Master of Science in Mathematics and Computing

2014

COURSE STRUCTURE

Semester I	L T P C
1. MA501 Analysis I	3 1 0 8
2. MA503 Ordinary Differential Equations	3 1 0 8
3. MA505 Complex Analysis	3 1 0 8
4. MA507Discrete Mathematics	3 1 0 8
5. MA511 Computer Programming	3 0 2 8
Total 40	

Semester II	L T P C
1. MA502 Analysis II	3 1 0 8
2. MA504 Partial Differential Equations	3 1 0 8
3. MA512 Data Structures and Algorithms	3 0 2 8
4. MA506Linear Algebra	3 1 0 8
5. MA508Topology	3 1 0 8
Total 40	

Semester III	L T P C
1. MA601Modern Algebra	3 1 0 8
2. MA603Functional Analysis	3 1 0 8
3. MA605 Theory of Computation	3 1 0 8
4. MA611 Numerical Analysis	3 0 2 8
5. Elective I	3 0 0 6
6. Seminar	0 0 3 3
Total 41	

Semester IV	L T P C
1. MA602Probability and Statistics	3 1 0 8
2. MA604Optimization Techniques	3 1 0 8
3. Elective II	3 0 0 6
4. Elective III	3 0 0 6
5. Project	0 0 1212
Total 40	

Total credits 161

MA501 Analysis I [3-1-0-8]

Real number system and set theory: Completeness property, Archimedian property, Denseness of rationals and irrationals, Countable and uncountable, Cardinality, Zorn's lemma, Axiom of choice. Metric spaces: Open sets, Closed sets, Continuous functions, Completeness, Cantor intersection theorem, Baire category theorem, Compactness, Totally boundedness, Finite intersection property. Functions of several variables: Differentiation, inverse and implicit function theorems. Riemann-Stieitjes integral: Definition and existence of the integral, Properties of the integral, Differentiation and integration. Sequence and Series of functions: Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation. Equicontinuity, Ascoli's Theorem.

Text:

1. Walter Rudin, Principles of Mathematical Analysis (Third edition) McGraw-Hill, Kogakusha, 1976, International Student Edition.

References:

1. H.L. Royden, Real Analysis, FourthEdition, Macmillan, 1993.
2. E. Hewitt and K. Stromberg, Real and Abstract Analysis, Springer, 1969.
3. T. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.

MA502 Analysis II [3-1-0-8]

Lebesgue measure on R^n: Introduction, outer measure, measurable sets, Lebesgue measure, regularity properties, a non-measurable set, measurable functions, Egoroff's theorem, Lusin's theorem. Lebesgue integration: Simple functions, Lebesgue integral of a bounded function over a set of finite measure, bounded convergence theorem, integral of nonnegative functions, Fatou's Lemma, monotone convergence theorem, the general Lebesgue integral, Lebesgue convergence theorem, change of variable formula. Differentiation and integration: Functions of bounded variation, differentiation of an integral, absolutely continuity, L^p-spaces: The Minkowski's inequality and Hölder's inequality, completeness of L^p, denseness results in L^p. Fourier series: Definition of Fourier series, formulation of convergence problems, The L^2 theory of Fourier series, convergence of Fourier series.

Text:

1. Walter Rudin, Principle of Mathematical Analysis (Thirdedition) McGraw-Hill Kogakusha, International Student Edition, 1976.

References:

1. H.L. Royden, Real Analysis, FourthEdition, Macmillan, 1993.
2. P. R. Halmos, Measure Theory, Van Nostrand, 1950.
3. G. de Barra, Measure Theory and Integration, Wiley Eastern, 1981.
4. E. Hewitt and K. Stromberg, Real and Abstract Analysis, Springer, 1969.
5. P. K. Jain and V. P. Gupta, Lebesgue Measure and Integration, New Age International, New Delhi, 2000.
6. R. G. Bartle, The Elements of Integration, John Wiley, 1966.

MA503 Ordinary Differential Equations [3-1-0-8]

Review of fundamentals of Differential equations (ODEs); Existence and uniqueness theorems, Power series solutions.

Higher Order Linear Equations and linear Systems: fundamental solutions, Wronskian, variation of constants, matrix exponential solution, behaviour of solutions.

Two Dimensional Autonomous Systems and Phase Space Analysis: critical points, proper and improper nodes, spiral points and saddle points.

Asymptotic Behavior: stability (linearized stability and Lyapunov methods).

Boundary Value Problems for Second Order Equations: Green's function, Sturm comparison theorems and oscillations, eigenvalue problems.

Texts:

1. E. A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, Tata McGraw Hill, 1990.
2. S. L. Ross, Differential Equations, 3rd Edn., Wiley India, 1984.

References:

1. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
2. F. Brauer and J. A. Nohel, The Qualitative Theory of Ordinary Differential Equations: An Introduction, Dover Publications, 1969.

MA504 Partial Differential Equations [3-1-0-8]

Cauchy Problems for First Order Hyperbolic Equations: method of characteristics, Monge cone. Classification of Second Order Partial Differential Equations: normal forms and characteristics. Initial and Boundary Value Problems: Lagrange-Green's identity and uniqueness by energy methods. Stability theory, energy conservation and dispersion. Laplace equation: mean value property, weak and strong maximum principle, Green's function, Poisson's formula, Dirichlet's principle, existence of solution using Perron's method (without proof). Heat equation: initial value problem, fundamental solution, weak and strong maximum principle and uniqueness results. Wave equation: uniqueness, D'Alembert's method, method of spherical means and Duhamel's principle.

Texts:

1. I. N. Sneddon, Elements of Partial Differential Equations, Dover Publications, 2006.
2. F. John, Partial Differential Equations, Springer, 1982.

Reference:

1. S. J. Farlow, Partial Differential Equations for Scientists and Engineers, Dover Publications, 1993.

MA505 Complex Analysis [3-1-0-8]

Review of complex numbers; Analytic functions, harmonic functions, elementary functions, branches of multiple-valued functions, conformal mappings, bilinear transformation; Complex integration, Cauchy's integral theorem, Cauchy’s integral formula, higher order derivatives, Morera’s theorem, Cauchy’s inequality and Liouville’s theorem, maximum-modulus theorem; Power series, Taylor's theorem and analytic continuation, zeros of analytic functions, open mapping theorem; Singularities, Laurent's theorem, Casorati-Weierstrass theorem, argument principle, Rouche's theorem, residue theorem and its applications in evaluating real integrals.

Texts:

1. R.V. Churchill and J.W. Brown, Complex Variables and Applications, 5th edition, McGraw Hill, 1990.
2. J. H. Mathews and R. W. Howell, Complex Analysis for Mathematics and Engineering, 3rd edition, Narosa, 1998.

References:

1. L. V. Ahlfors, Complex Analysis, 3rd Edn., McGraw Hill, 1979.
2. D. Sarason, Complex function theory, 2nd Edn., Hindustan book agency, 2007.
3. J.B. Conway, Functions of One Complex Variable, 2nd Edn.,Narosa, 1973.

MA506 Linear Algebra [3-1-0-8]

Systems of linear equations, vector spaces, bases and dimensions, change of bases and change of coordinates, sums and direct sums, spanning sums and independence, Quotient space; Linear transformations, matrix representations of linear transformations, the rank and nullity theorem; Dual spaces, second dual, transposes of linear transformations; trace and determinant, eigenvalues and eigenvectors, invariant subspaces, generalized eigenvectors; Cyclic subspaces and annihilators, the minimal polynomial, the Jordan canonical form; Inner product spaces, orthonormal bases, Gram-Schmidt process; Adjoint operators, normal, unitary, and self-adjoint operators, Schur's theorem, spectral theorem for normal operators.

Text:

1. K. Hoffman and R. Kunze, Linear Algebra, Prentice Hall of India, 1996.

References:

1. G. Schay, Introduction to Linear Algebra, Narosa, 1997.
2. G. Strang, Linear Algebra and Its applications, Nelson Engineering, 4th Edn., 2007.
3. Sernesi E., Linear Algebra, CRC Press, 1993.
4. Knop Larry E., Linear Algebra, CRC Press, 2008.

MA507 Discrete Mathematics [3-1-0-8]

Set Theory - sets and classes, relations and functions, recursive definitions, posets, Zorn’s lemma, cardinal and ordinal numbers; Logic - propositional and predicate calculus, well-formed formulas, tautologies, equivalence, normal forms, theory of inference. Combinatorics-permutation and combinations, partitions, pigeonhole principle, inclusion-exclusion principle, generating functions, recurrence relations. Graph Theory - graphs and digraphs, Eulerian cycle and Hamiltonian cycle, adjacency and incidence matrices, vertex colouring, planarity, trees.

Texts:

1. J.P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw Hill, New Delhi, 2001.
2. C. L. Liu, Elements of Discrete Mathematics, 2nd Edn., Tata McGraw-Hill, 2000.

References:

1. K. H. Rosen, Discrete Mathematics & its Applications, 6th Edn., Tata McGraw-Hill, 2007.
2. V. K. Balakrishnan, Introductory Discrete Mathematics, Dover, 1996.
3. J. L. Hein, Discrete Structures, Logic, and Computability, 3rd Edn., Jones and Bartlett, 2010.
4. N. Deo, Graph Theory, Prentice Hall of India, 1974.
5. Garnier Rowan, John Taylor, Discrete Mathematics, CRC Press, 2010.

MA508 Topology [3-1-0-8]

Topological spaces, Basis for a topology, The order topology, Subspace topology, Closed sets. Countability axioms, Limit points, Convergence of nets in topological spaces, Continuous functions, The product topology, Metric topology, Quotient topology. Connected spaces, Connected sets in R, Components and path components, Compact spaces, Compactness in metric spaces, Local compactness, One point compactification. Separation axioms, Uryshon's lemma, Uryshon'smetrization theorem, Tietz extension theorem. The Tychonoff theorem, Completely regular spaces, Stone -Czech compactification.

Text:

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

References:

1. J. L. Kelley, General Topology, Van Nostrand, 1995.
2. K. D. Joshi, Introduction to General Topology, Wiley Eastern, 1983.
3. James R. Munkres, Topology, Second Edition, Pearson International, 2000.
4. J. Dugundji, Topology, Prentice-Hall of India, 1966.
5. S. Willard, General Topology, Addison-Wesley, 1970.
6. N. Bourbaki, General Topology, Part I, Addison-Wesley, 1966.

MA511 Computer Programming [3-0-2-8]

Introduction - the von Neumann architecture, machine language, assembly language, high level programming languages, compiler, interpreter, loader, linker, text editors, operating systems, flowchart; Basic features of programming (Using C) - data types, variables, operators, expressions, statements, control structures, functions; Advance programming features - arrays and pointers, recursion, records (structures), memory management, files, input/output, standard library functions, programming tools, testing and debugging; Fundamental operations on data - insert, delete, search, traverse and modify; Fundamental data structures - arrays, stacks, queues, linked lists; Searching and sorting - linear search, binary search, insertion-sort, bubble-sort, selection-sort; Introduction to object oriented programming. Programming laboratory will be set in consonance with the material covered in lectures. This will include assignments in a programming language like C and C++ in GNU Linux environment.

Text:

1. A. Kelly and I. Pohl, A Book on C, 4th Ed., Pearson Education, 1999.

References:

1. H. Schildt, C: The Complete Reference, 4th Ed., Tata Mcgraw Hill, 2000.
2. B. Kernighan and D. Ritchie, The C Programming Language, 2nd Ed., Prentice Hall of India, 1988.
3. B. Gottfried and J. Chhabra, Programming With C, Tata Mcgraw Hill, 2005.

MA512 Data Structures and Algorithms [3-0-2-8]

Asymptotic notation; Sorting - merge sort, heap sort, priortiy queue, quick sort, sorting in linear time, order statistics; Data structures - heap, hash tables, binary search tree, balanced trees (red-black tree, AVL tree); Algorithm design techniques - divide and conquer, dynamic programming, greedy algorithm, amortized analysis; Elementary graph algorithms, minimum spanning tree, shortest path algorithms. Programming laboratory will be set in consonance with the material covered in lectures. This will include assignments in a programming language like C and C++ in GNU Linux environment.

Text:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, 2nd Ed.,Prentice-Hall of India, 2007.

References:

1. M. T. Goodrich and R. Tamassia, Data Structures and Algorithms in Java, Wiley, 2006.
2. A.V. Aho and J. E. Hopcroft, Data Structures and Algorithms, Addison-Wesley, 1983.
3. S. Sahni, Data Structures, Algorithms and Applications in C++, 2nd Ed., Universities Press, 2005.

MA601 Modern Algebra [3-1-0-8]

Groups, subgroups, normal subgroups, quotient groups and homomorphism; Group actions, Sylow theorems; p-group, Solvable and nilpotent groups; Rings, ideals and quotient rings, Euclidean domain, Principal ideal domians and unique factorization domains, maximal, prime and principal ideals; Euclidean and polynomial rings; Modules; Field extensions, Finite fields.

Text:

1. D. Dummit and R. Foote, Abstract Algebra, Wiley, 2004.

References:

1. I. N. Herstein, Topics in Algebra, Wiley, 2008.
2. J. Fraleigh, A First Course in Abstract Algebra, Pearson, 2003.
3. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, 1995.
4. Paulsen William, Abstract Algebra, Taylor & Francis, 2011.
5. H. Jonathan K., S. Steven and Sundstrom Ted, Abstract Algebra, CRC Press, 2011.

MA602 PROBABILITY THEORY [3-1-0-8]

Axiomatic definition of probability, probability spaces, probability measures on countable and uncountable spaces, conditional probability, independence; Random variables, distribution functions, probability mass and density functions, functions of random variables, standard univariate discrete and continuous distributions and their properties; Mathematical expectations, moments, moment generating functions, characteristic functions, inequalities; Random vectors, joint, marginal and conditional distributions, conditional expectations, independence, covariance, correlation, standard multivariate distributions, functions of random vectors; Modes of convergence of sequences of random variables, weak and strong laws of large numbers, central limit theorems; Introduction to stochastic processes, definitions and examples.

Texts:

1. J. Jacod and P. Protter, Probability Essentials, Springer, 2004.
2. V. K. Rohatgi and A. K. Md. E. Saleh, An Introduction to Probability and Statistics, 2nd Edn., Wiley, 2001.

References:

1. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2000.
2. G. R. Grimmett and D. R. Stirzaker, Probability and Random Processes, 3rd Edn., Oxford University Press, 2001.
3. S. Ross, A First Course in Probability, 6th Edn., Pearson, 2002.
4. W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Edn., Wiley, 1968.
5. J. Rosenthal, A First Look at Rigorous Probability Theory, 2nd Edn., World Scientific, 2006.

MA603 Functional Analysis [3-1-0-8]

Normed linear spaces, Banach spaces; Continuity of linear maps, Hahn-Banach theorem, open mapping and closed graph theorems, uniform boundedness principle; Duals and transposes, weak and weak* convergence, reflexivity; Spectra of bounded linear operators, compact operators and their spectra; Hilbert spaces, bounded linear operators on Hilbert spaces, orthonormal bases, Riesz representation theorem; Adjoint operators, normal, unitary, self-adjoint operators and their spectra, spectral theorem for compact self-adjoint operators.

Texts:

1. B. V. Limaye, Functional Analysis, 2nd edition, Wiley Eastern, 1996.
2. E. Kreyszig, Introduction to Functional Analysis with Applications, John Wiley and Sons, 1978.

Reference:

1. J.B. Conway, A Course in Functional Analysis, Springer, 1990.

MA604 Optimization Techniques [3-1-0-8]

Mathematical foundations and basic definitions: concepts from linear algebra, geometry, and multivariable calculus. Linear optimization: formulation and geometrical ideas of linear programming problems, simplex method, revised simplex method, duality, sensitivity snalysis, transportation and assignment problems. Nonlinear optimization: basic theory, method of Lagrange multipliers, Karush-Kuhn-Tucker theory, convex optimization. Numerical optimization techniques: line search methods, gradient methods, Newton's method, conjugate direction methods, quasi-Newton methods, projected gradient methods, penalty methods.

Texts:

1. N. S. Kambo, Mathematical Programming Techniques, East West Press, 1997.
2. E.K.P. Chong and S.H. Zak, An Introduction to Optimization, 2nd Ed., Wiley, 2010.

References:

1. R. Fletcher, Practical Methods of Optimization, 2nd Ed., John Wiley, 2009.

2. D. G. Luenberger and Y. Ye, Linear and Nonlinear Programming, 3rd Ed., Springer India, 2010.
3. M. S. Bazarra, J.J. Jarvis, and H.D. Sherali, Linear Programming and Network Flows, 4th Ed., 2010. (3nd ed. Wiley India 2008).
4. U. Faigle, W. Kern, and G. Still, Algorithmic Principles of Mathematical Programming, Kluwe, 2002.
5. D.P. Bertsekas, Nonlinear Programming, 2nd Ed., Athena Scientific, 1999.
6. M. S. Bazarra, H.D. Sherali, and C. M. Shetty, Nonlinear Programming: Theory and Algorithms, 3rd Ed., Wiley, 2006. (2nd Edn., Wiley India, 2004).

MA605 Theory of Computation [3-1-0-8]

Alphabets, languages, grammars; Finite automata, regular languages, regular expressions; Context-free languages, pushdown automata, DCFLs; Context sensitive languages, linear bounded automata; Turing machines, recursively enumerable languages; Operations on formal languages and their properties; Chomsky hierarchy; Decision questions on languages; NP-Completeness.

Texts:

1. M. Sipser, Introduction to the Theory of Computation, Thomson, 2004.
2. H. R. Lewis and C. H. Papadimitriou, Elements of the Theory of Computation, PHI, 1981.

References:

1. J. E. Hopcroft and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, Narosa, 1979.
2. Peter Linz, An Introduction to Formal Languages and Automata, Narosa, 2007.
3. D. C. Kozen, Automata and Computability, Springer-Verlag, 1997.
4. D. S. Garey and G. Johnson, Computers and Intractability: A Guide to the Theory of NP-Completeness, Freeman, New York, 1979.

MA611 Numerical Analysis [3-0-2-8]

Definition and sources of errors, solutions of nonlinear equations; Bisection method, Newton's method and its variants, fixed point iterations, convergence analysis; Newton's method for non-linear systems; Finite differences, polynomial interpolation, Hermite interpolation, spline interpolation; Numerical integration - Trapezoidal and Simpson's rules, Gaussian quadrature, Richardson extrapolation; Initial value problems - Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, multistep methods and stability; Boundary value problems - finite difference method, collocation method.

Texts:

1. D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, 3rd Edn., AMS, 2002.
2. K. E. Atkinson, Introduction to Numerical Analysis, 2nd Edn., John Wiley, 1989.

References:

1. S. D. Conte and Carl de Boor, Elementary Numerical Analysis - An Algorithmic Approach, 3rd Edn., McGraw Hill, 1980.

LIST OF ELECTIVES:

MA621 Number Theory and Cryptography [3-0-0-6]

Congruence, Chinese Remainder Theorem, Primitive Roots, Quadratic reciprocity, Finite fields, Arithmetic functions Primality Testing and factorization algorithms, Pseudo-primes, Fermat?s pseudo-primes, Pollard?s rho method for factorization, Continued fractions, Continued fraction method Hash Functions, Public Key cryptography, Diffie-Hellmann key exchange, Discrete logarithm-based crypto-systems, RSA crypto-system, Signature Schemes, Digital signature standard, RSA Signature schemes, Knapsack problem. Introduction to elliptic curves, Group structure, Rational points on elliptic curves, Elliptic Curve Cryptography. Applications in cryptography and factorization, Known attacks.

Texts/References:

1. N. Koblitz, A Course in Number Theory and Cryptography, Springer 2006.
2. I. Niven, H.S. Zuckerman, H.L. Montgomery, An Introduction to theory of numbers, Wiley, 2006.
3. L. C. Washington, Elliptic curves: number theory and cryptography, Chapman & Hall/CRC, 2003.

MA622 Cryptography [3-0-0-6]

Cryptanalysis; Shannon's Theory; Block Cipher: Data Encryption Standard, Advanced Encryption Standard, Linear and Differential Cryptanalysis; Primality Tests, Factoring Integers, Discrete Logarithm Problem; Public Key Cryptosystem: RSA; Cryptographic Hash Functions; Key Distribution and Key Agreement; Signature Schemes.

Texts/References:

1. Douglas R. Stinson, Cryptography: Theory & Practice, Second Edition, CRC Press, 2002.
2. Alfred J. Menezes, Paul C. Van Oorschot and Scott A. Vanstone, Handbook of Applied Cryptography, CRCPress, 2001.
3. Johannes. A. Buchmann, Introduction to Cryptography, Springer, September 2000.

MA631 Graph Theory [3-0-0-6]

Isomorphism, incidence and adjacency matrices, Sperner lemma, Trees, Cayley formula, connector problem, connectivity, constructing reliable communication network, Euler tours, Hamilton cycle, Chinese postman and traveling salesman problems, matchings and coverings, perfect matchings, edge colouring, Vizing Theorem, time table problem, Independent sets, Ramsey theorem, Turan theorem, Schur theorem, vertex colouring, Brook theorem, Hajos conjecture, chromatic polynomials, storage problem, planarity, dual graphs, Euler formula, Kuratowski theorem, five colour theorem, history of four colour theorem, nonhamiltonian planar graphs, planarity algorithm, directed graphs, job sequencing, one way road system, ranking participants in tournaments.

Texts:

1. J. A. Bondy and U. S. R. Murty. Graph Theory with Applications. North-Holland, 1976.
2. J. M. Aldous. Graphs and Applications. Springer, LPE, 2007

MA641 Operator Theory in Hilbert Spaces [3-0-0-6]

Review of Hilbert spaces, orthonormal bases, weak convergence; Bounded operators on Hilbert spaces, adjoints of bounded operators, algebra of bounded operators; Orthogonal projections, isometric and unitary operators, finite rank and compact operators, Hilbert-Schmidt operators, selfadjoint and normal operators; Spectra of bounded operators, invariant and reducing subspaces; Spectral theorem for compact operators, polar and singular value decompositions, Schatten class operators; Spectral theorem for bounded selfadjoint and normal operators.

Texts/References:

1. J. B. Conway, A course in Functional Analysis, 2nd Edn., Springer-Verlag, 1990.
2. J. Weidmann, Linear Operators in Hilbert Spaces, Springer-Verlag, 1980.
3. G. Helmberg, Introduction to Spectral Theory in Hilbert Space, North-Holland, 1975.
4. B. V. Limaye, Functional Analysis, 2nd edition, New Age International, New Delhi, 1996.

MA642 Wavelets and Applications [3-0-0-6]

Reviews of Fourier analysis and LP spaces. Wavelets and atomic decomposition of functions, Multiresolution signal decomposition, Multiresolution 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, Applications of wavelets in image and signal processing.

Software Support: MATLAB, MATHEMATICA

Texts/References:

1. Y. Meyer, Wavelets: Algorithm and Application , SIAM, 1993.
2. E. Aboufadel and S. Schlicker, Discovering Wavelets , John Wiley and Sons, 1999.

G. Kaiser, A Friendly Guide to Wavelets, Birkhauser, 1994.

MA651 Parallel Computing [3-0-0-6]

Scope of Parallel Computing - limits to parallelizability, NC-reductions, P-completeness; parallel programming platforms; parallel algorithm design - decomposition, task and ineractions; communication models - synchronous and asynchronous; analytical modeling of parallel programs; programming using message passing paradigm and shared address space - threads, MPI, unstructured communications; parallel algorithms and applications - matrix algorithms, sorting, graph algorithms and discrete optimization problems.

Texts:

1. A. Grama, G. Karypis, V. Kumar, A. Gupta. Introduction to parallel computing. Addison-Wesley, 2003.
2. J. Ja'Ja'. An introduction to parallel algorithms. Addison-Wesley, 1992

References:

1. R. Greenlaw, H. J. Hoover, W. L. Ruzzo. Limits to parallel computation. Oxford University Press, 1995

MA661 Fluid Dynamics [3-0-0-6]

Review of gradient, divergence and curl. Elementary idea of tensors. Velocity of fluid, Streamlines and path lines, Steady and unsteady flows, Velocity potential, 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. 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

Texts/References:

1. N. Curle and H. Davies, Modern Fluid Dynamics, Van Nostrand Reinhold, 1966.
2. L. M. Milne Thomson, Theoretical Hydrodynamics, Macmillan and Co., 1960.
3. G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press, 1993.
4. F. Chorlton, A Text Book of Fluid Dynamics, Von Nostrand Reinhold/CBS, 1985.
5. A. R. Patterson, A First Course in Fluid Dynamics, Cambridge University Press, 1992.

MA662 Mathematical Modelling and Numerical Simulation [3-0-0-6]

Model and its different types, Finite models, Statistical models, Stochastic models, Formulation of a model, Laws and conservation principles, Discrete and continuous models, Manipulation into its most respective form, Evaluation of a model. Case studies, Continuum model, Transport phenomena, Diffusion and air pollution models, Microwave heating, Communication and Information technology.

Software Support : MATHEMATICA, LSODE, GNUPLOT, MATLAB.

Texts/References:

1. R. Aris, Mathematical Modelling Techniques, Dover, 1994.
2. C. L. Dym and E. S. Ivey, Principles of Mathematical Modelling, Academic Press, 1980.
3. M. S. Klamkin, Mathematical Modelling: Classroom Notes in Applied Mathematics, SIAM, 1986.
4. A. Friedman and W. Littman, Industrial Mathematics for Undergraduates, SIAM, 1994.
5. Y. C. Fung, A First Course in Continuum Mechanics, Prentice Hall, 1969.
6. E. N. Lightfoot, Transport Phenomenon and Living Systems, Wiley, 1974.
7. M. Braun, C. S. Coleman and D. A. Drew, Differential Equation Models, Modules in Applied Mathematics, Volume1, Springer Verlag, 1978.

MA671 Mathematical Methods [3-0-0-6]

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, Z-transform, Hankel transform, Mellin transform. Solution of differential equation by Laplace and Fourier transform methods.

Texts/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

MA681 Differential Geometry of Manifolds [3-0-0-6]

Definition and examples of differentiable manifolds.Tangent spaces.Jacobian map.One parameter group of transformations. Lie derivatives. Immersion and imbeddings.Distributions.Exterior Algebra.Exterior derivative. Riemannian manifolds. Riemannian Connection.Curvature tensors.Sectional curvature.Schur’s theorem.Geodesics.Projective curvature tensor.Conformal curvature tensor.Semi-symmetric connections. Submanifolds and Hypersurfaces.Normals.Gauss’s formula.Weingarten equations.Lines of curvature.Generalized Gauss and Mainardi-Codazzi equations.

Text:

1. R. S. Mishra, Structures on a Differentiable Manifold and Their Applications, ChandramaPrakashan, Allahabad, 1984.

References:

1. Y. Matsushima, Differentiable Manifolds, Marcel Dekker, 1972.
2. B. B. Sinha, An Introduction to Modern Differential Geometry, KalyaniPrakashan, New Delhi, 1982.
3. K. Yano and M. Kon, Structure of Manifolds, World Scientific, 1984.

SYLLABUS FOR ONE SEMESTER PRE-PH. D. COURSE WORKS FOR MATHEMATICS

Common subject to all streams

SL	Name of the Subject	Subject Code	Credit
1	**RESEARCH METHODOLOGY**	Hss701	6

ELECTIVE PAPERS

Mathematics

SL	Name of the Subject	Subject Code	Credit
1	Introduction to Analytic Number Theory and Algebraic Number Fields	MA701	6
2	Number Theory	MA702	6
3	Linear Algebra and Functional Analysis	MA703	6
4	Real and Complex Analysis	MA704	6
5	Measure Theory	MA705	6
6	Differential Equations and Boundary-Value Problems	MA706	6
7	Theory of Partial Differential Equations	MA707	6
8	Advance Real Analysis	MA708	6
9	Topology	MA709	6
10	Fixed Point Theory	MA710	6

Detailed Syllabus

1. MA701Introduction to Analytic Number Theory and Algebraic Number Fields[3 0 0 6]

Arithmetic functions, Elementary theorems on distribution of prime numbers, Dirichlet's Theorem on primes in arithmetic progressions, Dirichlet series and Euler products, Zeta functions, Prime number theorem.

Number fields and Number rings, Prime decomposition in number rings, The ideal class group and the unit group, Dedekind zeta function and the class number formula, The distribution of primes and class field theory.

Texts:

1. Apostol, T.M., Introduction to Analytic Number Theory, UTM, Springer, 1976.
2. Marcus, D. A., Number Fields, Springer Verlag, 1977.
3. Janusz G.J. , Algebraic Number Fields, GSM, Vol-7 (2nd Ed.) AMS, 1996.

2. MA702 Number Theory[3 0 0 6]

Congruences: linear and polynomial congruences; prime numbers: counting primes, numbers of special forms, pseudo-primes and primality testing; factorization: factorization algorithms; arithmetic functions: multiplicative and additive functions, Euler's phi function, sum and number of divisors functions, the Mobius function and other important arithmetic functions, Dirichlet products; primitive roots and quadratic residues: primitive roots, index arithmetic, quadratic residues, modular square roots; Diophantine equations: linear Diophantine equations, Pythagorean triples, Fermat's last theorem, Tell's, Bachet's and Catalan's equations, sums of squares and Waring'sproblem; Diophantine approximations: continued fractions, convergent, approximation theorems; quadratic fields: primes and unique factorization.

References:

1. Kenneth H. Rosen, J.G. Michaels, J.L. Gross, J.W. Grossman, D.R. Shier, Handbook of Discrete and Combinatorial Mathematics, CRC Press, 1999
2. I. Niven, H.S. Zuckerman, H.L. Montgomery, An Introduction to the Theory of Numbers, Wiley, 1991.
3. K. Chandrasekaran, An Introduction to Analytic Number Theory, Springer, 1968.

3. MA703 Linear Algebra and Functional Analysis[3 0 0 6]

Linear algebra: Eigenvalues and eigenvectors, Gerschgorin disk theorem, Schur theorem, Spectral theorems for normal and Hermitian matrices. Jordan canonical form, Application of Jordan canonical form, Minimal polynomial,Companion matrices, Functions of matrices. Variational characterizations of eigenvalues of Hermitian matrices, Rayleigh-Ritz theorem, Courant-Fischer theorem, Weyl theorem, Cauchy interlacing theorem, Inertia and congruence, Sylvester's law of inertia. Matrix norms, Positive semidefiniteness, Singular value decomposition, Polar decomposition, Schur and Kronecker products.

Functional Analysis: Review of normed spaces. The open mapping and closed graph theorems, Uniform boundedness principle. Dual spaces, Hahn-Banach extension theorem, Weak and Weak-star topologies.Alaoglu theorem. Compact operators, Riesz theory for compact operators, Spectral theory for compact operators. Review of Hilbert spaces, Properties of selfadjoint and normal operators, Spectral theory of selfadjoint operators.

Texts/References:

1. R. A. Horn and C. R. Johnson, Matrix Analysis, CUP, 1985.
2. P. Lancaster and M. Tismenetsky, The Theory of Matrices, second ed., Academic Press, 1985.
3. F. R. Gantmacher, The Theory of Matrices, Vol-I, Chelsea, 1959.
4. B. V. Limaye, Functional Analysis, 2 nd ed., New Age International, 1996.
5. F. Riesz and B. Nagy, Functional Analysis, Dover, 1990.

4. MA704 Real and Complex Analysis [3 0 0 6]

Real Analysis: Functions of several variables. limit and continuity, partial and directional derivatives, total derivatives, inverse and implicit function theorems, open mapping theorem, rank theorem. Topological spaces, bases, sequences and nets, continuous functions, homeomorphisms; metric spaces: connectedness, pathwise connectedness and locally connectedness, compactness and local compactness, countability and separation axioms. Urysohn's lemma, Tietze's extension theorem, metrizability and Urysolm's theorem, compactness and completeness in metric spaces.

Complex Analysis: Analytic functions, elementary functions and mapping properties, conformal mappings, branches of multiple-valued functions. mapping properties of multiple-valued functions. Complex integration, Cauchy's theorem (homotopy version).Cauchy's integral formula, theorems of Morera and Lionville.maximum-modulus theorem. Power series.Taylor's theorem and analytic continuation, zeros of analytic functions, Hurwitz theorem.Singularities, Laurent's theorem.Casorati-Weierstrass theorem, winding number, argument principle, theorems of Rouche and Gauss-Lucas, residue theorem and its applications, Schwarz Lenima.

Texts/References:

1. W. Rudin, Principles of Mathematical Analysis, 3rd Edition, McGraw Hill, 1976.
2. C. D. Aliprantis and 0. Burkinshaw, Principles of Real Analysis, 3rd Edition, Academic Press, 1998.
3. G. F. Simmons. Introduction to Topology and Modern Analysis, McGraw Hill, 1963.
4. R. Munkres, Topology-A First Course, Prentice Hall of India, 1998.
5. L. V. Althors. Complex Analysis. 3rd Edition, McGraw Hill, 1978.
6. R. A. Silverman. Complex Analysis with Applications, Dover. 1974.

5. MA705 Measure Theory[3 0 0 6]

Fields and a-fields, generators; Borel a-field on Euclidean, metric and general topological spaces. Monotone classes, monotone class theorem. Finitely additive measures.Measures, finite and a-finite measures.Borel measures, regularity. Outer measures; Caratheodory's extension theorem.Lebesgue measure in Euclidean spaces. Distribution functions. Measurable functions and their properties.Induced measures.a-fields generated by classes of functions; Monotone class theorem for functions. Integrability of functions.Lebesgue integrals and their properties.Fatou's lemma, monotone convergence theorem, dominated convergence theorem. Finite-dimensional product measurable spaces and measures on them.Product measures.Fubini's Theorem.Holder's. Minkowski's and Jensen 's inequalities. LP spaces; Characterizations of compact, precompact sets in LP spaces.Complex-valued measurable and integrable functions. Fourier transforms of finite measures on the real line and inversion formulae. Signed and complex-valued measures.Absolute continuity and singularity of measures.Lebesgue's differentiation theorem.Hahn decomposition theorem.Radon-Nikodym Theorem.Lebesgue decomposition theorem.Spaces of measures.Weak convergence.Helly's Theorem. Measures on locally compact spaces.Radon measures; Riesz representation theorem.

Texts/References:

1. Donald L. Cohn. Measure Theory. Birkhauser Boston, 1993.
2. M. M. Rao, Measure Theory and Integration. Marcel Dekker (Monographs and Textbooks in Pure and Applied Mathematics. 265), 2004.
3. Walter Rudin. Real and Complex Analysis. 3rd ed. McGraw-Hill, 1987.

6. MA706 Differential Equations and Boundary-Value Problems[3 0 0 6]

Existence and uniqueness of solutions of ODEs, power series solution, singular points, some special functions. Nonlinear system of ODE : Preliminary concepts and definitions, the fundamental existence-uniqueness results, dependence on initial conditions and parameters, the maximum interval of existence, linearlization, stability and Liapunov functions, saddle, nodes, foci and centers, normal form theory and Hamiltonian systems. Boundary value problems : Green's function method, Sturm-Liouville problem. First-order PDEs, Cauchy problem, method of characteristics, Second-order PDEs, classification, characteristics and canonical forms. Elliptic boundary value problems : Maximum principle, Green's function, Sobolev spaces, variational formulations, weak solutions, Lax-Milgram theorem, trace theorem, Poincare inequality, energy estimates, Fredholm alternative, regularity estimates, system of conservation laws, entropy criteria.

Texts/References:

1. L. Perko, Differential Equations and Dynamical Systems, Springer, 2001.
2. J. Guckenheimer, P. Holmes, Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields, Springer-Verlag, New York, 1983.
3. S. Wiggins, Introduction to Applied Nonlinear Dynamical Systems and Chaos, Springer-Verlag, New York, 1990
4. Lawrence C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, American Mathematical Society, Providence, 1998
5. Robert C. McOwen, Partial Differential Equations - Methods and Applications, Pearson Education Inc., Indian Reprint 2004.
6. S.J. Farlow, Partial Differential Equations for Scientists and Engineers, Dover Publications,New York, 1982.

7. MA707 Theory of Partial Differential Equations[3 0 0 6]

Review of Sobolev spaces. weak solutions, eigenvalues and eigenfunctions of symmetric and non-symmetric elliptic operators. evolution equations, existence of weak solutions, maximum principle, interior and boundary regularities. Nonlinear elliptic equations: Nonlinear variational problems. first and second variations, existence of minimizers, nonlinear eigenvalue problems. Nonvariational techniques: monotonicity methods, fixed point methods, Nemytskii and pseudo-nRinotone operators. geometric properties of solutions. radial symmetry. Hamilton Jacobi equations: viscosity solutions, uniqueness, control theory, Hamilton-Jacobi-Bellman equations. Semigroup methods: Strongly continuous semigroups, infinitesimal generator, Hille-Yosida theorem, applications to wave and Schrodinger equations, analytic semigroups and their generators. Energy methods for evolution problems. System of conservation laws: Riemann's problem: simple waves, rarefraction waves, shock waves, contact discontinuities, local solution of Riemann's problem, vanishing viscosity, traveling waves, entropy/entropy-flux pairs.

Texts/References:

1. Lawrence C. Evans, Partial Differential Equations, Graduate Studies in Mathmatics, Vol.19. American Mathematical Society. Providence, 1998.
2. D. Gilberg, N.S. Trudinger, Elliptic Partial Differential Equations of Second Order, Springer-Verlag, New York. 1983.
3. A. Pazy, Sentigroup,s of Linear Operators and Applications to Partial Differential Equations, Springer-Verlag, New York, 1983.
4. M. Renardy, B.C. Rogers. An Introduction to Partial Differential Equations, Springer, New York, 1993.
5. O.A. Ladyzhenskaya. N.N. Uraltseva, Linear and Quasilinear' Elliptic Equations, Academic Press, 1968.
6. P.-L. Lions. Generalized Solutions of Hamilton-Jacobi Equations, Research Notes in Mathematics 69, Pitman, 1982.
7. P. Lax, Hyperbolic Systems of Conservation Laws and Mathematical Theory of Shock Waves, SIAM, 1973.

8. MA708 Advanced Real Analysis[3 0 0 6]

Metric space: Metric space, Open set closed set, neighbourhood, convergence, Cauchy sequence, completeness, completeness proofs, completion of metric space, compactness. Normed space: Vector space, normed space, Banach space, properties of normed space, finite dimensional normed spaces and subspaces, compactness and finite dimension, linear operators, boundedness and continuous linear operators, linear functional, linear operators and functionals in finite dimensional. Uniform space: Uniformities and basic definitions, metrisation, completeness and compactness.

Texts/References:

1. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons. 1989.
2. K. D. Joshi, Introduction to General Topology, Wiley Eastern Limited. 1983.

9. MA709 Topology[3 0 0 6]

Topological spaces: Definition of a topological space, examples of topological spaces, bases and sub-bases, subspaces. Closed sets and closure, neighbourhood, interior and accumulation points, continuity, quotient spaces, connectedness, separation axioms. Product and coproducts: Cartesian products of family of sets, product topology, productive properties, countably productive properties. Embedding and metrisation: Evaluation functions into products, embedding lemma and Tychonoff embedding, Urysohnmetrisation theorem.

Texts/References:

1. K. D. Joshi, Introduction to General Topology, Wiley Eastern Limited. 1983.
2. J. Dugundji, Topology, Prentice Hall. 1975.
3. J. L. Kelley, General Topology, Princeton. 1955.
4. J. R. Munkers, Topology-A First Course, prentice Hall, New Delhi. 1978.

10. MA710 Fixed Point Theory [3 0 0 6]

Fixed point theorems: Banach contraction principle and its generalisation, nonexpansive mappings, fixed point theorems of Brouwer and Schauder, fixed point theorems of multifunctions, common fixed point theorems, sequences of contractions and fixed points, fixed point theorems in ordered Banach spaces.Probabilistic functional analysis: Probabilistic concepts, random operators, random fixed point theorems, random operator equations involving monotone operators. Applications of fixed point theorems: Applications of fixed point theorems in differential equations, integral equations.

Texts/References:

1. M. C. Joshi and R. K. Bose, Some topics in nonlinear functional analysis, Wiley Eastern Limited. 1985.