BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY, LUCKNOW-226025
SCHOOL OF PHYSICAL & DECISION SCIENCES

DEPARTMENT OF MATHEMATICS

ACADEMIC SESSIONS: 2019-2021 AND ONWARDS

Program: M.Sc. Mathematics

Course Structure:

M.Sc. (Mathematics) First Year						
Semester-I						
S. No.	Category	Paper Code	Paper Title	Lecture	Practical	Credits
1	CP	MAM-101	Abstract Algebra	4	0	4
2	CP	MAM-102	Real Analysis	4	0	4
3	CP	MAM -103	Ordinary Differential equations	4	0	4
4	CP	MAM-104	Analytic Dynamics	4	0	4
5	CP	MAM-105	Computer Programming in C	2	2	4
6	**Open Elective from other Department**			4	0	4
7	CLP	MPDC-105	Remedial Language-English	1		1
				Total credits		**25**
Semester-II						
1	CP	MAM-201	Linear Algebra	4	0	4
2	CP	MAM-202	Complex Analysis	4	0	4
3	CP	MAM-203	Advanced Abstract Algebra	4	0	4
4	CP	MAM-204	Partial Differential Equations	4	0	4
5	CP	MAM-205	Advanced Numerical Analysis	4	0	4
6	**Open Elective from other Department**			4	0	4
7	CLP	MPDC-205	Ambedkar Studies	1		1
				Total credits		**25**

CP: Core Paper, EP: Elective Paper, OE: Open Elective, Compulsory Paper: CLP

Open Electives Papers offered by the Department of Mathematics to the Students of other Departments under **Choice Based Credit System**

Semester-I						
S. No.	Category	Paper Code	Paper Title	Lecture	Practical	Credits
1	OE	MAM-106	Mathematical Methods	4	0	4
Semester-II						
1	OE	MAM-206	Mathematical Modeling	4	0	4

M.Sc. (Mathematics) Second Year						
Semester-III						
1	CP	MAM-301	Topology	4	0	4
2	CP	MAM-302	Mathematical Methods	4	0	4
3	CP	MAM-303	Fluiddynamics	4	0	4
4	CP	MAM-304	Operations Research	4	0	4
5	**EP**	**Elective Paper-I: Any one of the following Elective papers**				
		MAM-305	Finite Element methods	4	0	4
		MAM-305	Mathematical modeling	4	0	4
		MAM-305	Industrial Mathematics	4	0	4
		MAM-305	Advanced graph theory	4	0	4
6	**EP**	**Elective Paper-II: Any one of the following Elective papers**				
		MAM-306	Dynamical Systems	4	0	4
		MAM-306	Fuzzy system & Analysis	4	0	4
		MAM-306	Information Theory	4	0	4
		MAM-306	Numerical Solutions of ODEs and PDEs	4	0	4
7	CLP	MPDC-305	Gender Studies	1		1
				Total credits		**25**
Semester-IV						
1	CP	MAM-401	Functional Analysis	4	0	4
2	CP	MAM-402	Measure theory	4	0	4
3	CP	MAM-403	Probability and Probability Distributions	4	0	4
4	CP	MAM-404	Discrete Mathematics	4	0	4
5	**EP**	**Elective Course-III: Any one of the following Elective papers**				
		MAM-405	Advanced Fluid Mechanics	4	0	4
		MAM-405	Biomathematics	4	0	4
		MAM-405	Computational Fluid Dynamics	4	0	4
		MAM-405	Advanced Optimization Techniques	4	0	4
6	**EP**	**Elective Course-IV: Any one of the following Elective papers**				
		MAM-406	Number theory and Cryptography	4	0	4
		MAM-406	Perturbation theory & Stability analysis	4	0	4
		MAM-406	Algebraic Coding theory	4	0	4
		MAM-406	Financial Mathematics	4	0	4

7	CLP	MPDC-405	Community Services	1		1
				Total credits		**25**

CP: Core Paper, EP: Elective Paper, OE: Open Elective, Compulsory Paper: CLP

Detail Syllabus:

SEMESTER-I

MAM-101: Abstract Algebra **Credits: 4**

Unit 1
Group, Cosets and normal subgroups, Normalizer and Centralizer, The class equation, Cauchy`s theorem, symmetric groups, direct products of groups.

Unit 2
Sylow's theorems, Application of Sylow's theorems, finite abelian groups, p-subgroups, Normal and subnormal series, Composition series, Jordan-Holder theorem.

Unit 3
Rings, Ideals, Algebra of ideals, Prime ideals and Maximal ideals, Ring of Polynomials, Characteristics of a ring, Field of fractions, factorization in Integral domains.

Unit 4
Extension fields: Finite, algebraic, and transcendental extensions. Perfect fields. Primitive elements. Splitting fields, Algebraically closed fields.

Text/Reference Books:

1. Contemporary Abstract Algebra; Joseph A Gallion, Narosa Pub.House P.Ltd.
2. A First Course In Abtract Algebra; Joseph B. Fraleigh, Pearson Edu. Inc. , 2003.
3. Algebra; Vivek Sahai, Vikas Bist, Narosa Pub. House Pvt. Ltd., 2010.
4. Abstract Algebra; V.K. Khanna and S.K.Bhabari, Vikash Pub. House P.Ltd.
5. Topics in Algebra; I.N.Herstein, John Wiley and Sons, New York.
6. M. Artin: Algebra, 1991
7. Modern Algebra: Surjeet and Qazi Zameeruddin.
8. I.B.S. Passi and I.S. Luthar; Algebra 1& 2.

MAM 102: Real Analysis **Credits: 4**

Unit 1:
Metric spaces, Neighbourhood, Interior points, Limit points, Open and closed sets, Subspaces, Convergent and Cauchy sequences, Complete metric space, Cantors intersection theorem, Baire's Category Theorem.

Unit 2:
Compactness, Connectedness. Continuity of functions, Continuity and compactness, Continuity and connectedness, Monotonic functions, Types of discontinuities, Uniform continuity, Differentiability, Mean Value Theorem.

Unit 3:
Riemann integral: Definition and existence of integral, Theorems on conditions for integrability of function, Mean value theorems, Fundamental theorem of integral calculus. Riemann-Stieltjes Integral, Functions of bounded variation.

Unit 4:

Sequences and Series of functions, Point wise and uniform convergence, Uniform convergence of continuous functions, Uniform convergence and Integration, Uniform convergence and differentiation, Weierstrass approximation theorem. Functions of several variables, continuity, directional derivative, partial derivative, Inverse function theorem, Implicit function theorem.

References:

1. Walter Rudin, Principles of Mathematical Analysis, (3rd edition) McGraw-Hill, Kogakusha, 1976.
2. R.R. Goldberg, Methods of Real Analysis, Oxford-IBH, New Delhi, 1970
3. R.G. Bartle, D.R. Sherbert, Introduction to Real Analysis, (4th edition) Wiley, Hoboken NJ, 2011.
4. H.L. Royden, Real Analysis, (4th Edition), Macmillan Publishing Co. Inc. New York,1993
5. S.C. Malik, Savita Arora, Mathematical Analysis, (2nd Edition), New Age International (P) Limited, Publishers, New Delhi, 2005.
6. T. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.

MAM 103: Ordinary Differential Equations **Credits : 4**

Unit 1:

Ordinary Differential Equations and their classifications, Applications of ordinary differential equations to model real life problems, Existence and uniqueness of solutions: The method of successive approximation, Picards theorem, Lipschitz Condition, Dependence of solution on initial conditions, Existence and Uniqueness theorems for systems and higher order equations.

Unit 2:

Linear differential equations of higher order, Homogeneous and Non-homogenous linear differential equations, Homogeneous linear equations with constant coefficients, Method of undetermined coefficients, Method of variation of parameters, Euler-Cauchy equations, Reduction of order. Reccati's Equations

Unit 3:

Two-point boundary value problem, Green's functions, Construction of Green's functions, Non-homogeneous boundary conditions, Sturm-Liouville boundary value problem, Eigenvalues and Eigenfunctions.

Unit 4:

Power series solution, Solutions about an ordinary point, Solution about singular points, The Method of Forbenius. Bessel's equation, Bessel functions, Generating functions, Recurrence relations.

References:

1. G. F. Simmons and S.G. Krantz, Differential Equations: Theory, Technique and Practice, Tata Mcgraw-Hill Publishing Company Ltd. New Delhi, 2007.
2. E.A. Coddington, Theory of ordinary Differential equations, Tata Mcgraw-Hill Publishing Company Ltd. New Delhi, 1972.
3. B. Rai, D.P. Chaudhary and H.I. Freedman: A Course in Ordinary Differ-ential Equations, Narosa Publishing House, New Delhi 2002.
4. S.L. Ross, Introduction to Ordinary Differential Equations, 4th Edition, Wiley, New York, 1989.
5. A. K. Nandakumaran, P. S. Datti, and Raju K. George; Ordinary differential equations: Principles and Applications
6. W.E. Boyce and R.C. DiPrima; Elementary Differential Equations. John Wiley & Sons.

MAM-104 : Analytic Dynamics **Credits : 4**

Unit-1

Rotation of a vector in two and three dimensional fixed frame of references.
Kinetic energy and angular momentum of rigid body rotating about its fixed point.
Euler dynamic and geometrical equations of motion.

Unit-2

Generalized coordinates, momentum and force components.
Lagrange equations of motion under finite forces, cyclic coordinates and conservation of energy.
Lagrangian approach to some known problems:-motion of a particle in polar system, motion of a particle in a rotating plane, motion of an insect crawling on a rod rotating about its one end, motion of masses hung by light strings passing over pulleys, motion of a sphere on the top of a fixed sphere and Euler dynamic equations.
Lagrange equations for constrained motion under finite forces.
Small oscillations for longitudinal and transverse vibrations.

Unit-3

Equations of motion in Hamiltonian approach and its applications on known problems as given above. Conservation of energy. Legendre dual transformations.
Hamilton principle and principle of least action. Hamilton-Jacobi equation of motion, Hamilton-Jacobi theorem and its verification on the motions of a projectile under gravity in two dimensions and motion of a particle describing a central orbit.

Unit-4

Phase space, canonical transformations, conditions of canonicality, cyclic relations, generating functions, invariance of elementary phase space, canonical transformations form a group and Liouville theorem.
Poisson brackets, Poisson first and second theorems, Poisson. Jacobi identity and invariance of Poisson bracket.

References:

1. N. C. Rana and P.S. Joag, *Classical Mechanics*, Tata McGraw-Hill, 1991.
2. H. Goldstein, *Classical Mechanics*, Narosa, 1990.
3. J. L. Synge and B. A. Griffith, *Principles of Mechanics*, McGraw-Hill, 1991.
4. L. N. Hand and J. D. Finch, *Analytical Mechanics*, Cambridge University Press, 1998.
5. Naveen Kumar, *Generalized Motion of Rigid Body*, Narosa, 2004.
6. R.G. Takwale and P.S. Puranik, Introduction to Classical Mechanics
7. C.R. Monal, Classical Mechanics
8. Grantmaccher: Analytic mechanics

MAM 105: Computer Programming in C **Credit: 4(2L 2P)**

Unit 1

Programmer's model of a computer. Algorithms, Flow Charts; Data Types, Arithmetic and input/output instructions.

Unit 2

Decisions control structures; Decision statements, Logical and Conditional operators; Loop: for loop, while loop, do while loops, Case control structures. Functions; Preprocessors; Arrays; Puppettting of strings.

Unit 3

Pointers. Structures; File formatting. Algorithms and programs to analyze statistical data. Measures of location and dispersion, sorting of data.

Unit 4

Constructing inverse matrices and determinant; Numerical algorithm for solving nonlinear equations-bisection, Regula falsi, functional iteration, Newton-Raphson methods for real roots.

References:

1. Henry Mullish & Hobert Looper, Spirit of C: An Introduction to Modern Programming,
2. Jaico Publishers, Bombay.
3. Kernighan B.W. and Ritchie D.M., C Programming Language, Prentice Hall, Software Series.
4. Y. Kanetkar, Let us C, BPB Publications, 2010
5. M.T. Somashekar; problem solving with C

MAM 106 (OE) Mathematical Methods Credits : 4

Unit 1

Solutions of linear systems: Existence & Uniqueness, Gauss-Elimination method, Gauss–Jordan method, LU-Factorization: Crout's decomposition and Doolittle's decomposition, Cholesky decomposition method

Unit 2

Bisection method, False Position method, Secant Method, Iteration Method, Newton-Raphson method. Error computation and convergence.

Unit 3

Laplace transform, linearity, first shifting theorem (s-shifting), transforms of derivatives and integrals, Unit-step function (Heaviside Function), second shifting theorem (t-shifting), Dirac's delta function, partial fractions, convolution, differentiation and integration of transforms, solution of ODEs with constant coefficients.

Unit 4

Different types of approximations: Least square polynomial approximation, Polynomial approximation using orthogonal polynomials.

Text/Reference Books

1. S.R.K. Iyengar, R. K. Jain, Numerical Methods, New Age International Publishers, 2009.
2. Erwin Kreyszig, Advanced Engineering Mathematics (10e) John Wiley & Sons, 2015.
3. S.S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall India Learning Private Limited; Fifth edition, 2012.
4. M. Spiegel, Schaum's Outline of Laplace Transforms, McGraw-Hill Education
5. L Debnath, D. Bhutta, Integral Transforms and Their Applications, Chapman and Hall/CRC; (2 edition) 2006
6. S.C. Gupta, Mathematical Statistics, Sultan Chand & Sons, 2014.

SEMESTER-II

MAM-201 : Linear Algebra Credits : 4

Unit 1

Systems of linear equations, Vector spaces, Subspaces, Linear independence of vectors, Bases and dimensions, Quotient space, Direct Sum, Complementry Subspace.

Unit 2

Linear transformations, Range and null space of linear transformations, Rank-nullity theorem, Algebra of linear transformations, Isomorphism, Matix Representation of linear transformation, Invertible linear transformations, Linear functional.

Unit 3

Elementary canonical forms: Characteristic values and characteristic vectors, Diagonalizable linear operator, Minimal polynomials of linear operators, Cayley-Hamilton theorem, Invariant subspace, T-conductors and T-annihilators, triangulation, Direct-Sum decompositions, Invariant direct sums, Primary decomposition theorem, Cyclic decomposition Theorem, Rational canonical form, Jordan canonical form and some applications.

Unit 4

Inner product spaces, Orthogonal bases, Gram-Schmidt orthogonalization process, Orthogonal projections, Linear functional and adjoints, Unitary operators, Normal operators, The spectral theorem. Bilinear forms, Symmetric, Skew-symmetric, Positive and semi-positive forms.

References:

1. K. Hoffman and R. Kunze, Linear Algebra, Second Edition, Prentice Hall of India, 1971.
2. S. Friedberg, A. Insel, and L. Spence, Linear Algebra, Fourth Edition, Prentice Hall of India, 2009
3. H. Helson, Linear Algebra, Hindustan Book Agency, New Delhi, 1994.
4. G.Strang, Introduction to Linear Algebra, Fifth Edition, Wellesley-Cambridge Press, 2016.Algebra; Vivek Sahai, Vikas Bist, Narosa Pub. House Pvt. Ltd., 2010.
5. Linear Algebra; Vivek Sahai, Vikas Bist, Narosa Pub. House Pvt. Ltd., 2010.

MAM-202 : Complex Analysis **Credits : 4**

Unit 1

Review of Analytic function and C-R Equations, Complex integration, Cauchy-Goursat Theorem, Cauchy's integral formula, Higher order derivatives, Morera's Theorem, Cauchy's inequality, Liouville's theorem and the fundamental theorem of algebra, Maximum modulus principle, Schwarz lemma. Power series representation of analytic functions, Taylor's theorem, Laurent's theorem.

Unit 2

Isolated singularities and their classification, Zeros of Analytic functions, Behaviour of function near isolated singular points, Casporati-Weierstress theorem. Meromorphic functions, Mittag-Leffler Theorem, The Argument principle, Rouche's theorem. Residues, Cauchy's residue theorem, Evaluation of integrals.

Unit 3

Bilinear transformations, their properties and classifications: Definitions and examples of conformal mappings, Branches of many valued functions with special reference to arg z, log z and z^a. Entire functions, Weierstrass' factorization theorem, Gamma function and its properties, Riemann zeta function, Riemann's functional equation.

Unit 4

Analytic Continuation, Uniqueness of direct analytic continuation, Uniqueness of analytic continuation along a curve, Power series method of analytic continuation. Canonical products, Jensen's formula, Poisson-Jensen formula.

References:

1. J. B. Conway, Functions of One Complex Variable, Springer-Verlag, International student Edition, Narosa Publishing House, 1980.
2. R.V. Churchill, Complex Variable and Applications, McGraw Hill. 1948.

3. L.V. Ahlfors, Complex Analysis, McGraw-Hill,1979
4. H. A. Priestly, Introduction to Complex Analysis, Clarendon Press, 1990
5. S. Punnusamy, Foundations of Complex Analysis

MAM-203 : Advanced Abstract Algebra
Credits: 4

Unit 1
Extension fields: Simple and normal extensions, Separable extensions, Automorphisms of extensions, Galois extensions.

Unit 2
Fundamental theorem of Galois theory. Galois group of a polynomials: Quardatic, Cubic and Quartic polynomials, Radical extensions. Irreducible criterion

Unit 3
Modules, Submodules, Quotient Modules, Isomorphism theorems, Schur’s lemma, Cyclic modules, simple modules and semi-simple modules, Module homomorphism.

Unit 4
Direct sums and exact sequences. Free modules. Free modules over PID’s, Finitely generated modules over PID’s, Projective and Injective modules.

Text/Reference Books

1. Joseph A Gallion Contemporary Abstract Algebra;, Narosa Pub. House P. Ltd.
2. Joseph B. Fraleigh A First Course in Abtract Algebra; Pearson Edu. Inc. , 2003.
3. Vivek Sahai, Vikas Bist Algebra; Narosa Pub. House Pvt. Ltd., 2010.
4. V.K. Khanna and S.K. Bhabari; Abstract Algebra, Vikash Pub. House P. Ltd.
5. I.N. Herstein; Topics in Algebra, John Wiley and Sons, New York.
6. I.B.S. Passi and I.S. Luthar; Algebra 1& 2.

MAM-204 : Partial Differential Equations **Credit:4**

Unit 1
Classification of Ist order partial differential equations, origin of partial differential equations, Cauchy’s problem for first order equations, classification of solution, Lagrange's method, Integral surface passing through a given curve, surfaces orthogonal to a given system of surfaces.

Unit 2
Cauchy’s method of characteristics for solving non-linear first order partial differential equations, compatible system of first order equations, Charpit's method, Jacobi's method, Monge’s method.

Unit 3
Second order partial differential equations: Origin of second order p.d.e., classification of second order p.d.e's, characteristic equation, separation of variables, Laplace equation, boundary value problems, properties of harmonic functions: the spherical mean and mean value theorem, maximum-minimum principles, Dirichlet problem for a rectangular region/circle/annulus, Neumann problem for a rectangular region, Green's function for Laplace equation.

Unit 4
Heat equation, boundary conditions, Heat conduction problem for an infinite rod, Heat conduction in a finite rod, existence and uniqueness of the solution, Wave equation, vibrations of a finite string, existence and uniqueness of solution.

Text/Reference Books:

1. Ian Sneddon, Elements of partial differential equation, McGraw-Hill Book Company, 1982.
2. M. D. Raisinghania, Ordinary and partial differential equations, S. Chand, 2014.
3. K. Sankara Rao, Introduction to partial differential equation, PHI Learning, 2009.
4. S. J. Farlow, Partial Differential equations for scientist and engineer, Wiley Publisher, 2006.
5. P. Prasad and R. Ravindran, Partial Differential equations, New Age International Pub., N. Delhi, 1985.
6. F. John, Partial Differential equations, Springer- Verlag, N. York, 2004.
7. Lawrence C. Evans; Partial Differential Equations.
8. Christian Constanda; Solution techniques for elementary Partial Differential Equations.

MAM-205: Advanced Numerical Analysis **Credits : 4**

Unit 1

Interpolation: Newton, Lagrange and Hermite Interpolations, error of the interpolating polynomial, piecewise-polynomial approximation, Spline interpolation.

Different types of approximations: Least square polynomial approximation, Polynomial approximation using orthogonal polynomials, Chebyehev polynomials.

Unit 2

Solutions of system of linear equations: Direct methods (LU Decomposition method and Gaussian elimination method with and without pivoting). Iterative Methods (Jacobi, Gauss-Seidel) and their error formats. Thomas algorithm for the solutions of tridiagonal system of linear equations.

Eigenvalue Problems: Power method, Jacobi’s method, Givens method, Householder method. Eigen values of complex matrices.

Unit 3

Numerical Integration: Newton-Cotes formula, Optimum choice of step length and methods based on undetermined coefficients, Quadrature methods, Gaussian integration, double integration.

Solution of ODEs: Numerical differentiation, difference equations, Taylor series method, Euler's method and its convergence, Second and fourth order Classical explicit Runge-Kutta methods, Milne and Adam Predictor-Corrector methods, Stability of numerical methods.

Unit 4

Finite difference method for linear second order differential equations: Finite difference methods for BVPs. Finite difference method for non-linear second order differential equations. Numerical solutions of second-order of linear and non-linear boundary value problems (BVP) by shooting method. Local truncation errors.

References:

1. M.K. Jain, S.R.K. Iyenger, R.K. Jain; Numerical methods Problems and Solutions, New Age International (P) ltd, 2009.
2. S.S. Sastry, Introductory method of Numerical Analysis, PHI, New Delhi, 2005.
3. D.V. Griffiths and I.M. Smith, Numerical Methods for Engineers (Taylor & Francis Group), 2006.
4. Froberg C.E., Numerical Mathematics - Theory and Computer Applications; The Benjamin Cummings Pub. Co. 1985.
5. John H. Mathews: Numerical Methods for Mathematics, Science and Engineering (Prentice-Hall) 2nd edition, 1992.
6. Radhey S. Gupta, Elements of Numerical Analysis, Macmillan India Ltd. New Delhi (2009).

MAM-206 : Mathematical Modeling **Credits : 4**

Unit 1

Introduction to Mathematical Modeling: modeling process, Classifications of mathematical models, Characteristics and limitations of mathematical models, Some simple illustrations. Basic concepts of ordinary differential equations; Mathematical modeling through differential equations, linear growth and decay models, Nonlinear growth and decay models.

Unit 2

Mathematical modeling through systems of ordinary differential equations of first order: Mathematical models in population dynamics and epidemics, Mathematical Modeling through second order differential equations: Mathematical Modeling of planetary motion, circular motion, motion of satellites, etc.

Unit 3

Mathematical modeling through difference equations, Basic theory of linear difference equations with constant coefficients, Mathematical modeling through difference equations in population dynamics, economic and finance.

Unit 4

Mathematical modeling through linear programming, Linear programming models in Transportation and assignment, Mathematical modeling through non-linear programming.

REFERENCES:

1. J. N. Kapur, Mathematical Modeling, Wiley Eastern,1988.
2. D. N. Burghes, Mathematical Modeling in the Social Management and Life Science, Ellie Herwood and John Wiley,1988.
3. F. Charlton, Ordinary Differential and Difference Equations, Van Nostrand,1989.

SEMESTER III

MAM-301 : Topology **Credits: 4**

Unit 1

Definition and examples of topological space. Interior points, Exterior points, Closed sets and Open sets, Neighborhoods, Closure, Interior, Boundary and accumulation points, Dense subset, Derived sets.

Bases and sub-bases, Subspaces and relative topology. Alternative methods of defining a topology in terms of Kuratowski closure operator and neighbourhood systems.

Unit 2

Continuous functions: Basic definitions and theorems, homeomorphisms, topological invariants, connected and disconnected sets, connected spaces and their basic properties. Connectedness on the real line, components, locally connected spaces.

Unit 3

Countability Axioms: First and second countable spaces, Lindelof's theorems, Separable spaces, second countability and separability.

Separation axioms: T0, T1, T2, T3; their characterizations and basic properties. Urysohn's lemma and Teitze extension theorem, Statement of Urysohn's metrization theorem.

Unit 4

Compactness – Continuous functions and compact sets, basic properties of compactness, compactness and finite intersection property, sequentially and countably compact sets, local compactness and one point compactification, Statements of Tychonoff's Product theorem and Stone-Cech compactification theorem.

References:

1. J. R. Munkres, Topology, A First Course, PHI Pvt. Ltd., N. Delhi, 2000.
2. J. Dugundji, Topology, Allyn and Bacon, (Reprinted in India by PHI), 1966.
3. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.
4. K D Joshi, Introduction to General Topology, Wiley Eastern Ltd., 1983.

KP Gupta, SS Gupta and GS Gupta, Topology, Pragati Prakashan, 1999.

MAM-302 : Mathematical Methods **Credits : 4**

Unit 1

Calculus of Variations: Motivational problems (Brachistocrone, isoperimetric and geodesics) functional, deduction of Euler's equations for functional of first order and higher order for fixed boundaries, isoperimetric problems, moving boundary problems, shortest distance between two non-intersecting curves.

Unit 2

Integral equation: definition and classification, relation of ODEs with integral equations, Fredholm equations (homogeneous and non-homogenous) of the second kind with separable kernels, characteristic numbers and eigenfunctions, Fredholm alternative theorem.

Unit 3

Method of successive approximations, iterated kernels, resolvent kernel, solution of Fredholm and Volterra integral equation of second kind by successive substitutions, solution of Fredholm and Volterra integral equation of second kind by successive approximations: Neumann series, solution of Fredholm and Volterra integral equation of first kind.

Unit 4

Fredholm's fundamental theorems, convolution type equations, solution of integral differential equations with the aid of Laplace transformation.

Text/Reference Books:

1. Ram P Kanwal, Linear Integral Equations, Academic Press, 1997.
2. Gelfand and Fomin, Calculus of Variations, Prentice Hall, Inc., 2000.
3. A.S. Gupta, Text Book on Calculus of Variation, Prentice-Hall of India, 2004.
4. Ian Sneddon, The use of integral transforms, Tata McGraw Hill, 1972.
5. F.B. Hildebrand, Method of Applied Mathematics, Dover Publications, 1992.
6. Abdul J Jerri, Introduction to integral equations with Applications, Marcel Dekker Inc.

MAM-303 : Fluiddynamics **Credits : 4**

Unit 1

Definition of fluid, streamlines, path lines and streak lines, material derivative, Lagrange's and Euler's methods, equation of continuity in Cartesian, polar and curvilinear coordinates system, boundary surfaces, vorticity, vortex lines, rotational and irrotational motions.

Unit 2
Euler's equation of motion in Cartesian, polar and curvilinear coordinate systems, Bernoulli's equation, Bernoulli's theorem and their applications.

Unit 3
Motion in two-dimensions, Conjugate functions, Source, sink, doublets and their images, conformal mapping, Two-dimensional irrotational motion produced by the motion of circular cylinder in an infinite mass of liquid, circulation and Kelvin circulation theorem.

Unit 4
Stress components in real fluid, Equilibrium equation in stress components, Transformation of stress components, Principal stress, Nature of strains, Transformation of rates of strain, Relationship between stress and rate of strain, Navier-Stokes equation of motion in Cartesian coordinates.

Text/Reference Books:

1. W. H. Besant and A. S. Ramsey, A Treatise on Hydrodynamics, CBS Publishers and Distributors, Delhi, 1988.
2. S. W. Yuan, Foundations of Fluid Dynamics, Prentice-Hall of India, 1988.
3. M.D. Raisinghania, Fluid Dynamics, S. Chand, 2010.
4. F. Charlton, Introduction to Fluid Dynamics, CBC Publishers, 2004.

MAM-304 : Operations Research **Credits : 4**

Unit 1
Definition, scope and applications, Linear programming problems, Convex sets, simplex method, Duality and sensitivity analysis, Primal and dual simplex method.

Unit 2
Transportation problems and assignment problems of linear programming. Travelling salesman problem, Dynamic Programming, Nonlinear Programming.

Unit 3
Queuing theory: Steady state solution of Markovian queuing models: M/M/1, M/M/1 with limited waiting space.

Unit 4
Game theory: Two person zero-sum games, Games with mixed strategies, Graphical solutions, Solutions by linear programming.

References:

1. Kanti Swarup, PK Gupta and Man Mohan, Operations Research, S Chand and sons, New Delhi,1977.
2. S.S. Rao, Optimization Theory and Applications, Wiley Eastern Ltd, New Delhi,1979.
3. G. Hadley, Linear Programming, Narosa Publishing House, 1995.
4. H.A. Taha: Operation Research- An introduction, Macmillan Publishing Co. Inc., NY.
5. N.S. Kamboo; Linear and nonlinear programming
6. Goyal and Mittal; Operations Research

MAM 305 : Finite Element Methods (Elective-I) **Credits: 4**

Unit 1
Introduction, Weighted residual methods: Galerkin, Least square, Subdomain, collocation and moment methods for homogeneous and non-homogeneous boundary conditions. Examples.

Unit 2
Variational method: Euler equation, Construction of Functional, Rayleigh-Ritz method, Equivalence of Galerkin and Rayleigh-Ritz methods. Examples.

Unit 3
Finite element methods: Shape functions-straight lines, triangular, rectangular. Natural coordinates in one, two and three dimensions. Shape functions using Lagrange's polynomials for one, two and three dimensions.

Unit 4
Solution of ODEs FEM, weighted-residue methods and parabolic, hyperbolic and elliptic equations using FEM.

References:

1. MK Jain, S.R.K. Iyengar, R.K. Jain; Numerical methods Problems and Solutions, New Age International (P) ltd,2007.
2. Radhey S. Gupta, Elements of Numerical Analysis, Macmillan India Ltd. New Delhi (2009).
3. Schaum series Partial differential equations,1986.
4. Chandraputla and Belagundu O.C. Zienkiewic, The finite element method in structural and continuum mechanics, 2005.

MAM 305: Mathematical Modeling (Elective-I) **Credits : 4**

Unit 1
Simple situations requiring mathematical modeling, techniques of mathematical modeling, Classifications of mathematical models, Characteristics and limitations of mathematical models, Some simple illustrations. Mathematical modeling through differential equations of first order: linear growth and decay models, Non linear growth and decay models.

Unit 2
Mathematical modeling through systems of ordinary differential equations of first order: Mathematical models in population dynamics and epidemics, compartmental models, Mathematical Modeling through second order differential equations: some simple models.

Unit 3
Mathematical modeling through partial differential equations, Methods of obtaining partial differential equation models: Mass-balance equation, moment balance equation and variational principle, Model for Traffic flow problem, Diffusion models in population dynamics.

Unit 4
Mathematical Modeling through second order differential equations: some simple models. Mathematical Modeling through delay differential equations and its application, Mathematical modeling through graphs: Mathematical models in terms of Directed graphs, signed graphs and weighted digraphs.

References:

1. J. N. Kapur, Mathematical Modeling, Wiley Eastern, 1988.
2. D. N. Burghes, Mathematical Modeling in the Social Management and Life Science, Ellie Herwood and John Wiley, 1988.
3. F. Charlton, Ordinary Differential and Difference Equations, Van Nostrand, 1989.

MAM 305 : Industrial Mathematics (Elective I) **Credits: 4**

Unit 1

Some Basic Definitions and Terminology. Basic option theory: single and multi-period binomial pricing models. Cox-Ross-Rubinstein (CCR) model, Black Scholes formula for potion pricing as a limit of CCR model.

Unit 2

Brownian and Geometric Brownian Motion. Theory of Martingales. Stochastic Calculus, Stochastic differential Equations, Ito's formula to solve SDE's. Feymann Kac theorem. Application of stochastic calculus in option pricing.

Unit 3

Black Scholes partial differential equations and Black Scholes formula.
Mean Variance portfolio theory: Markowitz model for Portfolio optimization and Capital Asset Pricing Model (CAPM).

Unit 4

Interest rates and interest rate derivatives: Binomial lattice model, Vasicek, Hull and White and Cox-Ingersoll-Ross (CIR) Model for bond pricing.

References:

1 D.G. Luembergar, Investment Science, Oxford University press, 1999.
2 S.Ross, An Introduction to Mathematical Finance, Cambridge University press, 1999.
3 J.C.Parikh, Stochastic Process and Financial Markets, Narosa, 2003.
4 S. Roman, An Introduction the Mathematics Of Finance, Springer, 2000.

MAM-305 : Advanced Graph Theory (Elective I) **Credits: 4**

Unit 1

Trees: Spanning trees and enumeration. Matching: Matching and Maximum Matching, Hall's Matching condition, Minimax Theorems. Independent Sets and Covers. Dominating Sets.

Unit 2

Connectivity: Connectivities of graphs, Cut-sets, Edge Connectivity and Vertex Connectivity. Menger's Theorem.
Network Flow problem, maximum network flows, flow augmenting paths, Ford-Fulkerson Theorem.

Unit 3

Coloring of graphs: Chromatic number and chromatic polynomial of graphs, Brook's Theorem. Four Color Theorem.

Unit 4

Planarity: Planar Graphs, Testing of Planarity, Kuratowski Theorem for Planar graphs, Random Graphs.

References:

1 D.B.West, Graph Theory, Pearson Publ. 2002.
2 F.Harary, Graph Theory. Narosa Publ. ND.
3 R. Diestel, Graph Theory, Springer, 2000.

MAM-306: Dynamical Systems (Elective II) **Credits : 4**

Unit 1

Linear dynamical systems: preliminary concepts, autonomous and non-autonomous systems, diagonalization, fundamental theorem of linear systems, stability, stable, unstable and center subspaces, flow of linear systems, nonhomogeneous linear systems.

Unit 2

Non-linear dynamical systems: Fundamental Existence and Uniqueness theorem, linearization, phase space, critical points and paths of nonlinear systems, invariant manifolds, Stable and unstable manifolds of equilibria.

Unit 3

Stable manifold theorem, Hartman-Grobman theorem, Examples and applications, Center manifold theorem, Normal form theory, Examples and applications to nonlinear systems.

Unit 4

Liapunov's function, Liapunov's Direct Method, Extstence and nonexistence of Limit cycles, Bendixson's Nonexistence Criterion, Poincare-Benedixon theorem and applications. Bifurcation theory, Forward bifurcation, Backward bifurcation, Hopf-bifurcation, Examples and applications.

References:

1. L. Perko, Differential Equations and Dynamical Systems, 3rd Edition, Springer, 2010.
2. F. Verhulst, Non-linear Differential Equations and Dynamical Systems, Springer, 1990.
3. Hirsch M.W. and Smale S., Dynamical Systems, Acad Press, 1974.
4. S. Wiggins, Introduction to applied nonlinear dynamical systems and chaos. Springer-Verlag, USA, 1990.

MAM -306: Fuzzy System and Analysis (Elective II) **Credits: 4**

Unit 1

Basic Concepts of Fuzzy Sets and Fuzzy Logic: Motivation. Fuzzy sets and their representations. Membership functions and their designing. Types of Fuzzy sets. Operations on fuzzy sets. Convex fuzzy sets. Alpha-level cuts. Geometric interpretation of fuzzy sets. Linguistic variables.

Unit 2

Possibility measure and distribution. Fuzzy rules. Fuzzy Relations and Fuzzy Arithmetic: Composition of fuzzy relations. Fuzzy numbers. Arithmetic operations on fuzzy numbers.

Fuzzy reasoning

Fuzzy mapping rules and fuzzy implication rules. Fuzzy rule-based models for function approximation.

Unit 3

Types of fuzzy rule-based models (the Mamdani, TSK, and standard additive models). Fuzzy Implications and Approximate Reasoning:

Fuzzy Logic and Probability Theory : Possibility versus probability. Probability of a fuzzy event. Baye's theorem for fuzzy events. Probabilistic interpretation of fuzzy sets. Fuzzy measure.

Unit 4

Decision making in Fuzzy environment: Fuzzy Decisions, Fuzzy Linear programming, Fuzzy Multi criteria analysis, Multiobjective decision making.

Fuzzy databases and queries: Introduction, Fuzzy relational databases, Fuzzy queries in crisp databases.

References:

1. J. Yen and R. Langari: Fuzzy Logic: Intelligence, Control, and Information, Pearson Education, 2003.
2. G. J. Klir and B. Yuan: Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice-Hall of India, 1997.

3. H.J. Zimmermann, Fuzzy Set theory and its applications, Kluwer Academic Publ, 2001.

MAM-306: Information Theory (Elective II) Credits: 4

Unit 1

Measure of Information: Axioms for a uncertainty measure, Uncertainty function and its properties, Joint and conditional entropies, The Shannon entropy and its properties, Axiomatic characterization of the Shannon entropy due to Shannon and Fadeev, Noiseless coding, Ingredients of noiseless coding problem, Uniquely decipherable codes, Noiseless coding theorem, Construction of optimal codes.

Unit 2

Discrete Memoryless Channel, Models for communication channels, Channel capacity, Decoding schemes, The ideal observer, The fundamental theorem of Information Theory and its converse, Exponential error bounds, Error correcting codes, Parity check coding, Application of group theory to parity check coding.

Unit 3

Cyclic codes and its properties, Single error correcting cyclic codes, Automatic decoding, Information sources, Mathematical model for information sources, Uncertainty of a source, Approximation of a general information source by a source of finite order, Asymptotic equipartition property and its consequences.

Unit 4

Channels with memory, Finite-state channels, The coding theorem for finite state regular channels, Continuous Channels, The time-discrete Gaussian channel, The converse to the coding theorem for time-discrete Gaussian channel, The time-continuous Gaussian channel, Band-limited channels.

References

1. Robert Ash, Information Theory, Dover Publications, 1990
2. F.M. Reza, An Introduction to Information Theory, MacGraw-Hill Book Company Inc., 1961.
3. David MacKay, Information Theory, Inference and Learning Algorithms, Cambridge University Press, 2003
4. T. M. Cover, J.A. Thomas, Elements of Information Theory, Wiley, 1991

MAM-306: Numerical Solutions of ODEs and PDEs (Elective II) Credits : 4

Unit 1

Initial value problems: definition, existence of solution, need for numerical solutions, Finite difference equation, truncation error, Picard's method of successive approximation. Taylor series method, Euler and modified Euler method, Runge-Kutta methods, Stability Analysis.

Unit 2

Multi-step methods: Predictor corrector methods Milne's method, Adams-Moulton method, Adams Bashforth method, Systems of equations and higher order equations, Linear Boundary value problems: Shooting methods, Finite Difference Methods, Convergence criteria, Errors and error propagation, Stiff equations, Nonlinear Boundary Value Problems.

Unit 3

Introduction to well posed PDE, Classification, various types of governing conditions, Finite Difference representation of derivatives, Parabolic PDE: Solution for one Dimensional equation, explicit and various implicit schemes, Discussion on compatibility, stability and convergence of above schemes, extension to 2d Heat Conduction equation.

Unit 4

Elliptic PDE:, Solution of Laplace/ Poisson PDE in Cartesian and Polar system, ADI and SOR schemes, Methods for solving diagonal systems, Treatment of irregular boundaries, Hyperbolic equations – wave equation, Finite difference explicit and implicit schemes, stability analysis, Method of characteristics and their significance.

Text/Reference Books:

1. G.D. Smith, Numerical Solution of Partial Differential Equations: Finite Difference Methods, Oxford Applied Mathematics & Computing Science Series, 1986.
2. M. K. Jain, Numerical suctions of differential equations, New Age International, 2002.
3. G. E. Forsythe & W. R. Wasow, Finite Difference methods for partial Differential equation, Literary Licensing, LLC, 2013.
4. C. F. Gerald & P. O. Wheatley, Applied Numerical Analysis, Addison Wesley Longman Publishing Co, 1989.
5. L. Fox, Numerical Solution of Ordinary & Partial Differential Equation, Pergamon Press, 1962.

SEMESTER IV

MAM-401: Functional Analysis **Credits : 4**

Unit 1

Normed linear spaces, Banach spaces, Examples and counter examples, Subspace, Quotient space of normed linear spaces and its completeness. Bounded linear transformations, Normed linear spaces of bounded linear transformations, Equivalent norms, Basic properties of finite dimensional normed linear spaces, Reisz Lemma.

Unit 2

Open mapping theorem, Closed graph theorem and its consequences, Uniform boundedness principle and its consequences, Bounded linear functionals, Hahn-Banach theorem and its application. Dual spaces with examples, Reflexive spaces.

Unit 3

Inner product spaces and Hilbert spaces, Properties of Hilbert Space, Orthogonal complements, Orthonormal sets, Bessel's inequality, Complete orthonormal sets and Perseval's identity.

Unit 4

Structure of Hilbert spaces, Projection theorem, Riesz representation theorem, Adjoint of an operator on a Hilbert space, Reflexivity of Hilbert spaces. Self adjoint operators, Normal and Unitary operators, Orthogonal projection operators.

References:

1. C.Goffan & G Pedrick: First course in Functional Analysis, PHI, New Delhi,1983.
2. P.K. Jain, O.P. Ahuja & Khalil Ahmad: Functional Analysis, New Age (International P. Ltd.) New Delhi,1996.

3. E. Kreyszig: Introductory Functional Analysis with Applications, John Wiley and Sons, New York,1989.
4. G.F. Simmons: Introduction to Topology and Modern Analysis, McGraw Hill Book Co., New York,1963.

MAM-402: Measure Theory **Credits : 4**

Unit 1
Countable and uncountable sets, Axiom of Choice, Cardinal numbers and its arithmetic, Schroeder-Burstein theorem, Cantor's continuum hypothesis, Zorn's lemma(without proof), Well-ordering theorem, Algebra's of sets, Borel sets, Cantor set, Lebesgue-Cantor function.

Unit 2
Lebesgue Outer Measure, the σ -Algebra of Lebesgue Measurable Sets, Outer and Inner Approximation of Lebesgue Measurable Sets, Countable additivity, Continuity, and the Borel-Cantelli Lemma, non-measurable sets
Measurable functions, algebra of measurable functions, Step functions, Characteristic functions, simple functions, Sequential pointwise limits and simple approximation of measurable functions.

Unit 3
Littlewood's Three Principles, Egoroff's Theorem, and Lusin's Theorem
The Lebesgue integral of a bounded function over a set of finite measure, the Lebesgue integral of measurable non-negative functions, The general Lebesgue integral, Countable additivity and continuity of integration, Uniform integrability: The Vitali convergence theorem.

Unit 4
Uniform integrability and tightness: A general Vitali convergence, Convergence in measure, Convex functions, Jensen's inequality
The L^p -Space, The inequalities of Young, Holder, and Minkowski, L^p -Space is Complete: The Riesz-Fischer Theorem.

Text/Reference Books:
1. H. L. Royden and F. M. Fitzpatrick, Real analysis, Pearson education 2010.
2. P. K. Jain and P. Jain, General Measure and Integration, New Age International Publishers, 2014.
3. S. Goldberg: Real analysis Oxford and IBH New Delhi,1997.
4. Inder K. Rana, An Introduction to Measure and Integration, Narosa Publishing House, Delhi, 1997.

MAM-403: Probability and Probability Distributions **Credits : 4**

Unit 1
Probability: Set theoretic approach, Baye's theorem, Geometric probability, Random experiments, Sample spaces, Random variables, Distribution functions, Joint probability distribution function, Conditional distribution function, Transformation of one and two dimensional Random variables.

Unit 2
Mathematical expectation: Covariance, Variance of variables, Chebysheff's inequality. Moment generating function, Cumulant Generating Function and Cumulants.
Discrete distributions: Geometric, Binomial, Poisson and uniform distributions. Continuous distributions: Normal, Exponential, Gamma, Chi-square, t , F, Beta and uniform on an interval.

Unit 3

Correlation and regression: Partial and multiple correlations, Correlation coefficients, rank correlation, Regression lines and its properties.

Unit 4
Elementary understanding of data: Frequency curves, Empirical measures of location, spread; Empirical moments. Analysis of bivariate data. Fitting of distributions.

References

1. V.K. Rohatgi, A. K. Md. Ehsanes Saleh: An Introduction to Probability and Statistics, Wiley-Interscience, 2011.
2. Kapoor and Kapoor, Mathematical Probability Distribution,
3. Kennedy and Gentle: Statistics Computing, Published by CRC Press, 1980
4. P.L. Mayer: Introductory Probability and Statistical Applications, IBH, 1970.
5. A.M. Mood and F. Graybill: Introduction to the Theory of Statistics, TMH, New Delhi, 1973.

MAM-404: Discrete Mathematics **Credits : 4**

Unit 1
Formal Logic: Statements, Symbolic Representation of statements, Truth tables, Logical equivalence, Algebra of propositions, Conditional proposition, Converse, Contrapositive and Inverse, Bi-conditional Proposition, Negation of compound statement, Tautologies and contradictions, Normal forms , Predicates and Validity of arguments, Quantifiers.

Unit 2
Lattices: Lattices as partially ordered sets, their properties, duality, Lattices as algebraic systems, Sub lattices, Direct products, Bounded Lattices, Complete Lattices, Complemented Lattices and Distributive lattices.

Unit 3
Boolean Algebras: Boolean Algebras as lattices, Various Boolean Identities, The Switching Algebra examples. Sub algebras, Direct products and Homeomorphisms,
Boolean forms and their Equivalence, Min-term Boolean forms, Sum of product Canonical forms, Minimization of Boolean functions.

Unit 4
Definition of graph, Walk, Path, Circuit, Cycles, Degree of a vertex, Types of graphs, Sub-graphs and Isomorphic graphs, Eulerian and Hamiltonian graphs, Shortest path problems.

Text/Reference Books:

1. Seymour Lipschutz, Finite Mathematics, McGraw-Hill Book Co. New –York, 2004.
2. J. E. Hopcroft and J.D. Ullman, Introduction to Automata Theory Languages & Computation, Narosa Publishing House, Delhi,2007.
3. S.K.Sarkar, A Text book of Discrete Mathematics, S Chand and Company Ltd., 2006.
4. C. L. Liu, elements of Discrete Mathematics, McGraw-Hill Book Co,2010.
5. N. Deo, Graph Theory with Applications to Engineering and Computer Sciences, PHI, New Delhi, 1794.

MAM-405 : Advanced Fluid Dynamics (Elective-III) **Credits : 4**

Unit 1

Similarity of flows: Dynamic similarity, Dimensional analysis, Dimensionless number, Buckingham π -theorem.

Unit 2

Laminar flow of viscous incompressible fluids: Flow between parallel flat plates- Couette flow, Generalized Couette flow, plane Poiseuille flow, temperature distribution, flow through a pipe-Hagen Poiseuille flow, flow between two co-axially cylinders and two concentric rotating cylinders, unsteady motion due to an oscillating flat plate.

Unit 3

Laminar boundary layer – Properties of Navier-Stokes equations, boundary layer equations in two-dimensional flows, boundary layer along a flat plate: Blasius solution, boundary layer displacement and momentum-thicknesses, momentum integral theorems with applications, effect of pressure gradient on the boundary layer development, separation of boundary layer flow.

Unit 4

Compressible Inviscid flow – Controlling parameters, equations of continuity, motion, energy and pressure, propagations of motion, formation of shock waves, Mach number, Mach lines and cones, Isentropic flow relations, Pressure density and temperature in terms of Mach number.

Text/Reference Books:

1. S. W. Yuan, Foundations of Fluid Dynamics, Prentice-Hall of India, 1988.
2. M. D. Raisinghania, Fluid Dynamics, S. Chand, 2010.
3. S. I. Pai, Introduction to the Theory of Compressible Flow, Affiliated East-West Press, 1970.
4. F. Charlton, Introduction to Fluid Dynamics, CBC Publishers, 2004.

MAM 405 : Boimathematics (Elective-III) Credits : 4

Unit 1

Role of Mathematics in biosciences, Continuous population Models for single species: Exponential growth model, logistic growth model, Gompertz growth, logistic models with time-delay effects, Stochastic Models of population growth, Harvesting models.

Unit 2

Continuous models for interacting populations: Two species models, Community matrix approach, Qualitative behavior of the community matrix, Predator-prey models: Dynamic of the Lotka Volterra model, Predator-prey models involving different kind of functional responses. Chemostat models, Competition models, Mutualism models.

Unit 3

Dynamics of Infectious diseases, simple epidemic models; SIS, SIR, SIRS, SEIS, rate of immigration, contact rate, types of interactions, types of transmission, basic reproduction number (definition and its calculation), endemic situation.

Unit 4

Reaction Diffusion models: Simple Random Walk and Derivation of the Diffusion Equation, Reaction Diffusion Equations, Diffusion models for Insects and Animal Dispersal, Chemotaxis.

References:

1. J.D. Murrey, Mathematical Biology I: An Introduction, Springer, 2010.
2. Alan Hastings, Population Biology Concepts and Models, Springer
3. Fred Brauer and Carlos Castillo-Chavez, Mathematical Models in Population Biology and Epidemiology, Springer.
4. M. *Kot*, *Elements of Mathematical Ecology*. Cambridge University Press, 2001.
5. J.N. Kapur, Mathematical Models in Biology and Medicine, EWP New Delhi, 1992.

MAM-405 : Computational Fluid Dynamics (Elective-III) Credits : 4

Unit 1
Finite Difference Method: Classification Of 2nd Order Partial Differential Equations - Parabolic, Hyperbolic And Elliptic Types, Governing Equations Of Fluid Dynamics, Introduction To Finite Difference Discretization, Explicit And Implicit Schemes. Truncation Error, Consistency, Convergence and Stability Analysis, Thomas Algorithm.

Unit 2
ADI Method For 2-D Heat Conduction Problem, Splitting And Approximate Factorization For 2-D Laplace Equation, Multigrid Method, Upwind Scheme, CFL Stability Condition, Lax-Wendroff And Maccormack Schemes.

Unit 3
Finite Volume Method: Preliminary Concepts, Flux Computation Across Quadrilateral Cells, Reduction Of A BVP To Algebraic Equations, Illustrative Example Like, Solution Of Dirichlet Problem For 2-D Laplace Equation, Conservation Principles Of Fluid Dynamics.

Unit 4
Basic Equations Of Viscous And Inviscid Flow, Basic Equations In Conservative Form, Associated Typical Boundary Conditions For Euler And Navier-Stokes Equations, Grid Generation Using Elliptic Partial Differential Equations, Incompressible Viscous Flow Field Computation: Stream Function Vorticity Formulation, Staggered Grid, MAC Method.

Text/Reference Books:

1. P. Niyogi, S. K. Chakraborty and M. K. Laha- Introduction to computational fluid Dynamics, Pearson Education, Delhi 2005.
2. C. A. J. Fletcher- Computational Techniques for Fluid Dynamics, Vol-I and Vol-II, Springer, 1988.
3. R. Peyret and T. D. Taylor- Computational Methods for Fluid Flow, Springer 1983.
4. J. F. Thompson, Z.U.A Warsi and C. W. Martin, Numerical Grid Generation, Foundations and Applications, North Hollamm, 1985.
5. J.D. Anderson Jr., Computational Fluid Dynamics, Mc-Graw Hill, 2012.

MAM 405 : Advanced Optimization Techniques (Elective III) Credits : 04

Unit 1
Non-linear optimization: Constrained and unconstrained optimization techniques, some direct search and indirect search methods.

Unit 2
Stochastic programming: uncertainty and modelling, probabilistic spaces and random variables, probabilistic programming basic properties, theory and solution methods, relationship with other decision making models.

Unit 3
Generalized convex functions, linear and nonlinear fractional programming: theory and computational methods. Multi-objective optimization: theory and computational methods.
Evolutionary methods and global optimization: genetic algorithm simulated annealing.

Unit 4
Neural network based optimization. Decision making in fuzzy environment, Fuzzy optimization: theory and computational methods. Comparative study of probabilistic, possibilistic and fuzzy programming by case study.

References:

1. J. Nocedal, S.J. Wright, Numerical Optimization, Springer 1999.
2. R. Fletcher, Practical Methods of Optimization, John Wiley 1980.

3. P. Kall, Stochastic Linear Programming, Springer 1976.
4. B.D. Craven, Fractional Programming, Heldermann Verlage 1988.
5. Y.J. Lai , C.L.Hwang, Fuzzy Mathematical Programming: Methods and Applications, Springer-Verlog 1995.

MAM-406: Number Theory And Cryptography (Elective-IV) Credits : 4

Unit 1

The Division Algorithm, the gcd, Euclidean Algorithm, Diophantine equation, The fundamental theorem of arithmetic, The Sieve of Eratosthenes, The Goldbach conjecture, Theory of Congruences–Basic properties of Consequence. Linear Congruences, Chinese remainder theorem, Fermat's Theorem. Number-Theoretic Functions, The mobius inversion formula, The Greatest integer function, Euler's Phi function. Applications to Cryptography.

Unit 2

The order of an integer modulo n, Primitive roots for primes, The theory of indices, Euler's criterion, Legendre's symbol and its properties, Quadratic reciprocity, Quadratic congruences with composite moduli. Perfect Numbers, Representation of integers as sum of two squares and sum of more than two squares.

Unit 3

Classical cryptography: Encryption schemes, Symmetric key encryption, Feistel ciphers, NDS, DES, Multiple encryptions, Modes of operation, Applications to authentication and identification.

Unit 4

Some Mathematical Tools: Algorithm, complexity, Modular arithmetic, Quadratic residues, Primality testing, Factoring and square roots, Discrete logarithm. Public key Cryptography: Public key cryptosystems and their applications, RSA algorithm and its security, Key management, Diffie-Hellman key exchange.

References

1. Davis M. Burton: Elementary Number Theory, USB (Indian Reprint), 1991.
2. U. Dudley, Elementary Number Theory, Freeman & Co,1965.
3. D. R. Hankerson et al, Coding Theory and Cryptography. Monographs and Textbooks # 234, Marcel Decker, 2000.
4. W. Stallings,Cryptography and Network Security, Prentice Hall India, 2000.
5. Neal Koblitz, Zuckermann, A Course in Number Theory and cryptography: A Graduate Text, Springer (second edition),1994.

MAM-406: Perturbation theory & Stability analysis (Elective IV) Credits : 4

Unit 1

Parameter Perturbations: Algebraic Equation and the van-der Pol Oscillator, Coordinate Perturbations: The Bessel Equation of Zeroth Order, and Simple Examples,Order Symbols and Gauge Functions, Asymptotic Expansions and Sequences: Asymptotic Series, Asymptotic Expansions, Uniqueness of Asymptotic Expansions, Convergent versus Asymptotic Series, Elementary Operations on Asymptotic Expansions.

Unit 2

The method of strained parameters, the Lindstedt-Poincare method, transition curves for the Mathieu equation, characteristic exponents for the Mathieu equation (Whittaker's method), the stability of the triangular points in the elliptic restricted problem of three bodies, characteristic exponents for the triangular points in the elliptic restricted problem of three bodies, a simple linear eigen-value problem, a quasi-linear eigen-value problem, the quasi-linear Klein-Gordon equation, Lighthill's technique for a first-order differential equation, temple's technique, renormalization technique,

Unit 3

Variation of parameters, time-dependent solutions of the Schrodinger equation, nonlinear stability examples, the method of averaging, van der pol's technique, the Krylov-Bogoliubov technique, the generalized method of averaging, Struble's technique, the Krylov-Bogoliubov-Mitropolski technique, the Dufiing equation, the Klein-Gordon equation, the method of averaging by using canonical variables.

Unit 4

The method of Multiple scales, many- variable version (the derivative-expansion procedure), the two-variable expansion procedure, generalized method-nonlinear scales, applications of the derivative-expansion method, the Duffing equation, the van-der pol oscillator, forced oscillations of the van-der pol equation, parametric resonances-the Mathieu equation, the van der pol oscillator with delayed amplitude limiting, the stability of the triangular points in the elliptic restricted problem of three bodies, swinging spring, model for weak nonlinear instability, a model for wave-wave interaction, limitations of the derivative-expansion method,

References:

1. J. Kevorkian & J.D. Cole, Perturbation Methods in Applied Mathematics, Springer-Verlag, 1981.
2. E.J. Hinch, Perturbation Methods, Cambridge University Press, 1991.
3. C.M. Bender & S.A. Orszag, Advanced Mathematical Methods for Scientists and Engineers, Springer, 1999.
4. A. H. Nayfeh, Perturbations Methods, John Wiley & Sons, 2000.

MAM-406 : Algebraic Coding Theory (Elective IV) **Credits : 4**

Unit 1

The Communication Channel**,** The coding problem, Types of codes, Error – Detecting and Error – Correcting Codes, Linear Codes, The Hemming Metric, Description of Linear Block Codes by Matrices.

Unit 2

Dual Codes, Standard Array Syndrome, Step by Step Decoding Modular Representation, Error – Correction Capabilities of linear codes, Bounds of Minimum Distance for Block Codes, Plotkin Bound, Hamming sphere packing Bound, Bounds for Burst – Error Detecting and Correcting Codes.

Unit 3

Important linear Block – Codes, Hamming Codes, Golay Codes, Perfect Codes Quasi – perfect Codes, Reed – Muller Codes, Codes derived by Hadamard Matrices, Product Codes, Concatenated Codes.

Unit 4

A double-error correcting decimal Code and an introduction to BCH Codes, BCH bounds, Cyclic Codes, Matrix representation of Cyclic Codes.

Hamming and Golay Codes as Cyclic Codes, Error detection with Cyclic codes, MDS Codes.

References:

1. J H Van Lint, Introduction to Coding Theory, Springer Verlag, Heidelberg.

2. V. Pless, Introduction to the theory of Error – Correcting Codes, 3rd Edition, Wiley Interscience, New York, 1998.
3. V. Pless and W C Huffman, Fundamentals of Error – Correcting Codes, Cambridge University Press, 2003.
4. Raymond Hill, A first course in Coding Theory, Oxford University Press, 1986.
5. Man Young Rhee, Error Correcting Coding Theory, McGraw Hill Inc., 1989.

MAM-406 : Financial Mathematics (Elective IV) Credits : 4

Unit 1

Time value of money and applications: Discrete compounding and increased frequency. Continuous compounding and discounting, Annuities and perpetuities - applications to mortgages and pensions, Nominal and effective rates, Market interest rate adjustments, Capital budgeting and Net Present Value (NPV).

Unit 2

Asset Classes: Equities exchanges, dividends, stock-splits, short selling, Currencies FX markets, currency pairs, Commodities different types, seasonality effects, Indices, Derivatives: Futures and forwards; options, No arbitrage, Payoff diagrams; P&L diagrams, Option strategies, Life-cycle of an option,Put Call parity, Speculation, hedging, gearing.

Unit 3

The greeks and their role in risk management, Plain vanilla types, Exotic Options: Over-the-counter (OTC), Early exercise embedded decisions, Americans and Bermudans, Classification features of exotics.

Unit 4

Sampling types discrete and continuous, Asian options arithmetic and geometric averaging; running averages, Look backs, Fixed and floating strike rate exotics, Fixed-Income Markets and Analysis: Fixed income markets and products zero-coupon bonds, swaps and their relationship; coupon bearing bonds.

References:

1. R. L. Burden, J. D. Faires, and A. C. Reynolds, Numerical analysis. Brooks/cole Pacific Grove, CA, 2001.
2. P. Glasserman, Monte Carlo methods in financial engineering. 2003.
3. K. Back, Asset pricing and portfolio choice theory. Oxford University Press, 2010.
4. H. Follmer and A. Schied, Stochastic finance: an introduction in discrete time. Walter de Gruyter, 2011.
5. A. J. McNeil, R. Frey, and P. Embrechts, Quantitative risk management: Concepts, techniques and tools. Princeton university press, 2015.
6. J. Hull, Options, Futures, and Other Derivatives, 9th ed. 2017.

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