NEHRU GRAM BHARATI

(DEEMED TO BE UNIVERSITY)

KOTWA- JAMUNIPUR- DUBAWAL
Prayagraj (UTTAR PRADESH)

SYLLABUS

For the

M.Sc. [Mathematics]

(Choice Based Credit System)

[W.e. f. 2019-2020]

N.G.B. (D.U.)
M.Sc. Mathematics (Syllabus)
Preamble:

Application of mathematics is increasing day by day in many spheres of life. Its utility has obtained significance in various fields of research and knowledge. Therefore there is a need to prepare the syllabus of mathematics according to the changed needs . It has become necessary to follow the interdisplinary approach. We have adopted CBCS (choice based credit system) pattern of syllabus. In this connection we have made sincere efforts to prepare the post graduation syllabus on CBCS mode . The syllabus will certainly meet the current needs of the PG students. There is wide class of problems typically coming from experimental sciences such as chemistry, environmental sciences, earth sciences, medical sciences etc. where one has to deal with large amounts of loosely structured data. To make breakthrough in tackling them one needs radical , theoretical ideas , as well as new ways of doing mathematics with computers and a more closer collaboration with experimental scientists in order to match mathematical theories with available experimental data. Both the theoretical and industrial inputs of these developments are enormous and clearly visible to day.These make the goal clear. Today, student needs thorough knowledge of fundamental principles , methods, results, a clear perception of the enormous power of mathematical ideas and tools to use them in all the three phases viz., modeling, solving and interpreting.

(Effective from 2019-20)
Semester-I

Type of paper	Paper Code	C /E /OE	Name of Paper	No. of Lectures	Credits	Ext. Exam	Int. Assessment	Total Marks
	Core Papers							
Core Paper	**MAT-101**	**C**	**Abstract Algebra**	**54**	**3**	**45**	**30**	**75**
	MAT-102	**C**	**Complex Analysis**	**54**	**3**	**45**	**30**	**75**
	MAT-103	**C**	**Ordinary Differential Equations**	**54**	**3**	**45**	**30**	**75**

	Elective Papers							
Optional Paper	**MAT-104/MAT-105/MAT-106**	**E**	(elective paper is to be opted out of the list of optional papers)	**54**	**3**	**45**	**30**	**75**
	Open Elective Papers							
Skill Development	**MAT-107**	**OE**	**Discrete Mathematics**	**36**	**2**	**30**	**20**	**50**
Interdisciplinary	**MAT-108**	**OE**	**Mathematical Statistics**	**54**	**3**	**45**	**30**	**75**
	MAT-109		**Viva-voce**		**3**	**45**	**30**	**75**

Semester-II

Type of paper	**Paper Code**	**C/E/OE**	**Name of Paper**	**No. of Lectures**	**Credits**	**Ext. Exam**	**Int. Assessment**	**Total Marks**
	Core Papers							
Core Paper	**MAT-201**	**C**	**Differential Geometry**	**54**	**3**	**45**	**30**	**75**
	MAT-202	**C**	**Partial Differential Equations**	**54**	**3**	**45**	**30**	**75**
	MAT-203	**C**	**Topology**	**54**	**3**	**45**	**30**	**75**
	Elective Papers							
Optional Paper	**MAT-204/M**	**E**	(elective paper is	**54**	**3**	**45**	**30**	**75**

	AT-205/MAT-206		to be opted out of the list of optional papers)					
	Open Elective Papers							
Skill Development	**MAT-207**	**OE**	**Difference Equations**	**36**	**2**	**30**	**20**	**50**
Interdisciplinary	**MAT-208**	**OE**	**Application of Mathematics in Finance**	**54**	**3**	**45**	**30**	**75**
	MAT-209		**Viva-Voce**		**3**	**45**	**30**	**75**

Semester-III

Type of paper	**Paper Code**	**C/E/OE**	**Name of Paper**	**No. of Lectures**	**Credits**	**Ext. Exam**	**Int. Assessment**	**Total Marks**
	Core Papers							
Core Paper	**MAT-301**	**C**	**Functional Analysis**	**54**	**3**	**45**	**30**	**75**
	MAT-302	**C**	**Riemannian Geometry**	**54**	**3**	**45**	**30**	**75**
	MAT-303	**C**	**Measure and Integration**	**54**	**3**	**45**	**30**	**75**
	Elective Papers							
Optional Paper	**MAT-304/MAT-**	**E**	(elective paper is to be	**54**	**3**	**45**	**30**	**75**

	305/MAT306		opted out of the list of optional papers)					
	Open Elective Papers							
Skill development	**MAT-307**	**OE**	**Sampling Theory**	**36**	**2**	**30**	**20**	**50**
Interdisciplinary	**MAT-308**	**OE**	**Bio-Mathematics**	**54**	**3**	**45**	**30**	**75**
	MAT-309		**Viva-Voce**		**3**	**45**	**30**	**75**

Semester-IV

Type of paper	**Paper Code**	**C/E/OE**	**Name of Paper**	**No. of Lectures**	**Credits**	**Ext. Exam**	**Int. Assessment**	**Total Marks**
	Core Papers							
Core Paper	**MAT-401**	**C**	**Number Theory**	**54**	**3**	**45**	**30**	**75**
	MAT-402	**C**	**Differential Manifolds**	**54**	**3**	**45**	**30**	**75**
	MAT-403	**C**	**Calculus of variations and Integral Equations**	**54**	**3**	**45**	**30**	**75**
	Elective Papers							
Optional Paper	**MAT-404/MAT-405/MAT-406**	**E**	(elective paper is to be opted out of the **list** of optional papers)	**54**	**3**	**45**	**30**	**75**
	Open Elective Papers							
Skill Development	**MAT-407**	**OE**	**Mathematical Modeling**	**36**	**2**	**30**	**20**	**50**

Interdisciplinary	**MAT-408**	**OE**	**Application of Mathematics in Insurance**	**54**	**3**	**45**	**30**	**75**
	MAT-409		**Viva-Voce /Dissertation/ Project Work**		**3**	**45**	**30**	**75**

Syllabus
Semester-I
MAT-101: Abstract Algebra

Unit-I: Isomorphism theorems for groups, Symmetric groups, Alternating groups, Dihedral groups, Matrix groups, Internal and External direct product and their relationship.

Unit-II: Subnormal and normal series, Zassenhaus' lemma (statement only), Schreier's refinement theorem, Composition series, Jordan-Hölder's theorem, Chain conditions.

Unit-III: Action of a group G on a set, Stabilizer subgroups and orbit decomposition, Class equation of an action, Transitive and effective actions, Equivalence of actions.

Unit-IV: Sylow subgroups, Sylow's Theorem I, II and III, p-groups, Examples and applications, Groups of order p q, commutator subgroup and commutator series of a group, Solvable groups, Solvability of subgroups and factor groups and of finite p-groups, Examples.

Unit-V: Factorization theory in commutative domains, Prime and irreducible elements, G.C.D., Euclidean domains, Maximal and prime ideals, Principal ideal domains, Divisor chain condition, Unique factorization domains, Examples and counter examples, Chinese remainder theorem for rings and PID's, Polynomial rings over domains.

Recommended Books:

1. D. S. Dummit and R.M. Foote, Abstract Algebra, John Wiley, N.Y., 2003.
2. N. S. Gopalakrishnan, University Algebra, Wiley Eastern, New Delhi, 1986.
3. J. A. Gallian, Contemporary Abstract Algebra, 4th Edition, Narosa Publ. House, 1998.
4. J. B. Fraleigh, A first Course in Abstract Algebra, Pearson Edu. Inc., 2002.

5. Ramji Lal, Algebra, Vol. I & II, Shail Publications, Allahabad, 2002.

MAT -102: Complex Analysis

Unit-I: Review of algebra and geometry of C. Stereographic correspondence, complex differentiable functions, analytic functions, Cauchy-Riemann equations, necessary and Sufficient conditions for analyticity, power series and its radius of convergence, analytic function represented by power series, complex exponential, trigonometric and hyperbolic functions, conjugate functions, construction of analytic functions.

Unit-II: Complex line Integral over a piecewise smooth paths and its elementary properties, length of a curve, necessary and sufficient condition for independent of the line integral, Cauchy-Goursat theorem (statement only), Cauchy integral formula for derivatives.

Unit III: Morera's theorem, Cauchy's estimate, Liouville's theorem, zeros of an analytic function, Cauchy's theorem for simply connected domains, Taylor series, isolated singularities (removable singularities, poles. and isolated essential singularities), Laurent series expansion theorem.

Unit IV: Open mapping theorem (Statement only), Maximum modulus theorem, Residue and singularity, residue at infinity, Cauchy theorem for residue, meromorphic function, argument principle, Rouche'stheorem, Evaluation of Contour integrals.

Unit V: Schwarz lemma, Mobius transformations, fixed points of a Mobius transformation, cross ratio and its invariance under Mobius transformation.

Recommended Books:

1. L.V. Ahlfors, Complex Analysis, Mc-Graw Hill, international Ed.

2. J. B. Conway, Functions of Complex variable, Narosa publication, 1973.

3. S. Ponnusamy, Fundation of Complex analysis, Narosa publication 1995.

4. A. R. Shastri, An introduction to Complex analysis Macmillan Pubhation.

MAT -103: Ordinary Differential Equations

Unit-I: Picard 's method of Successive Approximations, Lipschitz' conditions, Existence and Uniqueness Theorems of Picard, p-discriminants and c-discriminants, Singular solutions.

Unit-II: Linear differential equations of arbitrary order, Wronskians, Abel Formula, Linearly independent solutions.

Unit-III: Power series method for solution of general linear equations for higher order, Legendre equations, Orthogonality relations for Legendre polynomials, Rodrigues' formula, Recurrence relations, Bessel's equation, Bessel functions' of I and II kind, Recurrence Relations.

Unit-IV: Laplace transforms, Existence criteria, Properties. Transforms of standard functions, Transforms of derivatives and integrals.

Unit-V: Inverse Laplace transforms, Existence and uniqueness criteria, Exponential shift, Applications to initial value problems.

Recommended Books:

1. B Rai and D.P. Choudhury and H.l. Freedman, A Course in Ordinary Differential Equations, Narosa Publishing House, New Delhi, 2002.
2. E. A. Coddington, An Introduction to Ordinary Differential Equations. Prentice Hall India, New Delhi, 1968.
3. L. Elsgolts, Differential Equations and Calculus of Variations, Mir Publishers, 1970.
4. G. F. Simons, Differential Equations, Tata MacGraw Hill, New Delhi, 1972.
5. W. T. Reid, Ordinary Differential Equation, John Wiley & Sons, NY, 1971.

Elective
MAT -104: Fluid Dynamics

Unit-I: Kinematics-Lagrangian and Eulerian methods, Equation of continuity, Boundary surface, Stream lines, Path lines, Velocity potential, Irrotational and rotational motion, Vortex lines.

Unit-II: Lagrange's and Euler's equation of motion, Bernoulli's theorem, Equation of motion by flux method, Impulsive action, Equation referred to moving axes.

Unit-III: Motion in two dimension, Complex velocity potential, Source, sinks, doublets and their images, Milne-Thomson circle theorem, Two-dimensional motion produced by motion of circular, co-axial and elliptic cylinder in an infinite mass of liquid. Kinetic energy of liquid.

Unit-IV: BlasiusTheorem,Motion of a sphere through a liquid rest at infinity, Liquid streaming past a fixed sphere, Equation of motion of sphere, Vortex motion and its elementary properties, Motion due to circular and rectilinear vortices, Wave motion of a gas.

Unit-V: Speed of sound, Equation of motion of gas, Subsonic, sonic and supersonic flows of a gas, Stress component in a real fluid, Relation between rectangular components of stress, Connection between stresses and gradient velocity, Navier-Stoke's equation of motion.

Recommended Books:

1. W. H. Besant and A.S. Ramsey, A Treatise on Hydromechanics, Part-II, CBS Publishers, Delhi, 1988.
2. F. Chorlton, Text-book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985.
3. Michael E. O. Neill and F. Chorlton, Ideal and Incompressible Fluid Dynamics, John Wiley & Sons,1986.
4. S. W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Ltd., New Delhi, 1976.event.
5. L. D. Landau and E. M. Lipschitz, Fluid Mechanics, Pergamon Press, London, 1985.

MAT -105: Probability Theory

Unit-I: Random Experiment and Probability Measure Random experiments, sample space, events, algebra of events, axiomatic definition of probability, probability spaces, relationship of axiomatic and classical probability, role of frequency ratios, probability of union of events, conditional probability and associated probability space, Bayes theorem, independence of events.

Unit-II: Random Variable and Random Vector Random variables as functions, induced probability measure via inverse mapping, induced probability distribution, distribution functions, distribution functions and their properties, probability mass function (pmf) of discrete random variables, probability density function (pdf) of continuous random variables.

Unit-III: Mathematical Expectation and Functions of Random Variables, moments, factorial moments, moment generating function, probability generating function, Expectation of jointly distributed random variables.

Unit-IV: Statistical Distributions: Bernoulli distribution, binomial distribution, Poisson distribution, derivation of Poisson distribution as a limiting case of binomial distribution, negative binomial distribution.

Unit-V: Normal distribution and its relationship with the binomial and Poisson distribution, Cauchy distribution, bivariate normal distribution and its marginal and conditional distributions.

Book recommended:

1. Beumont, G. P., Probability and random variables.
2. Meyer, Paul L., Introductory probability and statistical applications, Addision Wesley.
3. Mukhopadhyay P., Theory of Probability, New Central Book Agency, Calcutta.
4. Parzen, E., Probability theory and its applications, Wiley Eastern.

MAT -106: Classical Mechanics

Unit-I: System of Particles –Energy and Momentum methods. Use of Centroid, .Motion of a Rigid Body- Euler's Theorem, Angular momenturm and kinetic energy.

Unit-II: Euler's equation of motion of rigid body with one point fixed, Eulerian angles, motion of a symmetrical top.

Unit-III: Generalized coordinates, Velocities and momenta, Holonomic and nonholonomic systems, D' Alembert's Principle, Lagrange's equations of motion, Conservative forces.

Unit- IV: Lagrange's equations for impulsive forces, Theory of small Oscillations of conservative holonomic dynamical system, Hamilton's equations of motion.

Unit-V: Variational Principle and Principle of Least Action, Contact transformations, Poisson's Brackets, Hamilton Jacobi equation.

Recommended Books:

1. H. Goldstein, Classical Mechanics, Narosa Publishing House, 1980.
2. F. Chariton, Text book of Dynamics, 2nd edition, CBS Publishers, 1985.
3. R. H. Takwale & P.S. Puranik, Introduction to Classical Mechanics, Tata McGraw Hill Publishing Co., New Delhi.

Open Elective
MAT -107: Discrete Mathematics

Unit-I: Partially ordered sets and lattices, Lattice as an algebraic system, Sublattices, Isomorphism of lattices, Distributive and modular lattices. Lattices as intervals, Similar and projective intervals.

Unit-II: Fundamental dimensionality relation for modular lattices, Decomposition theory for lattices with ascending chain conditions, i.e. reducible and irreducible elements. Independent elements in lattices.

Unit-III: Boolean algebras, Conversion of a Boolean algebra into a Boolean ring with unity and vice-versa, Direct product of Boolean algebras, Uniqueness of finite Boolean algebras, Boolean functions and Boolean expressions.

Unit-IV: Graphs, Konisberg seven bridges problem, Finite and infinite graphs, Incidence vertex, Degree of a vertex.Isolated and pendant vertices, Null graphs.Isomosphism of graphs, Subgraphs, walks, Connected and disconnected graphs, Components of a graph, Euler graphs.

Unit-V: Hamiltonian and circuits, The traveling salesman problem, Trees and their properties, Pendant vertices in a tree. Rooted and binary tree, Spanning tree and fundamental circuits.

Recommended Books:

1. Narsingh Deo, Graph Theory with application to Engineering and Computer Science, Prentice Hall of India.

2. Nathan Jacobson Lectures in Abstract Algebra Vol. I, D.Van Nostrand Company, Inc.

3. L. R. Vermani and A course in discrete Mathematical structures(Imperial College Shalini Press London 2011)

Interdisciplinary Paper
MAT -108: Mathematical Statistics

Unit-I: Types of data: Concepts of a statistical population and sample from a population, qualitative and quantitative data; nominal and ordinal data; cross sectional and time series data; discrete and continuous data; frequency and non-frequency data.

Unit-II: Presentation of Data: Construction of tables with one or more factors of classification. Diagrammatic and graphical representation of grouped data.Frequency distributions, cumulative frequency distributions and their graphical representation.

Unit-III: Analysis of Quantitative Data: Univariate data-Concepts of central tendency or location, dispersion and relative dispersion, skewness and kurtosis, and their measures including those based on quantiles and moments. Sheppard's correction for grouped data (without derivation).

Unit-IV: Bivariate Data: Scatter diagram. Product moment correlation coefficient and its properties. Coefficient of determination. Concepts of error in regression, linear Regression and related results, Correlation ratio, Rank correlation-Spearman's and Kendall's measures. Intra class correlation.

Unit-V: Multivariate Data Multiple regression, multiple correlation and partial correlation in three variables.

Recommended Books:

1. V. K. Kapoor and S. C. Gupta, Fundamentals of Mathematical Statistics
2. Goon, Gupta and Das Gupta,Fundamentals of Statistics, Vol-I.

Semester-II
MAT -201: Differential Geometry

Unit-I: Curves in space R^3, parameterized curves, regular curves, helices, arc length, reparametrization (by arc length), tangent, principal normal, binormal, osculating plane, normal plane, rectifying plane, curvature and torsion of smooth curves, Frenet-Serret formulae, Frenet approximation of a space curve.

Unit-II: Osculating circle, osculating sphere, spherical indicatrices, involutes and evolutes, intrinsic equations of space curves, isometries of R^3, fundamental theorem of space curves, surfaces in R^3, regular surfaces, co-ordinate neighborhoods.

Unit-III: Normal fields and orientability of surfaces, angle between two intersecting curves on a surface, Gauss map and its properties, Weingarten map, second and third fundamental forms, classification of points on a surface.

Unit-IV: Curvature of curves on surfaces, normal curvature, Meusnier theorem, principal curvatures, geometric interpretation of principal curvatures, Euler theorem, mean curvature, lines of curvature, umbilical points, minimal surfaces, definition and examples, Gaussian curvature, intrinsic formulae for the Gaussian curvature.

Unit-V: Christoffel symbols, Gauss formulae, Weingarten formulae, Gauss equations, Codazzi-Mainardi equations, curvature tensor, geodesics, geodesics on a surface of evolution, geodesic curvature of a curve.

Books Recommended:

1. M. P. Do Carmo, Differential Geometry of Curves and Surfaces, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1976.
2. B. O' Neill, Elementary Differential Geometry, Academic Press, 1997.
3. A. Gray, Differential Geometry of Curves and Surfaces, CRC Press, 1998.
4. A. Pressley, Elementary Differential Geometry, Springer (Undergraduate Mathematics Series), 2001.

5. J. A. Thorpe, Elementary Topics in Differential Geometry, Springer (Undergraduate Texts in Mathematics), 1979.

6. D. Somasundaram, Differential Geometry, A First Course, Narosa Publishing

House, New Delhi, 2005.

7. L. P. Eisenhart, A Treatise on the Differential Geometry of Curves and Surfaces,Ginn and Company, Boston, 1909.

MAT -202: Partial Differential Equations

Unit-I: Formation of P.D.E's, first order P.D.E.'s, Classification of first order P.D.E.'s, Complete, general and singular integrals, Lagrange's or quasi-linear equations.

Unit-II: Integral surfaces through a given curve, Orthogonal surfaces to a given system of surfaces, Characteristic curves.

Unit-III: Pfaffian differential equations, Compatible systems, Charpit's method, Jacobi's Method.

Unit-IV: Linear equations with constant coefficients, Reduction to canonical forms, Classification of second order P.D.E.'s.

Unit-V: Method of separation of variables:- Laplace, Diffusion and Wave equations in Cartesian, cylindrical and spherical polar coordinates, Boundary value problems for transverse vibrations of strings and heat diffusion in a finite rod, Classification of linear integral equations, Relation between differential and integral equations.

Books recommended:

1. I. N. Sneddon: Elements of Partial Differential Equations, McGraw-Hill Pub., 1957.

2. T. Amaranath: An Elementary Course in Partial Differential Equations, Narosa Pub. 2005.

MAT-203: Topology

Unit-I: Definition and examples of topological spaces (including metric spaces). Open and closed sets, Subspaces and relative topology. Closure and interior, Accumulation points and derived sets, Dense sets Neighborhoods, Boundary, Bases and sub-bases. Homeomorphism, First and second countability and separable space, Lindelof space.

Unit-II: The separation axioms T_0, T_1, T_2 T_3, $T_{3(1/2)}$ and T_4, their characterizations and basic properties, Urysohn's lemma, and Tietze extension theorem.

Unit-III: Compactness, Basic properties of compactness the finite intersection property; local compactness, One-point compactification.
Unit-IV: Connected spaces and their basic properties, Connectedness of the real line, Components, Locally connected spaces.

Unit-V: Product topology in terms of the standard sub-base and its characterizations, Product topology and separation axioms, connectedness. countability properties and compactness.

Books Recommended:

1. J. L. Kelley, General Topology, Van Nostr and, 1995.

2. K. D Joshi, Introduction to General Topology, Wiley Eastern 1983.

3. James. R. Munkres, Topology 21. Editich, Pearson International, 2000.

4. J Dugundji, Topology, Prentice-Hail of India,1966.

5. George F. Simmons, Introduction to Topology and Modern Analysis McGraw-Hill, 1963.

6. S. Willard, General Topology, Mdison-wesley, 1970.

Elective
MAT-204: Ring Theory

Unit-I: Ring, Homomorphisms of rings, Ideals, factor rings, Endomorphism of rings, idempotent and Nilpotent elements, Matrix rings, Modules and their Lattice, change of rings, Bimodules, Annihilators, Module homomorphisms, factor theorem, Exact sequences, Five lemma, Faithful and balanced module.

Unit-II: Direct summands, split exact sequences, Large and Small submodules, Direct products, Internal and external Direct sums. Decomposition of rings, idempotent. Semi simple modules, and Jacobson radical Generation and cogeneration, Trace and Reject, Finite generation and cogeneration.

Unit-III: Chain conditions, Composition series, Jordan- Holder theorem, fitting's lemma Indecomposable decomposition of modules, Azumaya decomposition and Krui Schmidt Theorem.

Unit-IV: Simple Artinian rings, Wedderburn's theorem, Wedderburn-Artin theorem, Jacobson density theorem, Primitive Jacobson radical of rings, Nakayana lemma, Simiprimitive rings, Local Hopkin's theorem, Levitzki's theorem.

Unit-V: Projective and Injective modules, Homfunctor, Exact Functors, Dual basis lemma, projective covers, Injective Test lemma (Bear's criterion), injective

Envelopes, Direct sum of injectives, Injective cogenerators. Tensor products and functors, flat modules.

Books Recommended:

1. F. W. Anderson and K. R. Fuller, Rings and Categories of Modules, Springer, GTM No.13, 1974.
2. N. Jacobson, Basic Algebra ll. Hindustan Publishing Corporation, New Delhi, 1984.
3. T. Y. Lam, Lectures on modules and Rings, Springer GTM, 189, 199.
4. L. H. Rowen, Ring Theory, Academic Press, 1991.

MAT -205: Operations Research

Unit-I: Linear programming, convex sets, hyperplanes and half spaces, vertices of convex set, polyhedron and polytopes, separating and supporting hyperplanes, basic definition and theorem for a general linear programming problems using convex set theory, a simple LPP model and its graphical solution, standard form of general LPP, basic feasible solution, simplex Method and algorithm.

Unit-II: Transportation problem, mathematical formulation of a transportation problem, balanced and unbalanced transportation problem, initial basic feasible solution of a transportation problem using North-West corner rule, least cost method and vogel's approximation method (VAM), optimum solution of transportation problem using u-v method.

Unit-III: Assignment problem, mathematical formulation, Hungarian method for solving assignment problems, sales man routing problems.

Unit-IV: Sequencing problem, problem with n-jobs and 2-machines, problems with n-jobs more than 2-machines (Johnson's method).

Unit-V: Network analysis, construction of network, time calculation in network by CPM and PERT method, critical activity and slack time.

Books recommended:

1. Mokhtar S. Bazarra, John J. Jarvis and Hanif D. Shirali, Linear Programming and Network Flows, John Wiley & Sons, 1990.
2. Kanti Swaroop and P. K. Gupta and Man Mohan, Operation Research, Sultan Chand & Sons, New Delhi,1998.
3. S. I. Gass, Linear Programming Methods and Application (4^{th} edition) McGraw-Hill, New York, 1975.

4. G. Hadley, Linear Programming, Narosa Publishing House, 1995.

MAT -206: Fields and Galois Theory

Unit-I: Eisenstein's irreducibility criterion, Characteristic of a field, Prime subfields, Field extensions, Finite extensions, Simple extensions, Algebraic and transcendental extensions. Factorization of polynomials in extension fields.

Unit II: Splitting fields and their uniqueness. Separable field extensions, Perfect fields, Separability over fields of prime characteristic, Transitivity of separability.

Unit III: Automorphisms of fields, Dedekind's theorem, Fixed fields, Normal extensions, Splitting fields and normality, normal closures, Galois extensions, Fundamental theorem of Galois theory.

Unit-IV: Primitive element theorem, Finite fields, Existence and uniqueness, Subfields of finite fields, Characterization of cyclic Galois groups of finite extensions of finite fields, fundamental theorem of algebra.

Unit-V: Cyclotomic extensions and polynomials, Cyclic extensions, Solvability by radicals, Galois' characterization of such solvability, Generic polynomials, Abel-Ruffini theorem, geometrical constructions.

Books Recommended:

1. D. S. Dummit and R. M. Foote, Abstract Algebra, John Wiley & Sons, N.Y., 2003.

2. N. S. Gopalakrishnan, University Algebra, Wiley Eastern, New Delhi, 1986.

3. T. W. Hungerford, Algebra, Springer (India), Pvt. Ltd., 2004.

Open Elective
MAT -207: Difference Equations

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, Applications, Equations with variables coefficients, Non-linear equations that can be linearized, The Z-transform.

Unit-III: Stability theory-Initial value problems for linear systems, Stability of linear systems, Stability of non-linear systems, Chaotic Behavior

Unit-IV: The self adjoint second order linear equation, Sturmian theory Green functions, Disconjugacy, Riccati equations, Sturm-Liouvile problem, Finite Fourier Analysis.

Unit-V: Boundary Value problems for non-linear equations, The Lipschitz case, Existence of solutions, Discretization of Partial differential equations.

Books Recommended:

1.Walter G. Kelley and Allan C. Peterson, Difference Equations An Introduction with Applications, Academic Press Inc., Harcourt Brace Joranovich Publishers, 1991.

2.Calvin Ahlbrandt and Allan C. Peterson, Discrete Hamiltonian Systems, Difference Equations, Continued Fractions and Riccati Equations, Kluwer, Boston, 1996.

Interdisciplinary Paper

MAT -208: Application of Mathematics in Finance

Unit-I: Financial Derivative-An Introduction, Types of Financial Derivative-Forwards and Futures, Option and its kinds, and SWAPS, The Arbitrage Theorem and Introduction to Portfolio Selection and Capital Market Theory, Static and Continuous, Time Model.

Unit-II: Pricing by Arbitrage-A single-Period option Pricing Model, Multi-Period Pricing Model, Bounds on Option Prices, The Ito's Lemma and the Ito's Integral.

Unit-III: The Dynamics of Derivative Prices-Stochastic Differential Equations (EDEs)-Major Models of SDEs, Linear Constant Coefficient SDEs, Geometric SDEs, Square Root Process.

Unit-IV: Mean Reverting Process and Omstein-Uhlenbeck Process, Martingale Measure and Risk-Neutral Probabilities, Pricing of Binomial Options with equivalent martingale measure.

Unit-V: The Black-Scholes Option Pricing Model-using no arbitrage approach, Limiting case of Binomial Option Pricing and Risk-Neutral Probabilities.

Books Recommended:

1. Aswath Damodaran, Corporate Finance-Theory and Practice, John Wiley & sons, Inc.

2. John C. Hull, Options, Futures and other Derivatives, Prentice-Hall of India Private limited.

3. Sheldon M. Ross. An Introduction to Mathematical Finance, Cambridge Press.

Semester-III
MAT -301: Functional Analysis

Unit-I: Normed linear spaces, Quotient spaces, Banach spaces and examples, Bounded linear transformations on normed linear spaces, B (X, Y) as a normed linear space.

Unit-II: Open mapping and closed graph theorems, Uniform boundedness principle, Hahn-Banach theorem and its applications, Dual space, Separabillty, Reflexivity, Weak and weak* convergence of operators, Compact operators and their basic properties.

Unit-III: Inner product spaces, Hilbert spaces. Orthogonal sets, Bessel's inequality, complete orthonormal sets and Parseval's identity, Structure of Hilbert spaces.

Unit-IV: Projection theorem, Riesz representation theorem Riesz-Fischer theorem, Adjoint of an operator on a Hilbert space, Reflexivity of Hilbert spaces.

Unit-V: Self-adjoint operators, Positive, projection, normal and unitary operators and their basic properties.

Books Recommended:

1. G. Bachman and L. Narici, Fuctional Analysis, Academic Press, 1966.
2. J. B. Conway, A First Course in Functional Analysis, Springer 2000.
3. R. E. Edwards, Functional Analysis, Holt Rinehart and Winston 1965.
4. C. Goffman and G. Pedrick First Course in Functional Analysis Prentice- Hall of India, 1987.
5. B.V. Lirnaye, Functional Analysis, New Age International, 1996.
6. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.

MAT -302: Riemannian Geometry

Unit-I: Riemannian metrics, Riemannian manifolds, examples, Levi-Civita connection, fundamental theorem of Riemannian geometry, Curvature tensors-Riemannian curvature tensor, sectional curvature, Schur's Theorem, Ricci curvature, scalar curvature.

Unit-II: Gradient vector fields, divergence of a vector field, Covariant derivative along a curve, parallel transport, length of a curve. Distance function, geodesics.

Unit-III: Jacobi fields, Gauss Lemma, complete Riemannian manifolds, Hopf-Rinow Theorem, The theorem of Hadamard, Riemannian immersions, second fundamental form, Gauss equation.

Unit-IV: Lie derivative, Lie derivatives of scalars, vectors, tensors and linear connections, commutation formula for Lie differential operator and covariant differential operator.

Unit-V: Motion, Affine motion, projective motion in a Riemannian space, curvature collineation, conformal and homothetic transformations.

Books Recommended:

1. M. P. do Carmo, Riemannian Geometry, Berkhauser, 1992.

2. P. Peterson; Riemannian Geometry, Springer, 2006.

3. J. Jost, Riemannian Geometry and Geometric Analysis, Springer, (6^{th} edition), 2011.

4. J. M. Lee, Riemannian Manifolds: An Introduction to Curvature, Springer, 1997.

5. S. Gallot, D. Hullin. J. Lafontaine, Riemannian Geometry, Springer,3^{rd} edition, 2004

6. K. Yano, The Theory of Lie derivatives and its Applications, North Holland Publishing Company, Amsterdom, 1957.

MAT -303: Measure and Integration

Unit-I: Countable and uncountable sets, cardinalty and cardinal arthimatic, Schroder-Bernstein theorem, the Cantor's ternary set and its properties.

Unit-II: Semi-algebras, algebras, monotone class, σ-algebras, measure and outer measure, Caratheodory extension process of extending a measure on a semi-algebra to generate σ-algebra, completion of a measure space.

Unit-III: Borel sets, Lebesague outer measure and Lebesgue measure on R, translation invariance of Lebesgue measure , existence of a non measurable set, characterization of Lebesgue measurable sets, the Cantor- Lebesgue function.

Unit- IV: Measurable functions on a measure space and their properties, Borel and Lebesgue measurable function, simple functions and their integrals, Littlewood's three principle(statement only) Lebesgue integral on R and its properties.

Unit-V: Bounded convergence theorem, Fatou's lemma, Lebesgue monotone convergence theorem, Lebesgue dominated convergence theorem, Minkowski;s and Holder;s inequalities.

Books Recommended:

1. H. L. Royden and P. M. Fitzpatrick, Real Analysis, (Fourth edition), Prentic Hall of India, 2010.

2. Inder K. Rana, An introduction Measure and integration,(Second edittion) Narosa, Publishing House, New Delhi, 2005.

3. G. de Barra, Measure Theory and integration, John Wiley & Sons, 1981.

4. J. L. Kelly. T. P. Srinivasan, Measure and Integration Springer, 1988.

5. K. R. Parthasarathy, Introduction to Probability and Measure TRIM 33 Hindustan Book Agency, New Delhi , 2005.

Elective

MAT -304: Theory of Relativity

Unit-I: The special theory of relativity: inertial frames of reference: postulates of the special theory of relativity; Lorentz transformations; length contraction, time dilation; variation of mass; composition of velocities; relativistic mechanics; world events, word regious and light cone; Minkowski space-time.

Unit-II: Energy-momentum tensors: the action principle; the electromagnetic theory; energy-momentum tensors (general); energy-momentum tensors (special cases); conservation laws.

Unit-III: General Theory of Relativity: introduction; principle of covariance; principle of equivalence; derivation of Einstein's equation; Newtonian approximation of Einstein's equations.

Unit-IV: Solution of Einstein's equation and tests of general relativity: Schwarzchildc solution; particle and photon orbits in S. chwarzschild space-time gravitational red shift; planetary motion; bending of light; radar echo delay.

Unit-V: Brans-Dicke theory: scalar tensor theory and higher derivative gravity; Kaluzaklein theory.

Books Recommended:

1. R. K. Pathria, The Theory of Relativity (second. edition), Hindustan Publishing Co. Delhi, 1994.

2. J.V. Narlikar, General Relativity & Cosmology (second edition) Macmillan Co of India Limited,. 1988.

3. S. K. Srivastava and K.P. Singha, Aspects of Gravitational Interactions, Nova Science Publishers Inc. Commack, New York, 1998.

4. W. Rindler, Essential Relativity, Springer-Verlag, 1977.

5. R. M. Wald, General Relativity, University of Chicago Press, 1984.

6. Ronald Adler, Maurice Bezin and ManamenSchiffer, Introduction to General Relativity, McGreaw-Hill Kogakusha Ltd.

7. Rosser W.G.V, Introduction to theory of relativity, ELBS (1972).

8. Rindler W., Relativity Special, General and Cosmology, Oxford University Press (2003).

MAT -305: Wavelet Analysis

Unit-I: The discrete Fourier transform and the inverse discrete Fourier transform, their basic properties and computations, The fast Fourier transform, The discrete cosine transform and the fast cosine transform.

Unit-II: Construction of wavelets on $\mathbf{Z}_N$, First stage and by iteration, The Haar system, Shannon wavelets, Daubechies D_6 wavelets on $\mathbf{Z}_N$, Description of $l^2(\mathbf{Z})$, $L^2[-\pi,\pi)$, $L^2(R)$, their orthonormal bases, Fourier transform and convolution on $l^2(\mathbf{Z})$, wavelets on ZHaar wavelets on Z.

Unit-III: Orthonormal bases generated by a single function in $L^2(R)$, Fouriertransform and inverse Fourier transform of a function f in $L^1(R)\cap L^2(R)$, Parseval'srelation, Plancherel's formula, Orthonormal wavelets in $L^2(R)$, Balian-Low theorem.

Unit-IV: Multi-resolution analysis and MRA wavelets, certain function in $L^2(R)$

For which $\{\psi_{j,k}\}$ does not form an orthonormal system, compactly supported wavelets, band-limited wavelets.

Unit-V: Franklin wavelets on R, Dimension function, Characterization of MRA Wavelets (Sketch of the proof), Minimally Supported Wavelets, Wavelet Sets, Characterization of two-interval wavelet sets, Shannon wavelet.

Book Recommended:

1. Michael W. Frazier, An Introduction to Wavelets through Linear Algebra, Springer-Verlag, 1999.

2. Eugenio Hernández and Guido Weiss, A First Course on Wavelets, CRC Press, 1996.

3. C. K. Chui, an Introduction to Wavelets, Academic Press, 1992.

4. Ingrid Daubechies, Ten Lectures on Wavelets, CBS-NFS Regional Conferences.

MAT -306: Algebraic Topology

Unit-I: Homotopy of paths, fundamental group of a topological space, fundamental groups, functor, homotopy of maps of topological spaces; homotopy equivalence; contractible and simply connected spaces.

Unit-II: Fundamental group of the circle, Calculation of fundamental groups of S^n ($n > 1$), $RP^{2,}$ torus and dunce cap, Brouwer's fixed- point theorem for the disc, fundamental theorem of algebra, vector fields.

Unit-III: Covering spaces, unique lifting theorem, path-lifting theorem, covering homotopy theorem, criterion of lifting of maps in terms of fundamental groups, universal covering space.

Unit-IV: Singular complex of a topological space, singular homology groups and their funcoriality, homotoy invariance of homology, Eilenberg-Steenrod axioms (without proof), abelianization of the fundamental group.

Unit-V: Calculations of homology of $S^{n,}$ Brouwer's fixed point theorem for f: $D^n \rightarrow D^n$ ($n > 2$) and its applications to spheres and vector fields, Meyer-Vietoris sequence and its Applications,

Books Recommended:

1. J. R. Munkres , Topology, Prentice-Hall of India, 2000.

2. M. J. Greenberg and J. R. Harper, Algebraic topology, a first course, Addison-Wesley Publishing co., 1997.

3. S. Deo, Algebraic Topology, A Primer, Hindustan Book Agency, 2006.

4. J. W. Vick, Homology Theory, An introduction to Algebraic Topology, Springer-Verlag, 1994.

Open Elective
MAT -307: Sampling Theory

Unit-I: Simple random sampling and Stratified sampling Sample surveys versus complete enumeration, Non sampling errors, Simple random sampling with and

without replacement, simple random sampling for attributes, Stratified random sampling, advantages of stratification, methods of allocation.

Unit-II: Use of auxiliary information, systematic and cluster sampling Use of auxiliary information: Ratio, regression and product method of estimation, Systematic sampling, Cluster sampling with equal clusters.

Unit-III: Quality Control Importance of statistical methods in industrial research and practice, specification of items and lot qualities corresponding to visual gauging, count and measurements, types of inspection, determination of tolerance limits.

Unit-IV: Vital Statistics Crude, death rates, infant mortality rates, standardized death rate, complete and abridge life table – construction and uses, mortality rate and probability of dying, use of survival tables.

Unit-V: Measurement of fertility - crude birth rate, general fertility rate, total fertility rate, gross reproduction rate, net reproduction rate, population growth and logistic model for population projection.

Books recommended:

1. Agrawal, S. N. India's population problem.
2. Cochran, W. G. (1977) Sampling Techniques, Third Edition, Wiley.
3. Goon, A.M., M.K. Gupta and B. Dasgupta (1996): Fundamentals of statistics, vol, II, World Press, Calcutta.
4. Montgomery, D. C. (2003): Introduction to the statistical quality control. John Wiley & Sons.
5. Mukhopadhyay, P. (1996): Inferential Problems in Survey Sampling. New Age International.
6. Mukhopadhyay, P. (1999): Applied Statistics. New Central Book Agency Pvt. Ltd., Calcutta.
7. Mukhopadhyay, Parimal (1998): Theory and Methods of Survey Sampling. Prentice Hall.

Interdisciplinary Paper
MAT -308: Bio-Mathematics

Unit-I: Dimensional Analysis in Mathematical Physiology, Budckingham's Theorem, mathematics of diffusion, Fick's Law of diffusion, Diffusion Through a Membrane, Convective Transport.

Unit-II: Population Biology: Malthusion Model, Logistic model, Equilibrum Analysis, Stability & Classification of equilibrium points, predator- Prey Models, Lotka- Volterra Model.

Unit-III: Biofluid mechanics: Basic Equations of Viscous Fluid motion, Poiseuille's Pulsatile Flow of Blood, Analysis of Arterial Flow Dynamics

Unit-IV: Blood flow in Veins: Elastic Instability, Steady Flow in CallapsibleTube,unsteady Flow in Veins: Heart Mechanics- Equations, Active Contraction to Heart Muscle, Fluid and solid Mechanics of Heart

Unit-V: Micro-circulation: Introduction, Pressure and velocity distribution in micro vessels, Velocity- Hematocrit Relation, Bolus Flow, Stokes flow, mechanics of flow at low Reynolds number, Blood flow in pulmonary blood vessels.

Book Recommended:

1. J. Mazumdar, An Introduction to Mathematical physiology & Biology, Cambridge University Press.

2. Y. C Fung, Biomechanics, Springer New York.

Semester-IV
MAT -401: Number Theory

Unit-I: Primes, Fundamental Theorem of Arithmetic, Euclid's theorem, Fermat and Mersenne Primes, Infinitude of Primes of certain types. Congruence's, Euler's phi function, Euler-Fermat theorem, Fermat's little theorem, Wilson's theorem.

Unit-II: Linear congruence equations, Chinese Remainder theorem, multiplicatively and expression for (n), Congruence eqution of higher degree, Prime power congruence's, Power residues.

Unit-III: Quadratic Residues, Legendre symbols, Gauss' lemma, Quadratic Reciprocity law and applications, Jacobi symbol, Tests of Primality, Factors of Mersenne numbers.

Unit-IV: Multiplicative functions τ and μ their multiplicatively, Moebius inversion formula and its converse, Group structure under convolution product and relations between various standar functions, Diophantine equations, Sums of squares.

Unit-V: Simple continued fractions, Infinite continued fractions and irrational numbers, Periodicity, Pell's equation. Distribution of primes, Function $\pi(x)$, Tschebyschef's theorem, Euler's identity, Euler's formula for (n), Jacobi's formula.

Books Recommended:

1. Niven and T. Zuckerman, An Introduction to the Theory of Numbers, Wiley Eastern.

2. G. H. Hardy and E. M. Wright, Theory of Numbers, Oxford University Press & E.L.B.S.

3. D. E. Burton, Elementary Number Theory, Tata McGraw-Hill.

4. S. G. Telang, M. Nadkarni& J. Dani, Number Theory, Tata McGraw-Hill.

MAT -402: Differential Manifolds

Unit-I: n-dimensional real vector space, contravariant vectors, dual vector space, covariant vectors, tensor product, second order tensors, tensors of type (r, s), symmetry and skew symmetry of tensors, fundamental algebraic operations, quotient law of tensors.

Unit-II: Topological manifolds, compatible charts, smooth manifolds, examples, smooth maps and diffeomorphisms, definition of a Lie group, examples.

Unit-III: Tangent and cotangent spaces to a manifold, derivative of a smooth map, immersions and submersions, submanifolds , vector fields, algebra of vector fields, φ-related vector fields.

Unit-IV: Integral curves of smooth vector fields, complete vector fields, flow of a vector field, distributions, tensor fields on manifolds, r-forms, exterior product, exterior differentiation.

Unit-V: Affine connections (covariant differentiation) on a smooth manifold, torsion and curvature tensors of an affine connection, identities satisfied by curvature tensor.

Books Recommended:

1. Kobayashi and Nomizu; Foundations of Differential geometry, Vol-1, Interscience Publishers, 1963.

2. T. J. Willmore; Riemannian geometry, Oxford Science Publication, 1993.

3. S. Kumaresan; A course in Differential Geometry and Lie groups, Hindustan Book Agency, 2002.

4. M. Spivak; A comprehensive Introduction to Differential Geometry, Vols. 1-5, Publish or Perish, Inc., Houston, 1999.

5. W. M. Boothby; An Introduction to Differentiable Manifolds and Riemannian Geometry, Academic Press, revised, 2003.

6. U. C. De, A. A. Sheikh; Differential Geometry of Manifolds, Narosa Publishing House, 2007.

7. R. S. Mishra, A course in Tensors with Applications to Riemannian Geometry, Pothishala, Pvt. Ltd., Allahabad, 1965.Book Recommended:

MAT -403: Calculus of Variations and Integral Equations

Unit-I: Euler's equations, Functional dependence order derivatives, Functional dependence on functions of several independent variables. Variational problems with moving boundaries.

Unit-II: One sided variation, Variational problems with subsidiary conditions, isoperimetric problems, Rayleigh-Ritz method, Galerkin's method.

Unit-III: Classification of integral equations, Neumann's siterative method for Fredholm's equation of second kind,

Unit-IV: Volterra type integral equation, integral. Equation of first kind convolution type integral

Unit-V: Non-linear voltera equations. Hilbert Schmidt theory.

Book Recommended:

1. A. S. Gupta, Calculus of variations, Prentice Hall of India Put. Ltd. 2003.

2. I. M. Gelfand and S.V. Francis. Calculus of variations, Prentice Hall.New Jersey, 2000.

3. L. G. Chambers, Intergral equation, International Text book company Ltd. London, 1976.

4. F. G. Tricomi, Integral equation, Inter science New York 1957.

5. R. P. Kanwal, Linear Integral equation : Theory and Technique, Birkhauser 1997.

Elective
MAT -404: Finsler Geometry

Unit-I: Line elements, Finsler space, Minkowskian space, Tangent space, Indicatrix, Metric Tensor, Dual tangent space, Angle between two vectors, Generalized Christoffel symbols, Geodesics.

Unit-II: δ-derivative, Partial δ-derivative, Fundamental postulates of E. Cartan, Different deductions, Cartan's two processes of covariant differentiation, Berwald connection parameters, Berwald's covariant differentiation.

Unit-III: Commutation formulae resulting from Cartan's covariant differentiation, Cartan curvature tensor, Commutation formulae resulting from

Berwald's covariant differentiation, Berwald curvature tensor, Generalizations of Bianchi identities, Space of scalar curvature, Space of constant curvature, Generalization of Schur's theorem, Recurrent spaces.

UNIT IV: Projective change, Projective invariants, Projective change of Berwald's connection parameters, Projective deviation tensor, Generalized Weyl's projective curvature tensor, Projective connection parameters, Projectively flat spaces,

Unit-V: Infinitesimal transformations, Lie derivative of scalars, vectors and tensors, Lie derivative of connection parameters of Cartan and Berwald, Motion, Affine motion and Projective motion.

Books Recommended:

1. H. Rund, The Differential Geometry of Finsler Spaces, Springer-Verlag, Berlin, 1959.

2. M. Matsumoto, Foundations of Finsler Geometry and Special Finsler Spaces, Kaisheisha Press, Otsu, 1986.

4. P. L. Antonelli (ed.), Handbook of Finsler Geometry, Kluwer Academic Publishers, Dordrecht, the Netherlands, 2003.

MAT-405: Module Theory

Unit-I: Modules over a ring, Endomorphism ring of an abelian group, R-Module structure on an abelian group M as a ring homomorphism from R to End_Z (M), submodules, Direct summands, Annihilators, Homomorphism, Factor modules, Statements of Correspondence theorem and Isomorphism theorems, Hom_R (M, N) as an abelian group and Hom_R(M, M) as a ring, Exact sequences.

Unit-II: Free modules, Homomorphism extension property, equivalent characterization as a direct sum of copies of the underlying ring, existence of a basis of a vector space, Split exact sequences and their characterizations.

Unit-III: Projective modules, Injective modules, Baer's characterization, Divisible groups, Examples of injective modules.

Unit-IV: Submodules of finitely generated free modules over a PID, Torsion submodule, Torsion and torsion-free modules, Direct decomposition into T(M) and a free module, p-primary components, Decomposition of p-primary finitely generated torsion modules, Decomposition into invariant factors and uniqueness, Direct sum decomposition of finite abelian groups into cyclic groups and their enumeration.

Unit-V: Reduction of matrices over polynomial rings over a field, Similarity of matrices and F[x]-module structure, Rational canonical form of matrices, Elementary Jordan matrices, Reduction to Jordan canonical form, Diagonalizable and nilpotent parts of a linear operator.

Books Recommended:

1. D. S. Dummit and R. M. Foote, Abstract Algebra, John Wiley, N.Y., 2003.

2. F. W. Anderson and K. R. Fuller, Rings and Categories of Modules, Springer, N.Y., 1974.

3. I. A. Adamson, An Introduction to Field Theory. Oliver & Boyd, Edinburgh, 1964.

4. N. S. Gopalakrishnan, University Algebra, Wiley Eastern Ltd., New Delhi, 1986.

5. Ramji Lal, Algebra, Vols. II, Shail Publications, Allahabad, 2002.

MAT- 406: Magneto-hydrodynamics

Unit-1: Maxwell's electromagnetic field equations, equation of motion of conducting fluid, energy equation magneto fluid dynamics approximation.

Unit-II: Properties of MFD equations, MFD equation for special cases , magnetic Reynolds numbers, Boundary conditions Alfven's theorem, magnetic body force, Ferrar's law of isorotation**.**

Unit-III: One dimensional flows- Quasi one dimensional assumptions, Equation of continuity, Equations for average electric current density, electric and magnetic fields, Equations of motion and energy.

Unit-IV: Study flow of inviscid, Viscous and heat conducting fluids, Viscous flows- Hartmann flow, Hydromagnetic coquette flow, Hydromagnetic flow through an annulus.

Unit-V: MFD Pipe flow, MFD boundary Layer approximations, MFD flow past on infinite flat plate, MFD flow past a semi infinite flat plate, MFD Rayleigh problem.

Books Recommended:

1. K. R. Cramer and S. I. Pai, Magnetofluid Dynamics for Engineers and Physicists, Scripta Publishing Co., Washington D. C., 1973.

2. R. K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Pub. Co., New Delhi, 1976.

Open Elective
MAT -407: Mathematical modeling

Unit-I: Uncoupled and coupled linear Systems, Reduction of coupled linear system to uncoupled linear system, Exponentials of operators, Fundamental theorem for linear systems, Non-homogeneous linear systems.

Unit-II: Non-linear Autonomous system, Linearization, The phase plane & its phenomena, Critical points, Types of critical points, Phase plane analysis, Conservative systems.

Unit-III: Variational matrix, Stability analysis of linear and nonlinear systems using variational matrix, Liapunov Function, Stability by Liapunov's Direct Method.

Unit-IV: Mathematical model, Formulation of mathematical models, Classification of mathematical models, Malthusian growth model, Logistic growth model, Regrowth Model, Delayed differential models.

Unit-V: Lotka-Volterra predation model, Rosenzweig-MacArthur model, Lotka-Volterra competition model, Lotka-Volterra models of mutualism, obligate and non-obligate mutualism, effect of mutualism on predator-prey and competitive systems.

Books Recommended:

1. Lawrence Perko, Differential Equations and Dynamical Systems, Springer-Verlag, New York, Inc., 2001.
2. G. F. Simmons, Differential Equations with Applications and Historical Notes, Tata-McGraw Hill, 1991.
3. H. I. Freedman, Deterministic Mathematical Models in Population Ecology, Marcel Dekker, New York, 1980.

Interdisciplinary Paper
MAT -408: Application of Mathematics in Insurance

Unit-I: Concepts from Insurance-Introduction, The claim Number Process, The claim Size Process, Solvability of the Portfolio, Reinsurance and Ruin Problem.

Unit-II: Premium and ordering of Risks-Premium Calculation Principles and Ordering Distributions, Distribution of Aggregate claim Amount-Individual and Collective Model, Compound Distributions, Claim Number of Distributions.

Unit-III: Recursive Computation Methods, Lundberg Bounds and Approximation by compound Distribution.

Unit-IV: Risk Processes-Time Dependent Risk Models, Poisson Arrival Processes, Ruin Probabilities and Bounds Asymptotic and Approximation.

Unit-V: Time Dependent Risk Models-Ruin Problems and Computations of Rui Functions, Dual Queuing Model, Risk Model in Continuous Time and Numerical Evaluation of Ruin Functions.

Books Recommended:

1. Robert J. Elliott and P. Ekkehard Kopp, Mathematics of Financial Markets, Springer-Verlg, New York Inc.
2. Robert C. Merton, Continuous-Time Finance, Basil Blackwell Inc.
3. C. D. Daykin, T. Pentikainen and M. Pesonen, Practical Risk Theory for Actuaries, Chapman & Hall.