DEPARTMENT OF MATHEMATICS

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY
(DEEMED UNIVERSITY)
ALLAHABAD

POST GRADUATE PROGRAMME

MASTER OF SCIENCE

IN

MATHEMATICS AND SCIENTIFIC COMPUTING

M. Sc. Program in Mathematics and Scientific Computing

About the programme:

Full time M.Sc. in Mathematics & Scientific Computing will be of four semester program. This two year programme offers an exciting opportunity to students who are interested in Mathematics and who wish to pursue courses for industry, research and teaching. This Programme with a broad based curriculum has the following main attractive features:

The programme offers computer oriented courses and extensive laboratory training in Mathematics. As part of an effort to learn new mathematical techniques that can be used to address regional industrial problems. Mathematica, Matlab and Mapple will be used as the main tools to deal with most of the computational subject matter of the M. Sc. courses being offered. These courses will include Mathematical Analysis, Statistics, Algebra, Applied Analysis, Applied Algebra-Coding Theory, Industrial Mathematics, Mathematical Statistics and Mechanics.

In the third and fourth semester each student will take up a project under the guidance of a faculty member. In the Project, a student explores a specific topic outside the course programme, surveys the available literature on the topic and submits a critical review in the form of a report which may also include original theoretical results and/or results of experimental work. This process provides an initiation into mathematical research and also equips the student with the skills of presentation of research/technical literature.

Eligibility Conditions:

A candidate having three years B. Sc. Degree with minimum 60% marks (or equivalent grade) with Mathematics as one of the main subject.

Seats: No. of students to be admitted – 15.

Admission Procedure: On the basis of admission test.

Credit Hours Required:

Credit hours and performance criterion are given in Article 7.1 and 7.7 of P.G. ordinance, salient points of which are given below:

1. The minimum credit hours required for the award of M. Sc. Degree is 80. These 80 credit hours may be earned through minimum of four semesters and maximum of six semesters.
2. There is a provision of two semester leave in the duration of M.Sc. Program.

3. A student has to maintain CPI (Cummulative Performance Index) of 6.0 (out of 10) and SPI (Semester Performance Index) of 5.5 (out of 10) in every semester.

Program Structure:

First Semester:

S. No.	Course code	Name of the Course	Credit	L+T+P
1.	MA 111	Introduction to Continuum Mechanics	4	3+1+0
2.	MA 112	Data Structure and Programming Languages	4	3+0+2
3.	MA 113	Real Analysis	4	3+1+0
4.	MA 114	Algebra	4	3+1+0
5.	MA 115	Probability and Statistics	4	3+1+0

Second Semester:

S. No.	Course code	Name of the Course	Credit	L+T+P
1.	MA 211	Discrète Mathematics	4	3+1+0
2.	MA 212	Principles of Numerical Computations	4	3+0+2
3.	MA 213	Mathematical Methods	4	3+1+0
4.	MA 214	Mathematical Modeling and Simulation	4	3+0+2
5.	MA 215	Automata Theory	4	3+0+2

Third Semester:

S. No.	Course code	Name of the Course	Credit	L+T+P
1.	MA 311	Design and Analysis of Algorithm	4	3+0+2
2.	MA 312	Complex Analysis	4	3+1+0
3.	MA 313	Optimization	4	3+0+2
4.		Elective 1	4	
5.	MA 399	Project	4	

List of Electives for Third Semester

Students can choose a course from the following as an elective:

Elective 1

- MA 314 Coding Theory
- MA 315 Commutative Algebra
- MA 316 Differential Geometry and Tensor Analysis
- MA 317 Cryptography
- MA 318 Financial Mathematics
- MA 319 Computational Fluid Dynamics
- MA 320 Topology
- MA 321 Special Functions
- MA 322 Numerical Methods for ODE

Note: Before going to summer vacation each student will choose a project under a teacher in the department. This project will be of two semesters for III and IV. At the end of IIIrd Semester half of the project will be evaluated by the teacher concerned and at the end of IV semester student will submit thesis/report of the project and will make presentation in the department.

Fourth Semester:

S. No.	Course Code	Name of the Course	Credit	L+T+P
1.	MA 411	Fuzzy Theory and its applications	4	3+1+0
2		Elective –2	4	
3		Elective- 3	4	
4.		Open Elective	4	
5.	MA 499	Project	4	

Note: Open elective is to be chosen any subject from M.Tech./ M.C.A./ M.B.A. or from B. Tech. IV year.

List of Electives for Fourth Semester

Elective –2/ Elective –3

- MA 412 Statistical Simulation and Data Analysis
- MA 413 Graph Theory
- MA 414 Numerical Methods for PDE
- MA 415 Image Processing
- MA 416 Functional Analysis
- MA 417 Computational Algebraic Geometry
- MA 418 Algebraic Number Theory
- MA 419 Wavelet Analysis
- MA 420 Stochastic Process and Simulation

Syllabus
for
M. Sc. in Mathematics and Scientific Computing

MA 111: Introduction to Continuum Mechanics

L T P
3 1 0

Stress Analysis**:** Introduction to tensors. Stress tensor. Equilibrium equations. Mohr's circle for plane stress. Deformation, Strain tensor, Rate of deformation tensor. Equations of motion. Dynamic similarity. Exact solutions. Laminar boundary layer over a float plat. Vorticity circulation & irrational flow. Torsion of cylindrical bars, Plane elastic waves. Magnetohydrodynamics

Text: George Backus; Continuum Mechanics.
D. S. Chandrasekharaiah, Lokenath Debnath; Continuum Mechanics.

MA 112: Data Structure and Programming Language:

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3 0 2

Introduction: Basic Terminology, elementary organization, data structure operations, algorithm complexity. The flow-chart concepts, Programming, Integer and real operations, Control statements, Do statements, While statements, For statements, Nested loops, if-else statements, Switch statements, Break statements, continue statements, Functions, Program structures, arrays, , stacks and queues, linked lists, trees, pointers, file structures and unions, data files.

Programming Lab:

Laboratory experiments will be set in consonance with the material covered in the course MA -112; this will include assignments in programming language.

Texts / References:

1. V. Rajaraman, Computer Programming in C, Prentice Hall India, 1994.
2. B. Kernighan and D. Ritchie, the C Programming Language. Prentice Hall India, 1995
3. Herbert Schield, Complete reference in C, TMH
4. Yashwant Kanetkar, Let us C , BPB
5. Balaguruswamy, Programming in ANSI C, TMH
6. Yashwant Kanetkar Pointers in C

MA 113: Real Analysis

L T P
3 1 0

- Archimedean property, Completeness property of real numbers.
- Metric spaces, compactness, connectedness, (with emphasis on R^n).
- Continuity and uniform continuity. Monotonic functions, Functions of bounded variation; Absolutely continuous functions. Derivatives of functions and Taylor's theorem.
- Functions of several variables., derivatives in an open subset of R^n, derivatives of higher order, partial derivatives, Taylor's theorem., Lagranges Multiplier method, Inverse function theorem, Implicit function theorem.
- Riemann integral and its properties, characterization of Riemann integrable functions. Improper integrals, Sequences and series of functions, uniform convergence and its relation to continuity, differentiation and integration. point wise convergence, Fejer's theorem, Weierstrass approximation theorem.

Measure Theory

- Measurable sets; Lebesgue Measure and its properties.
- Measurable functions and their properties; Integration and Convergence theorems.
- Introduction to Lp-spaces, Riesz-Fischer theorem; Riesz Representation theorem for L2 spaces. Absolute continuity of measures, Radon-Nikodym theorem. Dual of Lp-spaces.
- Product measure spaces, Fubini's theorem. Fundamental Theorem of Calculus for Lebesgue Integrals (an outline).

Texts / References:

- T. Apostol, Mathematical Analysis, 2nd ed., Narosa Publishers, 2002.
- K. Ross, Elementary Analysis: The Theory of Calculus, Springer Int. Edition, 2004.
- W. Rudin, Principles of Mathematical Analysis, 3rd ed., McGraw-Hill, 1983.
- P.R. Halmos, Measure Theory, Graduate Text in Mathematics, Springer-Verlag, 1979.
- Inder K. Rana, An Introduction to Measure and Integration (2nd ed.), Narosa Publishing House, New Delhi, 2004.
- H.L. Royden, Real Analysis, 3rd ed., Macmillan, 1988.

MA 114: Algebra

L T P
3 1 0

An overview of Groups, Rings and Fields. Principal Ideal Domains, Properties, Polynomial Rings. Field extensions, finite extensions, algebraic extensions, irreducible polynomial of an algebraic element, splitting fields and their uniqueness, Finite fields their existence and characterization, extensions and subfields of finite fields. Construction and representation of finite fields using polynomials over Zp.

Linear Operators on Finite Dimensional Vector Spaces, Eigenvalues and eigenvectors, Annihilating polynomials, Invariant subspaces, Direct Sum Decomposition, Invariant direct sums, Primary Decomposition.

Cyclic subspaces, Annihilators, Cyclic Decomposition, Rational Canonical Form, Jordan Canonical Form, Computation of Invariant Factors. Inner Product Spaces, Gram-Schmidt Orthonormalization,

Polynomials and Affine spaces, Affine Varieties, Parametrization, Monomial Orders, Division Algorithm in several variables, Monomial Ideals and Dickson's lemma, Hilbert basis Theorem, Groebner Bases, Properties, Buchberger's Algorithm, Applications, Solving systems of Polynomial equations, Elimination and Extensions, Implicitization, Unique Factorization and Resultants, Extension Theorems, Hilbert's Nullstellensatz, Radical Ideals and Varieties, Operations on Ideals, Irreducible Varieties and Irreducible Decompositions.

Modules, Short exact sequence, Projective Modules.

Texts: 1. Lidl and Niederreiter, Finite Fields and Applications.
2. Hoffman and Kunze, Linear Algebra.
3. Henry Helson, Linear Algebra.
4. Cox, Little and O'Shea, Ideals and Algorithms.
5. Algebra Vol I & II, Ramji Lal

MA 115: Probability and Statistics

L T P
3 1 0

Probability: - Axiomatic definition, Properties. Conditional probability, Bayes rule and independence of events. Random variables, Distribution function, Probability mass and density functions, Expectation, Moments, Moment generating function, Chebyshev's inequality. Special distributions: Bernoulli, Binomial, Geometric, Negative Binomial, Hypergeometric, Poisson, Uniform, Exponential, Gamma, Normal joint distributions, Marginal and conditional distributions, Moments, Independence of random variables, Covariance, Correlation. Functions of random variables. Weak law of large numbers, P. Levy's central limit theorem (finite variance case), Normal and Poisson approximations to binomial.

Statistics: - Population, Sample, Parameters. Point Estimation: Method of moments, MLE, Unbiasedness, Consistency, Comparing two estimators (Relative MSE). Confidence interval estimation for means, difference of means, variance, proportions, Sample size problem.
Test of Hypotheses:-N-P Lemma, Examples of MP and UMP tests, p-value, Likelihood ratio test, Tests for means, variance, two sample problems, Test for proportions, Relation between confidence intervals and tests of hypotheses, Chi-square goodness of fit tests, Contingency tables, SPRT
Regression Problem:- Scatter diagram, Simple linear regression, Least squares estimation, Tests for slope and correlation, Prediction problem, Graphical residual analysis, Q-Q plot to test for normality of residuals, Multiple regression, Analysis of Variance: Completely randomized design and randomized block design, Quality Control: Shewhart control charts and Cusum charts.

Texts: R. Murray, Probability and Statistics.
Frederich Mosteller, Probability and Statistics.
S. C. Gupta and V. K . Kapur, Probability and Statistics.

MA 211: Discrete Mathematics

L T P
3 1 0

1.Mathematical Logic: Statements, Connectives, Statement Variables and Formulas, Tautologies, Equivalences and Implications, Disjunctive and Conjunctive Normal Forms, Inference Theory in Statement Logic, Indirect Proofs, Automatic Deduction due to Hao Wang, First Order Predicate Logic, Inference Theory in Predicate Logic, Prenex Normal Form, Skolemization, Herbrand's Theorem, Resolution Priciple.

2. Relations and Functions: Boolean Matrices, Join, Meet and Boolean Product, Directed Graphs, Matrix and Digraph representations of Relations, Paths and Connectivity, Transitive Closures, Warshall's Algorithm, Growth of Functions Recursive Functions.

3. Lattices and Boolean Algebra: Partially Ordered Sets, Lattices, Modular and Distributive Lattices, Complements, Boolean Algebra, Stone Representation Theorem for Finite Boolean Algebras, Boolean Functions, Free Boolean Algebras, Relationship with Statement Logic.

4. Combinatorics: Permutations and Combinations, Permutations and Combinations with repetitions Ordered and Unordered Partitions, Sterling Numbers of First and Second Kind, Partition Functions, Linear Recurrence

Relations(Difference Equations), Solution by Characteristic Roots, Generating Functions.

5. Graphs and Trees: Graphs, Eulerian and Hamiltonian Graphs, Graph Colourings, Trees, Tree Searching, Minimal Spanning Trees, Prim's and Kruskal's Algorithms.

Texts: 1. Tremblay and Manohar, Discrete Mathematical Structures
2. Kolman, Busby and Ross, Discrete Mathematical Structures
3. Mott, Kandel and Baker, Discrete Mathematical Structures
4. Chang and Lee, Symbolic Logic and Mechanical Theorem Proving.

MA 212: Principles of Numerical Computations

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- Introduction: Errors in numerical computation, Machine Computations, Computer Software.

- Algebraic and Transcendental Equations: Bisection method, Iteration method, Method of False Position, rate of convergence, Method for complex root, Muller's Method, Quotient Difference method, Newton-Raphson Method.
- Numerical solution of linear systems, Direct & Iterative methods, Numerical eigenvalue problems. Jacobi, Givens & Householder's method for symmetric matrices, Hessenberg QR iteration. QR- Factoring, LU-Factoring, Cholesky (LLT) Decomposition, Singular Value Decomposition.
- Interpolation: Introduction, Errors in Polynomial interpolation, Finite differences, Decision of errors, Newton's formula for interpolation, Gauss, Sterling, Bessel's, Everett's Formula, Interpolation by unevenly spaced points, Lagrange interpolation formula, Divided Difference, Newton's General interpolation Formula.

- Curve Fitting, Cubic Spline & Approximation: Introduction, Method of Least Square curve fitting procedures, fitting a straight line, Curve fitting by sum of exponential, Data fitting with cubic splines, Approximation of functions.

- Numerical Integration and Differentiation: Introduction, Numerical differentiation, Numerical integration, Trapezoidal rule, Simpson 1/3 rule, Simpson 3/8 rule, Booles & Weddles rule, Euler-Maclariaun formula, Gaussian Formula, Numerical evaluation of singular integrals. Numerical Solution of Ordinary Differential Equations, Related software development.

Books and References:

- Conte and de Boor, Elementary Numerical Analysis.
- C F Gerald and P. O. Wheatley, Applied Numerical Analysis
- Jain , Iyengar and Jain, Numerical methods for Engineering and Scientists.
- Kendall E. Atbinson, Introduction to Numerical Analysis.
- S. S. Sastry, Introductory methods of Numerical Analysis.

MA 213: Mathematical Methods

L T P
3 1 0

- Laplace Transform, Fourier series, Fourier integral, and Fourier transform.
- Power Series solutions of linear differential equation, Special functions (Hypergeometric function, Legendre's function, Bessel's function).
- Sturm-Liouville Problem; Oscillation Theorems, Orthognal polynomials, Integral transforms, Integral equations; Classifications, properties and solutions, Partial Differential Equations
- First order equations, Cauchy Kowaleski Theorem, Characteristics, Classification of second order equations. Uniqueness theorems for hyperbolic equations with initial and boundary conditions, Elliptic equations, Dirichlet and Neumann problems. Maximum Minimum theorem, Poisson's Integrals, Green's and Neumann's functions. Heat equations
- Calculus of variations: Introduction, Euler - Lagrange equations, Degenerate Euler equations, Natural boundary conditions, Transversality conditions, Simple applications of variational principle, Sufficient conditions for extremum. Variational formulation of BVP, Minimum of quadratic functional, Approximate Methods.
- Integral equations. Volterra integral equations of first and second kind. Iterative methods and Neumann series.

Texts / References:

- R. Courant & D. Hilbert, Methods of Mathematical Physics, Vol. I & II, Wiley Eastern Pvt. Ltd. New Delhi, 1975.
- Jain and Iyengar, Advanced Engineering Mathematics
- Kreyszig E. , Advanced Engineering Mathematics

MA-214: Mathematical Modeling and Simulation

L T P
3 0 2

- **Mathematical Modeling**: Principle of modeling, Elementary models, Models by nature of environment, Models by the Extent of generality, Solution method for models, Characteristics , Advantages and Limitations of a model, Discrete and continuous dynamical system modeling, Modeling from input/output data, Stochastic Modeling, Queuing system modeling, Single server, Unlimited queue model, Service in random order, Single server, Finite queue model, Multi- channel queuing model.

- **Simulation:** Introduction to simulation, General concept in discrete event simulation, Random number generation, Nature of Simulation, Simulation models, Monte-carlo simulation , Event type simulation, Demand pattern Simulation, Simulation in inspection work , Simulation of queuing models, Simulation of job sequencing, Advantage of simulation , Limitations of simulation.

Modeling and Simulation (lab)

- Simulation to study differential equations and stochastic models, Software simulation of simple dynamical systems, Linear feedback control systems, Simulation of piecewise linear systems, Simulation of nonlinear mathematical models. Simulation of Mechanical Systems.

- SIMULINK (and/or similar package) based experiments on graphical synthesis of systems; Control synthesis for typical dynamical systems. Control law evaluation experiment on a variable stability platform; Software-hardware interface experiment using external devices.

Texts/References:

- Doeblin, E.O., System Modeling and Response, John Wiley & Sons, 1980.
- Ogata, K., Modern Control Engineering, Prentice Hall India, 1995 Narasingh Deo, System Simulation with Digital Computer, Prentice Hall India, 1997.
- Law, A.M., and Kelton, W.D., Simulation, Modeling & Analysis , McGraw-Hill,1991.
- Rolfe. J.M., and Staples, K.J., Flight Simulation, Cambridge Aerospace Series, Cambridge University Press, 1986. Manuals of Analog Computer, MATLAB, SIMULINK and other software.
- Taha, H. A., Operation Research-An Introduction, Maxwell Macmillan,4/e New York(1989) Mathematical Modeling (Third Edition) Giordano Weir Fox.(Vikas Publishing House)

MA 215 : Automata Theory

L T P
3 1 0

- Introduction: Deterministic and Nondeterministic Finite Automata, Regular Expression, Two way Finite Automata, Finite Automata with output, Properties of regular sets, pumping lemma Closure properties, My-Hill-Nerode Theorem.

- Context Free Grammars: Derivation trees, simplification forms.

- Pushdown Automata: Definitions, Relationship between PDA and context free language, Properties of context free languages, Decision Algorithms.

- Turing Machine: The Turing Machine Model, Complete Languages and Functions, Modification of Turing Machines, Church's Machines, Undecidability.
- Properties of recursive and recursively enumerable languages, Universal turing Machines, Post correspondence problems, introduction to recursive function theory.

- Chomsky Hierarchy: Regular grammars, unrestricted grammars, Context Sensitive Language, Relation between classes of languages.

Books & References:

1. Hopcroft and Ullman, Introduction to Automata Theory, languages and computation, Addision Wesley.
2. Kohan, Theory of Computer Sciences.
3. Korral, Theory of Computer Sciences.
4. Mishra & Chandrashekharan, Theory of Computer Sciences, PHI.

MA 311: Design and Analysis of Algorithm

L T P
3 0 2

- Basic Tools on designing algorithms: what is algorithm, basic steps for the development of an algorithm, Analyzing of an algorithm, asymptotic notations
- Divide and conquer approach: applications in binary search, merge sort, quick sort, Strassen's matrix multiplication,
- Greedy method the general method, application to optimal storage on tapes, job sequencing with deadlines, optimal merge, minimum spanning tree.

- Dynamic Approach: Principle of optimality, applications in shortest path problem ,Matrix chain multiplication, knapsack problem
- Optimal binary search trees
- Back tracking: applications to 8 queen problem, puzzle problem, sum of subset problem
- Branch and bound approach: application to traveling salesman problem, sum of subset problem ,assignment problem
- NP hard, NP complete problem: reducibility, deterministic and non deterministic algorithm. halting problem satisfiabilty problem.

Reference:

- Fundamentals of Computer algorithms: Horowitz, Sahani and Rajasekaran
- Introduction to Algorithms: Coremen, Leiserson
- The Design and Analysis of Computer Algorithms : Aho, Hopcroft and Ullman

MA 312: Complex Analysis

L T P
3 1 0

- Complex Integration, Cauchy-Goursat Theorem, Cauchy's integral formula, higher order derivatives, Morera's Theorem, Cauchy's inequality and Liouville's theorem. The fundamental theorem of algebra, Taylor's theorem, Maximum modulus principles, Schwarz lemma,
- Weierstrass Theorem, Taylor series, Laurent's series, Zeroes and poles, isolated singularities, Meromorphic functions. The argument princilple, Rouche's theorem, inverse function theorem.
- Residues, Cauchy's residues theorem, evaluation of integrals, branches of many valued functions with special reference to arg z, log z and z^a.
- Bilinear transformations, their properties and classifications, definition and examples of conformal mappings,
- Spaces of analytic functions, Hurwitz's theorem, Montels theorem, Riemann Mapping theorem. Uniform convergence of sequences and series. Taylor and Laurent series. Isolated singularities and residues, Evaluation of real integrals,
  Riemann Zeta function, Riemann mapping theorem, conformal mapping of polygons, analytic continuation, Picard's Theorem.

Texts / References:

- J.B. Conway, Functions of One Complex Variable, 2nd ed., Narosa, New Delhi.
- L.V. Ahlfores, Complex Analysis, McGraw Hill book company.
- T.W. Gamelin, Complex Analysis, Springer International Edition, 2001.
- R. Remmert, Theory of Complex Functions, Springer Verlag.
- A.R. Shastri, An Introduction to Complex Analysis, Macmilan India.

MA 313: Optimization

L T P
3 0 2

- Introduction: Nature and Scope of operations research.

- Linear Programming: Introduction, Mathematical formulation of the problem, Graphical Solution methods, Mathematical solution of linear programming problem, Slack and Surplus variables. Matrix formulation of general linear programming Problem.

- The Simplex Method: Fundamental properties to solution corroboration of extreme points, Simplex algorithm, Computational procedures, Artificial variables, Two phase Simplex Method, Formulation of linear programming problems and its solution by simplex method. Unrestricted variables, problems of degeneracy, Principle of duality in simplex method, Formation of dual with mixed type of constraints, Solution of primal and dual constraints.

- Sensitivity Analysis. Non-Linear programming, Integer Programming, Dynamic Programming.

- Allocation, assignment and Transportation models, Construction and solution of these Models, the transportation problem, matrix form of transportation problem, Initial basic feasible solution, Selecting the entering variables, Selecting the leaving variables, Transportation algorithm, Degeneracy in transportation Problem, Inventory Control, Replacement problem.

- Game Theory: Introduction, Two persons zero sum games, The maxmin and minimax principles. Graphical Solution: Reduction of game problem to LPP.

Books and References:

- Operation Research, Theory and Application by J.K. Sharma, Macmillan India
- Quantitative techniques in Management by N. D. Vohra, TMH
- Linear Programming by N.P. Loomba
- Operation Research: An Introduction by H.A. Taha,

MA 314: Coding Theory

L T P
3 1 0

- Polynomial rings over fields, Extension of fields, computation in GF(q), Root fields of polynomials, Vector space over finite fields, Binary group codes, Hamming codes, polynomial codes, Linear block codes, The structure of cyclic codes, Quadratic residue codes, Reed Mueller codes, Simplex codes. Nonlinear codes, Golay, Hadamard, Justeen, Kerdock, Nordstorm-Robinson codes. First and Second order Reed-Mueller codes, t-designs, steiner systems. Weight distribution of codes. Generalized BCH codes. Self dual codes and invariant theory. Covering radius problem, Convolutional codes.

Books and References:

- Coding Theory, Cryptography and Related Areas by J Buchmann, T Hoholdt, H Stichtenoth
- Error-correcting codes, self-checking circuits and applications by Wakerly, J. North-Holland, New York 1978.
- Algebra und Codes by Wan Zh. Wissenschaftsverlag, Peking, 1980.
- Codes and Kryptography, Welsh, D., VCH, Weinheim 1991.
- Coding theorems of information theory by Wolfowitz, J., Springer, Berlin, 1978.
- Principles of communication engineering by Wozencraft, M., Jacobs, I. John Wiley, New York.
- Sequential Decoding by Wozencraft, M., Reiffen, B, M.I.T. Press, Cambridge/Mass.
- Codes for error control and synchronization by Wiggert, D. Artech, Boston/Mass, 1988.

MA 315: Commutative Algebra

L T P
3 1 0

- Prerequisites: Algebra
- Commutative rings, Noetherian Artinian rings, Primary decomposition and Noetherian rings, Modules over commutative rings, Exact sequences, the Hom and tensor functors, rings and modules of fractions, integral dependence, valuations and dedekind domains.
- Dimension theory of affine algebras: Principal ideal theorem, Noether normalization lemma, dimension and transcendence degree, category, property of affine rings, dimension and degree of the Hilbert polynomial of a graded ring, Nagata's altitude formula, Hilbert's Nullstellensatz, finiteness of integral closure.
- Hilbert-Samuel polynomials of modules :
- Associated primes of modules, degree of the Hilbert polynomial of a graded module, Hilbert series and dimension, Dimension theorem, Hilbert-Samuel multiplicity,
- Complete local rings: Basics of completions, Artin-Rees lemma, associated graded rings of filtrations, completions of modules, regular local rings
- Basic Homological algebra: Categories and functors, derived functors, Hom and tensor products, long exact sequence of homology modules, free resolutions, Tor and Ext, Koszul complexes.

Texts:

1. Atiyah and Macdonald: Commutative Algebra.
2. Gopalakrishnan: Commutative Algebra.

MA 316: Differential Geometry and Tensor Analysis

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3 1 0

- Curves in space, Curvature of plane curves, arc length and line integrals, Graphs and level sets of functions on Euclidean spaces, vector fields, integral curves of vector fields, tangent, normal, binormal, tangent spaces, Helix.
- Surfaces in Euclidean spaces, vector fields on surfaces, orientation, Gauss map.
- Surface theory: Fundamental forms, Curvature of curves in surface, Curves on a surface: Principle directions, lines of curvature, conjugate curves, asymptotic lines, isometric lines
- Geodesics, parallel transport, Weingarten map.

- Curvature of plane curves, arc length and line integrals. Curvature of surfaces.
- Parametrized surfaces, local equivalence of surfaces. Gauss-Bonnet Theorem, Poincare-Hopf Index Theorem.

Tensor Analysis and Applications

- Space of N-dimensions, second order tensors, Higher order tensors, Tensor algebraic operations, Eigen value and eigen vectors of tensors, symmetric tensors, skew symmetric tensors, orthogonal tensors, Quotient law, relative tensor, Metric tensors, Principal directions for a symmetric covariant tensor, Permutations symbols and tensors, Christoffel symbols and covariant differentiation Ricci theorem, Curl, divergence gradient Intrinsic derivative, curvative tensor and Riemannian survature, Tensor processing. Case studies with applications of tensor analysis in science and engineering.

References:

- Differential Geometry of Curves and Surfaces by M. doCarmo, Prentice Hall, 1976.
- Elementary Differential Geometry by B. O'Neill, Academic Press, New York, 1966.
- Differential Geometry: T.J. Wilmore
- Differential Geometry: B.B. Sinha
- Differential Geometry by J.J. Stoker, Wiley-Inter science, 1969.
- Elementary Topics in Differential Geometry by J.A. Thorpe, Springer (India), 2004
- Vector and Tensor Analysis, Brand, L., John Wiley and Sons 1990.
- Tensor Calculus, Theory and Problem, J.L. Bansel, Jaipur Publishing House, 2000

MA 317: Cryptography

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- Introduction to Security attacks, services And mechanisms, Introduction to cryptology. Conventional Encryption model, classical encryption techniques-substitution ciphers & transposition ciphers, cryptanalysis, stereography, stream & block ciphers.

- Modern Block ciphers: Block Ciphers principles, Shandars (DES), Strength of DES, Differential & Linear Cryptanalysis of DES, Block cipher model of operation, triple DES, IDEA encryption & decryption, Strength of

IDES, Confidentiality using conventional encryption, traffic confidentiality, key distribution, random number generation.

- Principles of Public Key Cryptography: principle of public key cryptography, prime and relative prime numbers, modular arithmetic, PSA algorithm, security of RSA key management.
- Authentication recruitments, Authentications functions, and Message Authentication codes, Digital Signatures, authentication protocols Digital signatures Standard (DES) ,proof of digital signatures algorithm.

- Electronics mail security: pretty good privacy (PGP), S/MIME IP security: IP security overview, architecture, Authentication header, encapsulating security payloads, combining security association, key management.

- Web security: security socket layer & transport layer security, secure electronic transaction (SET)

- System security: intruders, viruses and related threads, firewall design principles.

Books and References:

- William Stalling " Cryptography and networks security: Principles and Practice," Prentice Hall, New jersey,
- Johannes A Buchmann, "Introduction to cryptography," Spiringer–verlag
- Bruce Schiener, "Applied Cryptography".

MA 318: Financial Mathematics

L T P
3 1 0

- Review Of probability, finite probability space. Derivatives security, interest rates, other financial instruments, Arbitrage and pricing, risk less issue, yield curves, mean terms matching and immunization, interest rate models. Dependent annual rates of return, random walk and Markov process, stochastic calculus, option pricing, portfolio optimization, Fokker-plank equation, distribution and green functions, Feynman-kac formula options, dividends revisted. Exoticoptions, bond pricing, transaction costs, time series ,stochastic processes, Neural nets.

Textbooks/References:

- Financial mathematics-Richard Brass, Springer(2003)
- Mathematics of financial derivatives- Wilmott & Howison, Springer(2005)
- Hand book of stochastic methods-Gardiner, Wiely (2000)

- The Mathematics of Financial Derivatives: A Student Introduction, by Wilmott, Dewynne, and Howison(Cambridge University Press, 1995)
- Futures, and Other Derivatives, 5th ed, by Hull (Prentice Hall, 200

MA 319: Computational Fluid Dynamics

L T P
3 0 2

- 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, Schemes for advective diffusion equation, Upwind differencing and artificial vorticity, Solution for primitive variables.

Texts and References:

- C. A. J. Fletcher, Computational Techniques for Fluid Dynamics, Volume 1 & 2, Springer Verlag, 1992.
- C. Y. Chow, Introduction to Computational Fluid Dynamics, John Wiley, 1979.
- M. Holt, Numerical Methods in Fluid Mechanics, Springer Verlag, 1977.
- H. J. Wirz and J. J. Smolderen, Numerical Methods in Fluid Dynamics, Hemisphere, 1978.
- D. A. Anderson, J. C. Tannehill and R. H. Pletcher, Computational Fluid Dynamics and Heat Transfer, McGraw Hill, 1984.

MA 320 : Topology

L T P
3 1 0

- Topological Spaces: open sets, closed sets, neighbourhoods, bases, subbases, limit points, closures, interiors, continuous functions, homeomorphisms.
- Examples of topological spaces: subspace topology, product topology, metric topology, order topology.
- Quotient Topology: Construction of cylinder, cone, Moebius band, torus, etc.
- Connectedness and Compactness: Connected spaces, Connected subspaces of the real line, Components and local connectedness, Compact spaces, Heine-Borel Theorem, Local -compactness.

- Separation Axioms: Hausdorff spaces, Regularity, Complete Regularity, Normality, Urysohn Lemma, Tychonoff embedding and Urysohn Metrization Theorem, Tietze Extension Theorem.
- Tychnoff Theorem, One-point Compacti-fication.
- Complete metric spaces and function spaces, Characterization of compact metric spaces, equicontinuity, Ascoli-Arzela Theorem, Baire Category Theorem. Applications: space filling curve, nowhere differentiable continuous function.

Optional Topics:

- Topological Groups and orbit spaces.
- Paracompactness and partition of unity.
- Stone-Cech Compactification.
- Nets and filters.

Texts / References:

- M. A. Armstrong, Basic Topology, Springer (India), 2004.
- K.D. Joshi, Introduction to General Topology, New Age International, New Delhi, 2000.
- J.L. Kelley, General Topology, Van Nostrand, Princeton, 1955.
- J.R. Munkres, Topology, 2nd Ed., Pearson Education (India), 2001.
- G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, New York, 1963.

MA 321: Special Functions

L T P
3 1 0

Differential equations with three regular singularities hypergeometric differential equations Gauss hypergeometric functions elementary properties-contiguous relations, integral representation linear and quadratic transformation and summation formulae. Analytic continuation. Barnes' contour integral representation. Confluent hypergeometric function and its elementary properties. Generalised hypergeometric function pFq and its elementary properties linear and quadratic transformations, summation formulae. Hermite, Laguerre, Jacobi and Ultraspherical polynomials Definition and elementary properties.

Asymptotic Series : Definition, elementary properties-term by term differentiation, integration, theorem of uniqueness, Watson's lemma, Asymptotic expansions of 1F1, 2F1.
Orthogonal polynomials : Definition their zeros expansion in term of orthogonal polynomials, three term recurrence relation, Christofel-Darboux formula, Bessel's inequality.

Characterization – Appell, Sheffes and o-type characterization of polynomial sets.
Weirstrass' Elliptic Functions : Jacobi's first and second question, irreducible zeros and poles of elliptic functions.Weierstrass' functions p(z), (z) and o(z), pseudo periodicity of (z) and o(z). Differential equation, addition theorem for p(z). Algebraic relation between two elliptic functions, expansion for elliptic functions in term of o(z), (z) and p(z). Evaluation of elliptic integrals.

References/Books

1. Theory of complex variables E. T. Copsom Wile limited 1997.
2. Resonance of Ramanujan Mathematics volume I, II, III, R. P. Agrawal Narosa publishing house 1996.
3. Theory of Hypergeometric functions and applications, Gasper and Rehman M. allied publishers 2000.

MA 322: Numerical Methods for Ordinary Differential Equations:

L T P
3 0 1

Introduction. Runge-Kutta methods- derivation, error bounds and error estimates. Weak stability theory for Runge-Kutta methods. Order and convergence of the general explicit one-step methods. Linear multi-step methods-derivation, order consistency, zero-stability and convergence. Weak stability theory for general linear multi-step methods. Predictor-Corrector methods. Stiff systems.

Texts: E. A. Coddington and N. Levinson; Theory of Ordinary Differential Equation.
P. F. Hsieh and Y. Sibuya; Basic Theory of Ordinary Differential Equation.
M. K. Jain; Numerical Solution of Ordinary Differential Equation.

MA 411: Fuzzy Theory and Applications

L T P
3 1 0

Fuzzy sets, Types of Fuzzy sets; operation on Fuzzy sets, Fuzzy measures, Measures of fuzziness. Fuzzy relations. Properties of MinMax compositions. Fuzzy relation equations and its role. Fuzzy graphs, Fuzzy sets and possibility theory, Fuzzy logics, Fuzziness of fuzzy sets, Fuzzy sets and expert systems, Uncertainty modeling in expert systems, Fuzzy rule based modeling, Fuzzy rule

systems for exact physical system described by partial differential equations, Fuzzy decisions, Fuzzy linear programming, Fuzzy database, Fuzzy information retrieval, Fuzzy theory and weather classifications, Water demand forecasting, Soil water movement and applications in environmental science, Medical diagnosis, Financial markets, Uncertainty in Business management, Psychology, Foods and nutrition with good number of case studies.

References:

- Fuzzy sets and fuzzy logic, theory and applications – George J. Klir, Yuan Prentice Hall 2006.
- Analysis and management of uncertainty: Theory and applications: Ayyub, B. M., L.N. Kanal, North Holland, Newyork 1992.
- Fuzzy data Analysis : Bandler, W. and W. Nather, Kluwer 1996.

MA 412: Statistical Simulation and Data analysis

L T P
3 1 0

- Introduction to Data Mining and its Virtuous Cycle.
- Cluster Analysis: Hierarchical and Non-hierarchical techniques. Classification and Discriminant Analysis Tools: CART, Random forests, Fisher's discriminant functions and other related rules, Bayesian classification and learning rules.
- Dimension Reduction and Visualization Techniques: Multidimensional scaling, Principal Component Analysis, Chernoff faces, Sun-ray charts.
- Algorithms for data-mining using multiple nonlinear and nonparametric regression.
- Neural Networks: Multi-layer perceptron, predictive ANN model building using back-propagation algorithm. Exploratory data analysis using Neural Networks – self organizing maps. Genetic Algorithms, Neuro-genetic model building.
- Discussion of Case Studies.

Text Books /References:

- L. Breiman, J.H. Friedman, R.A. Olschen and C.J. Stone, Classification of Regresion Trees, Wadsowrth Publisher, Belmont, CA, 1984.
- D.J. Hand, H. Mannila and P. Smith, Principles of Data Minng, MIT Press,
- Cambridge, MA 2001.
- M.H. Hassoun, Fundamentals of Artificial Neural Networks, Prentice-Hall of India,
- New Delhi 1998.

- T. Hastie, R. Tibshirani & J. H. Friedman, The elements of Statistical Learning: Data Mining, Inference & Prediction, Springer Series in Statistics, Springer-Verlag, New York 2001.
- R.A. Johnson and D.W. Wichern, Applied Multivariate Analysis, Upper Saddle River, Prentice-Hall, N.J. 1998.
- S. James Press, Subjective and Objective Bayesian Statistics: Principles, Models, and Applications, 2nd Edition, Wiley, 2002.

MA 413: Graph Theory

L T P
3 1 0

- Graphs, Blocks, Paths and circuits, Trees, fundamental circuits, Connectivity, Menger's theorem, partitions, Eulerian and Hamiltonian graphs, Line graphs, tournaments, Factorization, Coverings, Directed graphs, Capacitated directed networks, Max flow-Min cut theorem, Matrices, Planar graphs, Four colour problem. Basic Diagraph Models and properties. Application to Time Tabeling, Perfect Graph, Distance in Graphs, Band width , Searching, Dynamic Graph algorithm , Algorithm on recursively constructed graphs maximum flows, minimum cost flow matching and assignment network design model.

References/Text

1. Graph theory with applications J. Bondy, Murthy U. S. R. Johnwley addition 1996.
2. Graph theory and applications N. Dev. Printeress, Hall India 2005.

MA 414: Numerical Methods for partial differential equations

L T P
3 0 1

Basic linear algebra - vector and matrix norms and related theorems. Parabolic equations in one and two space dimensions - explicit and implicit formulae. Consistency, stability and convergence. Iterative methods for linear systems. Split operator methods. Multilevel difference schemes. Nonlinear equations. Elliptic Equations - Dirichlet, Neumann and mixed problems. Direct factorization methods and successive over-relaxation (S.O.R.). ADI and conjugate gradient methods. Hyperbolic equations. First order hyperbolic systems in one and two space dimensions-stability and convergence. Second order equations in one and two space dimensions. The Galerkin method and applications.

Text: F. John; Partial Differential Equations
W. E. Williams; Partial Differential Equations
Jain, Iyengar and Jain; Computational Methods for Partial Differential Equations

MA 415: Image Processing

L	T	P
3	0	2

Catalog Description: Discrete time signals, and systems. Sampling, reconstruction, and quantization. Digital image representation. Digital image fundamentals. Image transforms. Image enhancement. Image restoration. Image segmentation and description.

Course Objectives: To provide development of skills to effectively integrate new concepts in image processing almost independently with the previous knowledge.

Course Conduct:

- The digitized image and its properties
- Data structures for image analysis
- Image pre-processing
- Segmentation
- Shape representation and description
- Mathematical morphology
- Linear discrete image transforms
- Image data compression
- Texture

Text Book:

- M. Sonka, V. Hlavac, R. Boyle, "Image Processing, Analysis, and Machine Vision".

References:

- R. C. Gonzalez, R. E. Woods, "Digital Image Processing", Addison-Wesley.
- A. K. Jain, "Fundamentals of digital Image Processing", Prentice-Hall.
- K. R. Castleman, "Digital Image Processing".
- M. Seul, "Practical Algorithms for Image Analysis: Descriptions, Examples, and Code".

MA 416 : Functional Analysis

L T P
3 1 0

- Normed Linear Spaces Fixed point theorem, Baires Category theorem, Banach Spaces, dual spaces, Hahn-Banach theorem, Open mapping and Closed graph theorems, Uniform boundedness principle; Compact operators; Hilbert Spaces; Self adjoint, normal and unitary operators; Banach Algebras.

Text/References:

- G.F. Simmons: Topology and Modern Analysis
- B. V. Limaye: Functional Analysis
- K. Yoshida : Functional Analysis , Springer

MA 417: Computational Algebraic Geometry

L T P
3 0 2

- Review of some basic commutative algebra. Then graded objects and varieties in projective space; examples (Grassmannians, curves, rational varieties, secant varieties). Use these examples to illustrate fundamental geometric constructions--tangent spaces, smoothness, dimension and degree, and even (time permitting) connections to things like fundamental forms and Gauss maps.
- Curves in the plane: rational curves, rational maps, singular points and regular local rings. Affine space: algebraic sets and Zariski topology, regular functions and maps. Rational functions, Quasiprojective varieties: rational fns, regular fns, maps between QPV's. Image of a map: image is closed, finite maps, projections, integral dependence. Dimension: Transcendence degree again, integrality, dimension of fibers of map, fun examples with Grassmannians. Smoothness, again: local ring, tangent space, tangent cone , Power series expansions and properties of smooth points, Birational maps, Normal varieties. Singularities of a map. Simplicial homology, functors, projective/injective objects. Derived functors, long exact sequence from s.e.s.; Cech cohomology), Divisors, line bundles on curves, Riemann-Roch for curves.
- Text : Shafarevich. Basic Algebraic Geometry 1, ISBN 0-387-54812-2,
- Cox-Little-O'Shea ``Ideals, varieties, and algorithms".

MA 418: Algebraic Number Theory

L T P
3 1 0

- Prerequisites: Algebra
- Algebraic number fields, Localisation, discrete valuation rings.
- Integral ring extensions, Dedekind domains, unique factorisation of ideals. Action of the galois group on prime ideals. Valuations and completions of number fields, discussion of Ostrowski's theorem, Hensel's lemma, unramified, totally ramified and tamely ramified extensions of p-adic fields.
- Discriminants and Ramification. Cyclotomic fields, Gauss sums, quadratic reciprocity revisited.
- The ideal class group, finiteness of the ideal class group, Dirichlet units theorem.

Texts / References:

- K. Ireland and M. Rosen, A Classical Introduction to Modern Number Theory, 2nd ed., Springer-Verlag, Berlin, 1990.
- S. Lang, Algebraic Number Theory, Addison- Wesley, 1970.
- D.A. Marcus, Number Fields, Springer-Verlag, Berlin, 1977.

MA 419: Wavelet Analysis

L T P
3 1 0

- The Scalable Structure of Information: The New Mathematical Engineering, Good Approximations, Wavelets: A Positional Notation for Functions, Review of linear algebra: Vector spaces, basis, dimension, linear transformations, matrices and digitalization, inner products and orthonormal bases. Wavelet Theory: Algebra and Geometry of Wavelet: Matrices, One-Dimensional Wavelet Systems, Examples of One-Dimensional Wavelet Systems, Higher Dimensional, Wavelet Systems. Wave lets on Z, Z_n, l^2(Z), Fourier series, transform and convolution on l*2.
- Wavelet Approximation and Algorithms: The Mallat Algorithm.

Text: George J. Klir**;** Wavelet Analysis and its Applications.
Y. Y. Tang; Wavelet Analysis and its Applications.

MA 420: Stochastic Process and Simulation:

L T P

3 1 0

Stochastic processes, filtrations, conditional expectations, martingales and stopping times, Brownian motion and its properties; Itô integral and its extension to wider classes of integrands, isometry and martingale properties of the integral; Itô calculus, Itô's formula and its application in calculating stochastic integrals; Stochastic differential equations, existence and uniqueness of solutions; Risk-neutral measure, Girsanov's theorem for change of measure, martingale representation theorems, representation of Brownian martingales, Feynman-Kac formula; Stock prices as geometric Brownian motions, Black-Scholes option pricing, delta hedging, derivation of the Black-Scholes differential equation, the Black-Scholes formula and simple extensions of the model; Application of Girsanov's theorem to Black-Scholes dynamics, self-financing strategies and model completeness, risk neutral measures, the fundamental theorem of asset pricing; The Black-Scholes model, the Black-Scholes option pricing formula and the market price of risk. Continuous time optimal stopping and pricing of American options.

Statistical Simulation

Introduction to S-Plus and data analysis: Financial data, random variables and their distributions, exploratory data analysis tools, kernel density estimation; Quantiles and Q-Q plots; Random generators and Monte Carlo samples; Continuous time processes: Maximum likelihood estimation (MLE) for common diffusion processes (Brownian Motion, Ornstein-Uhlenbeck, Cox-Ingersoll-Ross), approximate MLE of general diffusions, simulation of exact method for common diffusions, Euler and Milstein discretization schemes for general diffusions. Time series analysis: AR, MA, ARMA, ARCH and GARCH models; Identification, estimation and forecasting; Stochastic volatility time series models for term structure of interest rates. Multivariate Data Analysis: Multivariate normal samples, estimation, hypothesis testing, and simulation; Copulas and random simulations, examples of copulas families, fitting Copulas, Monte Carlo simulations with Copulas; Dimension reduction techniques, Principal Component Analysis. Elements of extreme value theory: Generalized extreme value (GEV) and generalized Pareto distribution (GPD); Block maxima, GPD and Hill methods; Quantile estimation with the Cornish-Fisher expansion.

Texts/References:

R. A. Carmona, *Statistical Analysis of Financial Data in S-PLUS,* Springer, 2004.
E. Zivot and J. Wang, *Modeling Financial Time Series with S-PLUS,* 2nd Edition, Springer, 2006.
P. Glasserman, *Monte Carlo Methods in Financial Engineering,* Springer, 2004.
S. Shreve, *Stochastic Calculus for Finance,* Vol. 2, Springer, 2004.
R. A. Dana and M. Jeanblanc, *Financial Markets in Continuous Time,* Springer 2001.

N. H. Bingham and R. Kiesel, *Risk Neutral Valuation,* 2nd Edition, Springer, 2004.
M. Baxter and A. Rennie, *Financial Calculus,* Cambridge University Press, 1996.
J. M. Steele, *Stochastic Calculus and Financial Applications,* Springer, 2001 T. Bjork, *Arbitrage theory in Continuous Time,* Oxford University Press, 1999.
R. J. Elliott and P. E. Kopp, *Mathematics of Financial Markets,* Springer, 1999.
P. Wilmott, *Derivatives,* Wiley, 1997.
D. Lamberton and B. Lapeyre, *Introduction to Stochastic Calculus Applied to Finance,* Chapmans & Hall/CRC, 2000.
R. Korn and E. Korn, *Option Pricing and Portfolio Optimization, Graduate Studies in Mathematics*, Vol. 31, American Mathematical Society, 2001.