COURSE STRUCTURE AND SYLLABI

5-yr INTEGRATED M. Sc. in Mathematics

Semester-I to Semester-X
(Mathematics)

DEPARTMENT OF MATHEMATICAL SCIENCES
TEZPUR UNIVERSITY
Updated: 2011

COURSE STRUCTURE

FIRST SEMESTER

Course No.	Name	L-T-P	CH	CR
PI 101	Physics-I	2-0-1	4	3
CI 101	Chemistry-I	2-0-2	6	4
BI 101	Biology-I	2-0-1	4	3
MI 101	Mathematics-I	2-1-0	3	3
CS 101	Basics in Computer Applications	2-0-1	4	3
EG 101	Communicative English	2-0-0	2	2

Total credit = 18

SECOND SEMESTER

Course No.	Name	L-T-P	CH	CR
PI 102	Physics-II	2-0-1	4	3
CI 102	Chemistry-II	2-0-2	6	4
BI 102	Biology-II	2-0-1	4	3
MI 102	Mathematics-II	2-1-0	3	3
ES 102	Elementary Environmental Science	2-0-0	2	2
SC 102	Basic Sociology	2-0-0	2	2
NS 102	NSS	0-0-1	1	1

Total credit = 18

THIRD SEMESTER

Course No.	Name	L-T-P	CH	CR
MI 201	Introductory Statistics (Common Paper)	2-1-0	3	3
MI 203	Linear Spaces and Complex Numbers	2-1-0	3	3
MI 205	Algebra	2-1-0	3	3
MI 207	Co-ordinate Geometry	2-1-0	3	3
MI 209	Statics and Dynamics	2-1-0	3	3
PI 201	Electronics-I (Common Paper)	2-1-0	3	3
PI 209	Physics Laboratory-II	0-0-2	4	2

Total credit for Major Students = 20

FOURTH SEMESTER

Course No.	Name	L-T-P	CH	CR
MI 202	Probability and Mathematical Statistics	3-1-0	4	4
MI 204	Mathematical Methods and PDE (Common Paper)	2-1-0	3	3
MI 206	Integral Equations and Transforms	3-1-0	4	4
MI 208	Linear Algebra	3-1-0	4	4
BI 202	Ecology and Environmental Biology	2-1-0	3	3
OR				
PI 202	Introductory Quantum Mechanics	2-1-0	3	3
BI 210	Bioscience Laboratory-IIB	0-0-2	4	2
OR				
PI 210	Physics Laboratory-IV	0-0-2	4	2

Total credit for Major Students = 20

FIFTH SEMESTER

	Course No.	Name	L-T-P	CH	CR
	MI 301	Computer Programming[+]	3-1-0	4	4
	MI 303	Real Analysis	3-1-0	4	4
	MI 305	Abstract Algebra	3-1-0	4	4
	MI 307	Elementary Number Theory	3-1-0	4	4
	MI 309	Computer Laboratory	0-0-2	4	2

Total credit = 18

SIXTH SEMESTER

	Course No.	Name	L-T-P	CH	CR
	MI 302	Numerical Analysis[+]	3-1-0	4	4
	MI 304	Topology	3-1-0	4	4
	MI 306	Functional Analysis	3-1-0	4	4
	MI 308	Theory of Ordinary Differential Equations	3-1-0	4	4
	MI 310	Computer Laboratory	0-0-2	4	2

Total credit = 18

SEVENTH SEMESTER

Course No.	Name	L-T-P	CH	CR
MI 401	Classical Mechanics	3-1-0	4	4
MI 403	Measure Theory	3-1-0	4	4
MI 405	Graph Theory	3-1-0	4	4
MI 407	Mathematical Software	1-0-1	3	2
Open Elective I		3-1-0	4	4

Total credit = 18

EIGHTH SEMESTER

Course No.	Name	L-T-P	CH	CR
MI 402	Advanced Analysis	2-1-0	3	3
MI 404	Partial Differential Equations	2-1-0	3	3
MI 406	Probability Theory	3-1-0	4	4
MI 408	Complex Analysis	3-1-0	4	4
Open Elective II		3-1-0	4	4

Total credit = 18

NINETH SEMESTER

Course No.	Name	L-T-P	CH	CR
MI 501	Stochastic Process-I	3-1-0	4	4
MI 503	Advanced Numerical Analysis	3-1-0	4	4
Open Elective III		3-1-0	4	4
Open Elective IV		3-1-0	4	4
MI 515	Project (to be continued to 10th semester)	0-0-8	16	0

Total credit = 16

TENTH SEMESTER

Course No.	Name	L-T-P	CH	CR
MI 502	Mathematical Programming	3-1-0	4	4
Open Elective V		3-1-0	4	4
Open Elective VI		3-1-0	4	4
MI 515	Project	0-0-8	16	8

Total credit = 20

Total Credit Load: (18+18+18+18+18+18+18+18+16+20) =**180**

Note: A student has to choose a minimum of four courses from the list of electives offered by the Department of Mathematical Sciences. The other two elective courses may be chosen from the Departments under the School of Science & Technology and the School of Engineering.

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

List of Electives

	L	T	P	CR	*Prerequisites*
MI 541 Fluid Mechanics	3	1	0	4	Nil
MI 542 Electrodynamics	3	1	0	4	Nil
MI 543 Relativity	3	1	0	4	Nil
MI 544 Operations Research	3	1	0	4	Nil
MI 545 Elliptic Curves	3	1	0	4	MI 305
MI 546 Algebraic Number Theory	3	1	0	4	MI 305
MI 547 Numerical Linear Algebra	3	1	0	4	Nil
MI 550 Discrete Mathematics	3	1	0	4	Nil
MI 552 Operator Theory-I	3	1	0	4	MI 306
MI 554 Advanced Algebra-I	3	1	0	4	MI 305
MI 556 Quantum Mechanics-I	3	1	0	4	Nil
MI 557 Mathematical Modeling-I	3	1	0	4	Nil
MI 558 General Theory of Relativity	3	1	0	4	MI 543
MI 560 Sampling Techniques-I	3	1	0	4	Nil
MI 562 Statistical Quality Control	3	1	0	4	Nil
MI 564 Multivariate Analysis-I	3	1	0	4	Nil
MI 565 Fuzzy Sets and Applications-I	3	1	0	4	Nil
MI 566 Fourier Analysis	3	1	0	4	MI 306
MI 567 Continuum Mechanics	3	1	0	4	Nil
MI 568 Theory of Distribution and Sobolev Spaces	3	1	0	4	MI 306
MI 572 Operator Theory –II	3	1	0	4	MI 552
MI 573 Analytic Number Theory	3	1	0	4	MI 307
MI 574 Advanced Algebra-II	3	1	0	4	MI 305
MI 576 Quantum Mechanics –II	3	1	0	4	MI 556
MI 577 Mathematical Modeling-II	3	1	0	4	MI 557
MI 580 Sampling Techniques-II	3	1	0	4	MI 560
MI 581 Stochastic processes –II	3	1	0	4	MI 501
MI 582 Reliability Theory	3	1	0	4	Nil
MI 584 Multivariate Analysis-II	3	1	0	4	MI 564
MI 585 Fuzzy Sets and Applications-II	3	1	0	4	MI 565
MI 586 Parallel Numerical Algorithms	3	1	0	4	Nil
MI 587 Finite Element Method	3	1	0	4	Nil
MI 588 Applied Matrix Theory	3	1	0	4	Nil
MI 591 Computational Fluid Dynamics	3	1	0	4	MI 541
MI 593 Wavelets and Applications	3	1	0	4	Nil
MI 594 Advanced Topology-I	3	1	0	4	MI 304
MI 595 Numerical Solutions of ODE	3	1	0	4	Nil
MI 596 Advanced Topology-II	3	1	0	4	MI 594
MI 597 Numerical Solutions of PDE	3	1	0	4	Nil
MI 598 Algebraic Geometry	3	1	0	4	Nil

DETAILED SYLLABUS

MI 101 MATHEMATICS-I (2-1-0 Credit 3)

Inequalities involving arithmetic, geometric, and harmonic means, Cauchy-Schwarz inequality.
Real numbers, Sequences, Cauchy sequence, Cauchy's General principle of convergence, Subsequences, Convergence and divergence of monotonic sequences, Sandwich theorem; Infinite series, statements of basic properties of infinite series (without proofs), Absolute and conditional convergences, Test for convergence: Comparison test, Ratio test, Raabe's test, Leibnitz's test.
Limit, Continuity, Differentiability, Rolle's theorem, Mean value theorems and applications; Linear Approximation, Newton and Picard method, Taylor's theorem (one variable), Approximation by polynomials, Critical points, convexity, curvature of plane curves, Asymptotes, Curve tracing: tracing of catenary, cissoids, asteroid, cycloid, folium of Descartes, cardiod, lemniscate.
Functions of two or more variables, limit, continuity, differentiability, chain rule, Euler's theorem on homogeneous functions; Directional derivatives, Gradient vectors and tangent planes, partial derivatives, Taylor's theorem (statement only) and criteria for maxima/minima/saddle points, Lagrange's method of multipliers.
Improper integrals, Numerical Integration: Trapezoidal and Simpson's rule; error bounds.

References:

1. Thomas and Finney: Calculus and Analytic Geometry, Pearson Education, Eleventh (Indian) Edition.
2. R. G. Bartle, D. R. Sherbert: Introduction to Real Analysis, John Wiley and Sons, Third (Indian) Edition.
3. T. M. Apostol: Calculus, Vol I & II, John Wiley and Sons, Second (Indian) Edition.
4. S.K Mapa, Higher Algebra, Asoke Prakashan, Kolkata.

MI 102 MATHEMATICS-II (2-1-0 Credit 3)

Ordinary differential equations: Basic definitions: order and degree of differential equation, primitives, solutions of differential equations, Integral curves, isoclines, formulation of ODE. Linear, non-linear differential equations. Variables separable, homogeneous, non-homogeneous exact equations and integration factors, equations reducible to first order, Clairaut's equation. Second order Differential Equations: Linear equations with constant coefficients. Standard Methods for solution, Nonhomogeneous, linear with constant coefficients. Method of Variation of Parameter.
Line integral, Double, triple integrals, Jacobian; Surface integrals.

Vector Calculus, vector point function, continuity and differentiation of vector point function, partial derivative of vectors, Curl, Grade, Divergence; Green, Gauss, and Stokes Theorems.
Space co-ordinates, lines and planes, Polar coordinates, Cylinders, Quadric surfaces, Volume, Area, length, volume and surface area of solids of revolution.

References:

1. Thomas and Finney: Calculus and Analytic Geometry, Pearson Education, Eleventh (Indian) Edition.
2. William E.Boyce and Richard C.DiPrima: Elementary Differential Equations, John Wiley, Indian Edition, 2000.
3. M.R. Spiegel: Vector Analysis, Schaum's outline series.

MI 201: INTRODUCTORY STATISTICS L2-T1-P0-CH3-CR3

Collection of data, methods of collections of primary data, presentation and classification of data, Discrete and continuous variables, Frequency distributions, Graphical representation, cumulative frequency distribution and ogives.
Measure and location of dispersion, the arithmetic mean of group data, properties of arithmetic mean, median and mode; other measures of location: quartiles, deciles and percentiles.
Variance and standard deviation of ungrouped and grouped data, properties of standard deviation. Binomial distribution, stirling approximation.
Moments of higher order, relation between m_r and m_r', skewness and Kurtosis.
Elements of probability theory, classical definition of probability, axiomatic approach to probability, probability of a simple event, probability of composite event, addition rule, multiplication rule: conditional probability.
Correlation and regression: scatter diagram, coefficients of correlation, linear regression, fitting of regression line, the method of least squares, explained and unexplained variation, coefficient of variation, correlation and regression for grouped data.
Tests of significance, Null hypothesis and hypothesis testing; Chi-square distribution and tests related. Non parametric tests, 't' tests – paired and student 't' tests, 'F' test, critical difference at 0.01 and at 0.05.

Textbooks

1. Medhi, J., *Statistical Methods: An introductory Text*, (New Age International (P) Ltd,, 2000).
2. Gupta, S.C. and Kapoor, V. K., *Fundamentals of Mathematical Statistics*, (S. Chand & Co., 2007).

Reference books

1. Feller, W., *An Introduction to Probability Theory and Its Applications*, *Vol. I,* (Wiley, 2005).
2. Uspensky, J.V., *Introduction to Mathematical Probability*, (McGraw Hill, 2005).

MI 202: PROBABILITY AND MATHEMATICAL STATISTICS
L3-T1-P0-CH4-CR4

Discrete sample space, Bayes' formula, Discrete random variable, expected value of a random variable, standard probability distribution: Bernoulli, Binomial, Hypergeometric, Geometric, Poisson and Normal distribution.
Elements of Sampling theory: sampling with and without replacement, sampling distribution of the sample mean, sampling distribution of proportion, standard error.

Text books

1. Medhi, J., *Statistical Methods: An introductory Text*, (New Age International (P) Ltd,, 2000).
2. Gupta, S.C. and Kapoor, V. K., *Fundamentals of Mathematical Statistics*, (Sultan Chand. & Company, 2007).

Reference books

1. Uspensky, J.V., *Introduction to Mathematical Probability*, (McGraw Hill, 2005).
2. Feller, W., *An Introduction to Probability Theory and Its Applications*, *Vol. I,* (Wiley, 2005).

MI 203: LINEAR SPACES AND COMPLEX NUMBERS L2-T1-P0-CH3-CR3

Algebra of matrices, symmetric, skew symmetric, Hermitian and skew hermitian matrices, rank of a matrix, elementary transformations, reduction to echelon and normal form; System of linear equations, existence and uniqueness of solutions, rank of matrix.
Definitions and examples of vector spaces, elementary properties of R^n and C^n as vector spaces, subspaces, operations on subspaces; linear dependence and independence of vectors, basis and dimension of vector spaces; linear mappings and their algebraic properties; eigen values and eigen vectors, characteristic equation, statement of Cayley-Hamilton theorem and its use in finding the inverse of a matrix.
Complex numbers, geometrical representation, modulus and argument of complex numbers; exponential and trigonometric functions of a complex variable; theorems on limit and continuity of a function of complex variable, differentiability, analytic function, Cauchy-Riemann equations, Harmonic functions, derivatives of elementary functions; Contour integration, Cauchy's integral theorem, Cauchy's integral formula.

Text books

1. Churchill R. V., Brown, J. W., *Complex Variables and Applications,* (McGraw-Hill International Edition, 2006).
2. Hoffman K. and Kunze, R., *Linear Algebra*, 2nd Edition (Prentice Hall, 2008).

Reference books

1. Datta, K. B., *Matrix and Linear Algebra*, (Prentice Hall of India, 2000).
2. Lang, S., *Linear Algebra*, (Springer-Verlag, 2006).
3. Spiegel, M. R., *Theory and Problems of Complex Variables*, Schum's Outline Series (McGraw-Hill, 2000).

MI 204 MATHEMATICAL METHODS AND PARTIAL DIFFERENTIAL EQUATIONS (Common Paper) L2-T1-P0-CH3-CR3

Partial differential equations: What are partial differential equations (PDEs), and where do they come from? Flows, vibrations and diffusions. Solutions of first order PDEs: Charpits method, Jacobi method. Second-order linear equations and their classification. Initial and boundary conditions, with an informal description of well-posed problems. D'Alembert's solution of the wave equation. Duhamel's principle for one dimensional wave equation.
Separation of variables: application of the method to simple problems in Cartesian coordinates for one dimensional wave and heat equations.
Calculus of variation: Variational problems with fixed boundaries-Euler's equation for functionals containing first order derivative and one independent variable. Extremals. Functionals dependent on higher order derivatives. Functionals dependent on more than one independent variable. Variational problems in parametric form. Invariance of Euler's equation under co-ordinate transformation. Variational problems with Moving boundaries-Functionals dependent on one and two functions. One sided vatiations. Sufficient conditions for an extremum - Jacobi and Legendre conditions.
Special Functions: Series solution of differential equations. Power series method. Bessel and Legendre equations. Bessel and Legendre functions and their properties. Convergence. Recurrence and generating functions.

Text books

1. Rao, K. S., *Introduction to Partial Differential Equations*, 2nd Edition (Prentice Hall of India, 2007).
2. Gupta, A. S. *Calculus of Variation with Applications*, (Prentice Hall of India, 1997).
3. Gelfand, I. M. and Fomin, S. V. *Calculus of Variation*, (Dover Publications, 2000).

Reference book

1. Andrews, G.E., Askey, R. A. and Roy, R. *Special Functions*, (Cambridge University Press, 1999).
2. Sneddon, I. N. *Elements of Partial Differential Equations*, 4th ed., (Dover, 2006).

MI 205: ALGEBRA **L2-T1-P0-CH3-CR3**

Relations, Equivalence relations, Mapping, and binary operations, Groups, subgroups, cosets, Lagrange's theorem, Subgroup generated by a set, cyclic groups, permutation groups, normal subgroups, quotient groups.
Polynomials, Euclid's Algorithm greatest common divisor, unique factorization of polynomials over a field F of numbers (statement only), Fundamental theorem of Algebra (statement only), roots and their multiplicity, Irreducible polynomials over Q, R, C. Relationship between roots and the coefficients, Fundamental theorem of symmetric polynomial (without proof) Evaluation of symmetric functions of roots. Rational roots of polynomials with integral coefficients.
Descartes rule of sign, Strum's theorem (statement only) Solution of cubic equation, Cardon's method and solution of bi-quadratic equation.

Textbooks

1. Gallian, J. A., *Contemporary Abstract Algebra*, Narosa, 1995.
2. Mapa, S. K., *Higher Algebra*, Asoke Prakashan, Calcutta, 2006.

Reference books

1. Herstein, I. N., *Topics in Algebra*, 2nd Edition (Wiley Eastern Limited, 1998).
2. Fraleigh, J. B., *A First Course in Abstract Algebra*, (Narosa, 1995).
3. Barbeau, E. J., *Polynomials*, (Springer 2003).
4. Prasad, C., *A Text Book of Algebra and Theory of Equations*, (Pothishala Private Ltd., 2006).
5. Barnard, S. & Child, J. M. *Higher Algebra*, Macmillan, 2001.

MI 206: INTEGRAL EQUATIONS AND TRANSFORMS L3-T1-P0-CH4-CR4

Elementary idea of Improper Integrals, their convergence, Beta and Gamma fnctions, their properties. Integral as a function of parameter (excluding improper integrals). Continuity and derivability of an integral as a function of a parameter.
Linear integral equations of the first and second kind of Fredholm and Volterra type: Definitions of integral equations and their classification. Eigen values and Eigen functions. Integral equations of second kind with separable kernels. Reduction to a system of algebraic equations. Method of successive approximations. Iterative scheme for integral equations of the second kind.

Integral Transform Methods: Fourier Series, Generalized Fourier series, Fourier Cosine series, Fourier Sine series, Fourier integrals. Fourier transform, Laplace transform.
Inverse Transform: Inverse Laplace and Fourier Transform, Solution of differential equation by Laplace and Fourier transform methods.
Tensor: Transformation of coordinates, summation convention, kronecker delta. Definition of tensors, covariant, contravarient and mixed tensor, symmetric and antisymmetric tensors, outer and inner product of tensors, contraction, quotient law.

Text books

1. Parashar, B.P., *Differential and Integral Equations*, 2nd ed., (CBS Publishers, 2008).
2. Mikhlin, S. G., *Linear Integral Equations*, (Hindustan Book Agency, 1990).
3. Spain, B., *Tensor Calculus*, (Radha Publishing House, 2000).

Reference book

1. Kanwal, R. P., Linear Integral Equation. Theory and Techniques, (Academic Press, 1991).
2. Poularikas, D., *The Transforms and Applications*, (CRC Press, 1996).

MI 207: CO-ORDINATE GEOMETRY L2-T1-P0-CH3-CR3

Transformation of co-ordinate axes. Pair of straight lines. General equation of second degree and the conditions for representing a pair of straight lines, a parabola, an ellipse, a hyperbola and a circle, the equation of tangent, condition of tangency of line, pole and polar, centre of a conic, equation of a pair of tangents. Reduction to standard forms, central conics, Equation of the axes and length of the axes. Polar equation of a conic, tangent and normal, properties. Parabola, parametric co-ordinates, tangent and normal. Ellipse and its conjugate diameters with properties. Hyperbola and its asymptotes. Circle and its parametric form, Orthogonal circle, condition of orthogonality of circles.
Plane, straight line and shortest distance. change of axes, shift of origin, rotation of axes, Sphere, Cone and Cylinder. Central Conicoids, Ellipsoid, Hyperboloid of one and two sheets. Generating lines, Diametral planes, tangent lines, plane section of conicoids, director sphere, polar plane, section with a given centre, enveloping cone and cylinder. Confocal conicoids. Reduction of second degree equations.

Text books

1. Jain, P. K. and Ahmed, K., *Textbook of Analytical Geometry of Two Dimensions*, (New Age Publications, 2006).
2. Jain, P. K. and Ahmed, K., *Textbook of Analytical Geometry of Three Dimensions*, 2nd Edition (New Age Publication, 2006).
3. Das, B., *Analytical Geometry and Vector Analysis*, (Orient Book Company, 1995).

Reference books

1. Khan, R.M., *Analytical Geometry & Vector Analysis*, (New Central Book Agency Pvt. Ltd., 2004).
2. Askwith, E. H., *A Course of Pure Geometry*, Michigan Historical Reprint Series, (University of Michigan Library, 2005).
3. Askwith, E. H. and Askwith, E., *A Course Of Pure Geometry*, (Hard Press, 2007).
4. Spain, B., *Analytical Conics*, (Dover, 2007).
5. McCrea, W. H., *Analytical Geometry of Three Dimensions*, (Dover, 2006).

MI 208: LINEAR ALGEBRA **L3-T1-P0-CH4-CR4**

Review of vector spaces, linear maps, matrix representation of linear maps, Eigen vectors and Eigen values of linear maps, characteristic equation, and statement of Cayley-Hamilton theorem.
Linear functional and the double dual; annihilating polynomial, minimal polynomial, triangulation and diagonalization; direct sum decomposition, invariant direct sums, the Primary Decomposition theorem; rational and Jordan forms.

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

Text books

1. Strang, G. *Linear Algebra and Its Applications*, 4th Edition, (Cengage, 2006).
2. Halmos P. R., *Finite Dimensional Vector Spaces, (*Springer-Verlag, 1987).
3. Hoffman, K. and Kunze, R., *Linear Algebra*, 2nd Edition, (Prentice Hall, 2008).

Reference books

1. Williams**,** G., *Linear Algebra with Applications***, (**Jones and Burlet Publishers, 2001).
2. Lang, S., *Linear Algebra*, (Springer-Verlag, Indian Reprint, 2008).
3. Halmos**,** P. R., *Linear Algebra Problem Book***, (**The Mathematical Association of America (MAA), USA, 1995).

MI 209: STATICS AND DYNAMICS **L2-T1-P0-CH3-CR3**

Parallel forces, Couples, Reduction of coplanar forces. Analytical conditions of equilibrium of coplanar forces.
Centre of gravity of a plane area, arc and sector of a curve. C. G. of solids and surface of revolution.

Friction, laws of friction, limiting friction, equilibrium of a particle in rough inclined plane.
Principle of virtual work in two dimensions. Stable and unstable equilibrium.
Velocities and acceleration along radial and transverse directions, along tangential and normal directions.
Rectilinear motion with variable acceleration. Motion under inverse square law and other laws of force. Simple harmonic motion. Motion in resisting medium. Motion of particles of varying mass. Motion of a projectile.
Central orbit and Kepler's laws of planetary motion.
Moments and products of inertia. Parallel axes theorem, theorem of six constants. Principal axes.

Textbooks

1. Whittaker, E.T. and McCrea, W. *A Treatise on the Analytical Dynamics of Particles and Rigid Bodies: with an Introduction to the Problem of Three Bodies*, (Cambridge University Press, 1988).
2. Loney**,** S. L., *Elements of Statics & Dynamics*, *Part I***, (**Maxford Books, 2003).
3. Rao, S. *Engineering Mechanics - Statics and Dynamics*, (Pearson Education, 2008).

Reference books

1. Spiegel, M. R., *Schaum's Outline of Theory and Problems of Theoretical Mechanics: with an Introduction to Lagrange's Equations and Hamiltonian Theory*, (McGraw-Hill, 2007).
2. Ramsey, A. T., *Dynamics*, 2nd Edition, (The University Press, 2007).
3. Chorlton, F. *Textbook of Dynamics*, 2nd edition (Horwood, 1983).
4. Loney, S. L., *An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies*, (Read Books, 2007).
5. Meriam, J.I., *Engineering Mechanics Statics*, 5th Edition, (John Wiley & Sons, 2002).

MI 301 COMPUTER PROGRAMMING+ L3-T1-P0 CH4 CR 4

Computer fundamentals, major hardware and software components of a digital computer, concepts of machine language, assembly language and high level language. Number systems: binary, octal, hexadecimal; algebraic operations and conversions.
Algorithms and flow charts.
Fundamentals of C: introduction to C; comments in C; data types in C, variables in C, input output statements, constant declaration, arithmetic operators in C, arithmetic expressions, assignment statements, arithmetic assignment operators, increment and decrement operators, type conversions, Boolean expressions, operator precedence.

Loops and decisions: for loop, while loop, do…while loop, if statement, if…else statement, switch statement, conditional operators. The break statement, the continue statement, the goto statement.
Arrays and pointers: Arrays, declaration of one dimensional arrays, two dimensional arrays, pointers.
Structures: User defined data types, structures, array of structures, enumerated data type.
Function in C: Simple functions, passing arguments to functions with return value, call by value; call by reference, overloaded functions, inline functions, default arguments.
Object and classes: class, types of accesses, difference between structure and classes, accessing members of a class, constructors, destructors.
Searching and sorting: Bubble sort, selection sort, insertion sort, linear search and binary search.

Text books

1. Balaguruswamy, E., *Programming in ANSI C*, (Tata McGraw-Hill, 2004).
2. Venkateshmurthy, M. G., *Programming Techniques through C*, (Pearson Education, 2002).

Reference book

1. Kanetkar, Y. P., *Let us C*, (BPB Publication, 2001).
2. Rajaraman, V., *Fundamentals of computers*, (Prentice Hall of India, 2002).

MI 302 NUMERICAL ANALYSIS+ L3-T1-P0 CH4 CR 4

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

Text books

1. Atkinson, K. E., *Introduction to Numerical Analysis*, 2nd Edition, (John Wiley,1989).
2. Sastry, S. S., *Introductory methods of Numerical Analysis*, (Prentice Hall of India, New Delhi, 1997).
3. Jain, M. . K., Iyengar, S. R. K. Jain, , R. K., *Numerical methods, Problems and Solutions*, (New Age International (P) Ltd., 1996).

Reference books

1. Conte, S. D. and Boor, C. de, *Elementary Numerical Analysis - An Algorithmic Approach*, 3rd Edition (McGraw Hill, 1980).
2. Burden, R. L and Faires, J. Douglas Numerical Analysis, Eighth Edition, Cengage, 2005.
3. Hilderbrand,F. B *Introduction to Numerical Analysis*, (Tata McGraw Hill, New Delhi, 1974).
4. Gerald , C. F and Wheatley, P. O. *Applied Numerical Analysis, 5th edition*, (Addison Wesley, 1994.)

MI 303 REAL ANALYSIS **L3-T1-P0 CH4 CR 4**

Elements of set theory, finite, countable and uncountable sets, Axiom of choice, Real number system.

Metric spaces, convergence, continuity, compactness, connectedness, completeness, Heine-Borel theorem, Intermediate value theorem, Baire Category theorem.

Riemann-Stieltjes integrals, properties, mean value theorems, the fundamental theorem of calculus.

Sequences and series of functions, uniform convergence and its relation to continuity, differentiation and integration.

Functions of several variables, differentiation, implicit function theorem, inverse function theorem, maxima and minima.

Text books

1. Rudin, W. *Principles of Mathematical Analysis*,(McGraw Hill, 1982).
2. Flemming, W. *Functions of several variables* (3/e), (Springer, 1987).
3. Carothers, N. L *Real analysis*, (Cambridge University Press, 1999).

Reference books

1. Goldberg, R. R *Methods of real analysis,* (Oxford & IBH, 1970).
2. Apostol, T. M. *Mathematical Analysis*, (Narosa Publishing House, 1985).
3. Simmons, G. F. *Introduction to Topology and Modern Analysis*, (Tata McGraw Hill Book Co. Ltd., 1963.)

MI 304 TOPOLOGY **L3-T1-P0 CH4 CR 4**

Topological spaces, basis and sub-basis, subspaces, closure, interior and boundary. Continuity, open functions, homeomorphisms, embeddings, strong and weak topologies. Quotient and product spaces. Countability axioms, separability, Lindelof

spaces. Separation axioms (T_0, T_1, T_2, T_3, T_4), regularity, complete regularity, normality. Compactness, local compactness, Tychonoff's product theorem, compactification. Connectedness, local and path connectedness, components, products of connected spaces.

Text books

1. Kelley, J. L *General Topology* (Graduate Texts in Mathematics, Vol. 27), (Springer, 1991).
2. Munkres, J. R. *Topology : A first course* (2/e), (Prentice-Hall, 2000 or (1/e) Prentice Hall of India, 1983.)

Reference books

1. Joshi, K. D. *Topology*, (Wiley-Eastern, 1988.)

MI 305 ABSTRACT ALGEBRA **L3-T1-P0 CH4 CR 4**

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

Text books

1. Gallian, J. A. Contemporary Abstract Algebra, (Narosa, 1995).
2. Dummit, D. S & Foote, R. A. Algebra, (John Wiley & Sons, 2005).

Reference books

1. Gopalakrishnan, N. S. *University Algebra*, (Wiley Eastern, 1991).
2. Fraleigh, J. B. *A First Course in Abstract Algebra*, (Narosa, 1995).
3. Herstein, I. N. *Topics in Algebra*, (Wiley Eastern Limited, New Delhi, 1975).
4. Lang, S. *Algebra*, 3rd edition, (Addison-Wesley, 1993).

MI 306 FUNCTIONAL ANALYSIS **L3-T1-P0 CH4 CR 4**

Normed linear spaces; equivalent norms; bounded linear operator and functional; Hahn-Banach theorem; Banach spaces.
Uniform boundedness theorem; Open mapping theorem; Closed graph theorem.
Hilbert spaces; polarization identity and parallelogram law; orthogonality; Riesz representation theorem; orthonormal systems; Bessel's inequality; Parseval's identity.

Adjoint operators; normal and self adjoint operators; unitary operators; isometry; orthogonal projection; spectrum of an operator and it's non emptiness.

Text books

1. Nair, M Thamban *Functional Analysis: A First Course*, (Prentice Hall of India, 2003).
2. Kreyszig, E *Introductory functional analysis with applications,* (John Wiley and Sons, New York, 1978).

Reference books:

1. Youngson, M. A. and Rynne, B *Linear Functional Analysis*, (Springer, 2007).
2. Bachman, George and Narici, Lawrence *Functional Analysis*, (Academic Press, New York, 1966).
3. Halmos, P. R. *A Hilbert Space Problem Book.* (Springer-Verlag, Berlin, Second Edition, 1982).
4. Limaye, B. V *Functional Analysis*, (Wiley Eastern Limited, New Delhi, 1989).

MI 307 ELEMENTARY NUMBER THEORY L3-T1-P0 CH4 CR 4

Divisibility, greatest common divisor, least common multiple, prime numbers, factorisation in prime numbers, fundamental theorem of arithmetic, the Euclidean algorithm, perfect numbers, Mersenne numbers, Fermat numbers.

Concept of congruences and its elementary properties, congruences in one unknown, complete residue system, reduced residue system, Gauss function, Mobius function, Euler function.

Diophantine equations, linear Diophantine equations, pythagoras equation, sum of two squares.

Quadratic residues and congruences of second degree in one unknown, Legendre symbol, Jacobi symbol, congruences of second degree with prime modulus and with composite modulus.

Primitive roots and indices, order, necessary and sufficient condition for the existence of primitive roots, construction of reduced residue system.

Continued fractions, simple continued fractions, approximation of irrational numbers by continued fractions, solution of Pell's equation.

Text books

1. Niven and Zuckerman, H. *An Introduction to the Theory of Numbers*, 5th edition, (Wiley Eastern, 2000).
2. Burton, M. *Elementary Number Theory*, 3rd edition, (Tata Mcgraw Hill,, New Delhi, 2007).

Reference books

1. Hsiung, Y. *Elementary Theory of Numbers*, (World Scientific, 1992; First Indian Reprint, Allied Publishers Limited, 1995).
2. Hardy, G. H. and Wright, E. M. *An Introduction to the Theory of Numbers*, 4th edition, (Oxford, Claredon Press, 1960).
3. Andrews, G. E. *Number Theory*, (Hindustan Publishing Corporation, New Delhi, 1992).
4. Telang, S. G. *Number Theory*, (Tata McGraw Hill, New Delhi, 1996).

MI 308 THEORY OF ORDINARY DIFFERENTIAL EQUATIONS L3-T1-P0 CH4 CR 4

Review of fundamentals of ODEs. Existence and Uniqueness of Initial Value Problems: Picard's and Peano's Theorems, Gronwall's inequality, continuation of solutions and maximal interval of existence, continuous dependence.

Power series solutions of ODE, Higher Order Linear Equations, Wronskian, Reduction of higher order linear ODEs to first order linear systems, Fundamental matrix and solutions of linear systems, matrix exponential solution, behaviour of solutions, Stability of linear systems.

Boundary Value Problems, Green's Matrix, Self adjoint boundary value problems, Lagrange Identity, Green's formula, Sturm-Liouville problems, Sturm comparision theorems and oscillations, eigenvalue problems.

Text books

1. Simmons, G. F. *Differential Equations*, (Tata McGraw Hill, 1993).
2. Boyce & DiPrima, *Ordinary Differential Equations and Boundary value problems*, (John Wiley & Sons, 2000).

Reference books

1. Rao, M. R. M. *Ordinary Differential Equations: Theory, Method and Applications*, (Affiliated East-West Press Pvt. Ltd., New Delhi, 1979).
2. Coddington, E. A. *An Introduction to Ordinary Differential Equations*, (Prentice-Hall, 1974).
3. Somasundaram, D. *Ordinary Differential Equations: A First Course*, (Narosa, 2001).
4. Brauer, Fred & Nohel, J. *The Qualitative Theory of Ordinary Differential Equations: An Introduction*, (Dover Publications, 1989).

MI 309 COMPUTER LABORATORY (Practical unit for the Course MI 301)
L0-T0-P2 CH4 CR 2

MI 310 COMPUTER LABORATORY (Practical unit for the Course MI 302)
L0-T0-P2 CH4 CR 2

MI 401 CLASSICAL MECHANICS L3-T1-P0 CH4 CR 4

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

Text books

1. Goldstein, H. *Classical Mechanics*, 2nd ed., (Narosa, 2000).
2. Rana, N. C. & Joag, P. C. *Classical Mechanics*, (Tata-McGraw Hill, 1991).

Reference books

1. Arnol'd, V.I. & Vogtmann, K. *Mathematical Methods of Classical Mechanics*, 4th ed., (Springer, 1989)

MI 402 ADVANCED ANALYSIS L2-T1-P0 CH3 CR 3

Functions of several variables, Derivative on a open subset of R^n,Chain rule , partial derivative, derivative of higher order, Taylor's theorem, Inverse function theorem, Implicit function theorem, Jacobians, Extermum problem with constraints, Lagrnges method of multipliers, Differntiation under integrals, Partition of Unity, Differential forms, Stoke's theorem.
The four derivatives, Lebesgue differentiation theorem, Lebesgue set.
Complex measures, L^p Space, convex functions, Jensen's inequality, Holder and Minkowski's inequalities, Convergence and completeness, Approximation in L^p, Convergence in measure, integration of convex functions.
Total Variation, absolute continuity, consequences of Radon-Nikodym theorem, Bounded linear functional on L^p Space, Riesz representation theorem.
Fourier transforms, the inversion formula, the Plancherel theorem, the Banach algebra L^1

Text books

1. Royden, H. L. *Real Analysis*, 3rd Edition, (Macmillan Publishing Company, New York, 1988) (Reprint 2003).
2. Rudin, W. *Principle of Mathematical Analysis*, Third Edition , (McGraw Hill Book Company, 2003).
3. Rana, I. K. *An Introduction to Measure and Integration*, 2nd edition, (Narosa Publishing House India, 2000).

Reference book

1. Rudin, W. *Real and Complex Analysis*, Third Edition , (McGraw Hill Book Company, 2003).

MI 403 MEASURE THEORY **L3-T1-P0 CH4 CR 4**

Sigma algebra, Borel sigma algebra, Set Function, Construction of Lebesgue measure, Lebesgue outer measure, Properties of outer measure, Measurable sets, Non-measurable sets, Lebesgue measure and its properties.
Measurable functions, Borel measurability, Borel Measures, Littlewood's three principles.
Lebesgue Integration: Step function, Simple functions, Approximation of every function by a simple function, Lebesgue integral of bounded non-negative functions, Bounded convergence theorem, Integral of non-negative functions, Fatou's Lemma, Monotone convergence theorem, Lebesgue Dominated convergence theorem, Comparison with Riemann integral, Lebesgue general integral, Fundamental Theorem of Calculus for Lebesgue Integrals.
Introduction to general measure space: Measure and outer measures, Extension of a measure, Measure space. Measurable functions and their properties; Integration with respect a measure, Convergence theorems.
Signed measure, Hahn decomposition theorem, Mutually singular measures.
Radon-Nikodym theorem, Lebesgue decomposition.
Product measure spaces, Fubini's theorem, Integration on Product spaces: Measurability on Euclidean spaces, completion of product measures, Invariant measures.

Text books

1. Royden, H. L. *Real Analysis*, 3rd Edition, (Macmillan Publishing Company, New York, 1988)(Reprint 2003).
2. Barra, G.De *Measure Theory and Integration*, (New Age International(P) Ltd, Publishers, New Delhi 2003).

Reference books

1. Rana, I. K. *An Introduction to Measure and Integration*, 2nd edition, (Narosa Publishing House India, 2000).
2. Halmos, P. R. *Measure Theory*; (Springer-Verlag, 1974).

MI 404 PARTIAL DIFFERENTIAL EQUATIONS L2-T1-P0 CH3 CR 3

Review of PDE, Canonical Transformation, Characteristics, Initial and Boundary Value Problems: Lagrange-Green's identity and uniqueness by energy methods.
Theory of distributions: supports, test functions, generalized derivatives, Sobolev Spaces, trace and imbedding results (without proof).
Elliptic Boundary Value Problems: abstract variational problems, Lax-Milgram Lemma, weak solutions, regularity result, maximum principles, eigen value problems.
Semigroup Theory and Applications: exponential map, C_0-semigroups, Hille-Yosida and Lummer-Phillips theorems, applications to heat and wave equations.

Text books

1. Evans, L.C. Partial Differential Equations, (AMS, Providence, 1998).
2. John, F. Partial Differential Equations, 3rd ed., (Narosa Publ. Co., New Delhi,1979).

Reference books

1. Sneddon, I.N. Elements Of Partial Differential Equations, (Dover Publications, 2006).
2. Zauderer, E. Partial Differential Equations of Applied Mathematics, 2nd ed., (John Wiley and Sons, New York, 1989).
3. Kesavan, S. Topics in Functional Analysis (Wiley Eastern Ltd., New Delhi, 1989).
3. Renardy, M. and Rogers, R.C. An Introduction to Partial Differential Equations,2nd ed., (Springer Verlag International Edition, New York, 2004).

MI 405 GRAPH THEORY L3-T1-P0 CH4 CR 4

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

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

Text books

1. Foulds, L. R. *Graph Theory Applications*, (Narosa Publishing House, New Delhi, 1992).
2. Wilson, Robin J. *Introduction to Graph Theory*, (Longman, England, 1996).

Reference book

1. Deo, Narsingh *Graph Theory with Applications to Engineering and Computer Science*, (Prentice Hall of India, 1974).

MI 406 PROBABILITY THEORY L3-T1-P0 CH4 CR 4

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

Generating functions. Some basic inequalities in Probability. Radon-Nikodym derivative, Definition of Conditional Expectation. Conditional Probability, Baye's theorem , Conditional probability distributions.
Convergence of a sequence of random variables (Weak convergence or convergence in probability, almost sure convergence and convergence in Law). Borel-Cantelli-lemma, Weak and Strong law of large numbers, Central limit theorems.

Text books

1. Rao, C.R. *Linear Statistical Inference and its applications*, 2nd edition, (wiley Eastern, 1991).
2. Chow Y. and Teicher, H. *Probability Theory*: Independence, Interchangeability, Martingales; 3rd Edition , (Springer, 2007).

Reference book

1. Royden, H.L. *Real Analysis*, 3rd Edition, (Prentice Hall, 2008).

MI 407 MATHEMATICAL SOFTWARE L1-T0-P1 CH3 CR 2

Concept of a software, Introduction to Matlab, Numerical Methods in Matlab, linear-non-linear algebraic equations, Numerical quadrature, Initial and boundary value problems, Numerical Methods in Matlab for PDEs.
Mathematica: common and useful built-in Mathematica functions; variable assignment and function definition; the Front End and the Kernel; Notebooks; organization of data in Mathematica; lists and expressions; simple programming; functions; nesting. Use of Mathematica in Calculus, Linear Algebra, Algebra, ODE & PDE, Number Theory, and so on.

Text books

1. Pratap, R. *Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers*, (Oxford University Press, USA , 2005)
2. Otto, S.R. & Denier, J. P. *An Introduction to Programming and Numerical Methods in MATLAB*, (Springer, 2009).
3. Torrence, Bruce F. & . Torrence, Eve A The student's introduction to Mathematica, 2nd edition, (Cambridge University Press, 2009).

Reference books

1. Hunt, B. R. , Lipsman, R. L, Osborn, John E. & Rosenberg, Jonathan *Differential Equations with Matlab*, (Wiley, 2005).
2. Wolfram, S. *The Mathematica Book*, (Wolfram Media, 2008).
3. Gray, T. W. & Glynn, G. *The Beginners Guide to Mathematica*, Version 4, Addision-(Wesley, 2008).

4. Various resources for Mathematica users on the Internet (Main Link: http://www.wolfram.com/mathsource)

MI 408 COMPLEX ANALYSIS **L3-T1-P0 CH4 CR 4**

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

Text books

1. Churchill, R. V. and Brown**,** J. W. *Complex Variables and Applications*, 8th Edition, (McGraw-Hill Publishing Company, 2008).
2. Conway**,** J. B. *Functions of One Complex Variable*, 2nd Edition, (Narosa Publishing House, India, 1994).

Reference book

1. Ahlfors, L. V. *Complex Analysis,* 3rd Edition, (McGraw-Hill Publishing Company, 1979).
2. Priestly, H.A. *Introduction to Complex Analysis*, 2nd ed., (Cambridge, 2008).

MI 501 STOCHASTIC PROCESSES I **L3-T1-P0 CH4 CR 4**

Preliminaries of probability distributions, Laplace transforms, Laplace transforms of probability distributions of random variables, Simple random walk, and multidimensional random walk. Stationary processes, Martingales, Markov chains, Higher transition probability and its determinations, Sequence of chain-dependent trials, Classifications of States and chains, Stability of Markov chains with denumerable number of states, Reducible chains. Poisson Processes and its related distributions, generalization of Poisson processes, Birth and Death processes, Markov processes with discrete state space (Continuous time Markov chain), Erlang processes. Renewal

processes, Renewal processes in continuous time, Renewal equation, Renewal reward processes.

Text books

1. Parzen, E *Stochastic Processes*, (Holden-Day, San Francisco, Calif, 1962.)
2. Medhi, J.. *Stochastic Processes*, (Wiley Eastern Ltd., New Delhi, 1994.)
3. Feller, W *An Introduction to Probability Theory and its Applications*, Vols. I & II, (Wiley, 1966.)

Reference books

1. Trivedi, K. S *Probability & Statistics with reliability*, *Queuing and Computer Science Applications*, (PHI, 1992.)
2. Kleinrock, L *Queueing Systems*, Vol. –I, II, (John Wiley & Sons, 1976.)
3. Khintchine, A. Y. *Mathematical Methods in Queueing*, (Grieffen, London, 1960.)
4. Medhi, J. *Stochastic Models in Queueing Theory*, (Academic Press, 1991.)

MI 502 MATHEMATICAL PROGRAMMING L3-T1-P0 CH4 CR 4

Introduction to Mathematical Programming Problems, Formulation techniques of LP problems, Graphical solution of two-variable problem. Standard form of linear programming problem, Fundamental theorem of Linear Programming.

Definition with examples: Hyper planes, convex set, convex combination, convex hull, convex polyhedron and simplex.

Simplex method for standard canonical form: Two-phase simplex method, degeneracy problem. Solution of simultaneous equations by simplex, inverse of a matrix by simplex method; Duality in linear programming, comparison of solutions of primal and its dual. Development of computer software for the solution of LPP using simplex.

Formulation of LP problem in revised simplex form. Computational procedure (algorithms). Advantage of revised simplex over simplex. Introduction to dual simplex method along with its limitations. Development of computer software for the solution of LPP using Dual Simplex algorothm.

Importance of Integer programming problems. Gomory's All IPP technique. How to construct Gomory's constraint. Computational method. Branch-and-Bound algorithm and computation procedure.

Game theory: Two-person zero-sum games, maximum criterion, dominance rules, mixed strategies, mini-max theorem, solutions of 2x2 and 2xm games.

Text books

1. Taha, H.A. *Operations Research: An Introduction*, 8th ed., (Pearson Education, 2008).
2. Swarup, K., Gupta, P. K and Singh, M. M. *Operations Research*, (Sultan Chand and Sons, 2007).

3. Sharma, J. K. Operations Research: Theory and Applications, 3rd edition, (Macmillan, 2006).

Reference books

1. Thomas, L. C. *Games: Theory and Applications*, (John Wiley, 1984).
2. Shabik, M. *Game Theory in the Social Sciences*, (MIT Press, 1982).

MI 503 ADVANCED NUMERICAL ANALYSIS **L3-T1-P0 CH4 CR 4**

Iterative methods for Linear Systems: Classical iterative methods (Jacobi, Gauss-Seidel and successive over-relaxation methods), Krylov subspace methods, Conjugate-Gradient (CG), BiConjugate-Gradient (BiCG), BiCG Stabilised (BiCGStab), Generalised Minimum Residual (GMRES). Preconditioning Techniques, parallel implementations.
Finite Difference method: Explicit and Implicit schemes, consistency, stability and convergence, Lax equivalence theorem. Numerical solutions of elliptic, parabolic and hyperbolic partial differential equations.
Approximate method of solution: Galerkin method, properties of Galerkin aproximations, Petrov-Galerkin method, Generalised Galerkin method.
Finite Element method: Test Function and distribution, definition, operations with distributions. Sobolev spaces, definition and properties, theorems. Application of finite element method for second order problems, one and two dimensional problems. Weak solution of elliptic boundary value problem, regularity of weak solutions, maximum principle. Element types triangular, rectangular, quadrilateral, sector, curved, isoparametric elements and numerical integration.

Text books

1. Watkins, D. S. *Fundamental of Matrix Computations*, 2nd edition, (Wiley-Interscience, 2002).
2. Smith, G. D. Numerical *Solution of Partial Differential Equations: Finite Difference Methods*, 3rd edition, (Oxford University Press, 1986).
3. Reddy, J. N. *An Introduction to the Finite Element Method*, 3rd Edition, (McGraw Hill India, 2006).

Reference books

1. Trefethen, L. N and Bau, David *Numerical Linear Algebra*, (SIAM, 1997).
2. Hoffman, Joe D. *Numerical Methods for Engineers and Scientist*, 2nd edition, (Mc-Graw Hill 2004).
3. Ciarlet, P. G. *The Finite Element Method for Elliptic Problems*, (North Holland, 1978).
4. Johnson, C.*Numerical Solution of Partial Differential Equations by the Finite Element Method*, (Cambridge University Press, 1987).

MI 515 PROJECT **L0-T0-P8 CH16 CR 8**

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

MI 541 FLUID MECHANICS **L3-T1-P0 CH4 CR 4**

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

Text books

1. Munson, B.R.,Young, D.F. & Okiishi, T.H. *Fundamentals of Fluid Mechanics,* 6th ed., (John Wiley & Sons, 2009).
2. White, Frank M. *Fluid Mechanics,* (Mc-Graw Hill, 2005).

Reference books

1. Batchelor, G. K. *An Introduction to Fluid Dynamics*, (Cambridge University P, 1993).
2. Panton, R. L. *Incompressible Flow*, (John Wiley & Sons, 2005).
3. Schlichting, H. *Boundary Layer Theory.(*Mc-Graw Hill, 2005).
4. Chorlton, F. *Textbook of Fluid Mechanics*, (C. B. S. Publishers, Delhi, 1985).
5. Besant, W. H & Ramsey, A. *A Treatise on Hydro-mechanics*, (ELBS, 1990).
6. Milne, L. M –T. *Theoretical Hydrodynamics*, (Macmillan & Co., 1990).
7. Yuan, S. W. *Foundations of Fluid Mechanics*, (PHI, 1976).

MI 542 ELECTRODYNAMICS **L3-T1-P0 CH4 CR 4**

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

Text books

1. Griffiths, D. J. *Introduction to Electrodynamics*,(Prentice Hall of India, 1983).
2. Reitz, J. R. , Milford, F. J. and Christy, R. W. *Foundations of Electromagnetic theory*, (Narosa Publishing House, 1988).
3. Jackson, J. D. *Classical Electrodynamics*, (Wiley Eastern Ltd., 1989).

Reference books

1. Miah, M. A. W. *Fundamentals of Electrodynamics*, (Tata McGraw Hill, 1986).
2. Laud, B. B. *Electromagnetics*, (Wiley Eastern Ltd., 1990).

MI 543 RELATIVITY **L3-T1-P0 CH4 CR 4**

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

Text books

1. Narlikar, J. V. *Introduction to Cosmology*, (James and Barlett, 1983).
2. Landau and Lifshitz, *Classical Theory of Fields*, (Pergamon Press, 1975).
3. Dirac, P. A. M *General Theory of Relativity*, (Prentice Hall of India, 2001).

Reference book

1. Weinberg, S. *Gravitation and Cosmology*, (John Wiley & Sons, 1972).

MI 544 OPERATIONS RESEARCH **L3-T1-P0 CH4 CR 4**

Definition and scope of operational research, different types of models, replacement model and sequencing theory, Inventory problems and their analytical structure, economic lot size models with uniform rate of demand, with different rate of demand in different cycle; simple deterministic and stochastic model of inventory control; basic characteristics of queueing system; Steady state solution of Markovian queueing model; M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space.

Text books

1. Sharma, J. K. *Operations Research: Theory and Applications*, 4th ed., (Macmillan, 2009).
2. Taha, H. A. *Operations Research - An Introduction*, (Prentice Hall of India, New Delhi, 1999).

MI 545 ELLIPTIC CURVES **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 305**

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

Text books:

1. Silverman, J. H. & Tate, J. *Rational Points On Elliptic Curves*, (Springer-Verlag, 2005).
2. Washington, L. C. *Elliptic Curves*, (Chapman & Hall, CRC, 2005).

Reference books:

1. McKean, M. & Moll, V. *Elliptic Curves,* (Cambridge University Press, 1999).
2. Husemoller, D. *Elliptic Curves*, 2nd ed., GTM, vol. 111, (Springer-Verlag, 2003).

MI 546 ALGEBRAIC NUMBER THEORY **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 305**

Algebraic numbers and number fields, Discriminants, Norms and Traces, Algebraic Integers, rings of integers, Integral Bases, Problems for quadratic and cubic cases.
Arithmetic of Number Fields: Quadratic Fields, Cyclotomic polynomials and fields. Units in Number Rings, Dirichlet's Unit Theorem.

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

Text books

1. Mollin, R. A. *Algebraic Number Theory,(* CRC Press, 1999).
2. Stewart, I. N. & Tall, D. *Algebraic Number Theory and Fermat's Last Theorem,* 3rd Edition, (A K Peters Ltd., 2002).
3. Esmonde, J. and Murty, M. R. *Problems in Algebraic Number Theory*, GTM Vol. 190, (Springer-Verlag, 2004).

Reference book

1. Neukirch, J.*Algebraic Number Theory*, (Springer-Verlag, 2002).

MI 547 NUMERICAL LINEAR ALGEBRA L3-T1-P0 CH4 CR 4

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

Text books

1. Trefethen, L. N. and Bau, David *Numerical Linear Algebra*, (SIAM, 1997).
2. Watkins, D. S. *Fundamentals of Matrix Computation*, (Wiley, 1991).
3. Golub, G. H and Loan, C.F.Van *Matrix Computation*, (John Hopkins U. Press, Baltimore, 1996).

Reference books

1. Stewart, G. W. Introduction *to Matrix Computations*, (Academic Press, 1973).
2. Demmel, J.W. *Applied Numerical Linear Algebra*, (SIAM, Philadelphia, 1997).

MI 550 DISCRETE MATHEMATICS **L3-T1-P0 CH4 CR 4**

Set Theory: Sets and classes, Relations and functions, Equivalence relations and equivalence classes, Principle of mathematical induction, Recursive definitions, Posets, Chains and well-ordered sets, Axiom of choice, Cardinal and ordinal numbers, Cantor's lemma, Set theoretic paradoxes.
Combinatorics: Principles of addition and multiplication, Arrangements, Permutation and combinations, Multinomial theorem, Partitions and allocations, Pigeonhole principle, Inclusion-exclusion principle, Generating functions, Recurrence relations.

Text Books

1. Lovasz, L., Pelikan J., Vesztergombi K. *Discrete Mathematics* (Springer, 2003).
2. Balakrishnan, V. K. *Introductory Discrete Mathematics* (Dover, 1996).

Reference Books

1. Johnsonbaugh, R. *Discrete Mathematics* (Prentice Hall, 2008)
2. Grimaldi, R. *Discrete and Combinatorial Mathematics*, 5th Edition (Pearson Education, 2003).

MI 552 OPERATOR THEORY –I **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 306**

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

Text books

1. Halmos, P. R. *Introduction to Hilbert spaces and theory of spectral multiplicity*, (Chelsea Publishing Co., New York, 1957).
2. Kreyszig, Erwin *Introductory functional analysis with applications*, (John Wiley and Sons, 1978).

Reference book

1. Bachman, G. and Narici, L. *Functional Analysis*, (Academic Press, New York, 1966).

MI 554 ADVANCED ALGEBRA I **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 305**

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

Text books

1. Atiyah, M. F. and Macdonald, I. G. *Introduction to commutative Algebra*, (Manohar Publisher and Distributors, 2008).
2. Sharp, R. Y. *Steps in Commutative Algebra*, (London Mathematical Society Student Text, Vol 51., 2006).

Reference books

1. Cohn, P. M. *Algebra*, Vols. I & Vol. II, (John Wiley & Sons, 1985 and 1988.)
2. Jacobson, N. *Basic Algebra*, Vols. I & II, 2nd ed., (Dover, 2009).
3. Zariski, O. & Samuel, P. *Commutative Algebra*, Vols. I and II, (Springer, 2000).

MI 556 QUANTUM MECHANICS –I **L3-T1-P0 CH4 CR 4**

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

Text books

1. Schiff, L. I. *Quantum Mechanics*, (McGraw Hill Book Co., 2010).
2. Methews, P. M. *A Textbook of Quantum Mechanics*, 2nd ed., (Tata McGraw Hill, 2010).

Reference books

1. Merzbacher, *Quantum Mechanics*, (John Wiley & Sons, NY, 1970) .
2. Ghatak, A. K. and Loknathan, *Quantum Mechanics*, (Macmillan India Ltd, 1982).
3. . Dirac, P. A. M *The Principles of Quantum Mechanics*, (Oxford University Press, 1958).
4. Bjorken, J. D. and Drell, S. D. *Relativistic Quantum Mechanics*, (McHill, New York, 1964).

MI 557 MATHEMATICAL MODELLING-I L3-T1-P0 CH4 CR 4

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

Text books

1. Glendinning, P. *Stability, Instability and Chaos*, (Cambridge University Press, 1994).
2. Burton, T.A. *Stability By Fixed Point Theory For Functional Differential Equations*, (Dover, 2006).

Reference books

1. Salle, J. La and Lefschetz, S. *Stability by Liapunov's Direct Mehtod*, (Pringer, 1977).
2. Bacciotti, A. & Rosier, L. *Liapunov Functions and Stability in Control Theory*, (Springer, 2005).

MI 558 GENERAL THEORY OF RELATIVITY L3-T1-P0 CH4 CR 4
***Prerequisite* MI 543**

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

Text books

1. Adler, R., Bazin, M. &. Schiffer, M. *Introduction to General Relativity*, (McGraw Hill, 1975).
2. Will, C.M. *Theory and Experiment in Gravitational Physics*, (Cambridge University Press, 1981).
3. Narlikar, J.V *Introduction to Cosmology*, (Cambridge UP, 1993) .

Reference books

1. Landau, L. D.& Lifshitz, E.M. *Classical Theory of Fields*, (Pergamon Press, 1975.)
2. Weinberg, S. *Gravitation and Cosmology,* (John Wiley & Sons, 1972.)
3. Kenyon, I. R. *General Relativity*, (Oxford University Press, 1991.)
3. Dirac, P. A. M *General Theory of Relativity*, (Prentice Hall of India (reprinted), 2001.)

MI 560 SAMPLING TECHNIQUES-I L3-T1-P0 CH4 CR 4

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

Text books

1. Cochran, W. G. *Sampling Technique*, (Wiley Eastern, New Delhi, 1997).
2. Mukhopadhyay, P *Theory and Methods of Survey Sampling*, (Prentice-Hall of India Pvt. Ltd, New Delhi, 1998).

Reference books

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

MI 562 STATISTICAL QUALITY CONTROL **L3-T1-P0 CH4 CR 4**

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

Text books

1. Hansen, B. L and Ghare, P. M. *Quality control and application*, (PHI, N.J., 1993).
2. Guttman, I., Wilks, S. S and Hunter, J. J. *Introductory Engineering Statistics*, (John Wiley, N.J., 1992).
3. Montgomery, D. C. *Introduction to Statistical Quality Control*, (John Wiley, N.Y., 1985).

Reference books

1. Hansen, B. L. *Quality Control: Theory and Applications*, (Englewood Cliffs, N. J.: Prentice Hall, 1963).
2. Grant, E. L. and Leavenworth, R.S. *Statistical Quality Control*, 5th Ed., (N. Y., McGraw Hill, 1980).
3. Hines, W. W. and Montgomery, D. C. *Probability and Statistics in Engineering and Statistics*, 2nd Ed., (N.Y., John Wiley, 1980).

MI 564 MULTIVARIATE ANALYSIS-I **L3-T1-P0 CH4 CR 4**

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

Text books

1. Anderson, T. W. *An Introduction to Multivariate Analysis* (2nd edition), (Wiley, 1984).
2. Johnson, R.A. *Applied Multivariate Statistical Analysis*, 6th ed., (Pearson, 2008).

Reference books

1. Johnson, N. L. and Kotz, S. *Continuous Multivariate Distributions*, (John Wiley, New York, 2004).
2. Kendall, M. G. *Multivariate Analysis*, (NY, Hamer Press, 1975).
3. Maxwell, A. E. *Multivariate Analysis in Behavioural Research*, (London, Chapman & Hall, 1977).
4. Chatterjee, S. and Price, *Regression Analysis by Examples*, (John Wiley, NY, 1977).
5. Johnson, N. L., Kotz, S. and. Balakrishnan, N *Discrete Multivariate Distributions*, (Wiley, N.Y., 1997).
6. Johnson, N. L., Kotz, S. and Kemp, A. W. *Univariate Discrete Distributions*, 2nd ed., (Wiley, 1993).

MI 565 FUZZY SETS AND APPLICATIONS-I **L3-T1-P0 CH4 CR 4**

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

Text books

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

Reference books

1. Ruan, R.D. & Ruan, D. *Fuzzy Set Theory And Advanced Mathematical Applications*, (Kluwer, 1995).
2. Smithson, M.J. & Verkuilen, J. *Fuzzy Set Theory Applications to Social Sciences,* (Sage Publications, 2004).

MI 566 FOURIER ANALYSIS **L3-T1-P0 CH4 CR 4**
***Prerequisite* MI 306**

Orthogonal systems, Trigonometric system, Fourier series in these systems, Uniqueness and convergence ,Approximate identity , Fourier series of continuous and smooth functions, L^2 theory of Fourier series – inversion formula and the Parseval identity,

Fourier analysis and complex function theory, Bessel functions, Orthogonal polynomials, Fourier analysis and filters.

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

Classical Hardy spaces F and M. Reisz theorem.

Text books

1. Dym, I.H. and Mc Kean, H.P. *Fourier Series and Integrals*, (Academic Press, 1985).
2. Folland G.B., *Fourier Analysis and Applications*, (AMS, 2010).

Reference books

1. Katznelson, Y., *An Introduction to Harmonic Analysis*, (Dover, New York, 1976).
2. Korner, T., *Fourier Analysis*, (Cambridge, 1989).
3. Rudin, W., *Functional Analysis*, (Tata Mc. Graw Hill, 1974).
4. Elias M. Stein and Shakarchi, Rami *Fourier Analysis An Introduction* ,(Princeton University Press, Princeton , 2004).

MI 567 CONTINUUM MECHANICS **L3-T1-P0 CH4 CR 4**

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

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

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

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

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

Text books

1. Chatterjee, R. *Mathematical Theory of Continuum Mechanics,* (Narosa, 1999).
2. Mase, G.E, *Schaum's Outline of Continuum Mechanics (Schaum's Outline series)*, (Mc-Graw Hill, 1990).

Reference book

1. Truesdell, C. *The elements of continuum Mechanics,* (Springer-Verlag, 2000).

MI 568 THEORY OF DISTRIBUTION AND SOBOLEV SPACES

Prerequisite **MI 306** **L3-T1-P0 CH4 CR 4**

Test Function and distribution: Definition, operations with distributions, convolution of distributions, Fourier transform of tempered distributions.
Sobolev spaces: Definition and properties, extension theorem, imbedding and completeness theorem, fractional order Sobolev spaces, trace theory.
Application to Elliptic Problems: Weak solution of elliptic boundary value problem (BVP), regularity of weak solutions, maximum principle, eigenvalue problems, fixed point theorems and their application in semilinear elliptic BVP.

Text books

1. Adams, R.A. & Fournier, J. *Sobolev Spaces*, 2nd ed., (Academic Press, 2003).
2. Oden, J.T. & Reddy, J.N *An Introduction to Mathematical Theory of Finite Elements, (*Wiley Interscience, 1976).
3. Kesavan, S. *Topics in Functional Analysis and Applications*, (Wiley Eastern Ltd., New Delhi, 1989).

Reference books

1. Brennan, K. E. and Scott., R. *The Mathematical Theory of Finite Element Methods* (Springer-Verlag, Berlin, 1994).
2. Lieb, Elliot H and Loss, Michel *Analysis,* (Narosa Publishing House, New Delhi, 1997).
4. Strihartz, Robert S. *A guide to Distribution Theory and Fourier Transforms, (Studies in Advanced Mathematics), (*CRC Press,USA ,1994).
5. Rudin, W. *Functional Analysis*, (Tata McGraw Hill, 1974).

MI 572 OPERATOR THEORY –II **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 552**

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

Text books

1. Conway, J. B. *A Course in Functional Analysis,(* Springer-Verlag, New York, 1985).
2. Kreyszig, E. *Introductory functional analysis with applications,(* John Wiley and Sons, New York, 1978).
3. Fillmore, P. A. *Notes on operator theory*, (Van Nostrand Reinhold Company, New York, 1970).

Reference book

1. Halmos, P. R. *A Hilbert space problem book*, (Van Nostrand, Princeton, New Jersey, 1967).

MI 573 ANALYTIC NUMBER THEORY **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 307**

Arithmetical functions and Dirichlet multiplication, averages of arithmetical functions. Elementary theorems on the distribution of primes, the prime number theorem, Chebyshev's functions $\psi(x)$ and $\vartheta(x)$, relations connecting $\vartheta(x)$ and $\pi(x)$.
Dirichlet's theorem for primes of the form 4n-1 and 4n+1, distribution of primes in arithmetic progressions.
Quadratic residues and quadratic reciprocity law, applications of the reciprocity law, Gauss sums.
Dirichlet series and Euler products, Riemann zeta functions $\zeta(s)$ and Dirichlet L-function $L(s, \chi)$.
Introduction to partitions, geometric representation, generating functions, Euler's Pentagonal number theorem, Jacobi triple product identity, recursion formula for $p(n)$, partition identities of Ramanujan.

Text books

1. Apostol, T. M. *Introduction to Analytic Number Theory*, (Narosa, 1998).
2. Hardy, G. H. & Wright, E. M. *An Introduction to the Theory of Numbers*, 4th ed., (Oxford University Press, 2008).
3. Berndt, B. C. *Number Theory in the Spirit of Ramanujan*, (AMS, 2006).

Reference books

1. Niven, I., Zuckerman, H. and. Montgomery, H. L *An Introduction to the Theory of Numbers*, 5th edition, (Wiley Eastern, 2008.)
2. Andrews, G. E. *Theory of Partitions*, Cambridge (University Press, 1998.)
3. Chan, H. H. *Analytic Number Theory for Undergraduates*, (World Scientific, 2009).

MI 574 ADVANCED ALGEBRA –II **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 305**

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

Text books:

1. Morandi, P.*Field and Galois Theory*, GTM Vol. 167, (Springer-Verlag, 1996).
2. Lang, S.*Algebra*, (Springer Verlag, Indian Edition, 2008).
3. Dummit & Foote, *Abstract Algebra*, (John Wiley & Sons., 2005).

Reference book:

1. Cohn, P. M *Algebra*, Vols. I & Vol. II, (John Wiley & Sons, 1985 and 1988).

MI 576 QUANTUM MECHANICS -II **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 556**

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

Text books

1. Schiff, L. I. *Quantum Mechanics*, (McGraw Hill Book Co., 1986).
2. Enderson, E. E. *Introduction to Modern Physics and Quantum Mechanics*, (Macmillan India Ltd., 1979).
3. Mathews, P. M. and. Venkatesan, K *Quantum Mechanics*, (Tata McGraw Hill, 1990).

Reference books

1. Merzbacher, *Quantum Mechanics*, (John Wiley & Sons, New York, 1990).
2. Ghatak, A. K. and Loknathan, *Quantum Mechanics*, (Macmillan India Ltd., 1992).
3. Dirac, P. A. M. *The Principles of Quantum Mechanics*, (Oxford University Press, 1958).
4. Bjorken, J. D. and Drell, S. D. *Relativistic Quantum Mechanics*, (McHill, New York, 1964).

MI 577 MATHEMATICAL MODELING-II **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 557**

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

Text Books

1. Freedman, H.I. *Deterministic Mathematical Models in Population Ecology*, (Marcel Decker, 1980).
2. Renshaw, E. *Modelling Biological Populations in Space and Time*, (Cambridge University Press, 1991).

Reference books

1. Goh, B.S. *Management and Analysis of Biological Populations*, (Elsevier Scientific Publishing Company, 1980).

MI 580 SAMPLING TECHNIQUES-II **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 560**

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

Text books

1. Cochran, W. G. *Sampling Technique*, (Wiley Eastern, New Delhi, 1977).
2. Mukhopadhyay, P. *Theory and Methods of Survey Sampling*, (Prentice-Hall of India Pvt. Ltd, New Delhi, 1998).

Reference books

1. Lish, L. *Survey Sampling*, (Wiley, N.Y., 1965).
2. Murthy, M. N. *Sampling Theory and Methods*, 2nd edition, (Stat. Pub. Soc., Calcutta., 1977).

3. Jensen, R. J. *Statistical Survey Techniques*, (Wiley, N.Y., 1978).
4. Sukhatme, P. V. & Sukhatme, B. V. & Sukhatme, S. and Ashok, C. *Sampling Theory of Survey with Applications*, (Iowa State University Press, Ames, Iowa, 1984).
5. Raj, Des and Chandhok, Promod *Sample Survey Theory*, (Narosa Publishing House, New Dehi, 1998).
6. Hansen, M. H. &. Hurwitz, H. N and Madow, W. G. *Sample Survey Methods and Theory*, Vols. I and II, (Wiley, N.Y., 1953).

MI 581 STOCHASTIC PROCESSES –II **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 501**

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

Text books

1. Parzen, E. *Stochastic Processes*, (SIAM, 1999).
2. Medhi., J. *Stochastic Processes*, (Wiley Eastern Ltd., New Delhi, 1994).
3. Trivedi, K. S. *Probability & Statistics with reliability*, *Queueing and Computer Science Applications*, (PHI, 1992).

Reference books:

1. Kleinrock, L *Queueing Systems*, Vol. – I, II, (John Wiley & Sons, 1976).
2. Khintchine, A. Y. *Mathematical Methods in Queueing*, (Grieffen, London, 1960).
3. Medhi, J. *Stochastic Models in Queueing Theory*, (Academic Press, 1991).
4. Feller, W. *An Introduction to Probability Theory and its Applications*, Vol. I & II, (Wiley, 1998).

MI 582 RELIABILITY THEORY **L3-T1-P0 CH4 CR 4**

Exponential failure model: properties of exponential distributions, estimation of mean life with complete samples, reliability estimation, estimation with censored samples, estimation based on components of order statistics: k out of n. Gamma and Weibull

distributions (one, two and three parameters), estimation of complete samples, truncated and censored samples, reliability estimation, Normal and related distributions and reliability estimation, mixture distributions and competing risks. Reliability of series / parallel systems : Series system with identical components, reliability bounds - classical approach, reliability - Bayesian approach, parallel systems.

Text books

1. Polvoko, A. M., *Fundamental of Reliability Theory*, (Academic Press, New York, 1968).
2. Zacks, S., *Theory of Statistical Inference*, (Wiley, New York, 1971).
3. Sinha, S. K., *Reliability and Life Testing*, (Wiley Eastern Ltd., New Delhi, 1986).

Reference books

1. Ravichandran, N., *Stochastic Methods in Reliability Theory*, (Wiley Eastern Ltd., 1990).
2. Trivedi, Kishor Shribharbhai *Probability & Statistics with reliability, Queueing and Computer Science Applications*, (PHI, 1992).
3. Bazowsky, I., *Reliability*: *Theory and Practice*, Englewood Cliffs, (N.J., Prentice Hall, 1961).
4. Kapur, K., *Reliability in Engineering Design*, N.Y., (Wiley, 1977).

MI 584 MULTIVARIATE ANALYSIS-II **L3-T1-P0 CH4 CR 4**
Prerequisite **MI 564**

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

Text books

1. Anderson, T. W. *An Introduction to Multivariate Analysis* (2nd Edition), (Wiley, 1984).
2. Khirsagar, A. M. *Multivariate Analysis*, (Marcell Dekker, New York).
3. Kendall, M. G. *Multivariate Analysis*,(NY, Hamer Press, 1975.)

Reference books

1. Krishnaiah, P. R. (eds.), *Some recent developments on real multivariate distributions*, *Development in Statistics*, Vols. I & II, (Academic Press, New York, 1978.)
2. Maxwell, A. E. Multivariate Analysis in Behavioural Research, London, (Chapman & Hall, 1977.)
3. Chatterjee, S. and Price, B. *Regression Analysis by Examples*, (John Wiley, NY, 1977.)
4. Johnson, R. A. and. Wichern, D. W *Applied Multivariate Statistical Analysis*, 3rd Edition, (PHI, 1998.)

MI 585 FUZZY SETS AND THEIR APPLICATIONS-II L3-T1-P0 CH4 CR 4
***Prerequisite* MI 565**

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

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

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

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

Text books

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

Reference books

1. Ruan, R.D. & Ruan, D. *Fuzzy Set Theory And Advanced Mathematical Applications*, (Kluwer, 1995).
2. Smithson, M.J. & Verkuilen, J. *Fuzzy Set Theory Applications to Social Sciences,* (Sage Publications, 2004).

MI 586 PARELLEL NUMERICAL ALGORITHMS L3-T1-P0 CH4 CR 4

Fundamentals of Parallel computing. Parallel techniques and algorithms. Theoretical models of parallel computation: Variants of the PRAM model. Performance of parallel

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

Text book

1. Quinn, Michael J. Parallel computing theory and practice, 2nd ed, (Mc-Graw Hill, 2001).

Reference books

1. Jaja, Joseph, *An introduction to parallel algorithms*, Addision (Wesley, 1992).
2. Reif H.H., *Synthesis of parallel algorithms*, (Morgan Kaufmann publishers, San mateo, California, 2003) .
3. Leighton, F.T., *Introduction to parallel algorithms and architectures: Arrays trees, Hypercubes,(* Morgan Kaufmann publishers, San mateo, California, 2003).

MI 587 FINITE ELEMENT METHOD **L3-T1-P0 CH4 CR 4**

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

Text books

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

MI 588 APPLIED MATRIX THEORY L3-T1-P0 CH4 CR 4

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

Text books

1. Datta, K. B *Matrix and Linear Algebra*, (PHI, 1991).
2. Watkins, D. S. *Fundamentals of Matrix Computation*, (Wiley, 1991).

Reference books

1. Horn, R. A. and Johnson, *Matrix Analysis*, (Cambridge University Press, 2005).
2. Golub, G. H. and Loan, C.F.Van *Matrix Computation*, (John Hopkins U. Press, Baltimore, 1996) .
3. Stewart, G. W. *Introduction to Matrix Computations*,(Academic Press, 1973).

MI 591 COMPUTATIONAL FLUID DYNAMICS L3-T1-P0 CH4 CR 4
***Prerequisite* MI 541**

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

Text books

1. Anderson, J. D. *Computational Fluid Dynamics*, (Mc-Graw Hill, 1995).
2. Chung, T.J. *Computational fluid Dynamics*, (Cambridge University Press, 2005).
3. Anderson, D. A. &. Tannehill, J. C and Pletcher, R. H. *Computational Fluid Dynamics and Heat Transfer*, (McGraw Hill, 1984).
4. Versteeg, H.K. and Malalasekera, W. *An introduction to computational fluid Dynamics: the finite volume methods,* (Addison-Wesley, 1995).

Reference books

1. Fletcher, C. A. J. *Computational Techniques for Fluid Dynamics, Vol. 1 & 2*, (Springer, 1992) .
2. Chow, C. Y *Introduction to Computational Fluid Dynamics*, (John Wiley, 1979) .
3. Holt, M. *Numerical Methods in Fluid Mechanics*, (Springer Verlag, 1977).
4. Wirz, H. J. and. Smolderen, J. J *Numerical Methods in Fluid Dynamics*, (Hemisphere, 1978).

MI 593 WAVELETS AND APPLICATIONS L3-T1-P0 CH4 CR 4

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

Text books

1. Meyer, Y. *Wavelets: Algorithm and Application*, (SIAM, 1993).
2. Kaiser, G. *A Friendly guide to Wavelets*, (Birkhauser, 1994).

Reference book

1. Daubechies, I. *Ten Lectures on Wavelets*, (SIAM, 1992).

MI 594 ADVANCED TOPOLOGY -I L3-T1-P0 CH4 CR 4
***Prerequisite* MI 304**

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

Text books

1. Willard, S.*General Topology*, (Addision-Wesley, Reading, 1990).
2. Kelley, J. L. *Topology*, (Van Nostrand, 1985).

Reference books

1. Munkres, J. R. *Topology: A first course*, (Dorling Kindersley,India, 2005).
2. Joshi, K. D. *Topology*, (Wiley-Eastern, 1988).

MI 595 NUMERICAL SOLUTIONS OF ODE L3-T1-P0 CH4 CR 4
***Prerequisite* MI 308**

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

Text books

1. Lambert, J. D. *Numerical methods for Ordinary Differential equations,* (John Wiley & Sons, 1991).
2. Jain, M. K &. Iyenger, S. R. K and Jain, R. K. *Numerical Methods for Scientific and Engineering Computation*, (Wiley Eastern, 1993).

Reference books

1. Henrici., P *Discrete Variable Methods in Ordinary Differential Equations*. (John Wiley & Sons, New York, 1962).
2. Jain, M. K. *Numerical Solutions of Differential Equations*, (Wiley Eastern, 1991).
3. Miller, Richard K. *Introduction to Differential Equations*,(Prentice Hall, New Jersey, 1991).
4. Hoffman, J. D. Numerical methods for Engineers and Scientists, (Mc-Graw Hill, 2000).

MI 596 ADVANCED TOPOLOGY – II L3-T1-P0 CH4 CR 4
***Prerequisite* MI 594**

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

Text books

1. Willard, S.*General Topology*, (Addision-Wesley, Reading, 1990).
2. Kelley, J. L. *Topology*, (Van Nostrand, 1985).
3. Munkres, J. R. *Topology: A first course*, (Dorling Kindersley (India) Pvt. Ltd., 2005).
4. Joshi, K. D. *Topology*, (Wiley-Eastern, 1988).

Reference books

1. Engelking, R *General Topology*, (Polish Scientific Publishers, Warshaw, 1977).
2. Bourbaki, N.*Elements of Mathematics: General Topology*, Vols. I & II, (Springer-Verlag, 1988).

MI 597 NUMERICAL SOLUTIONS OF PDE L3-T1-P0 CH4 CR 4
***Prerequisite* MI 404**

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

Text books

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

Reference books

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

MI 598 ALGEBRAIC GEOMETRY **L3-T1-P0 CH4 CR 4**

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

Text books

1. Smith, K.E. etc all, *An Invitation To Algebraic Geometry*, (Springer, Indian Reprint 2005).
2. Musili, C. *Algebraic Geometry for Beginners*, TRIM 20, (Hindustan Book Agency, 2001).

Reference book

1. Hartshorne, R. *Algebraic Geometry*, GTM Vol. 52, (Springer, 2005).

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PI 201: ELECTRONICS-I (COMMON PAPER) L2-T1-P0-CH3-CR3

Foundations: Voltage and current. Relation between voltage and current: resistors (colour code, resistors in series and parallel, power in resistors, ratings) Voltage dividers. Voltage and current sources. Thevenin's equivalent circuit. Small signal resistance - example of zener diode.

Signals: Sinusoidal signals. Signal amplitudes and decibels. Other signals (ramp, triangle, noise, square waves, pulses, steps and spikes). Logic levels. Signal sources (signal generators, pulse generators, function generators).

Capacitors and ac circuits: Capacitors (The relations Q = CV and I = C(dV/dt), capacitors in parallel and series, capacitor colour codes and voltage ratings.) RC circuits. V and I versus time.Differentiators. Unintentional capacitive coupling. Integrators.

Inductors and transformers: Inductors, transformers, impedance and reactance. Frequency analysis of reactive circuits. Voltages and currents as complex numbers. Reactance of capacitors and inductors. The generalised Ohm law. Power in a reactive circuit. Generalised voltage dividers.

RC Filters: Phasor diagrams. High pass filters, low pass filters, "Poles" and decibels per octave. Resonant circuits and active filters. Other capacitor applications (bypassing, power supply filtering, timing and wave form generation). Generalised Thevenin theorem.

Diodes and Diode Circuits: Diodes. Rectification, Power supply filtering. Full wave bridge, center tapped full wave rectifier, split supply, voltage multipliers. Regulators. Circuit application of diodes. Inductive loading and diode protection.

Transistors: First transistor model - the current amplifier. Transistor switch. Emitter follower. Emitter followers as voltage regulators. Emitter follower biasing. Transistor current source. Common emitter amplifier. Unity-gain phase splitter. Transconductance.

Amplifier building blocks: Push-pull output stages. Darlington connection. Bootstrapping. Differential amplifiers. Feedback voltage regulator.

Textbook

1. Horowitz P. and Hill W., *The Art of Electronics*, 2nd Edition (Cambridge University Press, 1995).

Reference book

1. Hambley, A. R., *Electronics*, 2nd Edition (Prentice Hall, 2000).

PI 209: Physics Laboratory-II (For Non-Physics Majors in 3rd Semester) **L0-T0-P2-CH4-CR2**

PRACTICALS FOR PI 207 AND PI 209 WILL BE CHOSEN FROM THE FOLLOWING LIST.

(A) **General properties of matter**:

1. Determination of Young's modulus of the material of a wire by torsional oscillation according to Searle's method.
2. Determination of moment of inertia of some regular bodies by using a moment of inertia table.
3. Determination of the co-efficient of viscosity of water by Poiseullies's method

(B) Heat:

4. Determination of the co-efficient of liner expansion of a metal by optical lever.
5. Determination of the thermal conductivity of a metal by Searle's method.

(C) Light:

6. Determination of the focal length of a concave lens by combination method.
7. Measurement of the wavelength (λ) of a monochromatic light by using Lloyd's mirror
8. Measurement of of the wavelength (λ) of a monochromatic light by using Fresnel's Biprism.
9. Laser Experients
   (a) Determine the power distribution within the beam of a laser .
   (b) Measure the beam-spot size of the given laser.
   (e) Determine the slit width from the study of Fraunhofer diffraction pattern using laser.
   (g) Verify the Malus law using laser.
10. To draw i- δ curve of a prism by spectrometer and hence to find out the angle of minimum deviation.
11. Determination of the slit width and the separation between the slits of a double slit by observing the diffraction and interference fringes.
12. Calibration of a polarimeter for the study of optical rotation of a solution and hence determination of the concentration of sugar solution.

(D) **Magnetism**:

13. Determination of the moment of a bar magnet and horizontal component of earth's magnetic field by magnetometers.

(E) Electricity:

14. Measurement of resistance per unit length of the bridge wire by Carey Foster method.
15. Measurement of resistance of a suspended coil galvanometer by half deflection

method.

16. Determination of mechanical equivalent of heat by Joule's calorimeter.
17. Determination of the reduction factor of tangent galvanometer using a copper voltameter.
18. Determination of e.m.f. of a cell by a potentiometer
    (a) Using a milliammeter (b) without using a milliammeter (c) with the help of a standard cell.
19. Measurement of the thermo-e.m.f. with a potentiometer and to draw the E-T curve.

(F) Sound:

20. Determination of the frequency of a tuning fork by a sonometer.
21. To draw (υ-l) curve with the help of a sonometer and hence to find the frequency of a unknown tuning fork.

(G) Electronics:

22. To draw the static characteristics of a triode and hence to determine the valve constants.
23. To draw the I-V characteristic curve of a semiconductor diode (p-n junction).
24. To draw the static characteristics of a transistor in common emitter, common collector and common base configuration.
25. To design and develop a circuit to measure the (a) Input offset voltage (b) Input offset current (d) Slew rate and (e) Voltage gain

Advanced practicals:

(H) Surface Tension:

26. To determine the coefficient of surface tension using Jaegar's formula, the value of f(r) and hence to determine surface tension at two different temperatures by Jaegar's method.

(I) Thermal Conductivity:

27. Determination of thermal conductivity of the given disc of bad conductor of heat by Lee's and Chorlton method.

(J) Spectroscopy:

28. To draw δ-λ curve for the given spectrometer and hence to determine the wavelength of an unknown source.

(K) Magnetism:

29. To determine the horizontal component of earth's magnetic field by using reflection and vibration magnetometers.

(L) Electricity:

30. To determine the boiling point of a liquid by a platinum resistance thermometer.

31. Determination of the melting point of a solid by using a thermocouple.
32. To determine with the help of a search coil and a ballistic galvanometer the strength
of the magnetic field and to draw H - I curve.
33. Measurement of coefficient of self-inductance of a coil by Anderson's method.
34. To determine the coefficient of a mutual inductance between the two given coils by Carey Foster's method.

PI 202: Introductory Quantum Mechanics (Common Paper) L2-T1-P0-CH3-CR3

Limitations of classical physics: Qualitative discussions of the problem of the stability of the nuclear atom. The photo-electric effect. Franck-Hertz experiment and the existence of energy levels. Experimental evidence for wave-particle duality; X-ray diffraction and Bragg law. Compton scattering. Electron and neutron diffraction. Einstein and de Broglie's relations ($E = h\gamma$, $p = h/\lambda$).
Schroedinger equation: The concept of the wave function as a probability amplitude and its probabilistic interpretation. Plane wave solutions of the one-dimensional time-dependent Schroedinger equation for a particle in free space and elementary derivation of the phase and group velocities (quantitative discussion of wave packets is not required).
Uncertainty relation: The position-momentum uncertainty relation and simple consequences. Qualitative wave mechanical understanding of the size and stability of the hydrogen atom. Solutions of the one-dimensional Schroedinger's equation for an infinite square well potential; qualitative treatment of the finite well (derivation not required). Reflection and transmission at potential steps. Qualitative treatment of barrier penetration for simple rectangular barriers. Simple examples and comparison with classical mechanics.

Textbooks
1. Schiff, L.I., *Quantum Mechanics,* 3rd Edition (McGraw-Hill, New Delhi, 1968).

Reference books
2. Merzbacher, E., *Quantum Mechanics*, (John Wiley, New York, 2005)
3. Richtmyer, F.K., Kennard E. H. and Lauritsen, T., *Introduction to Modern Physics* (McGraw-Hill, 1976).

PI 210: Physics Laboratory-IV (For Non-Majors in 4th Semester) **L0-T0-P2-CH4-CR2**

PRACTICALS FOR PI 208 AND PI 210 WILL BE CHOSEN FROM THE FOLLOWING LIST.

(A) **General properties of matter**:

1. Determination of Young's modulus of the material of a wire by torsional oscillation according to Searle's method.
2. Determination of moment of inertia of some regular bodies by using a moment of inertia table.
3. Determination of the co-efficient of viscosity of water by Poiseullies's method

(B) Heat:

4. Determination of the co-efficient of liner expansion of a metal by optical lever.
5. Determination of the thermal conductivity of a metal by Searle's method.

(C) Light:

6. Determination of the focal length of a concave lens by combination method.
7. Measurement of the wavelength (λ) of a monochromatic light by using Lloyd's mirror
8. Measurement of of the wavelength (λ) of a monochromatic light by using Fresnel's Biprism.
9. Laser Experients
   (a) Determine the power distribution within the beam of a laser .
   (b) Measure the beam-spot size of the given laser.
   (e) Determine the slit width from the study of Fraunhofer diffraction pattern using laser.
   (g) Verify the Malus law using laser.
10. To draw i- δ curve of a prism by spectrometer and hence to find out the angle of minimum deviation.
11. Determination of the slit width and the separation between the slits of a double slit by observing the diffraction and interference fringes.
12. Calibration of a polarimeter for the study of optical rotation of a solution and hence determination of the concentration of sugar solution.

(D) **Magnetism**:

13. Determination of the moment of a bar magnet and horizontal component of earth's magnetic field by magnetometers.

(E) Electricity:

14. Measurement of resistance per unit length of the bridge wire by Carey Foster method.
15. Measurement of resistance of a suspended coil galvanometer by half deflection method.

16. Determination of mechanical equivalent of heat by Joule's calorimeter.
17. Determination of the reduction factor of tangent galvanometer using a copper voltameter.
18. Determination of e.m.f. of a cell by a potentiometer
(a) Using a milliammeter (b) without using a milliammeter (c) with the help of a standard cell.
19. Measurement of the thermo-e.m.f. with a potentiometer and to draw the E-T curve.

(F) Sound:

20. Determination of the frequency of a tuning fork by a sonometer.
21. To draw (υ-l) curve with the help of a sonometer and hence to find the frequency of a unknown tuning fork.

(G) Electronics:

22. To draw the static characteristics of a triode and hence to determine the valve constants.
23. To draw the I-V characteristic curve of a semiconductor diode (p-n junction).
24. To draw the static characteristics of a transistor in common emitter, common collector and common base configuration.
25. To design and develop a circuit to measure the (a) Input offset voltage (b) Input offset current (d) Slew rate and (e) Voltage gain

Advanced practicals:

(H) Surface Tension:

26. To determine the coefficient of surface tension using Jaegar's formula, the value of f(r) and hence to determine surface tension at two different temperatures by Jaegar's method.

(I) Thermal Conductivity:

27. Determination of thermal conductivity of the given disc of bad conductor of heat by Lee's and Chorlton method.

(J) Spectroscopy:

28. To draw δ-λ curve for the given spectrometer and hence to determine the wavelength of an unknown source.

(K) Magnetism:

29. To determine the horizontal component of earth's magnetic field by using reflection and vibration magnetometers.

(L) Electricity:

30. To determine the boiling point of a liquid by a platinum resistance thermometer.
31. Determination of the melting point of a solid by using a thermocouple.

32. To determine with the help of a search coil and a ballistic galvanometer the strength of the magnetic field and to draw H - I curve.
33. Measurement of coefficient of self-inductance of a coil by Anderson's method.
34. To determine the coefficient of a mutual inductance between the two given coils by Carey Foster's method.