SYLLABUS
&
SCHEME OF EXAMINATION

M.A/M. Sc. IN MATHEMATICS

DEPARTMENT OF MATHEMATICAL SCIENCES
TEZPUR UNIVERSITY
2007

COURSE STRUCTURE

MA/MSc In MATHEMATICS

FIRST SEMESTER

Course No.	Name	L-T-P	CH	CR
MS 401	Abstract Algebra	3-1-0	4	4
MS 403	Linear Algebra	3-1-0	4	4
MS 405	Real Analysis	3-1-0	4	4
MS 409	Probability & Statistics	3-1-0	4	4
MS 411	Computer Programming^{+}	3-1-0	4	4
MS 421	Computer Laboratory	0-0-2	4	2

Total credit = 22

SECOND SEMESTER

Course No.	Name	L-T-P	CH	CR
MS 406	Complex Analysis	3-1-0	4	4
MS 408	Topology	3-1-0	4	4
MS 410	Functional Analysis	3-1-0	4	4
MS 414	Ordinary Differential Equations	3-1-0	4	4
MS 416	Numerical Analysis^{+}	2-1-0	3	3
MS 424	Computer Laboratory	0-0-1	2	1

Total credit = 20

THIRD SEMESTER

Course No.	Name	L-T-P	CH	CR
MS 501	Classical Mechanics	3-1-0	4	4
MS 507	Partial Differential Equations	3-1-0	4	4
MS 513	Project (to continue through 4th semester)		6	--
Elective-I		3-1-0	4	4
Elective-II		3-1-0	4	4

Total credits = 16

FOURTH SEMESTER

Course No.	Name	L-T-P	CH	CR
MS 503	Mathematical Programming	3-1-0	4	4
MS 508	Mathematical Methods	3-1-0	4	4
MS 513	Project (continued from 3rd semester)		6	6
Elective-III		3-1-0	4	4
Elective-IV		3-1-0	4	4

Total credits = 22

MS: Courses offered by the Department of Mathematical Sciences
+ *Course for which there is a separate practical unit assigned as Computer Laboratory*
L: Lectures T: Tutorials P: Practical CH: Contact Hours (all per week) CR: Credit

Electives to be offered from the following units:

Elective-I, Elective-II, Elective-III and Elective-IV are to be chosen from the following:

	L T P	**CR**	*Prerequisites*
MS 541 Fluid Mechanics	3 1 0	4	Nil
MS 542 Electrodynamics	3 1 0	4	Nil
MS 543 Relativity	3 1 0	4	Nil
MS 544 Operations Research	3 1 0	4	Nil
MS 545 Elliptic Curves	3 1 0	4	MS-401
MS 546 Algebraic Number Theory	3- 1 0	4	MS 401
MS 547 Numerical Linear Algebra	3-1-0	4	Nil
MS 548 Mathematical Logic	3-1-0	4	Nil
MS 549 Graph Theory	3-1-0	4	Nil
MS 552 Operator Theory-I	3 1 0	4	Nil
MS 553 Number Theory-I	3 1 0	4	Nil
MS 554 Advanced Algebra-I	3 1 0	4	Nil
MS 556 Quantum Mechanics-I	3 1 0	4	Nil
MS 557 Mathematical Modeling-I	3 1 0	4	Nil
MS 558 General Theory of Relativity	3- 1 0	4	MS-543
MS 559 Magneto Hydrodynamics & Plasma Physics-I	3 1 0	4	Nil
MS 560 Sampling Techniques-I	3 1 0	4	Nil
MS 561 Stochastic processes-I	3 1 0	4	Nil
MS 562 Statistical Quality Control	3 1 0	4	Nil
MS 563 Advanced Analysis-I	3 1 0	4	MS 405
MS 564 Multivariate Analysis-I	3 1 0	4	Nil
MS 565 Fuzzy Sets and Applications-I	3 1 0	4	Nil
MS 566 Fourier Analysis	3-1-0	4	MS-410
MS 567 Continuum Mechanics	3-1-0	4	Nil
MS 568 Theory of Distribution and Sobolev Spaces	3-1-0	4	MS-410
MS 572 Operator Theory –II	3- 1 0	4	MS-552
MS 573 Number Theory-II	3- 1 0	4	MS-553
MS 574 Advanced Algebra-II	3- 1 0	4	MS-554
MS 576 Quantum Mechanics –II	3- 1 0	4	MS-556
MS 577 Mathematical Modeling-II	3 1 0	4	MS-557
MS 578 High Energy Astrophysics	3- 1 0	4	MS-558
MS 579 Magneto Hydrodynamics & Plasma physics-II	3- 1 0	4	MS-559
MS 580 Sampling Techniques-II	3- 1 0	4	MS-560
MS 581 Stochastic processes –II	3- 1 0	4	MS-561
MS 582 Reliability Theory	3- 1 0	4	Nil
MS 583 Advanced Analysis-II	3 1 0	4	MS 563
MS 584 Multivariate Analysis-II	3- 1 0	4	MS-564
MS 585 Fuzzy Sets and Applications-II	3 1 0	4	MS-565
MS 586 Parallel Numerical Algorithms	3-1-0	4	Nil
MS 587 Finite Element Method	3-1-0	4	Nil
MS 588 Applied Matrix Theory	3-1-0	4	Nil
MS 591 Computational Fluid Dynamics	3-1-0	4	MS-541
MS 592 An Introduction to Fourier Theory	3 1 0	4	Nil

MS 593 Wavelets and Applications	3	1 0	4	Nil
MS 594 Advanced Topology-I	3	1 0	4	Nil
MS 595 Numerical Solutions of ODE	3-	1 0	4	Nil
MS 596 Advanced Topology-II	3	1 0	4	MS 594
MS 597 Numerical Solutions of PDE	3	1 0	4	MS-507
MS 598 Algebraic Geometry	3-1-0		4	Nil
MS 599 Probability Theory	3	1 0	4	MS 405

DETAILS OF SYLLABI

MS 401 ABSTRACT ALGEBRA (3 1 0 4 Nil)

Group, Permutation, Automorphisms of groups, Structure of cyclic groups, conjugate elements, Normalizer of an element, Direct products, Cauchy's theorem, Double cosets, Sylow's theorems, Finite abelian groups, Generator of subgroups and derived subgroups, Normal series, Solvable groups.
Ring, Field and homomorphisms, Embedding theorems, Polynomial rings, Division algorithm, Factorization theory in integral domains, Euclidean domains, Gaussian domain, Separable and inseparable extension of fields, Elements of Galois theory.

References:

1. I. N. Herstein, *Topics in Algebra*, Wiley Eastern Limited, New Delhi, 1975.
2. J. B. Fraleigh, *A First Course in Abstract Algebra*, Narosa, 1995.
3. S. Lang, *Algebra*, 3rd edition, Addison-Wesley, 1993.
4. N. S. Gopalakrishnan, *University Algebra*, Wiley Eastern, 1991.
5. J. A. Gallian, Contemporary Abstract Algebra, Narosa, 1995.
6. Dummit & Foote, Algebra, John Wiley & Sons, 2005.

MS 403 LINEAR ALGEBRA (3 1 0 4 Nil)

Vector Space: Vector Spaces; bases and dimension; direct sum; dual space; quotient space (Revision).
Linear transformations: The algebra of linear transforms; representation of linear transforms by matrices; linear functionals; the double dual.
Eigen values and eigen vectors; annihilating polynomials; triangulation and diagonalization; the Primary Decomposition theorem; rational and Jordan forms.

Inner product spaces: inner product; Gram-Schmidt orthogonalization process; linear functionals and adjoints; self adjoint, normal and unitary operators; orthogonal projections; spectral theorem for normal operators on a finite dimensional vector space.
Bilinear forms: bilinear, positive and quadratic forms.

References:

1. P. R. Halmos, *Finite dimensional vector spaces,*Springer Verlag, New York, 1987.
2. K. Hoffman and R. Kunze, *Linear Algebra*, Prentice Hall, 1984.
3. P. R. Halmos**,** *Linear Algebra Problem Book***,** The Mathematical Association of America (MAA), USA, 1995.
4. G. Williams**,** *Linear Algebra with Applications***,** Jones and Burlet Publishers, 2001.

MS 404 ANALYSIS – II (3 1 0 4 Nil)

Set Function, Ring, Construction of Lebesgue measure, Lebesgue outer measure, Measurable sets, Non-measurable sets.
Measurable functions, Borel measurability, Littlewood's principles, Simple functions, Approximation of every function as a simple function.

Step function, Lebesgue integral of bounded functions, Bounded convergence theorem, Monotone convergence theorem.
Integral of non-negative functions, Fatou's Lemma, Comparison with Riemann integral, Lebesgue general integral, Convergence in measure, integration of convex functions.
L^p Space, Holder and Minkowski's inequalities, Convergence and completeness, Bounded linear functionals on L^p Space.

References:

1. H. L. Royden, *Real Analysis*, 3rd Edition, Macmillan Publishing Company, New York, 1988.
2. P. K. Jain and V. P. Gupta, *Lebesgue Measure and Integration,* New Age International (P) Limited, New Delhi, 1986.
3. P. R. Halmos, *Measure Theory*; Springer-Verlag, 1974.
4. G. de barra, *Measure Theory and Integration*; Wiley-Eastern, 1981.

MS 405 REAL ANALYSIS (3 1 0 4 Nil)

Elements of set theory, finite, countable and uncountable sets, Axiom of choice, Real number system.
Metric spaces, convergence, continuity, compactness, connectedness, completeness, Heine-Borel theorem, Intermediate value theorem, Baire Category theorem.
Riemann-Stieltjes integrals, properties, mean value theorems, the fundamental theorem of calculus.
Sequences and series of functions, uniform convergence and its relation to continuity, differentiation and integration.
Functions of several variables, differentiation, implicit function theorem, inverse function theorem, maxima and minima.

References:

1. T. M. Apostol, *Mathematical Analysis*, Narosa Publishing House, 1985.
2. W. Rudin, *Principles of Mathematical Analysis*, McGraw Hill, 1982.
3. W. Flemming, *Functions of several variables* (3/e), Springer, 1987.
4. R. R. Goldberg, *Methods of real analysis,* Oxford & IBH, 1970.
5. G. F. Simmons, *Introduction to Topology and Modern Analysis*, Tata McGraw Hill Book Co. Ltd., 1963.

MS 406 COMPLEX ANALYSIS (3 1 0 4 Nil)

Analytic functions, Caucy-Riemann Equations, analyticity of elementary functions.
Complex integration, contour integrals, antiderivatives, Cauchy-Gaursat's theorem, Cauchy integral formula, Morera's theorem, Maximum moduli of functions, Liouville's theorem, the Fundamental Theorem of Algebra.
Convergence of sequences and series, Taylor series, Laurent series.
Classification of singularities, Residues, Cauchy Residue Theorem, evaluation of improper integrals and definite integrals involving sines and cosines, integration through a branch cut, Logarithmic residues and Rouches theorem, the Argument Principle.
Linear fractional transformations, cross ratios, mappings of the half planes and circles, conformal mapping.

Condition under which a function is identically zero, Schwarz Reflection Principle, Analytic continuation, Riemann Surfaces.

References:

1. R. V. Churchill and J. W. Brown**,** *Complex Variables and Applications*, 5th Edition, McGraw-Hill Publishing Company, 1990.
2. L. V. Ahlfors, *Complex Analysis,* Third Edition, McGraw-Hill Publishing Company, 1979.
3. J. B. Conway**,** *Functions of One Complex Variable*, 2nd Edition, Narosa Publishing House, India, 1994.

MS 407 ODE & PDE (3 1 0 4 Nil)

Existence and uniqueness theorems on ordinary differential equations, Continuation of solutions, Gronwall-Reid-Bellman inequality and its applications, Linear systems of ODEs, Superposition principle, Fundamental matrix and Fundamental system of solutions, Abel-Liouvelle formula, Properties of homogeneous and inhomogeneous linear systems, Asymptotic behavior of solutions of homogeneous and inhomogeneous systems.
Orthogonal trajectory of a system of curves on a surface solution of Pafaffian differential equations in three variables. Origin of first order partial differential equations. Solutions of linear equations of first order of the form Pp + Qq = R. Integral surfaces passing through a given curve, Surfaces orthogonal to a given system of surfaces, Cauchy's method of characteristics, Compatible systems of first order equations, Lagrange's, Charpit's and Jacobi's method. First order PDEs with constant coefficients, Reduction to canonical forms, Solutions of PDEs of second order by the method of separation of variables, by the use of Green's function, the method of integral transforms and use of these methods in Laplace equations, wave equation and diffusion equations.

References:

1. M. R. M. Rao, *Ordinary Differential Equations: Theory, Method and Applications*, Affiliated East-West Press Pvt. Ltd., New Delhi, 1979.
2. G. F. Simmons, *Differential Equations*, Tata McGraw Hill,1993.
3. E. A. Coddington, *An Introduction to Ordinary Differential Equations*, Prentice-Hall, 1974.
4. S. J. Farlow, *An Introduction to Differential Equations and Their Applications*, McGraw-Hill International Editions, 1994.
5. I. N. Sneddon, *Partial Differential Equations*, McGraw-Hill, 1957.
6. F. John, *Partial Differential Equations*, 3rd edition, Narosa, 1979.
7. R. Haberman, Elementary Applied Partial Differential equations, Prentice-Hall, New Jersey, 1987.

MS 408 TOPOLOGY (3 1 0 4 Nil)

Topological spaces, basis and sub-basis, subspaces, closure, interior and boundary.
Continuity, open functions, homeomorphisms, embeddings, strong and weak topologies.
Quotient and product spaces.
Countability axioms, separability, Lindelof spaces.
Separation axioms (T_0, T_1, T_2, T_3, T_4), regularity, complete regularity, normality.
Compactness, local compactness, Tychonoff's product theorem, compactification.
Connectedness, local and path connectedness, components, products of connected spaces.

References:

1. K. D. Joshi**,** *Topology*, Wiley-Eastern, 1988.
2. J. L. Kelley**,** *General Topology* (Graduate texts in Mathematics, Vol. 27), Springer, 1991.
3. J. R. Munkres**,** *Topology : A first course* (2/e), Prentice-Hall, 2000 or (1/e) Prentice Hall of India, 1983.

MS 409 PROBABILITY & STATISTICS (3 1 0 4 Nil)

Sample spaces, events and probabilities, discrete probability, conditional probability, Baye's theorem, random variables, Discrete probability distribution, Distributions-Binomial, Poisson, Hyper Geometric; Probability density function and distribution function, Uniform, Exponential, Normal, Student's t-distribution, F-distribution, Goodness of fit test.
Basic Statistics, Measure of central tendencies-Mean, Median and Mode; Measure of dispersion-Range, variance and standard deviation, Frequency distribution and cumulative frequency distribution; Moments and moment generating functions, linear correlation coefficient, Linear regression, Multiple correlation and multiple regression.
Theory of sampling, Population and sample, sample survey method and estimation

References:

1. A. M. Groom, M. K. Gupta and B. Dasgupta, *Fundamentals of Statistics*, Vol. I & II, The World Press Pvt. Ltd., Calcutta, 1994.
2. V. K. Rohatgi, *Introduction to Probability and Mathematical Statistics*, Wiley Eastern, New Delhi, 1976.

MS 410 FUNCTIONAL ANALYSIS (3 1 0 4 Nil)

Normed linear spaces; equivalent norms; bounded linear operators and functionals; Hanh Banach theorem; Banach spaces.
Uniform boundedness theorem; Open mapping theorem; Closed graph theorem.
Hilbert spaces; polarization identity and parallelogram law; orthogonality; Reisz representation theorem; orthonormal systems; Bessel's inequality; Parsevals identity.
Adjoint operators; normal and self adjoint operators; unitary operators; isometry; orthogonal projection; spectrum of an operator and it's non emptyness.

References:

1. Erwin Kreyszig, *Introductory functional analysis with applications,* John Wiley and Sons, New York, 1978.
2. George Bachman and Lawrence Narici, *Functional Analysis*, Academic Press, New York, 1966.
3. Walter Rudin, *Functional Analysis*, McGraw Hill, 2000.
4. Balmohan V. Limaye, *Functional Analysis*, Wiley Eastern Limited, New Delhi, 1989.
5. P. R. Halmos, *Linear Algebra Problem Book*, The Mathematical Association of America, USA, 1995.

MS 411 COMPUTER PROGRAMMING+ (3 1 0 4 Nil)

Computer fundamentals, major hardware and software components of a digital computer, concepts of machine language, assembly language and high level language. Number systems: binary, octal, hexadecimal; algebraic operations and convertions.

Algorithms and flow charts.
Fundamentals of C: introduction to C; comments in C; data types in C, variables in C, input output statements, constant declaration, arithmetic operators in C, arithmetic expressions, assignment statements, arithmetic assignment operators, increment and decrement operators, type conversions, Boolean expressions, operator precedence.
Loops and decisions: for loop, while loop, do…while loop, if statement, if…else statement, switch statement, conditional operators. The break statement, the continue statement, the goto statement.
Arrays and pointers: Arrays, declaration of one dimensional arrays, two dimensional arrays, pointers.
Structures: User defined data types, structures, array of structures, enumerated data type.
Function in C: Simple functions, passing arguments to functions with return value, call by value, call by reference, overloaded functions, inline functions, default arguments.
Object and classes: class, types of accesses, difference between structure and classes, accessing members of a class, constructors, destructors.
Searching and sorting: Bubble sort, selection sort, insertion sort, linear search and binary search.

References:

1. V. Rajaraman, *Fundamentals of computers*, PHI, 2002.
2. E. Balaguruswamy, *Programming in ANSI C*, Tata McGraw-Hill, 2004.
3. Y. P. Kanetkar, *Let us C*, BPB Publication, 2001.
4. M. G. Venkateshmurthy, *Programming Techniques through C*, Pearson Education, 2002.

MS 414 ORDINARY DIFFERENTIAL EQUATIONS (3 1 0 4 Nil)

Review of fundamentals of ODEs. Existence and uniqueness theorems on ordinary differential equations, Continuation of solutions, Power series solutions of ODE, Systems of Linear ODEs, Linear ordinary differential equations of higher order with constant coefficients. General theory of homogeneous and non-homogeneous linear ODE, variation of Parameters. Reduction of higher order linear ODEs to first order linear systems, Stability of linear systems, Sturm-Liouville problems. Stability and boundedness of linear and nonlinear Gronwall-Reid-Bellman inequality and its applications, Superposition principle, Fundamental matrix and Fundamental system of solutions, Abel-Liouvelle formula, Properties of homogeneous and inhomogeneous linear systems, Asymptotic behavior of solutions of homogeneous and inhomogeneous systems.
Orthogonal trajectory of a system of curves on a surface solution of pfaffian differential equations in three variables.

References:

1. M. R. M. Rao, *Ordinary Differential Equations: Theory, Method and Applications*, Affiliated East-West Press Pvt. Ltd., New Delhi, 1979.
2. G. F. Simmons, *Differential Equations*, Tata McGraw Hill,1993.
8. E. A. Coddington, *An Introduction to Ordinary Differential Equations*, Prentice-Hall, 1974.
9. S. J. Farlow, *An Introduction to Differential Equations and Their Applications*, McGraw-Hill International Editions, 1994.
10. Boyce & DiPrima, Ordinary Differential Equations and Boundary value problems, John Wiley & Sons, 2000.

MS 416 NUMERICAL ANALYSIS+ (2 1 0 3 Nil)

Definition and sources of errors, Propagation of errors, Backward error analysis, Sensitivity and conditioning, Stability and accuracy, Floating-point arithmetic and rounding errors. Interpolation, extrapolation and inverse interpolation, Hermite interpolation, Spline interpolation, B-splines. Solution of algebraic and transcendental equations, numerical solution of simultaneous equations, solution of ordinary differential equations, curve fitting, Integration formulae: Gauss, Gauss-Legendre, Gauss-Hermite and Gauss-Laguerre quadrature formulae; Newton's formula for repeated integration, solving problems with C.

References:

1. F. B. Hilderbrand, *Introduction to Numerical Analysis*, Tata McGraw Hill, New Delhi, 1974.
2. S. S. Sastry, *Introductory methods of Numerical Analysis*, Prentice Hall of India, New Delhi, 1977.
3. M. K. Jain, S. R. K. Iyengar, R. K. Jain, *Numerical methods, Problems and solutions*, New Age International (P) Ltd., 1996.
4. S. D. Conte and Carl de Boor, *Elementary Numerical Analysis - An Algorithmic Approach*, 3rd Edition, McGraw Hill, 1980.
5. K. E. Atkinson, *Introduction to Numerical Analysis*, 2nd Edition, John Wiley, 1989.
6. C. F. Gerald and P. O. Wheatley, *Applied Numerical Analysis, 5th edition*, Addison Wesley, 1994.

MS 421 COMPUTER LABORATORY (*Practical unit for the Course MS 411*)
(0 0 4 2 Nil)

MS 424 COMPUTER LABORATORY (*Practical unit for the Course MS 416*)
(0 0 2 1 Nil)

MS 501 CLASSICAL MECHANICS (3 1 0 4 Nil)

Momentum and kinetic energy, motion about a fixed point, Euler's equation, General equation of motion, motion of a heavy sphere in a cylinder and a cone, motion under no forces, Torque, Poinst's representation of motion.
Lagrange's equation of motion for holonomic systems, Velocity dependent potential, conservation theorem and symmetric properties, Lagrange's multiplier for holonomic and nonholonomic systems, Lagrange's equation for impulsive motion.
Hamilton's canonical equation of motion, Cyclic coordinate, The Routhian, Conservation of energy, Lagrange's method for small oscillation, Normal modes, Equations and examples, Integral invariants of poincare, Lagrange's and Poisson's brackets, Infinitesimal contact transformation.
Euler's equation of calculus of variations, Brachistochrone problem, extremes under constraints, Hamilton's principle for conservative and non-conservative system, Holonomic and non-holonomic system; Derivation of Lagrange's and Hamilton's equations from Hamilton's principle of least action, Hamilton Jacobi theory.

References:

1. J. D. Jackson, *Classical Electrodynamics*, John Wiley and Sons, NY, 1999.
2. H. Goldstein, Classical Mechanics, 2nd ed, Narosa, 2000.
3. N. C. Rana & P C Joag Classical Mechanics, Tata-McGraw Hill, 1991.

MS 503 MATHEMATICAL PROGRAMMING (3 1 0 4 Nil)

Introduction to Mathematical Programming Problems, Formulation techniques of LP problems, Graphical solution of two-variable problem. Standard form of linear programming problem, Fundamental theorem of Linear Programming.
Definition with examples: Hyper planes, convex set, convex combination, convex hull, convex polyhedron and simplex.
Simplex method for standard canonical form: Two-phase simplex method, degeneracy problem. Solution of simultaneous equations by simplex, inverse of a matrix by simplex method; Duality in linear programming, comparison of solutions of primal and its dual. Development of computer software for the solution of LPP using simplex.
Formulation of LP problem in revised simplex form. Computational procedure (algorithms). Advantage of revised simplex over simplex. Introduction to dual simplex method along with its limitations. Development of computer software for the solution of LPP using Dual Simplex algorothm.
Importance of Integer programming problems. Gomory's All IPP technique. How to construct Gomory's constraint. Computational method. Branch-and-Bound algorithm and computation procedure.
Game theory: Two-person zero-sum games, maximum criterion, dominance rules, mixed strategies, mini-max theorem, solutions of 2x2 and 2xm games.

References:

1. F. Chorlton, *Textbook of Fluid Mechanics*, C. B. S. Publishers, Delhi, 1985.
2. W. H. Besant and A. Ramsey, *A Treatise on Hydro-mechanics*, ELBS, 1990.
3. L. M. Milne-Thompson, *Theoretical Hydrodynamics*, Macmillan & Co., 1990.
4. G. K. Batchelor, *An Introduction to Fluid Dynamics*, Cambridge University Press, 1993.
5. Munson, Young, Okiishi, *Fundamentals of Fluid Mechanics*, John wiley & Sons, 2002.
6. S. W. Yuan, *Foundations of Fluid Mechanics*, PHI, 1976.

MS 507 PARTIAL DIFFERENTIAL EQUATIONS (3 1 0 4 Nil)

Origin of first order partial differential equations. Solutions of linear equations of first order of the form Pp + Qq = R. Integral surfaces passing through a given curve, Surfaces orthogonal to a given system of surfaces, Cauchy's method of characteristics, Compatible systems of first order equations, Lagrange's, Charpit's and Jacobi's method. First order PDEs with constant coefficients, Reduction to canonical forms, Solutions of PDEs of second order by the method of separation of variables, by the use of Green's function, Solutions of hyperbolic, parabolic and elliptic equations, Dirichlet and Neumann problems, the method of integral transforms and use of these methods in Laplace equations, wave equation and diffusion equations.

References:

11. I. N. Sneddon, *Partial Differential Equations*, McGraw-Hill, 1957.
12. F. John, *Partial Differential Equations*, 3rd edition, Narosa, 1979.
13. R. Haberman, Elementary Applied Partial Differential equations, Prentice-Hall, New Jersey, 1987.

14. W. E. Willams, *Partial Differential Equations*, Oxford, 1980.
15. W.A. Strauss, *Partial Differential Equations: An Introduction*, John Wiley, 1992.

MS 508 MATHEMATICAL METHODS (3 1 0 4 Nil)

Linear functionals, minimal functional theorem, general variation of a functional, Euler-Lagrange equation. Variational problems with fixed boundaries. Sufficient conditions for extremum.
Linear integral equations of the first and second kind of Fredholm and Volterra type, solution by successive substitutions and successive approximations, solution of equations with separable kernels. Fredholm alternative.
General solution of Bessel equation, Recurrence relations, Orthogonal sets of Bessel functions, Modified Bessel functions, Applications. General solution of Legendre equation, Legendre polynomials, Associated Legendre polynomials, Rodrigues formula, Orthogonality of Legendre polynomials, Application. Concept and calculation of Green's function, Approximate Green's function, Green's function method for differential equations, Fourier Series, Generalized Fourier series, Fourier Cosine series, Fourier Sine series, Fourier integrals. Fourier transform, Laplace transform. Solution of differential equation by Laplace and Fourier transform methods.

References:

1. G. N. Watson, *A Treatise on the Theory of Bessel Functions*, Cambridge University Press, 1944.
2. G. F. Roach, *Green's Functions, Cambridge University Press*, 1995.
3. A. D. Poularikas, *The Transforms and Applications – Handbook*, CRC Press, 1996.
4. J. W. Brown and R. Churchill, *Fourier Series and Boundary Value Problems*, McGraw Hill, 1993.

MS 513 PROJECT (6-credit)

Each student under the supervision of a faculty member would decide upon the topic and prepare a project. The Project is to be continued through the III and IV semester and the Project report is to be submitted in semester IV.

MS 541 FLUID MECHANICS (3 1 0 4 Nil)

Lagrarian and Eulerian methods, Velocity and acceleration, Particle path, Stream lines, Streak lines velocity potential, Steady and unsteady flows, Conservation of mass and momentum, Total energy, Circulation, Boundary surface, Impulsive motion. Irrotational motion, Potential flow, Green's theorem, application of Green's theorem in fluid mechanics, Kinetic energy of liquid, Uniqueness theorem. Vorticity vector, Conservation of mass, Equation of continuity. Equations of motion of a fluid, Pressure at a point in fluid at rest, Pressure at a point in a moving fluid, Euler's equation of motion, Bernoulli's equation. Motion in two dimension, Singularities of flow, Source, Sink, Doublets, Rectilinear vortices. Complex variable method for two-dimensional problems, Complex potentials for various singularities, Circle theorem, Blasius theorem, Theory of images and its applications to various singularities. Three dimensional flow, Irrotational motion, Weiss's theorem and its

applications. Viscous flow, Vorticity dynamics, Vorticity equation, Reynolds number, Stress and strain analysis, Navier-Stokes equation, Boundary layer Equations.

References:

1. H. A. Taha, *Operations Research: an Introduction*, Macmillan, 1982.
2. Kanti Swarup, P. K. Gupta and M. M. Singh, *Operations Research*, Sultan Chand and Sons, 1985.
3. L. C. Thomas, *Games: Theory and Applications*, John Wiley, 1984.
4. M. Shabik, *Game Theory in the Social Sciences*, MIT Press, 1982.

MS 542 ELECTRODYNAMICS (3 1 0 4 Nil)

Electrostatics and magnetostatics, Time varying fields, Maxwell's equations, Wave equations, Reflection and refraction of plane waves, special theory of relativity and its applications in Maxwell's equations.

References:

1. D. J. Griffiths, *Introduction to Electrodynamics*, Prentice Hall of India, 1983.
2. J. R. Reitz, F. J. Milford and R. W. Christy, *Foundations of Electromagnetic theory*, Narosa Publishing House, 1988.
3. J. D. Jackson, *Classical Electrodynamics*, Wiley Eastern Ltd., 1989.
4. M. A. W. Miah, *Fundamentals of Electrodynamics*, Tata McGraw Hill, 1986.
5. B. B. Laud, *Electromagnetics*, Wiley Eastern Ltd., 1990.

MS 543 RELATIVITY (3 1 0 4 Nil)

Elementary tensor analysis - Covariant and Contravariant Tensor, Rank of a Tensor, Rules of Combination, Quotient Rule, Inner and Outer Product.
Metric tensor, Covariant Derivative, Gradient, Divergence and Curl of Tensor, Riemannian Tensor, Ricci Tensor, Bianchi Identities. Principle of covariance and Equivalence Principle. The Gravitational Field in Empty Space and in Presence of Matter, Schwarzshild line element. The three crucial tests of General Relativity - (1) Planetary Orbits (2) The advance of Perihelion and (3) Deflection of Light
The Energy Momentum Tensor, The Vanishing of the Divergence Energy momentum Tensor, Gravitational Field Equation of General Relativity, Robertson-Walker Metric, Static Cosmological Models, The Einstein-de Sitter Models, General Relativity Near Black Holes, Red Shifts and Horizons, Galactic Densities and the darkness of the Night Sky, Number Counts.

References:

1. J. V. Narlikar, *Introduction to Cosmology*, James and Barlett, 1983.
2. Landau and Lifshitz, *Classical Theory of Fields*, Pergamon Press, 1975.
3. P. A. M. Dirac, *General Theory of Relativity*, Prentice Hall of India (reprinted), 2001.
4. S. Weinberg, *Gravitation and Cosmology*, John Wiley & Sons, 1972.

MS 544 OPERATIONS RESEARCH (3 1 0 4 Nil)

Definition and scope of operational research, different types of models, replacement model and sequencing theory, Inventory problems and their analytical structure, economic lot size

models with uniform rate of demand, with different rate of demand in different cycle; simple deterministic and stochastic model of inventory control; basic characteristics of queueing system; Steady state solution of Markovian queueing model; M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space.

References:

1. J. K. Sharma, *Operations Research: Theory and Applications*, Macmillan, 1997.
2. Humdy A. Taha, *Operations Research - An Introduction*, Prentice Hall of India, New Delhi, 1999.

MS 545 ELLIPTIC CURVES (3 1 0 4 MS-401)

Introduction to algebraic curves, singular and non-singular curves, Mordell-Weil group law on elliptic curve, explicit formulas for group law, points of finite order, Nagell-Lutz theorem, Mordell's theorem, rank of elliptic curves, examples. Elliptic curves over finite fields, integer points on elliptic curves. Complex multiplication.

References:

1. J. H. Silverman & John Tate, *Rational Points On Elliptic Curves*, Springer-Verlag Indian Reprint 2005.
2. M. McKean & V. Moll, *Elliptic Curves,* Cambridge University Press, 1999.
3. D. Husemoller, Elliptic Curves, GTM Vol. 111, Springer-Verlag.

MS 546 ALGEBRAIC NUMBER THEORY (3 1 0 4 MS-401)

Algebraic numbers and number fields, Discriminants, Norms and Traces, Algebraic Integers, rings of integers, Integral Bases, Problems for quadratic and cubic cases.

Arithmetic of Number Fields: Quadratic Fields, Cyclotomic polynomials and fields. Units in Number Rings, Dirichlet's Unit Theorem.

Ideal Theory: Norms of Ideals, Ideal Classes-The Class Group, Class Numbers of Quadratic Fields and Cyclotomic fields.

References:

1. R. A. Mollin, *Algebraic Number Theory,* CRC Press, 1999.
2. I. N. Stewart & D. Tall, *Algebraic Number Theory and Fermat's Last Theorem,* 3rd Edition, A K Peters Ltd.
3. J. Esmonde and M. Ram Murty, *Problems in Algebraic Number Theory*, GTM Vol. 190, Springer-Verlag
4. J.P. Serre, *Local Fields*, GTM Vol. 67, Springer-Verlag, 1979

MS 547 NUMERICAL LINEAR ALGEBRA (3-1-0 4 Nil)

Fundamentals. Linear systems, LU decompositions, Gaussian elimination with partial pivoting, Banded systems, Positive definite systems, Cholesky decomposition. Vector and matrix norms, Perturbation theory of linear systems, Condition numbers, Estimating condition numbers, IEEE floating point arithmetic, Analysis of roundoff errors. Gram-Schmidt orthonormal process, Orthogonal matrices, Householder transformation, Givens rotations, QR factorization, Roundoff error analysis of orthogonal matrices, Stability of QR factorization. Solution of linear least squares problems, Normal equations, Singular Value Decomposition(SVD), Polar decomposition, Moore-Penrose inverse, Rank deficient least squares problems, Sensitivity analysis of least-squares problems. Review of eigenvalues and canonical forms of matrices, Sensitivity of eigenvalues and eigenvectors, Reduction to Hessenberg and tridiagonal forms, Power and inverse power methods, Rayleigh quotient iteration, Explicit and implicit QR algorithms for symmetric and non-symmetric matrices, Implementation of implicit QR algorithm. Computing the SVD, Sensitivity analysis of singular values and singular vectors. Overview of iterative methods: Jacobi, Gauss-Seidel and successive overrelaxation methods, Krylov subspace method, The Arnoldi and the Lanczos iterations.

References:

1. L. N. Trefethen and David Bau, *Numerical Linear Algebra*, SIAM, 1997.
2. D. S. Watkins, *Fundamentals of Matrix Computation*, Wiley, 1991.
3. G. H. Golub and C.F.Van Loan, *Matrix Computation*, John Hopkins U. Press, Baltimore, 1996.
4. G. W. Stewart, Introduction *to Matrix Computations*, Academic Press, 1973.
5. J.W. Demmel, *Applied numerical linear algebra*, SIAM, Philadelphia, 1997.

MS 548 MATHEMATICAL LOGIC (3 1 0 4 Nil)

Zermelo-Fraenkel set theory, Ordinalsand well-ordering, Axiom of choice cardinal Arithmatic. Boolean algebra and proportional calculus. First order theories, validity, consistency, completeness, Skolem-Iowenheim Theorem, compactness theorem, categoricity, Decidability; Godel's numbering. Godel's incompleteness theorems.
Propositional calculus, Truth on algebraic systems. The calculus of predicates. Model theory.

References:

1. Rene Cori and Daniel Lascar, *Mathematical logic,* Oxford, 2001.
2. P. R. Halmos, *Naïve Set Theory*, Springer-Verlag, New York, 1974.

MS 549 GRAPH THEORY (3 1 0 4 Nil)

Graph: History (The Konigsberg Bridge Problem)
Basic Ideas: Definitions of Graph, Sub Graph, Spanning and Induced Subgraph (with diagrams). Multi and Pseudo Graphs, Diagraph. Isomorphism and Homeomorphism, Degree and Incidence.
Operations on Graphs: Union, Intersection and Ring-Sum of graphs, addition and removal of Edges and Vertices.

Connectivity: connectivity, walk, path, circuit, cut-vertex, cut-set, Non_Separable Graph, Components of a Graph, Complete Graph. Edge and Vertex Connectivity and related theorems.
Traversability: Introduction, Eularian graph and its necessary-sufficient condition, Hamiltonian graph and its necessary condition . Structure-based Connectivity and bipartite graph and and its necessary and sufficient condition.
Some problems: The shortest path problem, The chinese postman problem and Travelling Salesman Problem.
Trees: Characterizations, Theorems on tree, Tree-distances, Forest, Rooted Tree, Binary Tree, Spanning Tree, Fundamental Cycles (to construct spanning Tree).
Planarity: The Utilities Problem, Plane and Planar Graph, Planar Graph Representation, Planarity Detection (Kuratowski's theorem), Duality, Thickness and Crossing Numbers.
Matrices: The Adjacency Matrix, The Incedence Matrix, The Cycle Matrix, The Cut-set Matrix, The Path Matrix.
Diagraphs: Connectivity, Traversibility, Directed Trees, More Diagraph Matrices, The principle of Directional Duality, Tournaments.
Coverings and Colourings: Covering, Independence and Domination, Colouring Vertices (Chromatic Number, 4, 5 and 6 – Colourable Graphs, k-Colourable Graph), Colouring edges, Chromatic Polynomials.

References:

1. L. R. Foulds, *Graph Theory Applications*, Narosa Publishing House, New Delhi, 1992.
2. Robin J. Wilson, *Introduction to Graph Theory*, Longman, England, 1996.
3. Narsingh Deo, *Graph Theory with Applications to Engineering and Computer Science*, Prentice Hall of India, 1974.

MS 551 TOPOLOGY -II (I) (3 1 0 4 Nil)

Nets and filters, convergenge in terms of nets and filters, ultrafilters and compactness.
Theories of metrization, Urysohn's Lemma, Tietze Extension theorem, Urysohn metrization theorem.
Paracompactness, characterisation in regular spaces, metrization based on paracompactness, Nagata-Smirnov theorem, Stone's theorem, Smirnov's metrization theorem.
Homotopy and the fundamental group, computation of the fundamental group of the circle.

References:

1. K. D. Joshi, *Topology*, Wiley-Eastern, 1988.
2. J. L. Kelley, *Topology*, Van Nostrand, 1955.
3. J. R. Munkres, *Topology: A first course*, Prentice-Hall, 1983.
4. S. Willard, *General Topology*, Addision-Wesley, Reading, 1970.

MS 552 OPERATOR THEORY –I (3 1 0 4 Nil)

Uniform, strong and weak convergences.
Compact linear operators on normed linear spaces; the ideal of compact operators; the separability of the Range and spectral properties of a compact operator; operator equations involving compact opertators.
Bounded operators on Hilbert spaces; adjoint operators; normal, unitary and self adjoint oprators; spectral properties of bounded self adjoint linear operators; positive operators and

their square root; projection operators; spectral representation of a bounded self adjoint linear operator.
Spectral measure; spectral theorem for bounded normal operators.

References:

1. P. R. Halmos, *Introduction to Hilbert spaces and theory of spectral multiplicity*, Chelsea Publishing Co., New York, 1957.
2. Erwin Kreyszig, *Introductory functional analysis with applications*, John Wiley and Sons, 1978.
3. G. Bachman and L. Narici, *Functional Analysis*, Academic Press, New York, 1966.

MS 553 NUMBER THEORY-I (3 1 0 4 Nil)

Divisibility, greatest common divisor, least common multiple, prime numbers, factorisation in prime numbers, fundamental theorem of arithmetic, the Euclidean algorithm, perfect numbers, Mersenne numbers, Fermat numbers.
Concept of congruences and its elementary properties, congruences in one unknown, complete residue system, reduced residue system, Gauss function, Mobius function, Euler function.
Diophantine equations, linear Diophantine equations, pythagoras equation, sum of two squares.
Quadratic residues and congruences of second degree in one unknown, Legendre symbol, Jacobi symbol, congruences of second degree with prime modulus and with composite modulus.
Primitive roots and indices, order, necessary and sufficient condition for the existence of primitive roots, construction of reduced residue system.
Continued fractions, simple continued fractions, approximation of irrational numbers by continued fractions, solution of Pell's equation.

References:

1. Niven and H. Zuckerman, *An Introduction to the Theory of Numbers*, 5th edition, Wiley Eastern, 2000.
2. M. Burton, *Elementary Number Theory*, 2nd edition, Universal Book Stall, New Delhi, 1994.
3. Y. Hsiung, *Elementary Theory of Numbers*, World Scientific, 1992; First Indian Reprint, Allied Publishers Limited, 1995.
4. G. H. Hardy and E. M. Wright, *An Introduction to the Theory of Numbers*, 4th edition, Oxford, Claredon Press, 1960.
5. G. E. Andrews, *Number Theory*, Hindustan Publishing Corporation, New Delhi, 1992.
6. S. G. Telang, *Number Theory*, Tata McGraw Hill Publishing Company Limited, New Delhi, 1996.

MS 554 ADVANCED ALGEBRA I (3 1 0 4 Nil)

Modules, direct sum and product, finitely generated modules, Tensor product of modules, exact sequences, chain conditions, free modules, projective and injective modules, categories and functors, Hom, modules over principal ideal domains, primary decompositions, Dedekind domains and modules over them.
Commutative rings, localisation, Noetherian and Artinian rings , integral extensions, Hilbert's Nullstellensatz, Noether's normalisation, valuation rings,

References:

1. M. F. Atiyah and I. G. Macdonald, *Introduction to commutative Algebra*, Addision Wesley, 1969.
2. P. M. Cohn, *Algebra*, Vols. I & Vol. II, John Wiley & Sons, 1985 and 1988.
3. N. Jacobson, *Basic Algebra*, Vols. I & II, W. H. Freeman, 1980 (also published by Hindustan Publishing Company, Delhi).
4. O. Zariski and P. Samuel, *Commutative Algebra*, Vols. I and II, Van Nostrand, 1958 and 1960.
5. Dummit & Foote, *Abstract Algebra*, John Wiley & Sons, 2005.

MS 555 NUMERICAL SOLUTIONS OF DIFFERENTIAL EQUATIONS-I

(3 1 0 4 Nil)

Ordinary Differential Equations, Initial value problems, Explicit and implicit single step methods, Euler's method, Runge-Kutta methods, System of differential equations, Adaptive numerical methods, Explicit and implicit multistep methods, Predator- Corrector methods, Hybrid methods, Stability Analysis of single and multistep methods, Higher order differential equations, Non-uniform step methods, Boundary value problems, Convergence of difference schemes, Linear eigenvalue problems, Non-uniform grid methods for second order boundary value problems.

References:

1. M. K. Jain, S. R. K. Iyenger and R. K. Jain, *Numerical Methods for Scientific and Engineering Computation*, Wiley Eastern, 1993.
2. J. D. Lambert, *Numerical methods for Ordinary Differential equations,* John Wiley & Sons, 1991.
3. P. Henrici. *Discrete Variable Methods in Ordinary Differential Equations*. John Wiley & Sons, New York, 1962.
4. M. K. Jain, *Numerical Solutions of Differential Equations*, Wiley Eastern, 1991.
5. Richard K. Miller, *Introduction to Differential Equations*, Prentice Hall, New Jersey, 1991.
6. J. D. Hoffman, Numerical methods for Engineers and Scientists, Mc-Graw Hill, 2000.

MS 556 QUANTUM MECHANICS –I (3 1 0 4 Nil)

Introduction: inadequacy of classical mechanics, plack's quantum idea, de Broglie waves, Heisenberg uncertainty principle, wave packet, phase velocity and group velocity.
Time independent and time dependent schrodinger equation, interpretation of wave function,
Particle constrained in one dimension, in three dimension, potential well, rectangular potential barrier, theory of alpha decay.
Linear vector space, basis, quantum mechanical operators, Dirac bra and ket notation, unitary transformation, formal structure of quantum mechanics
Quantum mechanical theory of angular momentum, spin, addition of angular momenta.

References:

1. L. I. Schiff, *Quantum Mechanics*, McGraw Hill Book Co., 1986.

2. E. E. Enderson, *Introduction to Modern Physics and Quantum Mechanics*, Macmillan India Ltd, 1979.
3. P. M. Methews and K. Venkatesan, *Quantum Mechanics*, Tata McGraw Hill, 1990.
4. Merzbacher, *Quantum Mechanics*, John Wiley & Sons, NY, 1970.
5. A. K. Ghatak and Loknathan, *Quantum Mechanics*, Macmillan India Ltd, 1982.
6. P. A. M. Dirac, *The Principles of Quantum Mechanics*, Oxford University Press, 1958.
7. J. D. Bjorken and S. D. Drell, *Relativistic Quantum Mechanics*, McHill, New York, 1964.

MS 557 MATHEMATICAL MODELLING-I (3 1 0 4 Nil)

Stability by Liapunov's Direct Method, Autonomous System, Nonautonomous System, Sylvester criterion, Liapunov's Theorems, Krasovskii's method, Construction of Liapunov function for linear system with constant coefficients, Test for stability based on first approximations, Two-dimensional nonlinear system and linearization technique, Limit sets and Limit cycles, Extent of Asymptotic Stability, Lienard Equation, Global Asymptotic Stability, Perturbation Theorems, Poincare's Linearization Theorem, Bifurcation and Chaos.

References:

1. P. Glendinning, *Stability, Instability and Chaos*, Cambridge University Press, 1994.
2. T. Yoshizawa, *The Stability Theory by Liapunov's Second Method*, Mathematical Society of Japan, Tokyo, 1966.
3. W. Hahn, *Stability of Motion*, Springer Verlag, Berlin, 1967.
4. J. La Salle and S. Lefschetz, *Stability by Liapunov's Direct Mehtod*, Academic Press, New York, 1961.

MS 558 GENERAL THEORY OF RELATIVITY (3 1 0 4 Nil)

Differential manifolds, tensor algebra, parallel transport, covariant differentiation, Riemannian tensor, Ricci tensor and their properties.
Equivalence principle, Einstein equation, vacuum solution, Schwarzschild metric, Schwarzschild singularity, Eddington-Finkelstein co-ordinates, Kruskal-Szekeres co-ordinates.
Linearised theory of gravity, weak field limit, emission of gravitational waves.
Olbers paradox, cosmological principle, FRW line element, cosmological redshift, elements of steady state cosmology.

References:

1. R. Adler, M. Bazin & M. Schiffer, *Introduction to General Relativity*, McGraw Hill, 1975.
2. C.M. Will, *Theory and Experiment in Gravitational Physics*, Cambridge University Press, 1981.
3. J.V. Narlikar, *Introduction to Cosmology*, James and Barret, 1983.
4. L. D. Landau, E.M. Lifshitz, *Classical Theory of Fields*, Pergamon Press, 1975.
5. S. Weinberg, *Gravitation and Cosmology,* John Wiley & Sons, 1972.
6. I. R. Kenyon, *General Relativity*, Oxford University Press, 1991.
7. P. A. M. Dirac, *General Theory of Relativity*, Prentice Hall of India (reprinted), 2001.

MS 559 MAGNETO HYDRODYNAMICS & PLASMA PHYSICS-I
(3 1 0 4 Nil)

MHD, the continuum approximation, the electrical properties of the fluid, the electric and the magnetic field, Action at a distance, the low-frequency approximation, energetic aspects of MHD Magnetic induction equation, the analogy with vorticity, Diffusion and concretion of magnetic field, Magnetic Reynold's number, the Dynamo problem, Aifren's theorem, Cowling's problem, Ferrano's law of isorotation, the two dimensional kinematic problems :

(i) Flow only in the direction of no variation.
(ii) Field in the direction of no variation.
(iii) Current flow (but no field) in the direction of no variation.

The magnetic force and the inertion force, Magnetohydrostatics, the Linear pinch, the pinch, Force-free fields, the magnetic force in moving fluids, Kelvin's theorem and vorticity, the case of irrotational force per unit mass, Boundary conditions for magnetic field. Boundary conditions for current, Boundary conditions for electric field.

References:

1. S. A. Pai, *Magnetogasdynamics and Plasmadynamics*, Springer Verlag, New York, 1962.
2. J. A. Scucliff, *A text book of Magnetohydrodynamics*, Pergamon Press, London, 1965.
3. A. B. Cambel, *Plasma Physics and Magnetofluidmechanics*, McGraw Hill, 1966.
4. V. C. A. Ferrareo and C. Phimpton, *An Introduction to Magnetohydrodynamics*, Oxford University Press, 1960.

MS 560 SAMPLING TECHNIQUES-I (3 1 0 4 Nil)

Sampling techniques and estimation, Simple random sampling with and without replacement, Stratified sampling, Allocation problems, Systematic sampling, Two stage sampling, Multistage sampling, Multiphase sampling, Ratio and Regression methods of estimation, Optimal Allocations, Related estimation problems in the above cases, Sequential sampling. A survey description of sample surveys conducted in India.

References:

1. W. G. Cochran, *Sampling Technique*, Wiley Eastern, New Delhi, 1977.
2. P. Mukhopadhyay, *Theory and Methods of Survey Sampling*, Prentice-Hall of India Pvt. Ltd, New Delhi, 1998.
3. M. H. Hansen, H. N. Hurwitz, and W. G. Madow, *Sample Survey Methods and Theory*, Vols. I and II, Wiley, N.Y., 1953.
4. L. Lish, *Survey Sampling*, Wiley, N.Y., 1965.
5. M. N. Murthy, *Sampling Theory & Methods*, 2nd edition, Stat. Pub. Soc., Calcutta., 1977.
6. R. J. Jensen, *Statistical Survey Techniques*, Wiley, N.Y., 1978.
7. P. V. Sukhatme, B. V. Sukhatme, S. Sukhatme and C. Ashok, *Sampling Theory of Survey with Applications*, Iowa State University Press, Ames, Iowa, 1984.
8. Des Raj and Promod Chandhok, *Sample Survey Theory*, Narosa Publishing House, New Dehi, 1998.

MS 561 STOCHASTIC PROCESSES I (3 1 0 4 Nil)

Preliminaries of probability distributions, Laplace transforms, Laplace transforms of probability distributions of random variables, Simple random walk, multidimensional random walk. Stationary processes, Martingales, Markov chains, Higher transition probability and its determinations, Sequence of chain-dependent trials, Classifications of States and chains, Stability of Markov chains with denumerable number of states, Reducible chains. Poisson Processes and its related distributions, generalization of Poisson processes,

Birth and Death processes, Markov processes with discrete state space (Continuous time Markov chain), Erlang processes. Renewal processes, Renewal processes in continuous time, Renewal equation, Renewal reward processes.

References:

1. E. Parzen, *Stochastic processes*, Holden-Day, San Francisco, Calif, 1962.
2. J. Medhi,. *Stochastic Processes*, Wiley Eastern Ltd., New Delhi, 1994.
3. Kishor Shribharbhai Trivedi, *Probability & Statistics with reliability*, *Queuing and Computer Science Applications*, PHI, 1992.
4. L. Kleinrock, *Queueing Systems*, Vol. –I, II, John Wiley & Sons, 1976.
5. A. Y. Khintchine, *Mathematical Methods in Queueing*, Grieffen, London, 1960.
6. J. Medhi, *Stochastic Models in Queueing Theory*, Academic Press, 1991.
7. W. Feller, *An Introduction to Probability Theory and its Applications*, Vols. I & II, Wiley, 1966.

MS 562 STATISTICAL QUALITY CONTROL (3 1 0 4 Nil)

Statistical control of processes, Control charts for variables and attribute; Special procedures in process control, Properties of control charts, Estimating process average, single, double and sequential sampling plans, OC and ASN functions, AOQL and ATI; Acceptance sampling by variables, tolerance limits.

References:

1. B. L. Hansen and P. M. Ghare, *Quality control and application*, PHI, N.J., 1993.
2. I. Guttman, S. S. Wilks and J. J. Hunter, *Introductory Engineering Statistics*, John Wiley, N.J., 1982.
3. D. C. Montgomery, *Introduction to Statistical Quality Control*, John Wiley, N.Y., 1985.
4. B. L. Hansen, *Quality Control: Theory and Applications*, Englewood Cliffs, N. J.: Prentice Hall, 1963.
5. E. L.Grant and R.S. Leavenworth, *Statistical Quality Control*, 5th Ed., N. Y., McGraw Hill, 1980.
6. W. W. Hines and D. C. Montgomery, *Probability and Statistics in Engineering and Statistics*, 2nd Ed., N.Y., John Wiley, 1980.

MS 563 ADVANCED ANALYSIS-I (3 1 0 4 Nil)

Set Function, Ring, Construction of Lebesgue measure, Lebesgue outer measure, Measurable sets, Non-measurable sets.

Measurable functions, Borel measurability, Littlewood's principles, Simple functions, Approximation of every function as a simple function.

Step function, Lebesgue integral of bounded functions, Bounded convergence theorem, Monotone convergence theorem.

Integral of non-negative functions, Fatou's Lemma, Comparison with Riemann integral, Lebesgue general integral,

Measure and outer measures , Extension of a measure ,Extension of

L^p Space, convex functions, Jensen's inequality ,Holder and Minkowski's inequalities, Convergence and completeness, Convergence in measure, integration of convex functions.Bounded linear functionals on L^p Space.

Signed mesure, Hahn decomposition theorem,Mutually singular measures.

Radon-Nikodym theorem . Lebesgue decomposition, Riesz representation theorem, Extension theorem(Caratheodory), Lebesgue-Stieltjes integral , Product measures , Fubinies theorem , Differentiation and integration , decomposition into absolutely continuous and singular parts.

References:

1. H. L. Royden, *Real Analysis*, 3rd Edition, Macmillan Publishing Company, New York, 1988.
2. P. K. Jain and V. P. Gupta, *Lebesgue Measure and Integration,* New Age International (P) Limited, New Delhi, 1986.
3. P. R. Halmos, *Measure Theory*; Springer-Verlag, 1974.
4. G. de barra, *Measure Theory and Integration*; Wiley-Eastern, 1981.
5. I. K. Rana , *An introduction to Measure and Integration* , Narosa Publishing House , India

MS 564 MULTIVARIATE ANALYSIS-I (3 1 0 4 Nil)

Bivariate Moment Generating Functions, Characteristics Functions, Bivariate Normal Distributions and its Properties, Singular and non-singular Multivariate Distributions, Multivariate Normal Distributions, Marginal and Conditional Distributions, Distributions of Linear forms, and Quadratic forms, Cochran's Theorem, Multiple Regression and Correlation, Correlation coefficient of a Bivariate sample, the distribution when the population coefficient is non-zero, tests of hypotheses and confidence region, the asymptotic distribution of a sample correlation coefficient and Fisher's z, Partial correlation coefficient, Multiple Logistic Regression. Multinomial Distributions, Multivariate Multinomial Distributions.

References:

1. T. W. Anderson, *An Introduction to Multivariate Analysis* (2nd edition), Wiley, 1984.
2. A. M. Khirsagar, *Multivariate Analysis*, Marcell Dekker, New York.
3. P. R. Krishnaiah (eds), *Some recent developments on real multivariate distributions*, *Development in Statistics*, Vol. I, Academic Press, New York, 1978.
4. N. L. Johnson and S. Kotz, *Continuous Multivariate Distributions*, John Wiley, New York.
5. M. G. Kendall, *Multivariate Analysis*, NY, Hamer Press, 1975.
6. A. E. Maxwell, *Multivariate Analysis in Behavioural Research*, London, Chapman & Hall, 1977.
7. S. Chatterjee and B. Price, *Regression Analysis by Examples*, John Wiley, NY, 1977.
8. R. A. Johnson and D. W. Wichern, *Applied Multivariate Statistical Analysis*, PHI, 3rd edition, 1998.
9. N. L. Johnson, S. Kotz and N. Balakrishnan, *Discrete Multivariate Distributions*, Wiley, N.Y., 1997.
10. N. L. Johnson, S. Kotz. and A. W. Kemp, *Univariate Discrete Distributions*, Wiley, 2nd edition, 1993.

MS 565 FUZZY SETS AND APPLICATIONS-I (3 1 0 4 Nil)

Fuzzy sets - basic definitions, α-level sets, convex fuzzy sets, basic operations on fuzzy sets, types of fuzzy sets, cartesian products, algebraic products, bounded sum and difference, t-norms and t-conorms. Fuzzy sets in contrast of probability theory.
The extension principle - the Zadeh's extension principle, image and inverse image of fuzzy sets, fuzzy numbers, elements of fuzzy arithmetic.
Fuzzy relations and fuzzy graphs, composition of fuzzy relations, min-max composition and its properties, fuzzy equivalence relations, fuzzy relation equations, fuzzy graphs.

References:

1. H. J. Zimmermann, *Fuzzy set theory and its Applications*, Allied publishers Ltd., New Delhi, 1991.
2. G. J. Klir and B. Yuan, *Fuzzy Sets and Fuzzy Logic : Theory and Applications*, Prentice Hall of India, New Delhi, 1997.

MS 566 FOURIER ANALYSIS (3 1 0 4 MS-410)

Orthogonal systems, Trigonometric system, Fourier series in these systems, Uniqueness and convergence ,Approximate identity , Fourier series of continuous and smooth functions, L^2 theory of Fourier series – inversion formula and the Parseval identity, Fourier analysis and complex function theory, Bessel functions, Orthogonal polynomials, Fourier analysis and filters.

Fourier transforms, the Schwartz space ,Plancherel formula, Maximal function and distributions, Tempered distribution. Paley Wiener's theorem, Tauberian theorem, Dirichlet problem.

Classical Hardy spaces F and M. Reisz theorem.

References:

1. Dym, I.H. and Mc Kean, H.P., *Fourier Series and Integrals*, Academic Press, 1985.
2. Folland G.B., *Fourier Analysis and Applications*, Brooks/Cole Mathematics Series, 1972.
3. Katznelson, Y., *An Introduction to Harmonic Analysis*, Dover, New York, 1976.
4. Korner, T., *Fourier Analysis*, Cambridge, 1989.
5. Rudin, W., *Functional Analysis*, Tata Mc. Graw Hill, 1974.
6. Elias M. Stein and Rami Shakarchi , *Fourier Analysis An Introduction* ,Princeton University Press, Princeton , 2004.

MS 567 CONTINUUM MECHANICS (3 1 0 4 Nil)

Analysis of StrainLagrangian and Eulerian finite strain tensor.. Geometrical interpretation of the components of atrain. Strain quadric of Cauchy. Principall strains and invariantsGeneral infinitesimal deformation. Saint-Venant's equations of compatibility. Finite deformation.

Analysis of stress-Stress tensor. Equations of equilibrium. Transformation of co-ordinates. Stress quadric of Cauchy. Principal stress and invariants. Maximum normal and shear stresses.

Equations of Elasticity. Generalosed Hooks's law. Homogeneous isotropic media, Elastic constants.Strain energy function and its connection with Hooke's law. Uniqueness of solution. Saint-Vernant's principle.

Two dimensional problems-Plane stress. Generalised plane stress. Airy stress function.

Fundamental laws of continuum mechanics-Continuity equation, Equation of motion, Moment of momentum principle, Second law of thermodynamics. The Clausius-Duhem inequality.

References:

1. Mase, G.E, *Schaum's Outline of Continuum Mechanics (Schaum's Outline series)*, Mc-Graw Hill, 1990.
2. Rabindranath Chatterjee, *Mathematical Theory of Continuum Mechanics,* Narosa, 1999.
3. C. Truesdell, *The elements of continuum Mechanics,* Springer-Verlag, 2000.

MS 568 THEORY OF DISTRIBUTION AND SOBOLEV SPACES

(3 1 0 4 MS-410)

Test Function and distribution: Definition, operations with distributions, convolution of distributions, Fourier transform of tempered distributions.

Sobolev spaces: Definition and properties, extension theorem, imbedding and completeness theorem, fractional order Sobolev spaces, trace theory.

Application to Elliptic Problems: Weak solution of elliptic boundary value problem (BVP), regularity of weak solutions, maximum principle, eigenvalue problems, fixed point theorems and their application in semilinear elliptic BVP.

References:

1. R.A. Adams, *Sobolev Spaces*, Academic Press, 1975.

2. J.T. Oden and J.N. Reddy, *An Introduction to Mathematical Theory of Finite Elements,*Wiley Interscience, 1976.

3. S. Kesavan, *Topics in Functional Analysis and Applications*, Wiley Eastern Ltd., New Delhi, 1989.

4. K. E. Brennan and R. Scott. *The Mathematical Theory of Finite Element Methods* Springer-Verlag, Berlin, 1994.

5. Elliot H. Lieb and Michel Loss, *Analysis,* Narosa Publishing House, New Delhi, 1997.

6. Robert S. Strihartz, *A guide to Distribution Theory and Fourier Transforms, (Studies in Advanced Mathematics),* CRC Press,USA ,1994.

7. Rudin, W., *Functional Analysis*, Tata Mc-Graw Hill, 1974.

MS 571 TOPOLOGY – II (II) (3 1 0 4 MS 551)

Uniformities, uniform continuity, product uniformities, metrisation, completeness and compactness.
Topological groups, subgroups, quotient groups, homogeneous spaces, product groups, uniform structures in groups, complete groups, completion of topological groups.
Function spaces, pointwise convergence, uniform convergence, compact-open topology, k-spaces, equicontiniuty, Ascoli theorem.

References:

1. K. D. Joshi, *Topology*, Wiley-Eastern, 1988.
2. J. L. Kelley, *Topology*, Van-Nostrand, 1955.
3. J. R. Munkres, *Topology: A first course*, Prentice-Hall, 1983.
4. S. Willard, *General Topology*, Addision-Wesley, Reading, 1970.
5. R. Engelking, *General Topology*, Polish Scientific Publishers, Warshaw, 1977.
6. N. Bourbaki, *Elements of Mathematics: General Topology*, Vols. I & II, Springer-Verlag, 1988.

MS 572 OPERATOR THEORY –II (3 1 0 4 MS 552)

Functional calculus and spectral mapping theorem for analytic functions; Riesz decomposition theorem.
Numerical range of an operator; spectral radius; subnormal and hyponormal operators; partial isometries; polar decomposition.
Unbounded linear operators and their Hilbert adjoint operators; symmetric and self adjoint linear operators; spectral properties of self adjoint linear operators; closed linear operators; closable operators and their closures; spectral representation of unitary and self adjoint linear operators; multiplication operator and differentiation operator.

References

1. P. R. Halmos, *A Hilbert space problem book*, Van Nostrand, Princeton, New Jersey, 1967.
2. J. B. Conway, *A course in Functional Analysis,* Springer Verlag, New York, 1985.
3. Erwin Kreyszig, *Introductory functional analysis with applications,* John Wiley and Sons, New York, 1978.
4. Peter A. Fillmore, *Notes on operator theory*, Van Nostrand Reinhold Company, New York, 1970.

MS 573 NUMBER THEORY-II (3 1 0 4 MS 553)

Arithmetical functions and Dirichlet multiplication, averages of arithmetical functions.
Elementary theorems on the distribution of primes, the prime number theorem, Chebyshev's functions $\psi(x)$ and $\vartheta(x)$, relations connecting $\vartheta(x)$ and $\pi(x)$.
Dirichlet's theorem for primes of the form 4n-1 and 4n+1, distribution of primes in arithmetic progressions.
Quadratic residues and quadratic reciprocity law, applications of the reciprocity law, Gauss sums.
Dirichlet series and Euler products, Riemann zeta functions $\zeta(s)$ and Dirichlet L-function $L(s, \chi)$.

Introduction to partitions, geometric representation, generating functions, Euler's Pentagonal number theorem, Jacobi triple product identity, recursion formula for *p(n),* partition identities of Ramanujan.

References:

1. T. M. Apostol, *Introduction to Analytic Number Theory*, Springer International Student Edition, Narosa Publishing House, Fourth Reprint, 1993.
2. I. Niven and H. Zuckerman, *An Introduction to the Theory of Numbers*, 3rd edition, Wiley Eastern.
3. G. H. Hardy and E. M. Wright, *An Introduction to the Theory of Numbers*, 4th edition, Oxford, Claredon Press, 1960.
4. G. E. Andrews, *Number Theory*, Hindustan Publishing Corporation, New Delhi, 1992.

MS 574 ADVANCED ALGEBRA –II (3 1 0 4 MS 554)

Algebraic, normal and separable extensions of field, splitting fields, automorphisms of extensions, the fundamental theorem of Galois theory, finite fields, primitive elements, norm and trace, cyclotonic fields, cyclic extension, solution of polynomialequations by radicals, Kummer theory

Semi-simple Artinian rings, central simple algebras, central simple algebras, Brauer group, crossed products, prime and semi-prime rings, Goldie's theorem, PI algebras.

References:

1. M. F. Atiyah and I. G. Macdonald, *Introduction to Commutative Algebra,* Addision Wesley, 1969.
2. P. M. Cohn, *Algebra*, Vols. I & Vol. II, John Wiley & Sons, 1985 and 1988.
3. N. Jacobson, *Basic Algebra*, Vol. II, W. H. Freeman, 1980. (also published by Hindustan Publishing Company).
4. O. Zariski and P. Samuel, *Commutative Algebra*, Vols. I and II, Van Nostrand, 1958 and 1960.
5. Dummit & Foote, *Abstract Algebra*, John Wiley & Sons., 2005.

MS 575 NUMERICAL SOLUTIONS OF DIFFERENTIAL EQUATIONS-II
(3 1 0 4 MS 555)

Partial Differential Equations, parabolic type, Difference schemes for equations in one space dimension with constant coefficients, Implementation of difference schemes for problems of different types of initial and boundary conditions, Difference schemes for equations with variable coefficients, Difference schemes for Hyperbolic equations in one space variable with constant and variable coefficients, Implementation of difference schemes. Elliptic differential equation. Dirichlet, Neumann and Mixed problems. Third boundary value problem, Biharmonic equation, Finite element method, Weightes small sample, Parametric tests.

References:

1. Joe D. Hoffman, Numerical methods for Engineers and Scientists, McGrow Hill.
2. G. D. Smith, Numerical solutions to Partial Differential Equations, Brunel University, Clarendon Press, Oxford, 1985.

3. C. Johnson, *Numerical Solution of Partial Differential Equations by the Finite Element Method,* Cambridge University Press, 1987.
4. K. Eriksson et. al, *Computational Differential Equations,* Cambridge University Press, 1996.
5. L. Lapidus and G. F. Pinder, *Numerical Solution of Partial Differential Equations in Science and Engineering,* John Wiley, 1982.
6. H. P. Langtangen, *Computational Partial Differential Equations* Springer Verlag, 1999.
7. M.K. Jain, S.R.K. Iyenger and R.K. Jain, *Numerical methods for Scientific and Engineering Computation*, Wiley Eastern, 1993.
8. M.K. Jain, S.R.K. Iyenger and R.K. Jain, *Computational Methods for Partial Differential Equations*, Wiley Eastern, 1994.

MS 576 QUANTUM MECHANICS -II (3 1 0 4 MS 556)

Time independent perturbation theory, variational method, WKB approximation
Time dependent perturbation theory, Quantum theory of scattering, motion in a magnetic field.
Relativistic quantum mechanics: Klein Gordon equation, equation of continuity and interpretation in Klein Gordon equation and its pitfalls.
Dirac equation for a free fermion, Dirac gamma matrices, bilinear forms, conservation of angular momentum, inherent existence of spin in Dirac theory, interpretation of negative energy solution of Dirac equation, concept of antiparticle and fermi sea

References:

1. L. I. Schiff, *Quantum Mechanics*, McGraw Hill Book Co., 1986.
2. E. E. Enderson, *Introduction to Modern Physics and Quantum Mechanics*, Macmillan India Ltd., 1979.
3. P. M. Mathews and K. Venkatesan, *Quantum Mechanics*, Tata McGraw Hill, 1990.
4. Merzbacher, *Quantum Mechanics*, John Wiley & Sons, New York, 1970.
5. A. K. Ghatak and Loknathan, *Quantum Mechanics*, Macmillan India Ltd., 1982.
6. P. A. M. Dirac, *The Principles of Quantum Mechanics*, Oxford University Press, 1958.
7. J. D. Bjorken and S. D. Drell, *Relativistic Quantum Mechanics*, McHill, New York, 1964.

MS 577 MATHEMATICAL MODELING-II (3 1 0 4 MS 557)

Fundamentals of Mathematical Modelling, Single-species growth, Malthusian growth, Logistic growth, The general autonomous model, Nonautonomous growth.
Predation and parasitism, Solutions of Lotka-Volterra Systems for predator-prey interactions, Increasing and diminishing returns, Perturbed models, Existence of limit cycle for perturbed models, Intermediate predator-prey models, A generalized Gauss model.
Lotka-Volterra competition models, The competitive exclusion principle, Competition for fixed resources, Competition for renewable resources.
Lotka-Volterra Cooperation models, Kolmogorov Type models.
Diffusion and pollution models, Models for fishery resources.

References:

1. H.I. Freedman, *Deterministic Mathematical Models in Piopulation Ecology*, Marcel Decker, 1980.
2. E. Renshaw, *Modelling Biological Populations in Space and Time*, Cambridge University Press, 1991.
3. B.S. Goh, *Management and Analysis of Biological Populations*, Elsevier Scientific Publishing Company, 1980.

MS 578 HIGH ENERGY ASTROPHYSICS (3 1 0 4 MS 558)

Basic equations of nonrelativistic stellar structure, Polytropic fluid spheres, integral theorems, simple stellar models.
Nuclear energy generation, energy transport equations, opacity.
Stellar evolution and nucleosynthesis, gravitational collapse, supernova explosion.
Compact stellar objects, TOV equation, white dwarf, neutron star, black hole.
Gravitational wave, generation and propagation.

References:

2. S. Chandrasekhar, *Introduction to the study of stellar structure*, Dover Publications, 1957.
3. Kippenhahn and Weigert, *Stellar Structure and Evolution*, Springer-Verlag, 1991.
4. S.L. Shapiro and S.A. Teukolsky, *Black Hole, White Darf and Neutron Star*, Willey and Sons, 1983.
5. S. Weinberg, *Gravitation and Cosmology*, John Wiley & Sons, 1972.
6. Erica Bohm-Vitense, *Introduction to stellar astrophysics*, Vols. I, II, III, Cambridge University Press, 1989.

MS 579 MAGNETO HYDRODYNAMICS & PLASMA PHYSICS-II
(3 1 0 4 MS 559)

Linear, one-dimensional problem, Two-dimensional problem, Staedy Hartmann Flows, Linear Alfven waves, MHD-Rayleigh problems, Two-dimensional linear problems, Steady laminar flow in or pipe under a uniform transverse field, Flow in a circular pipe with axial current in the fluid.
Alfven waves, MHD waves in non-uniform magnetic fields, Reflection and refraction of MHD waves, Dissipative effects, Plane polarized waves, Torsional oscillations, Elements of the theorem of characteristics.
Instability of linear pinch, flute instability, the method of small oscillation the energy priciple, Stewart's and Lock's condition. The problems of thermal instability in presence of a magnetic field, Variational principle.

References:

1. S. A. Pai, *Magnetogasdynamics and Plasma dynamics*, Springer Verlag.
2. J. A. Shucliff, *A text of Magnetohydrodynamics*, Pergamen Press.
3. A. B. Cambel, *Plasma Physics and magnetofluidmechanics*, McGraw Hill.

MS 580 SAMPLING TECHNIQUES-II (3 1 0 4 MS 560)

Probability proportion to size with replacement sampling, varying probability without replacement sampling, Hurwitz-Thomson estimator, Midzuno-Lahiri-Sen Sampling Strategy, Des Raj's, Murthy's Sampling strategies, etc., sampling on successive occation, Some problem of Inference under a fixed population set-up, Double Sampling, Cluster Sampling, Non-sampling errors, Interpenetrating samples, Errors of Surveys, Small area estimation.

References:

1. W. G. Cochran, *Sampling Technique*, Wiley Eastern, New Delhi, 1977.
2. P. Mukhopadhyay, *Theory and Methods of Survey Sampling*, Prentice-Hall of India Pvt. Ltd, New Delhi, 1998.
3. M. H. Hansen, H. N. Hurwitz and W. G. Madow, *Sample Survey Methods and Theory*, Vols. I and II, Wiley, N.Y., 1953
4. L. Lish, *Survey Sampling*, Wiley, N.Y., 1965.
5. M. N. Murthy, *Sampling Theory and Methods*, 2nd edition, Stat. Pub. Soc., Calcutta., 1977.
6. R. J. Jensen, *Statistical Survey Techniques*, Wiley, N.Y., 1978.
7. P. V. Sukhatme, B. V. Sukhatme, S. Sukhatme and C. Ashok, *Sampling Theory of Survey with Applications*, Iowa State University Press, Ames, Iowa, 1984.
8. Des Raj and Promod Chandhok, *Sample Survey Theory*, Narosa Publishing House, New Dehi, 1998.

MS 581 STOCHASTIC PROCESS –II (3 1 0 4 MS 561)

Branching processes- Properties of generating functions of Branching processes, Probability of Extinction, Distribution of the total number of progeny, Generalization of the classical Galton-Watson process. Continuous time Markov Branching process. Brownian motion, Wiener process, differential equations for a Wiener process, Kolmogorov equation, First passage time distribution for Wiener process, Ornstein-Ulhenbech process. Queueing systems, Single server queueing models (M/M/1/∞, M/M/1/k, M/M/∞/∞, etc.), multiple server queueing models (M/M/c/∞, M/M/c/k, M/M/∞/∞, etc.), Queues with finite populations, M/G/1, M/G/∞ Queueing systems, M/G/2 Queue with heterogeneous servers, Networks of Queues, Non-exponential service time distributions and multiple job type, Availability theory.

References:

1. E. Parzen, *Stochastic processes*, Holden-Day, San Francisco, Calif, 1962.
2. J. Medhi., *Stochastic Processes*, Wiley Eastern Ltd., New Delhi, 1994.
3. Kishor Shribharbhai Trivedi, *Probability & Statistics with reliability, Queueing and Computer Science Applications*, PHI, 1992.
4. L. Kleinrock, *Queueing Systems*, Vol. – I, II, John Wiley & Sons, 1976.
5. A. Y. Khintchine, *Mathematical Methods in Queueing*, Grieffen, London, 1960.
6. J. Medhi, *Stochastic Models in Queueing Theory*, Academic Press, 1991.
7. W. Feller, *An Introduction to Probability Theory and its Applications*, Vol. I & II, Wiley, 1998

MS 582 RELIABILITY THEORY (3 1 0 4 Nil)

Exponential failure model: properties of exponential distributions, estimation of mean life with complete samples, reliability estimation, estimation with censored samples, estimation based on components of order statistics: *k* out of *n*. Gamma and Weibull distributions (one, two and three parameters), estimation of complete samples, truncated and censored samples, reliability estimation, Normal and related distributions and reliability estimation, mixture distributions and competing risks. Reliability of series / parallel systems : Series system with identical components, reliability bounds - classical approach, reliability - Bayesian approach, parallel systems.

References:

1. Polvoko, A. M., *Fundamental of Reliability Theory*, Academic Press, New York, 1968.
2. Zacks, S., *Theory of Statistical Inference*, Wiley, New York, 1971.
3. Sinha, S. K., *Reliability and Life Testing*, Wiley Eastern Ltd., New Delhi, 1986.
4. Ravichandran, N., *Stochastic Methods in Reliability Theory*, Wiley Eastern Ltd., 1990.
5. Kishor Shribharbhai Trivedi, *Probability & Statistics with reliability*, *Queueing and Computer Science Applications*, PHI, 1992.
6. Bazowsky, I., *Reliability*: *Theory and Practice*, Englewood Cliffs, N.J., Prentice Hall, 1961.
7. Kapur, K., *Reliability in Engineering Design*, N.Y., Wiley, 1977.

MS 583 ADVANCED ANALYSIS-II (3 1 0 4 MS 563)

Baire sets , Baire measure , continuous functions with compact support . Regularity of measures on locally compact spaces. Integration of contionuos functions with compact support, Riesz-Markoff theorem.

Radon measure, positive linear functional on $C_c(X)$,The Dual of $C_0(X)$,Products of Radon Measures

Homogeneous spaces,Topological Groups,Invariant Measure (Haar measure),Hausdorff measure, Integration on manifolds.

Distributations, SobolevSpaces, Fourier Analysis of measures

References:

1. H. L. Royden, *Real Analysis*, 3rd Edition, Macmillan Publishing Company, New York, 1988.
2. W. Rudin , *Real and complex Analysis*, McGraw-Hill Book Company , New Delhi
3. P. R. Halmos, *Measure Theory*, Springer-Verlag, 1974.
4. R.G.Bartle , *The elements of Integration* , John Wiley & sons, New work 1966.
5. G. B. Folland , *Real Analysis –Modern Techniques and Their Applications* , John Wiley & sons, New work 1984.
6. R.L.Wheeden, Antoni Zygmund, *Measure and integral : -An introduction to real analysis*,
   Marcel, Dekker Inc,1977.

MS 584 MULTIVARIATE ANALYSIS-II (3 1 0 4 MS 564)

Inference on parameters of Multivariate normal distributions, One population and Two Population cases, Wishart Distributions, Hotellings T^2, Mahalanobis D^2, Discriminant analysis, Testing general linear hypotheses: Estimation of parameters in multivariate linear regression, distribution of $\hat{\beta}$ and $\hat{\Sigma}$, Computation of $\hat{\beta}$ and $\hat{\Sigma}$, Likelihood ratio criteria for testing linear hypotheses about regression coefficients, Moments of Likelihood ratio criterion, Principal Components: Definition of Principal Components in the Population, Maximum likelihood Estimates of the Principal Components and their Variances, Computation of the Maximum Likelihood Estimates of the Principal Components; Canonical Correlation and Canonical Variables: Canonical Correlations and Variables in the Population, Estimation of Canonical Correlations and Variables, Computation. Cluster Analysis.

References:

1. T. W. Anderson, *An Introduction to Multivariate Analysis* (2nd Edition), Wiley, 1984.
2. A. M. Khirsagar, *Multivariate Analysis*, Marcell Dekker, New York.
3. P. R. Krishnaiah (eds.), *Some recent developments on real multivariate distributions*, *Development in Statistics*, Vols. I & II, Academic Press, New York, 1978.
4. N. L. Johnson and S. Kotz, *Continuous Multivariate Distributions*, John Wiley, New York.
5. M. G. Kendall, *Multivariate Analysis*, NY, Hamer Press, 1975.
6. R. Gnanadesikan, *Methods for Statistical Data Analysis of Multivariate Observations.*
7. A. E. Maxwell, *Multivariate Analysis in Behavioural Research*, London, Chapman & Hall, 1977.
8. S. Chatterjee and B. Price, *Regression Analysis by Examples*, John Wiley, NY, 1977.
9. R. A. Johnson and D. W. Wichern, *Applied Multivariate Statistical Analysis*, (3rd Ed), PHI, 1998.

MS 585 FUZZY SETS AND THEIR APPLICATIONS-II (3 1 0 4 MS 565)

Fuzzy logic, fuzzy propositions, fuzzy quantifiers, linguistic variables, inference from conditional fuzzy propositions, compositional rule of inference.

Approximate reasoning - an overview of fuzzy expert systems, fuzzy implications and their selection, multi-conditional approximate reasoning, role of fuzzy relation equation.

An introduction to fuzzy control - fuzzy controllers, fuzzy rule base, fuzzy inference engine, fuzzification, defuzzification and the various defuzzification methods.

Decision making in fuzzy environment - individual decision making, multi-person decision making, multi-criteria decision making, multistage decision making, fuzzy ranking methods, fuzzy logic as a tool in soft computing.

References:

1. H. J. Zimmermann, *Fuzzy set theory and its Applications*, Allied publishers Ltd., New Delhi, 1991.
2. G. J. Klir and B. Yuan, *Fuzzy Sets and Fuzzy Logic : Theory and Applications*, Prentice Hall of India, New Delhi, 1997.

MS 586 PARELLEL NUMERICAL ALGORITHMS (3 1 0 4 Nil)

Fundamentals of Parallel computing. Parallel techniques and algorithms. Theoretical models of parallel computation: Variants of the PRAM model. Performance of parallel algorithms. Basic Techniques: Balanced trees, recursive doubling, divide and conquer,

partitioning. Pipe lining, Accelerated cascading, symmetry breaking. List ranking, the euler tour techniques, tree contraction. Algorithms for searching, merging and sorting. Graph algorithms: Connected components, colouring. Parallel algorithms on interconnection networks and other architectures. Limits to parallelisability. P-completeness.
Parallel algorithms for linear algebraic equations; Design of parallel algorithms for eigen value problem; parallel issues of factorization. Parallel implementation of classical iterative methods. Parallel methods for ordinary and partial differential equations.

References:

1. Michael J. Quinn, Parallel computing theory and practice, 2nd ed, Mc-Graw Hill, 200.
2. Jaja, Joseph, *An introduction to parallel algorithms*, Addision Wesley, 1992.
3. Reif H.H., *Synthesis of parallel algorithms*, Morgan Kaufmann publishers, San mateo, California.
4. Leighton, F.T., *Introduction to parallel algorithms and architectures: Arrays trees, Hypercubes,* Morgan Kaufmann publishers, San mateo, California.

MS 587 FINITE ELEMENT METHOD (3 1 0 4 Nil)

The standard discrete system, Finite elements of an elastic continuum-displacement approach, Generalization of the finite element concepts-weighted residual and variational approaches. Element types: triangular, rectangular, quadrilateral, sector, curved, isoparametric elements and numerical integration. Automatic mesh generation schemes. Application to structural mechanics problems: plane stress and plane strains, Axisymmetric stress analysis, three dimensional stress analysis, bending of plates. Introduction to the use of FEM in steady state field problems-heat conduction, fluid flow and non-linear material problems, plasticity, creep etc. Computer procedures for Finite element analysis.

References:

1. Dietrich Braess, Larry L. Schumaker, *Finite Elements: Theory, Fast Solvers, and Applications in Solid Mechanics (2nd edition),* Cambridge University Press, 2001.
2. C.S. Desai, *Introductory Finite Element Method*, CRC Press, 2001.

MS 588 APPLIED MATRIX THEORY (3 1 0 4 Nil)

Review of basic linear algebra, canonical factorization, Q-Forms, Courant-Fischer minmax & related theorems. Perron-Frobenius theory. Matrix-stability. Inequalities, g-inverse (A^-, A^m, A^+). Drect, iterative, projection and rotation methods for solving linear systems & eigenvalue problems. Applications.

References:

1. K. B. Datta, *Matrix and Linear Algebra*, PHI, 1991.
2. D. S. Watkins, *Fundamentals of Matrix Computation,* Wiley, 1991.
3. G. H. Golub and C.F.Van Loan, *Matrix Computation*, John Hopkins U. Press, Baltimore, 1996.
4. G. W. Stewart, *Introduction to Matrix Computations,* Academic Press, 1973.

MS 591 COMPUTATIONAL FLUID DYNAMICS (3 1 0 4 MS 541)

Basic equations of Fluid Dynamics. Analytical Aspects of PDE. Finite volume and finite difference methods on nonuniform grids. Stationary Convectin diffusion equations, Nonstationary convection diffusion equations. Conservation laws. Incompressible plane flows, Stream function and vorticity equations, Conservative form and normalizing systems, Method for solving vorticity transport equation, Basic finite difference forms, Conservative property, Convergence and stability analysis, Explicit and implicit methods, Stream function equation and boundary conditions, Solution for primitive variables. Simple C F D Techniques ,Lax-Wendroff Technique , Mac Cormack's Techniques,Finite volume method,Application to Euler equations,Upwind difference scheme,Viscous flow solutions,Staggered grid,SIMPLE Algorithm. Numerical Solutions of Navier-Stokes equations on collocated and on staggered grids. Iterative methods – Stationary Methods. Krylov subspace methods. Total variation diminishing schemes, Godunov-type schemes.

References:

1. T.J.Chung, *Computational fluid Dynamics*, Cambridge University Press, 2005.
2. C. A. J. Fletcher, *Computational Techniques for Fluid Dynamics, Volume 1 & 2*, Springer Verlag, 1992.
3. C. Y. Chow, *Introduction to Computational Fluid Dynamics*, John Wiley, 1979.
4. M. Holt, *Numerical Methods in Fluid Mechanics*, Springer Verlag, 1977.
5. H. J. Wirz and J. J. Smolderen, *Numerical Methods in Fluid Dynamics*, Hemisphere, 1978
6. J. D. Anderson, *Computational Fluid Dynamics*, Mc-Graw Hill, 1995.
7. D. A. Anderson, J. C. Tannehill and R. H. Pletcher, *Computational Fluid Dynamics and Heat Transfer*, McGraw Hill, 1984.

MS 592 AN INTRODUCTION TO FOURIER THEORY (3 1 0 4 Nil)

Convolutions - Fourier Transform – Two Domains – Fourier Transform Properties: scaling, shifting, convolution, correlation theorems – Parseval's theorem – Sampling Theorem – Discrete Fourier Transform – Fast Fourier Transform - Applications

References:

1. Ronald N. Bracewell. *The Fourier Transform and Its Applications*, McGraw-Hill International Editions, 2000.
2. James S. Walker, *Fast Fourier Transforms,* CRC Press, 1996.
3. C.S. Burrus and T.W. Parks, *DFT/FFT and Convolution Algorithms: Theory and implementation*, John Wiley & Sons, New York, 1985.
4. Jack D. Gaskill, *Linear Systems, Fourier Transforms, and Optics*, New York: John Wiley & Sons, 1978.

MS 593 WAVELETS AND APPLICATIONS (3 1 0 4 Nil)

Reviews of Fourier analysis and L^p spaces, Wavelets and atomic decomposition of functions, Multi-resolution signal decomposition, Multi-resolution analysis and the construction of wavelets, Examples of wavelets, QMF and fast wavelet transform, Localization, Regularity and approximation properties of wavelets, Construction of compactly support wavelets, Orthonormal bases of compactly supported wavelets, Wavelets sampling techniques, Convergence of wavelet expansion, Time frequency analysis for signal processing, Application of wavelets in image and signal processing.

References:

1. Y. Meyer, *Wavelets: Algorithm and Application*, SIAM, 1993
2. I. Daubechies, *Ten Lectures on Wavelets*, SIAM, 1992
3. G. Kaiser, *A Friendly guide to Wavelets*, Birkhauser, 1994

MS 594 ADVANCED TOPOLOGY -I (3 1 0 4 Nil)

Nets and filters, convergenge in terms of nets and filters, ultrafilters and compactness.
Theories of metrization, Urysohn's Lemma, Tietze Extension theorem, Urysohn metrization theorem.
Paracompactness, characterisation in regular spaces, metrization based on paracompactness, Nagata-Smirnov theorem, Stone's theorem, Smirnov's metrization theorem.
Homotopy and the fundamental group, computation of the fundamental group of the circle.

References:

1. K. D. Joshi, *Topology*, Wiley-Eastern, 1988.
2. J. L. Kelley, *Topology*, Van Nostrand, 1955.
3. J. R. Munkres, *Topology: A first course*, Prentice-Hall, 1983.
4. S. Willard, *General Topology*, Addision-Wesley, Reading, 1970.

MS 595 NUMERICAL SOLUTIONS OF ODE (3 1 0 4 Nil)

Ordinary Differential Equations, Initial value problems, Explicit and implicit single step methods, Euler's method, Runge-Kutta methods, System of differential equations, Adaptive numerical methods, Explicit and implicit multistep methods, Predator- Corrector methods, Hybrid methods, Stability Analysis of single and multistep methods, Higher order differential equations, Non-uniform step methods, Boundary value problems, Convergence of difference schemes, Linear eigenvalue problems, Non-uniform grid methods for second order boundary value problems.

References:

7. M. K. Jain, S. R. K. Iyenger and R. K. Jain, *Numerical Methods for Scientific and Engineering Computation*, Wiley Eastern, 1993.
8. J. D. Lambert, *Numerical methods for Ordinary Differential equations,* John Wiley & Sons, 1991.
9. P. Henrici. *Discrete Variable Methods in Ordinary Differential Equations*. John Wiley & Sons, New York, 1962.
10. M. K. Jain, *Numerical Solutions of Differential Equations*, Wiley Eastern, 1991.

11. Richard K. Miller, *Introduction to Differential Equations*, Prentice Hall, New Jersey, 1991.
12. J. D. Hoffman, Numerical methods for Engineers and Scientists, Mc-Graw Hill, 2000.

MS 596 ADVANCED TOPOLOGY – II (3 1 0 4 MS 594)

Uniformities, uniform continuity, product uniformities, metrisation, completeness and compactness.
Topological groups, subgroups, quotient groups, homogeneous spaces, product groups, uniform structures in groups, complete groups, completion of topological groups.
Function spaces, pointwise convergence, uniform convergence, compact-open topology, k-spaces, equicontiniuty, Ascoli theorem.

References:

1. K. D. Joshi, *Topology*, Wiley-Eastern, 1988.
2. J. L. Kelley, *Topology*, Van-Nostrand, 1955.
3. J. R. Munkres, *Topology: A first course*, Prentice-Hall, 1983.
4. S. Willard, *General Topology*, Addision-Wesley, Reading, 1970.
5. R. Engelking, *General Topology*, Polish Scientific Publishers, Warshaw, 1977.
6. N. Bourbaki, *Elements of Mathematics: General Topology*, Vols. I & II, Springer-Verlag, 1988.

MS 597 NUMERICAL SOLUTIONS OF PDE (3 1 0 4 MS 507)

Finite difference methods for Parabolic, Elliptic and Hyperbolic equations. Dirichlet, Neumann and Mixed problems. Sparseness and the ADI method, Iterative methods for Laplace equation. Backward Euler, Crank-Nicolson schemes, Stability, convergence and consistency analysis of finite difference methods, Lax's equivalence theorem. Method of characteristics, Lax-Wendroff explicit method, CFL conditions, Wendroff implicit approximation. Three dimensional elliptic problems.

References:

1. Joe D. Hoffman, Numerical methods for Engineers and Scientists, McGrow Hill.
2. G. D. Smith, Numerical solutions to Partial Differential Equations, Brunel University, Clarendon Press, Oxford, 1985.
3. C. Johnson, *Numerical Solution of Partial Differential Equations by the Finite Element Method*, Cambridge University Press, 1987.
4. K. Eriksson et. al, *Computational Differential Equations*, Cambridge University Press, 1996.
5. L. Lapidus and G. F. Pinder, *Numerical Solution of Partial Differential Equations in Science and Engineering*, John Wiley, 1982.
6. H. P. Langtangen, *Computational Partial Differential Equations* Springer Verlag, 1999.
7. M.K. Jain, S.R.K. Iyenger and R.K. Jain, *Numerical methods for Scientific and Engineering Computation*, Wiley Eastern, 1993.
8. M.K. Jain, S.R.K. Iyenger and R.K. Jain, *Computational Methods for Partial Differential Equations*, Wiley Eastern, 1994.

MS 598 ALGEBRAIC GEOMETRY (3 1 0 4 Nil)

Properties of affine and projective varieties defined over algebraically closed fields; rational mappings, bi-rational geometry and divisors, especially on curves and surfaces; introduction to the language of schemes; and Riemann-Roch theorem for curves.

References:

1. Robin Hartshorne, *Algebraic Geometry*, GTM Vol. 52, Springer-Verlag, Indian Reprint 2005.
2. Karen E. Smith, etc all, *An Invitation To Algebraic Geometry*, Springer, Indian Reprint 2005.
3. C. Musili, *Algebraic Geometry for Beginners*, TRIM 20, Hindustan Book Agency, 2001.

MS 599 PROBABILITY THEORY (3 1 0 4 MS 405)

Measurable space, Measure and its properties , finite and sigma-finite measures, Axiomatic definition of Probability, Measurable functions , definition of Random variable, measure induced by a measurable function, definition of Probability distribution and distribution function, properties of distribution function and classification of distributions. Reimann-Stieltjes integral, Integration theory(integration of measurable functions w.r.t an arbitrary measure), Fatou's lemma , Monotone Convergence theorem, Dominated convergence theorem, Definition of Mathematical Expectation of a random variable and its properties. Moments and moment inequalities.
Generating functions. Some basic inequalities in Probability. Radon-Nikodym derivative, Definition of Conditional Expectation. Conditional Probability, Baye's theorem , Conditional probability distributions.

Convergence of a sequence of random variables (Weak convergence or convergence in probability, almost sure convergence and convergence in Law). Borel-Cantelli-lemma, Weak and Strong law of large numbers, Central limit theorems.

References

1. C.R.Rao(1991), *Linear Statistical Inference and its applications*, 2nd edition, wiley Eastern.
2. H.L. Royden (1988) *Real Analysis*, 3rd Edition, Prentice Hall.
3. Y. Chow and H. Teicher(1997) *Probability Theory* , Independence,Interchangeability, Martingales ; 3rd Edition , Springer.