.
3. Shantanu Das: Functional Fractional Calculus, Berlin, Springer, 2011
4. Abdul-Majid Wazwaz: Partial Differential Equations and Solitary Waves Theory, Springer-Verlag Berlin Heidelberg 2009
5. Kai Diethelm: The Analysis of Fractional Differential Equations, Springer, -Verlag, Berlin Heidelberg, 2010.

Semester – IV

Course No.: MAT 538 **Credits: 06**

Coding Theory

Learning Objectives: The learning objectives are:

- Hamming distance
- Finite fields
- Linear Codes
- Some Codes and their bounds
- Cyclic Codes

Learning Outcomes: After successful completion of the course the students are able to:

- Decoding the distance of code
- Use the theory of finite fields in coding and decoding
- Find parity check matrix and equivalence of linear codes
- Use the bounds of different linear codes
- Construct Linear Code
- Find generator polynomial for Cyclic codes
- Decode Cyclic code

Unit I: Error detection, correction, decoding and Finite Fields

Error detection, correction and decoding introduction, Communication channels, Maximum livelihood decoding, Hamming distance, nearest neighbor / minimum distance, decoding distance of a code. Fields polynomials rings structure of finite fields, minimal polynomials vector spaces over finite fields.

Unit II: Linear Codes

Linear codes, Hamming weight bases for linear codes, Generator matrix and parity check matrix, Equivalence of linear codes, Encoding with linear codes, Decoding of linear codes, Cosets nearest neighbor, decoding for linear codes syndrome decoding .

Unit III: Bounds in Coding Theory

The main coding theory problem lower bounds sphere covering bound Gilber-Varshamav bound hamming bounds and perfect codes, Binary haming codes q-ray hamming codes, Goley code some remarks on perfect codes singleton bounds and MDS codes, Plotain bound.

Unit IV: Construction of Linear Code

Construction of Linear codes, propogation Reed -Mullar codes, Subfield codes.

Unit V: Cyclic Codes

Definition of cyclic codes, generator polynomial, Generator and parity check matrices, Decoding of cyclic codes, Bust error correcting codes.

Recommended Book:

1. **San Ling, Chaoping Xing** "Coding Theory A First course" Cambridge University Press.

Scope:

Unit-I: Chapter 2, Chapter 3 complete,

Unit-II: Chapter 4 Complete

Unit-III: Chapter 5 Art 5.1 5.2, 5.2.1,5.2.2,5.3,5.3.1,5.3.2,5.3.3,5.3.4,5.4,5.5

Unit-IV: Chapter 6 Complete

Unit-V: Chapter 7 Complete

Reference Books:

1. **M. Medard and A. Sprintson, (editors),** Network Coding – Fundamentals and Applications, Acadamic Press, 2012.
2. **F J MacWilliams and N J A Sloane,** "The Theory of Error –Correcting Codes" North-Holland Volume 16.
3. **Lid and Pilz** , "Applied Abstract Algebra" - 2nd Edition.
4. **R. Lidl, H. Neiderreiter**, "Introduction to finite fields and their applications", Cambridge University Press.
5. **J. A. Thomas and T. M. Cover**, "Elements of information theory", Wiley, 2006.
6. **J. H. van Lint**, Introduction to Coding Theory, Third Edition, Springer, 1998.
7. **D. Stinson**, Combinatorial Designs: Constructions and Analysis, Springer, 2003

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