DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD

DEPARTMENT OF MATHEMATICS

Curriculum for M.A. / M. Sc. (Mathematics)
Semester I, II, III, and IV
Under Choice Based Credit and Grading System
including Research Component and Indian Constitution as service course**.**
W.E.F. JUNE – 2019

The M. A. / M. Sc. (Mathematics) course consists of four semesters.

In Semesters I and II a student has to study four **core** courses and one **Elective** course. In Semesters III and IV he/she has to study two **core** courses, three **elective** courses including **research component** and **one service course (for one semester) from other Department.** In semester III and IV the student **will have to complete a project in each paper as research component.** Apart from this, the student will have to learn **the course on Indian Constitution** as decided / run by the University.

The M. A. / M. Sc. (Mathematics) course will be of 120 credits.

Semester	No. of papers (core + elective)	No. of credits For each paper	No. of credits for project	Total no. of credits
I	4 + 1 = 5	6 (6x5=30)	---	30
II	4 + 1 = 5	6 (6x5=30)	---	30
III	2 + 3 = 5	4 (4x5=20)	2Cr. x 5proj = 10	20+10=30
IV	2 + 3 = 5	4 (4x5=20)	2Cr. x 5proj = 10	20=10=30
Total credits		**100 (Theory)**	**20 (Project)**	**120**

Unit wise distribution of the syllabus for the courses currently taught is given below.

YEAR – I

SEMESTER--I

(Core Courses)

MAT – 401(R)	-	Abstract Algebra
MAT - 402	-	Real Analysis -I
MAT - 403	-	Topology -I
MAT - 404	-	Complex Analysis –I

Elective Courses **(Choose any one of the following)**

MAT - 421	-	Differential Equations -I.
MAT - 422	-	Advanced Discrete Mathematics -I.

SEMESTER –II

(Core Courses)

MAT - 411	-	Basic Linear Algebra
MAT - 412	-	Real Analysis -II
MAT - 413	-	Topology -II
MAT - 414	-	Complex Analysis –II

Elective Courses **(Choose any one of the following)**

MAT - 431	-	Differential Equations -II
MAT - 432	-	Advanced Discrete Mathematics -II.

YEAR - II

SEMESTER--III

(Core Courses)

MAT501 - Functional Analysis

MAT502 - Partial Differential Equations

Elective Courses (Choose any three of the following)

MAT - 521 - MATLAB Programming

MAT - 522 - Fluid Mechanics -I

MAT - 524 - Numerical Analysis .

MAT - 526 - Operations Research -I.

MAT - 529 - Wavelet analysis and applications – I

SEMESTER--IV

(Core Courses)

MAT - 511 - Linear Integral Equations

MAT - 512 - Mechanics

Elective Courses (Chose any three of the following)

MAT - 531 - Difference Equations

MAT - 532 - Fluid Mechanics -II

MAT - 534 - Fuzzy Mathematics

MAT - 536 - Operations Research -II.

MAT - 539 - Wavelet analysis and applications – II

YEAR - I

Semester – I

Course No: MAT – 401(R)

Abstract Algebra **Credits: 6**

Objective: To learn some basics from algebra

Unit- I
Definition of group, some examples of groups, some group properties, subgroups, cyclic group, cosets, Euler's theorem, Fermat theorem, Lagrange's theorem, order of generator of cyclic group.

Unit-II
Normal subgroups and quotient groups, group homomorphism, isomorphism, fundamental theorem of group homomorphism, automorphism.

Unit-III
Permutation groups, another counting principle, Sylow's theorem, direct product, finite abelian groups, Cauchy theorem.

Unit-IV
Defination and examples of rings, some special classes of rings, Homomorphisms, Characteristic of a ring, ideals, subrings.

Unit-V
Quotient rings, Maximal ideals, Homomorphism, the field of quotients of an integral domain, Euclidean rings and polynomial rings.

Outcome:
The student will become familiar with various algebraic structures and their properties.

Text Book:
Topics in Algebra, *I. N. Herstein*, Wiley, 1999, Chapters 2 and 3.

Reference Book:
Basic Abstract Algebra, *P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul*, Cambridge University Press, 2nd edition, 1995.

Semester – I

Course No. MAT- 402

Real Analysis- I **Credits 6**

Objective: The objective of this paper is to learn basics of mathematical analysis

Unit – I Definition and existence of Riemann-Stieltjes integral, Properties of the integral, Integration and Differentiation, The fundamental theorem of calculus, Examples.

Unit – III integration of vector valued functions. Rectifiable curve. Examples. Sequences and series of functions. Point wise and uniform convergence. Cauehy criterion for uniform convergence. Weierstrass M-test, uniform convergence and continuity, uniform convergence and Riemann-Stielljes integration. Examples.

Unit – III Uniform convergence and Differential, The Stone – Weierstrass theorem, Examples. Power series, Abel's and Taylor's theorems, Uniqueness theorem for power series. Examples.

Unit – IVFunctions of several variables, Linear transformations, Derivatives in an open subset of R^n, Chain rule, Examples

Unit – VPartial derivations. Interchange of the order of differentiation, The inverse function theorem, The implicit function theorem Jacobins, Derivatives of higher order, Differentiation of integrals. Examples,

Outcome: The student will be able to apply the knowledge in areas which use continuity of a function, uniform convergence, partial derivatives etc.

Text Book: Walter Rudin, Principles of Mathematical Analysis, (3^{rd} Edition) McGraw Hill, Kogakusha 1976.

Articles:

6.1 to 6.27, 7.1 to 7.18, 7.26, 7.27, 8.1 to 8.5, 9.1 to 9.21, 9.24 to 9.29, 9.38 to 9.42

Reference Books:

1. T. M. Apostol, mathematical Analysis, Narosa, New Delhi, 1985.
2. J. C. Burkill and H. Burkill, A second course in Mathematical Analysis, Cambridge University Press, 1970.
3. S. L. Lang, Analysis- I and II, Addison Wesley, 1969.

Semester – I

Course No: MAT- 403

Topology - I **Credits: 6**

Objective: To learn basics of general topology.

Unit I **:**Recall definitions of functions, images and inverse images of sets under given mappings, metric spaces, open disks in metric spaces, open and closed sets and their properties, continuity and its formulations in terms of open and closed sets.

Unit II **:**Introduction to topology and topological spaces, open sets, closed sets, closure, interior, neighborhoods, neighborhood systems, neighborhood bases at a point, weaker and stronger topologies, the Hausdorff Criterion, cluster point, derived set.

Unit III **:**Base for a topology, sub base for a topology, criterion for base, subspace of a topological spaces, nature of open sets, closed sets, Neighborhoods in subspaces, continuous functions on topological spaces and criterions of continuity, homeomorphism.

Unit IV**:** Product spaces, box topology on finite Cartesian product, Tychonoff topology or product topology on a general product, evaluation maps, quotient topology, quotient spaces, sequences in topological spaces and their inadequacy.

Unit V**:**Net, convergence of net, cluster point of a net, subnet, continuity of functions in terms of net, ultra net, Filters and their convergence, continuity of functions in terms of filters, ultra filter, relation between nets and filters.

Outcome: The students will be able to use the continuity of a function in abstract analysis.

Text Book: General Topology, Stephen Willard (Addison-Wesley Publishing Company, 1970.

Reference Book: Introduction to topology and modern analysis, G. F. Simmons (Tata McGraw-Hill Edition 2004)

Semester – I

Course No: MAT - 404

Complex Analysis – I **Credits: 6**

Objective: To get familiar with complex number system, functions of complex variables and their properties.

Unit- I: The Complex number system: The field of complex numbers, The complex plane, Rectangular and polar representation of complex numbers; Intrinsic function on the complex field; The Complex plane.

Unit – II Metric spaces and Topology of C: Definition and examples of metric spaces; connectedness; sequence and completeness; compactness; continuity; Uniform convergence.

Unit- III: Elementary properties and examples of Analytic functions:
Power series; The exponential function; Trigonometric and hyperbolic functions; Argument of nonzero complex number; Roots of unity; Branch of logarithm function. Analytic functions; Cauchy Riemann Equations; Harmonic function;

Unit-IV: Analytic functions as a mapping; Mobius transformations; linear transformations; The point at infinity; Bilinear transformations, Complex Integration: power series representation of analytic functions; zeros of an analytic function.

Unit–V: The index of a closed curve; Cauchy's theorem and integral formula; Gaursat's Theorem; Singularities: Classification of singularities; Residues; The argument principle.

Outcome: The student will become familiar with theory of complex functions.

Text Books:
1.John B. Conway; Functions of one complex variable, Narosa Publishing House, 2002.
2.J. V. Deshpande; Complex Analysis, Tata McGraw- Hill 1989.
Chapter-I:Articles: 2,3,4 from [1] & Articles 1.3 & 1.4 from [2].
Chapter–II: Articles: 1,2,3,4,5,6 from [1],
Chapter –VI: Articles:1,6.2,6.3,6.4,6.5,6.6from [2].
Chapter-VII: Articles:7.1,7.2,7.3 from [2].
Chapter- III: Article3 from [1]. Chapter–IV: Articles:2,3, 4 from [1].
Chapter –II: Articles: 2.1,2.2,2.3, from [2].
Chapter – IV: Articles 5 & 8 from [1], Chapter V: Articles1,2 & 3 from [1].

References:

1. Herb Silverman; Complex Variables, Haughton Mifflin Company Boston, 1975.
2. Ruel V. Churchill; Complex variables and applications, McGraw – Hill Publishing Company 1990.

Semester– I

Course No. MAT- 421

Differential Equations –I **Credits 6**

Objectives: To introduce the nonlinear 1^{st} order ODE, method of approximate solutions, existence and uniqueness theorems. To introduce various systems of 1^{st} order ODEs.

Unit – I Existence, uniqueness and Continuation of solutions: Introduction, Method of successive approximations for the initial value problem $y' = f(x,y)$, $y(x_0)=y_0$, The Lipschitz condition. Peano's existence theorem, maximal and minimal solutions.

Unit – II Continuation of solutions, Existence theorems for system of differential equations: Picard-Lindelof theorem, Peano's existence theorem, Dini's derivatives, differential inequalities.

Unit – IIII integral Inequalities: Gronwall- Reid-Bellman inequality and its generalization, Applications: Zieburs theorem, Peron's criterion, Kamke's uniqueness theorem.

Unit – IV Linear systems: Introduction, superposition principle, preliminaries and Basic results, Properties of linear homogeneous system, Theorems on existence of a fundamental system of solutions of first order linear homogeneous system, Abel-Liouville formula.

Unit – V Adjoin system, Periodic linear system, Floquet's theorem and its consequences, Applications, Inhomogeneous linear systems, applications.

Outcome: The student will able to solve the nonlinear 1^{st} order ODE and various systems of 1^{st} order ODEs.

Text Book:

1. E. A. Codington: An Introduction to Ordinary Differential Equations. Prentice-Hall international, Inc. Englewood Cliffs (1961). Chapter 6: Article 4&5.
2. Shair Ahmad and M. Rama Mohana Rao: Theory of Ordinary Differential Equations with Applications in Biology and Engineering, Affiliated East-West Press (1999)
Chapter – 1: Article 1.1 to 1.5
Chapter – 2: Article 2.1 to 2.3

References:

1. P. Hartman: Ordinary differential Equations, 2nd edition, SIAM, (2002.)
2. W. T. Reid: Ordinary Differential Equations, John Wiley, New York, (1971).
3. E. A. Codington and N. Levinson: Theory of Ordinary Differential Equations, McGraw-Hill, New York, (1955).

Semester – I

Course No: MAT - 422

ADVANCED DISCRETE MATHEMATICS–I Credits 6

Objective: The student will become familiar with discrete mathematics.

Unit – I Formal Logic: Statements, symbolic representation, tautologies. Semi groups and monoids: Definitions and examples of semi groups and Monoids

Unit- II Homomorphism of semi groups and monoids, congruence relation and quotient semi groups, Sub semi groups and submonoids, direct products, basic homomorphism theorem.

Unit- III Lattices: Lattices as partially ordered sets, their properties, lattices as algebraic systems, sub lattices, direct products and homomorphism, some special lattices eg complete, complemented and distributive lattices.

Unit- IV Boolean algebras: Boolean algebras as lattices, various Boolean identities, the switching algebra example, sub algebra, direct product and homomorphism, join-irreducible elements

Unit- V Atoms and midterms, Boolean forms and their equivalence, midterm Boolean forms, (excluding free Boolean algebras), sum and products of canonical forms. Minimization of Boolean functions, applications of Boolean algebra to switching theory (using AND, ok and NOT gates), the Karnaugh Map method.

Text Book:

1. J. P. Tremblay and R. Manohar: Discrete Mathematical structures with Applications to Computer science, McGraw-Hill Book Co., 1997.

Chapter 1 (Sections 1.1 to 1.3), Chapter 3 (Sections 3.1 and 3.2), Chapter 4 (Sections 4.1 to 4.4)

Reference Book: C. L. Liu: Elements of discrete Mathematics, McGraw-Hill Book Co.

Semester – II

Course No: MAT – 411(R)

Basic Linear Algebra **Credit 6**

Semester – II

Paper No. MAT-411(R) Basic Linear Algebra

Objective – To learn techniques of linear algebra and use the same in its applications

Unit- I
Vector space, subspace, linear span, sum of subspaces, direct sum of subspaces, internal direct sum of subspaces, quotient space.

Unit – II
Linear dependence, independence, bases, dimension, co-ordinate vector relative to basis, dual space.

Unit – III
The inverse of a matrix, application of the inverse of a matrix to a system of linear equations, the rank of a matrix, row rank and column rank, linear equations, homogeneous equations, non-homogeneous equations.

Unit – IV
The algebra of linear transformation, range and kernel of LT, isomorphism, First fundamental theorem on homomorphism, internal direct sum, external direct sum.

Unit – V
Matrix and linear transformation, Eigen values, Eigen vector, Cayley-Hamilton theorem, inner product space, orthogonal vectors, (Gram-Schmidt orthogonal process).

Outcome:
After learning this course, the student will know linear algebra and its techniques and their applications.

Recommended Books:

1. **Linear Algebra,** *Surjit Singh and Qazi Zameeruddin,* Vikas Publishing House, New Delhi, 1991.
2. **Topics in Algebra,** *Herstein I. N.*, Vikas Publishing House Pvt. Ltd. Sahibabad, 1979.
3. **Elementary Matrix Algebra,** *Hohn Franz E*, Amerind Publishing Co. Pvt. Ltd. 1964.
4. **Linear Algebra,** *Hoffman K. and Kunze Ray*, Prentice Hall of India, New Delhi, 1978.
5. **A Course in Abstract Algebra,** *Khanna V. K. and Shambri S. K.,* Vikas Publishing House, 1998.
6. **Linear Algebra,** *Lipschutz S.*, Schaum's Outline Series, McGraw Hill, Singapore, 1981

Semester II

Course No: MAT - 412

Real Analysis –II **Credits: 6**

Objective: The objective of this paper is to learn Measure theory, Lebesgue Integral and Mathematical inequalities

Unit – I Measure on the real line. Lebegue outer measure, measurable sets. Regularity. Measurable functions. Boral and Lebegue measurability. Examples.

Unit – III integration of functions of a Real variable. Integration of a simple function. Integration of non-negative functions. The general integral. Integration of series. Examples.

Unit – III Riemann and Lebeque Integrals, Differentiation. The four derivates, Functions of bounded variations. Lebegue's differentiation theorem, Examples.

Unit – IV Abstract Measure spaces. Measures and outer measures Extension of a measure. Uniqueness of the extension. Completion of a measure spaces. Integration with respective to a measure. Examples.

Unit – V The L^p spaces. Convex functions. Jensen's inequality. The inequalities of Holder and Minkowski Completeness of L^p (μ) Convergence in measure. Almost uniform convergence. Examples.

Outcome: The student will be able to apply the knowledge in advance research areas

Text Book:
G. de Barra, Measure Theory and Integration. Wiley Eastern Ltd. 1981. Reprint 2003.Articles: 2.1-2.5, 3.1 – 3.4, 4.1, 4.3 - 4.5, 5.1 – 5.6, 6.1 – 6.5, 7.1 and 7.2

Reference Books:

1. P. K. Jain and P. V. Gupta, Lebesgue Measure and Integration, New Age International (P) Ltd. Publication New Delhi. 1986 (Reprint 2000)
2. P. R. Halmos, Measure Theory, Von No strand, Princeton 1950
3. R. G. Bartle, The elements of Integration, John Wiley, New York 1966.
4. I. K Rana, An Introduction to measure and Integration, Narosa, Delhi 1997.

Semester II

Course No: MAT- 413

Topology -II **Credits 6**

Objective: To become familiar with various separation axioms, count ability axioms, compactness, connectedness in general topology.

Unit I: Separation axioms T_0, T_1, T_2, regularity and complete regularity, T_3 and Tychonoff spaces.

Unit II: Normality and its criterions, T_4-spaces, Urysohn's lemma, Countability axioms, first countability, second countability, Lindelof spaces, separable spaces

Unit III: Compactness and its characterizations, compactness together with Hausdorffness and regularity, locally compact spaces, compactification of topological spaces.

Unit IV: Refinement, star-refinement, barycentric refinement, locally finite collection, point-finite collection, paracompact spaces, metrication of topological spaces.

Unit V: Disconnected spaces, connected spaces, mutually separated sets and criterion of connectedness in terms of them, components, simple chain, Path wise connected spaces, arc wise connected spaces, locally connected spaces.

Outcome: The students will come to know how these concepts can be defined without metric concept.

Text Book:

General Topology, Stephen Willard (Addison-Wesley Publishing Company, 1970)

Reference Book:

Introduction to topology and modern analysis, G. F. Simmons (Tata McGraw-Hill Edition 2004)

Semester – II

Course No: MAT - 414

Complex Analysis –II **Credits: 6**

Objective: To become familiar with analytic functions and study their properties.

Unit – I Compactness and convergence in the space of Analytic functions:
Spaces of analytic functions; The weierstrass factorization theorem; factorization of the sine function; The gamma function; The Riemann zeta function.

Unit – II Harmonic functions: Basic properties of Harmonic functions and comparison with analytic function; Harmonic functions on a dick; Poisson integral formula; positive harmonic functions.

Unit– III Entire functions; Jensen's formula; The Poisson-Jenson formula; The genus and order of an entire function. Hadamard factorization Theorem.

Unit – IV Univalent functions; the class S; the class T; Bieberbach conjucture; sub class of s.
Unit – V Analytic continuation: Basic concepts; special functions.

Outcome: The student will become familiar with properties of analytic functions, harmonic functions, univalent functions and their properties.

Text Books:
1. John B. Conway; Functions of one complex variable, Narosa Publishing House, 1980.
2. Herb Silverman; Complex Variables Houghton Mifflin Company Boston 1975.
Chapter – VI: Articles 2,5,6,7 & 8 from [1]. Chapter – X: Articles 1& 2 from [1] Chapter- X: Articles 10.1, 10.2 & 10.3 from [2], Chapter- XI: Articles 1,2 & 3 from [1], Chapter XII: Articles 12.1& 12.2 from [2], Chapter – XIV: Articles 14.1 & 14.2 from [2]

Semester II

Course No: MAT - 431

Differential Equations - II **Credits: 6**

Objectives: To introduce general 2^{nd} and higher order ODE, its transformations and the methods of solutions,

Unit- I Preliminaries, Basic Facts: Superposition principles, Lagrange Identity, Green's formula, variation of constants, Liouville substitution, Riccati equations Prefer
Transformation. Higher order linear equations.

Unit– II Maximum Principles and their extensions, Generalized maximum principles, initial value problems, boundary value problems.

Unit– III Theorems of strum; sturm's first comparison theorem, sturm's separation theorem, strums second comparison theorem.

Unit– IV Sturm-Liouville boundary Value Problems: definition, eigenvalues, eigenfunctions, orthogonality.

Unit– V Number of zeros, Non oscillatory equations and principal solutions, Nonoscillation theorems.

Outcome: Student will able to solve the 2^{nd} and higher order ODE and Sturm-Liouville boundary value problems and understand the qualitative properties of the differential equations.

Text Books:1. Philip Hartman: Ordinary differential Equations, 2nd Edition SIAM, 2002.
Chapter – XI: Article 1 to 7. Chapter – 4 – article 8 only.
2. M. H. Protter and H. F. Weinberger, Springer: Maximum Principles in Differential Equations – Springer Verlag, New York, Inc, 1984.
Chapter 1. Articles 1 to 4.

Reference Books:

1. W. T. Reid: ordinary differential Equations, John Wiley N.Y. (1971).
2. E. A. Coddington and N. Levinson: Theory of Ordinary differential Equation, McGraw-Hill, New York, (1955).

Semester – II

Course No: MAT432

ADVANCED DISCRETE MATHEMATICS –II **Credits: 6**

Objective: To become familiar with some topics from discrete mathematics

Unit – I Definition of (undirected) graph, paths, circuits, cycles and subgraphs, degree of a vertex connectivity, planar graphs and their properties.

Unit-II Trees, rulers formula for connected planar graphs. Complete graphs, Kuratowski's theorem (statement only) spanning trees, cut sets, fundamental cut-sets and cycles, minimal spanning trees and Kruskal's (statement only) algorithm, matrix representation of graphs,

Unit-III Euler's theorem on the existence of Eulerian paths and circuits, directed graphs, in degree and out degree of a vertex, weighted undirected graphs, strong connectivity, directed trees, search trees,

Unit-IV Introductory computability theory: Finite state machines and their transition table diagrams, equivalence of finite state machines, reduced machines, homomorphism, finite automata, acceptors, no-deterministic finite automata.

Unit-V Grammars and languages: Phase structure grammars, rewriting rules, derivations, sentential forms, language generated by a grammar, regular, contest free and contest sensitive grammars and languages.

Outcome: The student becomes familiar with graph theory, finite state machines and related areas.

Text Books:

1.J. P. Tremblay and R. Manohar: Discrete Mathematical structures with Applications to Computer science, McGraw-Hill Book Co., 1997.Sections 3.3, 4.6, and 5.1 to 5.6
2.C. L. Liu: Elements of discrete Mathematics, McGraw-Hill Book Co. Sections 6.5 and 7.1 to 7.7

Reference Books:

1. Seymour Lepschutz: Finite Mathematics, McGraw-Hill, New York.
2. S. Wiitala: Discrete Mathematics - A Unified Approach, McGraw-Hill.
3. J. E. Hhopcroft and J.D. Ullman: Introduction to Automata Theory, Languages and Computation, Narosa, New Delhi.

YEAR – II

Semester – III

Course Number: MAT- 501

Functional Analysis **Credits 6**

Objective: To introduce Banach and Hilbert spaces.

Unit I : Definition of normed linear spaces, Banach spaces, continuity of norm, joint continuity of vector addition and scalar multiplication in nor med linear spaces, quotient spaces.

Unit II : Continuous linear transformations and different criterions of continuity of linear transformations on nor med linear spaces, space of bounded linear transformations, isometric isomorphism, equivalent norms, Conjugate spaces, Hahn-Banach theorem and its consequences, natural imbedding of nor med linear space into its second conjugate.

Unit III : The Open Mapping theorem, projections on Banach spaces, the Closed graph theorem, the Uniform Boundedness theorem, conjugate of an operator, Inner product spaces, Schwarz's inequality, joint continuity of an inner product, parallelogram law in inner product spaces.

Unit IV: Hilbert spaces, Orthogonal complements, Orthonormal sets, Bessel's inequality, conjugate space of a Hilbert space, adjoin of an operator, self-adjoin operators, normal and unitary operators.

Unit V: Project.Research **Component**

Outcome: The students will be able to study various fixed point theorems and spectrum of normal and self-adjoin operators which will be useful to them in existence of solution of various equations.

Text Book:
Introduction to topology and modern analysis, G. F. Simmons (Tata McGraw-Hill Edition 2004)

Reference Book:

Principles of Functional Analysis, Martin Schechter (American Mathematical Society, 2002)

Semester – III

Course No: MAT-502

Partial Differential Equations **Credits: 6**

Objectives: To know: Fundamentals of DE and PDE, General analysis of PDE, Fundamentals Linear and Nonlinear PDE and Fundamentals Jacobi's method, Charpit's Method

Unit-I First order partial differential equation, linear equations of the first order, 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, intermediate integrals or first integrals, Monge's method of integrating $Rr + Ss + Tt = V$, classification of second order partial differential equation (Canonical form).

Unit-V Project: **Research Component.**

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.

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

Reference books: (1) T. Amarnath: An elementary course in partial differential equation (2^{nd} Edition) – Narosa Publishing House 2003.
(2) Lawrence C. **Evance**: Partial Differential Equations, Graduate Studies in Mathematics Volume 19, AMS 1998.
(3) M.D. Raisighania: Ordinary and Partial Differential Equation, S. Chand & Company Ltd, New Delhi.

Semester – III

Course No: MAT – 521

MATLAB Programming **Credits 6**

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

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

Unit – II 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 – III 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 – IV 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.

Unit –V Project: **Research Component.**

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

Text Books: (1)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

Fluid Mechanics – I **Credits: 6**

Objectives: To know fundamentals of fluids, General Analysis of fluid motions, fluid pressure, Fundamentals of motion, Fundamentals of two dimensional flows

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: Project: **Research Component.**

Outcome: Student will become familiar with real and ideal fluids, fluid motion and other related properties.

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. M. D. Raisighania, Fluid Dynamics, 11/e, S. Chand Publications.
2. S. W. Yuan Foundations of Fluid Mechanics, Prentic Hall of India Pvt. Ltd, New Deli, 1976.

Semester – III

Course No: MAT - 524

Numerical Analysis **Credits :6**

Unit – I Solution of algebraic and transcendental equations: Introduction; Bisection method; Iteration methods based on first degree equations: Newton Raphson method; Secant and Regular 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; Langrange and Newton Interpolations; Finite difference operators; Interpolating polynomial using finite difference; Hermite interpolation; piecewise and spline interpolation.

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

Unit –V..Project **Research Component** .

Text Book:

1. Jain, Iyengar and Jain: Numerical methods for scientific and engineering computation. (4^{th} Edition) New Age Pub. New Delhi.

Reference Books:

1. S. S. Sastry: Introductory methods of Numerical Analysis (4^{TH} edition) Prentice Hall)

2. J. I. buchaman and P. R. Turner: Numerical method & Analysis (PHI)

Semester – III

Course No: MAT - 526

Operation Research - I **Credits: 6**

Objectives: Students who take this course can expect to know Fundamentals of Linear Programming Problems and methods of their solutions

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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: Project: **Research Component.**

Outcome: Student will become familiar with Linear Programming Problems and will able to find solution; Students will be able to handle Industrial Problem like – Transportation Problem, and Assignment Problem using various given methods.

Text Books:

1. Kanti Swarup, P.K. Gupta and Man Mohan: Operations Research,
   S. Chand; & Sons, New Delhi.
   Chapter- 0 (Related concepts) Chapter 1, 2,3,4,6,7,9,
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-529

WAVELET ANALYSIS AND APPLICATIONS – I Credits:6

Objectives: To introduce the latest mathematical technique of wavelet analysis which is useful in almost all branches of knowledge. After studying Fourier analysis which is instrumental in the study of wavelets, the continuous and discrete wavelet transforms are introduced.

Unit – I Vector Spaces, Bases, Orthonormality, Projections, Orthogonal and Orthonormal Functions, Function Spaces, Orthogonal Basis Functions, Orthonormality, Trigonometric series, Euler's formulae, Fourier integral theorem, Complex Fourier Series, Complex Exponential Bases .

Unit – II Fourier Transforms: Fourier Integral Theorem, Definition and existence of Fourier Transform(F.T.), Inverse F.T., Basic Properties of F.T.: Shifting, Scaling, translation, Modulation, Conjugate, Duality. Riemann-Lebesgue Lemma, F. T. of Dirac's delta function, Convolution and parsevals's relation, Poisson summation formula.

Unit – III Windowed Fourier Transform (STFT), Properties, Continuous Wavelet Transform, Discrete Wavelet Transform, Harr Scaling Functions, Function Spaces, Nested Spaces, Harr Wavelet Function, Orthogonality, Normalization at different Scales, Refinement Relation, Support of a Wavelet System, Daubechies Wavelets.

Unit – IV Designing Orthogonal Wavelet system: Refinement Relation for Orthogonal Wavelet systems, Restrictions on filter Coefficients, Designing Daubechies Orthogonal Wavelet System Coefficients, Design of Coiflet Wavelets, Symlets.

Unit –V Project: **Research Component.**

Outcome: Student will understand the merits and demerits of the Fourier analysis and wavelet analysis. Student will understand the method of construction of certain wavelet system.

Text Book:

1. *Soman K. P. and Ramachandran K. I. and Resmi N. G.* : **Insight in to Wavelets – Form Theory to Practice,** P.H.I. Pvt. Ltd, New Delhi, 2010.

2. L Debnath: Integral Transforms and their Applications CRC Press, Inc. 1995.

Semester – IV

Course No.: MAT - 511

Linear Integral Equations **Credits 6**

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

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 Eigen functions of kernels, Solution of linear integral equations, Verification of solution of linear integral equations, Conversion of Boundary Value Problem to integral equations and vice-versa, conversion of Initial Value Problems to integral equations and vice-versa.

Unit II : Methods of obtaining solution for Fredholm integral equations, Fredholm integral equations with separable kernels, Approximating kernels by separable kernels, Method of successive approximation, Iterated kernel method for Fredholm integral equations, Resolvant kernels and their properties, Methods of solutions for Volterra integral equations, Volterra type kernel, Method of differentiation, Method of successive approximations, Method of iterative kernels, Resolvant kernels and its use to solve Volterra integral equations.

Unit III : Symmetric kernel, trace of a kernel, Fredholm operator, Fundamental properties of symmetric kernels, Eigen values and Eigen functions of symmetric kernel and their properties, normalized Eigen functions, Iterated kernel of symmetric kernels and their properties, Truncated kernel of symmetric kernel and necessary and sufficient condition for symmetric kernel to be separable, The Hilbert-Schmidt theorem, Method of Solution for Integral equations with symmetric kernels.

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: Project: **Research Component.**

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

Text Book: Linear Integral Equations Theory and Applications, R. P. Kanwal (Academic Press, 1971)
Reference Books :(1)Integral Equations, Shanti Swarup (Krishna Publication)
(2) Integral Equations and Boundary Value Problems, M. D. Raisinghania (S. Chand &Company Pvt. Ltd. 2007)

Semester – IV

Course No: MAT- 512

Mechanics **Credits: 6**

Objectives: To know Fundamentals of equation of motion, analysis of Lagranges equation, Fundamentals and applications of Hamilton's equation, Fundamentals of calculus of variations.

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 Functional, Linear functional, 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. Kepler's law of planetary motion.

Unit-V: Project: **Research Component.**

Outcomes: Student will become familiar with equation of motions, Hamilton's equations and principle of least action and to handle to solve to extremals of the functional by using Euler's equation.

Text Books: (1) 1. H. Goldstein, Charles Poole, John Safko: Classical Mechanics, Pearson 3rd Education, 2002. Ch.. –1 , Ch.. – 2 (2.1 to 2.4), Ch.. (8.2-8.6) Ch. 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. N. Rana and B. Joag: Classical Mechanics, Tata McGraw Hill 1991.
2. F. Gantmacher, Lectures in Analytic Mechanics, NIR Publishing House, New Delhi.
3. A. S. Ramsey, Dynamics Part II, The Engilish Language book Society and Cambridge University Press 1972

Semester – IV

Course No.: MAT - 531

Difference Equations **Credits: 6**

Objective: To study the Difference equations to solve numerical problems

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 transform

Unit- IV
Stability Theory- Initial value problems for linear systems. Stability of linear systems Stability of nonlinear systems chaotic behaviors

Unit V: **Research Component** Project: Programs using MATLAB.

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

Fluid Mechanics – II **Credits :6**

Objectives: To know: 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.

Unit – I Viscous flows, stress components in a real fluid, Relation between Cartesian components of stress, translations 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], 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].

Unit – V Project: **Research Component.**

Outcomes: Student will become familiar with viscous flow, stress and strain, Navier Stock's equations, the energy equation and other aspects of fluid dynamics.

Text Books: (1) F. Chorlton: Textbook of Fluid Dynamics, C.B.S. Pub. Delhi, 1976, Ch. 8
(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) G. K. Batchelor: An Introduction to Fluid Mechanics, Foundation book New Delhi, 1994, (§ 4.2, § 4.8).

Reference Books:

1. M. D. Raisighania, Fluid Dynamics, 11/e, S. Chand Publications.
2. S. W. Yuan: Foundations of Fluid Mechanics Prentice Hall, of India, New Dehli, 1976.
3. W. H. Besaut and A. S. Ramsay: A Treatise on Hydrowecouies part II, CBS Pub. Delhi 1988.
4. A. J. Chorian and A Marsdeu: A Mathematical Introduction to Fluid Dynamics, Springer Verlag New York 1993.
5. L. D. Landau and E. M. Lipschitz: Fluid Mechanics, Press London 1985.
6. H. Schlicating: Boundary layer Tehory McGraw Hill New York, 1979.
7. A. D. Young: Boundary Layer AIAA Education Series, Washington, 1989.

Semester – IV

Course No : MAT - 534

Fuzzy Mathematics **Credits :6**

Objectives: To introduce the theory of fuzzy sets as a measure of uncertainty and a ambiguity. Also to introduce fuzzy and fuzzy logic and different operations on them.

Unit – I From classical (crisp) sets to fuzzy sets; Introduction: crisp sets: An overview; Basic concepts in fuzzy sets; convex fuzzy sets (Theorems and exercises)

Unit – II Fuzzy sets versus crisp sets: Additional properties of α - cuts; Representation of fuzzy sets; Decomposition Theorems. Operations on Fuzzy sets; Types of operations; Fuzzy complement (Axioms and theorems)

Unit – III
Operations on Fuzzy Sets: Types of operations; Fuzzy Complements; Fuzzy intersections: t- norms; fuzzy unions: t – co norms; Combinations of operations; Aggregation of operations.

Unit – IV
Fuzzy Arithmetic: fuzzy numbers; Linguistic Variables; Arithmetic operations on intervals of real numbers; Arithmetic operations on fuzzy numbers. Fuzzy relations: Introduction; fuzzy Relations; operations on fuzzy relations; α - cuts of a fuzzy relation; composition of fuzzy Relations; fuzzy relation on a domain.

Unit – V: Project: **Research Component.**

Text Books:

1. Klir George J. and Yuan Bo, Fuzzy sets and fuzzy logic. Theory and applications. Prentice Hall of India Pvt. Ltd. New Delhi. 1997.
2. M. Ganesh, Introduction to Fuzzy sets and Fuzzy logic, (OHI), New Delhi, 2006.

Reference books:

1. Kaufmann A and Gupta M. M., Introduction to Fuzzy arithmetic, Van Nostrand.
2. Zimmermann H. J., Fuzzy set theory and its applications, 1997.

Semester – IV

Course No: MAT - 536

Operations Research – II **Credits :6**

Objectives: To know: Fundamentals of Dynamic programming, Nonlinear Programming, Replacement problems Network scheduling and PERT CPM.

Unit – I : Dynamic programming, computational procedure, solution of LPP by dynamic programming.

Unit – II : Nonlinear Programming introduction, general nonlinear programming problems, problem of constrained maxima and minima, graphical solution Kuhn-Tucker conditions, Quadratic programming. Integer programming

Unit – III : Replacement problems, Applications to industrial problems.

Unit – IV : Network scheduling and PERT- CPM.

Unit – V : Project: **Research Component.**

Outcomes: To become familiar with Dynamic Programming, nonlinear Programming and to find out Shortest Path and Critical Path for given problem.

Text book:

1. Kanti Swarup P.K. Gupta and Manmohan: Operations Research, S. Chand and sons, New Delhi.(Fourteenth Edition:2008)

Chapter - 10,11,12 (sections 12.1 to 12.5),13 (sections 13.1 to 13.4), 18 (sections 18.1 to 18.5), 25 (sections 25.1 to 25.6 and 25.8),27. (Sections 27.1 to 27.5),28 (Section 28.1 to 28.4)

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- 539

WAVELET ANALYSIS AND APPLICATIONS – II Credits 6

Objectives: To introduce the analysis and synthesis of signal in orthogonal and biorthogonal wavelet system and construction of certain wavelet systems.

Unit – I Filter Banks: Signal Decomposition, Relation with filter Banks, Frequency Response, signal Reconstruction: Synthesis from Coarse Scale to Fine Scale, Unsampling and Filtering, Perfect Matching Filters Computing Initial S_{j+1} Coefficients.

Unit – II Generating and Plotting of Parametric Wavelets: Orthogonality Conditions and Parameterization, Poly phase Matrix and Recurrence Relation, Pollen-type Parameterizations of Wavelet Bases, Numerical Evaluation of ϕ and ψ by various Methods.

Unit – III Biorthogonal Wavelets: 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 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.

Unit – V: Project: **Research Component.**

Outcome: Student will understand the decomposition and reconstruction of a signal in orthogonal and biorthogonal wavelet system and will understand the method of construction of biorthogonal wavelets, B-splines and fractional splines.

Text Book: -

1. *Soman K. P. and Ramachandran K. I. and Resmi N. G.* : **Insight in to Wavelets – Form Theory to Practice,** P.H.I. Pvt. Ltd, New Delhi, 2010.