Department of Mathematical Sciences

(Course Structure and Syllabus of Integrated M.Sc. in Mathematics)

Minimum credit requirement: 180
Minimum duration: 5 years (10 semesters)
Maximum duration: years (semesters)

COURSE STRUCTURE

Semester I

Course Code	Course Name	L-T-P	CH	CR	Remark
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 credits				18	

Semester II

Course Code	Course Name	L-T-P	CH	CR	Remark
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	National Service Scheme	0-0-1	1	1	
Total credits				18	

MI: Courses offer by the Department of Mathematical Sciences
PI: Courses offer by the Department of Physics
CI: Courses offer by the Department of Chemical Sciences
BI: Courses offer by the Department of Molecular Biology and Biotechnology
SC: Courses offer by the Department of Sociology
NS:
+ 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

Semester III

Course Code	Course Name	L-T-P	CH	CR	Remark
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 202	Introductory Quantum Mechanics (Common)	2-1-0	3	3	
PI 209	Physics Laboratory-II	0-0-2	4	2	
Total credits for major students				20	

Semester IV

Course Code	Course Name	L-T-P	CH	CR	Remark
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 or PI 212	Ecology and Environmental Biology or Electronics (non physics major)	2-1-0 or 2-1-0	3 or 3	3 or 3	
BI 210 or PI 210	Bioscience Laboratory-IIB or Physics Laboratory-IV	0-0-2 or 0-0-2	4 or 4	2 or 2	
Total credits for major students				20	

Semester V

Course Code	Course Name	L-T-P	CH	CR	Remark
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 credits				18	

Semester VI

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 302	Numerical Analysis^{+}	3-1-0	4	4	
MI 304	Topology	3-1-0	4	4	
MI 408	Complex 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 credits				18	

Semester VII

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 306	Functional Analysis	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 credits				18	

Semester VIII

Course Code	Course Name	L-T-P	CH	CR	Remark
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 401	Classical Mechanics	3-1-0	4	4	
	Open Elective -II	3-1-0	4	*4*	
Total credits				18	

Semester IX

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 501	Stochastic Processes-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 10^{th} semester)	0-0-8	16	*0*	
Total credits				16	

Semester X

Course Code	Course Name	L-T-P	CH	CR	Remark
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 credits				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.

Electives to be offered from the following units:

Course Code	Course Name	L-T-P	CH	CR	Prequisites
MI 540	Mathematical Methods in Finance	3-1-0	4	4	Nil
MI 541	Fluid Mechanics	3-1-0	4	4	Nil
MI 542	Electrodynamics	3-1-0	4	4	Nil
MI 543	Relativity	3-1-0	4	4	Nil
MI 544	Operation Research	3-1-0	4	4	Nil
MI 545	Elliptic Curves	3-1-0	4	4	MI 305
MI 546	Algebraic Number Theory	3-1-0	4	4	MI 305
MI 547	Numerical Linear Algebra	3-1-0	4	4	Nil
MI 548	Mathematical Logic	3-1-0	4	4	Nil
MI 549	Graph Theory	3-1-0	4	4	Nil
MI 550	Discrete Mathematics	3-1-0	4	4	Nil
MI 551	Introduction to Category Theory	3-1-0	4	4	MI 208, 305, 304
MI 552	Operator Theory-I	3-1-0	4	4	MI 306
MI 554	Advanced Algebra-I	3-1-0	4	4	MI 305
MI 556	Quantum Mechanics-I	3-1-0	4	4	Nil
MI 557	Mathematical Modeling-I	3-1-0	4	4	Nil
MI 558	General Theory of Relativity	3-1-0	4	4	MI 543
MI 560	Sampling Techniques-I	3-1-0	4	4	Nil
MI 562	Statistical Quality Control	3-1-0	4	4	Nil
MI 564	Multivariate Analysis-I	3-1-0	4	4	Nil
MI 565	Fuzzy Sets and Applications-I	3-1-0	4	4	Nil
MI 566	Fourier Analysis	3-1-0	4	4	MI 306

MI 567	Continuum Mechanics	3-1-0	4	4	Nil
MI 568	Theory of Distribution and Sobolev Spaces	3-1-0	4	4	MI 306
MI 572	Operator Theory –II	3-1-0	4	4	MI 552
MI 573	Analytic Number Theory-II	3-1-0	4	4	MI 307
MI 574	Advanced Algebra-II	3-1-0	4	4	MI 305
MI 576	Quantum Mechanics –II	3-1-0	4	4	MI 556
MI 577	Mathematical Modeling-II	3-1-0	4	4	MI 557
MI 580	Sampling Techniques-II	3-1-0	4	4	MI 560
MI 581	Stochastic Processes –II	3-1-0	4	4	MI 501
MI 582	Reliability Theory	3-1-0	4	4	Nil
MI 584	Multivariate Analysis-II	3-1-0	4	4	MI 564
MI 585	Fuzzy Sets and Applications-II	3-1-0	4	4	MI 565
MI 586	Parallel Numerical Algorithms	3-1-0	4	4	Nil
MI 587	Finite Element Method	3-1-0	4	4	Nil
MI 588	Applied Matrix Theory	3-1-0	4	4	Nil
MI 591	Computational Fluid Dynamics	3-1-0	4	4	MI 541
MI 593	Wavelets and Applications	3-1-0	4	4	Nil
MI 594	Advanced Topology-I	3-1-0	4	4	MI 304
MI 595	Numerical Solutions of ODE	3-1-0	4	4	Nil
MI 596	Advanced Topology-II	3-1-0	4	4	MI 594
MI 597	Numerical Solutions of PDE	3-1-0	4	4	MI 507
MI 598	Algebraic Geometry	3-1-0	4	4	Nil

Detailed Syllabi

MI 101 Mathematics I **(L2 -T1 -P0 -CH3 -CR 3)**

Unit-1
Inequalities involving arithmetic, geometric, and harmonic means, Cauchy-Schwarz inequality, Real numbers.

Unit-2
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), Convergence, Absolute and conditional convergences, Test for convergence: Comparison test, Ratio test, Raabe's test, Leibnitz's test.

Unit-3
Functions of one variable: Limit, Continuity, Differentiability, Rolle's theorem, Mean value theorems and applications, Taylor's theorem.

Unit-4
Linear Approximation, Newton and Picard method, Approximation by polynomials, Critical points, convexity, curvature of plane curves, Asymptotes.
Curve tracing: tracing of catenary, cissoids, asteroid, cycloid, folium of Descartes, cardiod, lemniscate.

Unit-5
Functions of two or more variables: Limit, Continuity, Partial derivatives, Euler's theorem on homogeneous functions, Differentiability, Chain rule, Directional derivatives,, Gradient vectors and Tangent planes, Taylor's theorem (statement only), Criteria for Maxima/Minima/Saddle points, Lagrange's method of multipliers.

Unit-6
Improper integrals, Numerical Integration: Trapezoidal and Simpson's rule; error bounds.

Textbook(s)
1. Thomas and Finney, *Calculus and Analytic Geometry*, (Pearson Education, Eleventh (Indian) Edition).
2. Bartle, R. G. and Sherbert, D. R. *Introduction to Real Analysis*, (John Wiley and Sons, Third (Indian) Edition).

Reference book(s)
1. Apostol, T. M. *Calculus*, Vol I & II, (John Wiley and Sons, Second (Indian) Edition).
2. Mapa, S.K. *Higher Algebra*, (Asoke Prakashan, Kolkata).

MI 102 Mathematics II **(L2 -T1 -P0 -CH3 -CR 3)**

Unit-1
Ordinary differential equations(ODE): Basic definitions: order and degree of differential equation, primitives, solutions of differential equations, Integral curves, isoclines, formulation of ODE, Linear and non-linear differential equations.

Unit-2
Variables separable equation, homogeneous and non-homogeneous equation, exact equations and integrating factors, linear and Bernoulli's equation, equations reducible to first order Clairaut's equation.

Unit-3
Second order Differential Equations: Linear equations with constant coefficients. Standard methods for solution of homogeneous and non-homogeneous linear differential equations, linear differential equations with variable coefficients and Method of Variation of Parameter.

Unit-4
Line integral, Double integral, triple integral, Jacobian, Surface integral and their applications. Space co-ordinates, lines and planes, Polar coordinates, Cylinders, Quadric surfaces, Volume, Area, length, volume and surface area of solids of revolution.

Unit-5
Vector Calculus, vector point function, continuity and differentiation of vector point function, partial derivative of vectors, Curl, Grade, Divergence; Green, Gauss and Stokes Theorem.

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

Reference book(s)
1. Jain, R. K. and Iyengar, S. R. K. *Advanced Engineering Mathematics*, Third Edition, (Narosa publishing house, India).
2. Ramana, B. V. *Higher Engineering Mathematics*, (McGraw Hill, India).

MI 201 Introductory Statistics (L2 -T1 -P0 -CH3 -CR 3)

Unit-1
Collection of data, methods of collections of primary data, presentation and classification of data.

Unit-2
Discrete and continuous variables, Frequency distributions, Graphical representation, cumulative frequency distribution and ogives.

Unit-3
Measures of location, the arithmetic mean of group data, properties of arithmetic mean, median and mode; other measures of location: quartiles, deciles and percentiles.

Unit-4
Measures of dispersion,Variance and standard deviation of ungrouped and grouped data, properties of standard deviation.

Unit-5
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.

Unit-6
Probability Distributions: Binomial distribution, Properties of Binomial Distribution, Stirling approximation, Poisson Distribution, Properties of Poisson distribution. Moments of higher order, relation between m_r and $m_{r'}$, skewness and Kurtosis.

Unit-7
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.

Unit-8
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.

Textbook(s)
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 book(s)
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 -CR 4)

Unit-1
Discrete sample space, Bayes' formula, Discrete random variable, expected value of a random variable.

Unit-2
Standard probability distribution: Bernoulli, Binomial, Hypergeometric, Geometric, Poisson and Normal distribution.

Unit-3
Elements of Sampling theory: sampling with and without replacement.

Unit-4
Sampling distribution of the sample mean, sampling distribution of proportion, standard error.

Textbook(s)
1. Medhi, J. *Statistical Methods: An introductory Text* (New Age International (P) Ltd, 2000).

Reference book(s)
1. 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 -CR 3)

Unit-1
Algebra of matrices; symmetric, skew symmetric, Hermitian and skew Hermitian matrices; elementary transforms, reduction to echelon and normal form.

Unit-2
System of linear equations, existence and uniqueness of solutions, rank of a matrix.

Unit-3
Definitions and examples of vector spaces, elementary properties of and as vector spaces, subspaces, operations on subspaces.

Unit-4
linear dependence and independence of vectors, basis and dimension of vector spaces.

Unit-5
linear mappings and their algebraic properties; eigenvalues and eigenvectors, characteristic equation, statement of Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

Unit-6
Algebraic properties of complex numbers, geometrical interpretation of complex numbers, modulus and argument of complex numbers; exponential and trigonometric functions of a complex variable.

Unit-7
theorems on limit and continuity of a function of complex variable, differentiability, analytic function, Cauchy-Riemann equations, Harmonic functions.

Unit-8
derivatives of elementary functions; contour integration, Cauchy's integral theorem, Cauchy's integral formula.

Textbook(s)

1. Churchill R. V. and 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 book(s)

1. Dutta K. B. *Matrix and Linear Algebra*, (Prentice Hall of India, 2008).
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 (L2-T1 -P0 -CH3 -CR 3)

Unit -1
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.

Unit -2
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.

Unit -3
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.

Unit -4
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.

Textbook(s)
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(s)
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 -CR 3)**

Unit-1
Relations, Equivalence relations, Mapping and binary operations

Unit-2
Groups, subgroups, cosets, Lagrange's theorem, Subgroup generated by a set, cyclic groups permutation groups, normal subgroups, quotient groups.

Unit-3
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.

Unit-4
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.

Unit-5
Descartes rule of sign, Strum's theorem (statement only) Solution of cubic equation, Cardon's method and solution of bi-quadratic equation.

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

Reference book(s)

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).

MI 206 Integral Equations and Transforms (L3 -T1 -P0 -CH4 -CR 4)

Unit -1

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.

Unit -2

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.

Unit -3

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.

Unit -4

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.

Textbook(s)

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(s)

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 -CR 3)

Unit-1

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.

Unit-2

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.

Unit-3
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.

Unit-4
Plane, straight line and shortest distance. Change of axes, shift of origin, rotation of axes, Sphere, Cone and Cylinder.

Unit-5
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 book(s)
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 book(s)
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 -CR 4)**

Unit-1
Vector Space: Vector Spaces; bases and dimension; direct sum; dual space; quotient space (Revision).

Unit-2
Linear transformations: The algebra of linear transforms; representation of linear transforms by matrices; linear functionals; the double dual.

Unit-3
Eigen values and eigen vectors; annihilating polynomials; triangulation and diagonalization.

Unit-4
Primary Decomposition theorem; rational and Jordan forms.

Unit-5
Inner product spaces: inner product; Gram-Schmidt orthogonalization process.

Unit-6
Linear functionals and adjoints; self adjoint, normal and unitary operators; orthogonal projections; spectral theorem for normal operators on a finite dimensional vector space.

Unit- 7 Bilinear forms: bilinear, positive and quadratic forms.

Textbook(s)

1. Halmos, P. R. *Finite dimensional vector spaces, (*Springer Verlag, New York, 1987).
2. Hoffman, K. and Kunze, R. *Linear Algebra*, *(*Prentice Hall, 1984).

Reference book(s)

1. Halmos, P. R. *Linear Algebra Problem Book***, (**The Mathematical Association of America (MAA), USA, 1995).
2. Williams, G. *Linear Algebra with Applications***, (**Jones and Burlet Publishers, 2001).

MI 209 Statics And Dynamics (L2 -T1 -P0 -CH3 -CR 3)

Unit-1
Parallel forces, Couples, Reduction of coplanar forces. Analytical conditions of equilibrium of coplanar forces.

Unit-2
Centre of gravity of a plane area, arc and sector of a curve. C. G. of solids and surface of revolution.

Unit-3
Friction, laws of friction, limiting friction, equilibrium of a particle in rough inclined plane.

Unit-4
Principle of virtual work in two dimensions. Stable and unstable equilibrium.

Unit-5
Velocities and acceleration along radial and transverse directions, along tangential and normal directions.

Unit-6
Rectilinear motion with variable acceleration. Motion under inverse square law and other laws of force.

Unit-7
Simple harmonic motion. Motion in resisting medium. Motion of particles of varying mass. Motion of a projectile.

Unit-8
Central orbit and Kepler's laws of planetary motion.

Unit-9
Moments and products of inertia. Parallel axes theorem, theorem of six constants. Principal axes.

Textbook(s)

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 book(s)

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).

MI 301 Computer Programming+ (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Computer fundamentals: major hardware and software components of a digital computer, concepts of machine language, assembly language and high level language.

Unit-2
Number systems: binary, octal, hexadecimal; algebraic operations and conversions. Algorithms and flow charts.

Unit-3
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, operator precedence.

Unit-4
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.

Unit-5
Arrays and pointers: Arrays, declaration of one dimensional arrays, two dimensional arrays, pointers.

Unit-6
Structures: User defined data types, structures, array of structures, enumerated data type.

Unit-7
Function in C: Simple functions, passing arguments to functions with return value, call by value, call by reference, overloaded functions, inline functions, default arguments.

Unit-8
Searching and sorting: Bubble sort, selection sort, insertion sort, linear search and binary search.

Unit-9
Object and classes: class, types of accesses, difference between structure and classes, accessing members of a class, constructors, destructors.

Textbook(s)

1. Rajaraman V. *Fundamentals of Computers*, (Prentice Hall of India, New Delhi, 2002).
2. Balaguruswamy E. *Programming in ANSI C*, (Tata McGraw-Hill, 2004).

Reference book(s)

1. Kanetkar Y. P. *Let us C*, (BPB Publication, 2001).
2. Venkateshmurthy M. G. *Programming Techniques through C*, (Pearson Education, 2002).

[+] *Practical unit for the course MI 301 to be done in the course MI 309 Computer Laboratory.*

MI 302 Numerical Analysis+ (L3 -T1 -P0 -CH4 -CR 4)

Unit-1

Definition and sources of errors, Propagation of errors, Error analysis, Sensitivity and conditioning, Stability and accuracy, Floating-point arithmetic and rounding errors.

Unit-2

Interpolation, extrapolation and inverse interpolation, Newton divided difference, Lagrange, Hermite interpolation. Finite differences, divided differences are their properties.

Unit-3

Spline interpolation, B-splines. Special emphasis on cubic spline. Curve fitting.

Unit-4

Numerical solution of algebraic and transcendental equations, Iterative methods, Theory of one point iterative method, Newton Raphson method, rate of convergence, multipoint iterative methods.

Unit-5

Solution of system of linear algebraic equations using Gauss elimination and Gauss-Seidel methods, Numerical solution of non-linear simultaneous equations, Newton's method.

Unit-6

Trapezoidal and Simpson's method and error, composite integration. Double integration. Integration formulae: Gauss, Gauss-Legendre, Gauss-Hermite and Gauss-Laguerre quadrature formulae; Newton's formula for repeated integration**.**

Unit-7

Solution of ordinary differential equations. Picard method, Euler method, backward Euler method, modified Euler method, Runge-kutta class of methods.

Unit-8

Solving problems with C codes.

Textbook(s)

1. Atkinson, K.E. *Introduction to Numerical Analysis* (John Wiley, 1989)
2. Jain, M.K., Iyengar, S.R.K. and Jain R.K. *Numerical methods for Scientific and Engineering Computation,* 5th edition (New Age International (P) Ltd., New Delhi, 2006)

Reference book(s)

1. Sastry, S.S., *Introductory methods of Numerical Analysis* (Prentice Hall of India, New Delhi, 1977).
2. Hilderbrand, F. B. *Introduction to Numerical Analysis*, (Tata McGraw Hill, New Delhi, 1974).
3. Conte, S. D., Boor, Carl de. *Elementary Numerical Analysis - An Algorithmic Approach*, 3rd Edition, (McGraw Hill, 1980).

[+] *Practical unit for the course MI 302 to be done in the course MI 310 Computer Laboratory.*

MI 303 Real Analysis **(L3 – T1 – P0 - CH4 – CH 4)**

Unit-1
Elements of set theory, finite, countable and uncountable sets, Axiom of choice, Real number system.

Unit-2
Metric space, Open, closed sets, Interior, closure and boundary of sets, convergence of sequences, completeness, Cantor's Intersection Theorem, Baire category Theorem.

Unit-3
Continuity, Uniform continuity, open and closed maps, Homeomorphism.

Unit-4
Compactness in metric spaces, Bolzano Weiertrass Property, Lebesgue Number, Totally bondedness, Heine-Borel Theorem.

Unit-5
Connectedness, Components, Path connectedness, Intermediate Value theorem.

Unit-6
Riemann-Stieltjes integrals, properties, Mean value theorem, Fundamental theorem of calculus.

Unit-7
Sequences and series of functions, uniform convergence and its relation to continuity, differentiation and integration.

Textbook(s)

1. Apostol, T. M. *Mathematical Analysis*, (Narosa Publishing House, 1985).
2. Rudin, W. *Principles of Mathematical Analysis*, (McGraw Hill, 1982).

Reference book(s)

1. Goldberg, R. R. *Methods of real analysis*, (Oxford & IBH, 1970).
2. 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)**

Unit-1
Topological spaces, basis and sub-basis, Subspaces, closure, interior and boundary.

Unit-2
Continuity, open functions, homeomorphisms, embeddings, strong and weak topologies.

Unit-3
Quotient and product spaces.

Unit-4
Countability axioms, separability, Lindelof spaces. Separation axioms (T_0, T_1, T_2, T_3, T_4), regularity, complete regularity, normality.

Unit-5
Compactness, local compactness, Tychonoff's product theorem, compactification.

Unit-6
Connectedness, local and path connectedness, components, products of connected spaces.

Textbook(s)

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

Reference book(s)

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

MI 305 Abstract Algebra **(L3 -T1 -P0 -CH4 -CR 4)**

Unit-1
Group: Definition, elementary properties of groups, order of an element, examples of groups, subgroups, examples of subgroups, subgroup tests, subgroup generated by a subset, cosets, properties of cosets, Lagrange's theorem.

Unit-2
Cyclic groups: Definition and examples, properties of cyclic groups, classification of subgroups of cyclic groups.

Unit-3
Permutation groups: Definition and notation, cycle notation, properties of permutation, even and odd permutations, generators for symmetric group Sn, alternating group An.

Unit-4
Group homomorphisms: Definition and examples, propertis of homomorphisms, normal subgroups, factor groups, isomorphisms, isomorphism theorems, Caley's theorem, automorphisms of groups.

Unit-5
Direct products: Definition and examples of external direct products, properties of external direct products, definition and examples of internal direct products, fundamental theorem of finite Abelian groups and applications.

Unit-6
Group Action: Definition and examples, properties of group action, class equation of finite groups, Sylow's theorems, applications of Sylow's theorems, normal series, and solvable groups.

Unit-7
Rings: Definition and examples, elementary properties of rings, subrings, ideals, factor rings, ring homomorphisms, definition and examples of fields, embedding theorems, polynomial rings, division algorithm, irreducible polynomials, finite fields, structure of finite fields.

Unit-8
Factorization theory in integral domains, PID, Euclidean domains, Gaussian domain, Separable and inseparable extension of fields, elements of Galois theory.

Textbook(s)
1. Gallian, J. A. *Contemporary Abstract Algebra*, 4th edition (Narosa Publishing house, New Delhi, 2009).
2. Dummit, D. S. & Foote, R. M. *Abstract Algebra*, 3rd edition (John Wiley & Sons, Indian reprint, New Delhi, 2011).
3. Herstein, I. N. *Topics in Algebra*, 2nd edition (John Wiley & Sons, Indian reprint, New Delhi, 2006).

Reference book(s)
1. Fraleigh, J. B. *A First Course in Abstract Algebra*, 7th edition (Pearson Education India, New Delhi, 2008).
2. Lang, S. *Algebra*, 3rd edition (Springer India, New Delhi, 2006).
3. Gopalakrishnan, N. S. *University Algebra* (New Age International (P) Ltd, New Delhi, 2001).

MI 306 Functional Analysis **(L3 -T1 -P0 -CH4 -CR 4)**

Unit-1
Recap pre-requisite topics: Sets and relations, Linear spaces and linear maps, Metric spaces and continuous functions.

Unit-2
Introduce normed linear spaces with examples. Properties of nls, Riesz lemma, particular study of finite dimensional normed linear spaces, Discuss the interplay between linear structure and metric structure.

Unit-3
Define stronger, weaker and equivalent norms. Continuity and boundedness of linear maps, introduce complete normed linear spaces with examples. Function spaces and operator norm, bounded linear functional. Definition of Schauder basis. Dual spaces.

Unit-4
Hahn Banach separation and extension theorems. Applications of HBT.

Unit-5
Refer to the Ascoli-Arzela theorem and the definitions of uniform continuity, uniform boundedness, equicontinuity of a family of functions. Uniform boundedness theorem.

Unit-6
Closed graph theorem, open mapping theorem, bounded inverse theorem. Examples and applications of above theorems.

Unit-7
Inner product and Hilbert spaces, Bessel's inequality, Riesz-Fisher theorem, orthonormal basis. Fourier expansion and relation to orthonormal basis, Parseval formula, Separable Hilbert spaces.

Unit-8
Approximations, projection theorem, Riesz representation theorem. Hilbert adjoint operator, normal, self adjoint and unitary operators.

Textbook(s)

1. Limaye B. V. *Functional Analysis, (*Wiley Eastern Ltd., New Delhi, 1989).
2. Kreyszig E. *Introductory Functional Analysis with Applications*, (John Wiley and Sons, New York, 1978).

Reference book(s)

2. Rudin W. *Functional Analysis*, (McGraw Hill, 2000).
3. Yosida K. *Functional Analysis*, (Springer, 1995).
4. MacCluer B. *Elementary Functional Analysis*, (GTM 253, AMS, 2009).

MI 307 Elementary Number Theory (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Divisibility, greatest common divisor, least common multiple, Euclidean Algorithm.

Unit-2
Prime numbers, factorization in prime numbers, fundamental theorem of arithmetic.

Unit-3
Divisor functions, perfect numbers, Mersenne numbers, Fermat numbers.

Unit-4
Greatest integer function (Gauss function), Mobius function, Euler function.

Unit-5
Concept of congruences and its elementary properties, congruences in one unknown, complete residue system, reduced residue system.

Unit-6
Diophantine equations, linear Diophantine equations, Pythagoras equation, sum of two squares.

Unit-7
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.

Unit-8
Primitive roots and indices, order, necessary and sufficient condition for the existence of primitive roots, construction of reduced residue system.

Unit-9
Continued fractions, simple continued fractions, approximation of irrational numbers by continued fractions, solution of Pell's equation.

Textbook(s)

1. Burton, D. M. *Elementary Number Theory*, 6th Edition (Tata McGraw-Hill, New Delhi, 2007).
2. Niven, I. and Zuckerman, H. *An Introduction to the Theory of Numbers*, 5th Edition (Wiley Eastern, New Delhi, 2000).

Reference book(s)

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

MI 308 Theory of Ordinary Differential Equations (L3 -T1 -P0 -CH4 -CR 4)

Unit -1
Review of fundamentals of ODEs, Some basic mathematical models, direction fields, classification of differential equation, Solutions of some differential equation. 1st order non-linear differential equation.

Existence and Uniqueness problem, Gronwall's inequality, Peanao existence theorem, Picard existence and uniqueness theorem, interval of definition.

Unit -2
Second order linear differential equation, General solution for homogeneous equation, superposition of solutions, Methods of solution for non-homogeneous problem: undetermined coefficients, variation of parameters.

Unit -3
Series Solutions for ODE, Types of singularity, Solution at an Ordinary Point, Solution at a Singular Point.

Unit -4
nth order differential equation, system of equation, homogeneous system of equation, fundamental matrix, Abel-Liouvelle formula, System of non-homogeneous equations, Stability
of linear systems.

Unit -5
Theory of two point BVP, Greens function, Greens matrix, properties of greens functions, Adjoint and self adjoint BVP.

Unit -6
Strum-Liouvilles problem, Orthogonal functions, eigen values & eigen functions, Completeness of the Eigen functions.

Unit -7
Orthogonal trajectory of a system of curves on a surface solution of pfaffian differential equations in three variables.

Textbook(s)

1. Boyce, W. E. and DiPrima, R. C. *Elementary Differential Equation and Boundary Value Problems*, 7th Edition (John Wiley & Sons(Asia), 2001).
2. Ross, S. L. *Differential Equations*, 3rd edition (Wiley 1984).

Reference book(s)

1. Simmons, G. F. *Differential Equations with Applications and Historical Notes* (McGraw Hill, 1991).
2. Coddington, E. A. *An Introduction to Ordinary Differential Equations* (Prentice-Hall, 1974).
3. Farlow, S. J. *An Introduction to Differential Equations and Their Applications* (McGraw-Hill International Editions, 1994).

MI 309 Computer Laboratory+ (L0-T0-P2 -CH4 -CR 2)

+ *Practical unit for the course MI 301 Computer Programming.*

MI 310 Computer Laboratory+ (L0 -T0 -P2 -CH4 -CR 2)

+ *Practical unit for the course MI 302 Numerical Analysis+.*

MI 401 Classical Mechanics (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Momentum and kinetic energy, motion about a fixed point, Euler's equation, General equation of motion for a single particle and a system of N number of particles, General Solution.

Unit-2
Motion of a heavy sphere in a cylinder and a cone, motion under no force, Torque, Poinst's representation of motion.

Unit-3
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.

Unit-4
Hamiltonian of a dynamical system, Hamilton's canonical equation of motion, Cyclic coordinate, The Routhian, Conservation of energy and momentum.

Unit-5
Lagrange's method for small oscillation, Normal modes, Equations and examples.

Unit-6
Integral invariants of poincare, Lagrange's and Poisson's brackets and their properties, Equation of Motion and conserved quantities using Poisson's brackets, Infinitesimal contact transformation.

Unit-7
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.

Unit-8
Derivation of Lagrange's and Hamilton's equations from Hamilton's principle of least action, Hamilton Jacobi theory, Hamilton's Principal Function.

Textbook(s)

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

Reference book(s)

1. Takwale, R. G. & Puranik, P. S. *Classical Mechanics* (Tata-McGraw Hill, 1979, 41st reprint, 2010).
2. Yung-Kuo, L. *Problems and Solutions on Mechanics* (World Scientific, 1994).
3. Calkin, M. G. *Lagrangian and Hamiltonian Mechanics* (World Scientific, 1996).
4. Landau, L. & Lifshitz, E.M. *Mechanics: Course of Theoretical Physics, Vol. 1,* 3rd edition (Pergamon Press, 1976).

MI 402 Advanced Analysis (L2 -T1 -P0 -CH3 -CR 3)

Unit-1
Functions of several variables, Derivative on a open subset of R^n,Chain rule , partial derivative, derivative of higher order, Taylor's theorem.

Unit-2
Inverse function theorem, Implicit function theorem, Jacobians, Extermum problem with constraints, Lagrange's method of multipliers.

Unit-3
Differentiation under integrals, Partition of Unity, Differential forms, Stoke's theorem.

Unit-4
Lebesgue differentiation theorem, Lebesgue set, Complex measures, L^p Space.

Unit-5
Convex functions, Jensen's inequality, Holder and Minkowski's inequalities, Convergence and completeness, Approximation in L^p, Convergence in measure, integration of convex functions.

Unit-6
Total Variation, absolute continuity, consequences of Radon-Nikodym theorem, Bounded linear functional on L^p Space, Riesz representation theorem.

Unit-7
Fourier transforms, the inversion formula, the Plancherel theorem, the Banach algebra L^1.

Textbook(s)

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(s)

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

MI 403 Measure Theory (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Sigma algebra, Borel sigma algebra, Set Function.

Unit-2
Construction of Lebesgue measure, Lebesgue outer measure, Properties of outer measure, Measurable sets, Non-measurable sets, Lebesgue measure and its properties.

Unit-3
Measurable functions, Borel measurability, Borel Measures, Littlewood's three principles.

Unit-4
Lebesgue Integration: Step function, Simple functions, Approximation of every function by a simple function, Lebesgue integral of bounded non-negative functions, Bounded convergence theorem.

Unit-5
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.

Unit-6
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.

Unit-7
Signed measure, Hahn decomposition theorem, Mutually singular measures, Radon-Nikodym theorem, Lebesgue decomposition.

Unit-8
Product measure spaces, Fubini's theorem, Integration on Product spaces: Measurability on Euclidean spaces, completion of product measures, Invariant measures.

Textbook(s)
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 book(s)
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 -CR3)

Unit -1
Review of PDE, Canonical Transformation, Characteristics, Initial and Boundary Value Problems: Lagrange-Green's identity and uniqueness by energy methods.

Unit -2
Theory of distributions: supports, test functions, generalized derivatives, Sobolev Spaces, trace and imbedding results (without proof).

Unit -3
Elliptic Boundary Value Problems: abstract variational problems, Lax-Milgram Lemma, weak solutions, regularity result, maximum principles, eigen value problems.

Unit -4
Semigroup Theory and Applications: exponential map, C0-semigroups, Hille-Yosida and Lummer-Phillips theorems, applications to heat and wave equations.

Textbook(s)
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 book(s)
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)**

Unit-1
Graphs: History, The Konigsberg Bridge Problem, Basic Ideas: Definitions of Graph, Sub Graph, Spanning and Induced Subgraph (with diagrams), Degree and Incidence, Multi and Pseudo Graphs, Diagraph. Isomorphism and Homeomorphism of graphs.
Operations on Graphs: Union, Intersection and Ring-Sum of graphs, addition and removal of Edges and Vertices.

Unit-2
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.

Unit-3
Trees: Characterizations of trees, Theorems on tree, Forest, Rooted Tree, Binary Tree, Spanning Tree, Fundamental Cycles (to construct spanning Tree).

Unit-4
Traversability: Definition of Eularian graph, Properties of Eulerian Graphs: Necessary and sufficient conditions, Definition of Hamiltonian graph, Properties of Hamiltonian Graphs: Necessary and sufficient conditions .
Structure-based Connectivity and bipartite graph and and its necessary and sufficient condition.
Some Applications: The shortest path problem, The chinese postman problem and Travelling Salesman Problem.

Unit-5
Coverings and Colourings: Covering, Independence and Domination, Colouring Vertices (Chromatic Number, 4, 5 and 6 – Colourable Graphs, k-Colourable Graph), Colouring edges, Chromatic Polynomials.

Unit-6
Planarity: The Utilities Problem, Plane and Planar Graph, Planar Graph Representation, Planarity Detection (Kuratowski's theorem), Duality, Thickness and Crossing Numbers.

Unit-7
Diagraphs: Connectivity, Traversibility, Directed Trees, More Diagraph Matrices, The principle of Directional Duality, Tournaments.

Unit-8
Matrices: The Adjacency Matrix, The Incedence Matrix, The Cycle Matrix, The Cut-set Matrix, The Path Matrix.

Textbook(s)

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(s)

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

MI 406 Probability Theory (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Measurable space, Measure and its properties , finite and sigma-finite measures, Axiomatic definition of Probability, Measurable functions , definition of Random Variable.

Unit-2
Measure induced by a measurable function, definition of Probability distribution and distributionfunction, properties of distribution function and classification of distributions.

Unit-3
Some basic throrems 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.

Unit-4
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 theorem.

Textbook(s)

1. Feller, W. *An Introduction to Probability Theory and its Applications*, Vol. II (Wiley, 1966).
2. Chow, Y. and Teicher, H. *Probability Theory , Independence, Interchangeability, Martingales,;* 3rd Edition (Springer, 1997).

Reference book(s)

1. Ash, R. B. *Probability and Measure Theory, Second Edition* (Harcourt/Academic Press, 2000).

MI 407 Mathematical Software (L1 -T0 -P2 -CH2 -CR2)

Unit -1
Basic operations through Matlab, Input through keyboard and its illustration, Flow Control statements.

Unit -2
Iterative Method for Solving Non-linear Equation, Numerical Integration, Numerical Solution of 1st order IVP.

Unit -3
Numerical Differentiation and BVP.

Unit -4
Introduction to Mathematica, Symbolic Computation.

Textbook(s)

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 book(s)

1. Hunt, B. R., Lipsman, R. L., Osborn, John E. & Rosenberg, J. *DifferentialEquations 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).

MI 408 Complex Analysis (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Analytic functions, Cauchy-Riemann Equations, analyticity of elementary functions.

Unit-2
Complex integration, contour integrals, antiderivatives, Cauchy-Gaursat's theorem.

Unit-3
Cauchy integral formula, Morera's theorem, Maximum moduli of functions, Liouville's theorem, the Fundamental Theorem of Algebra.

Unit-4
Convergence of sequences and series, Taylor series, Laurent series.

Unit-5
Classification of singularities, Residue's, Cauchy Residue Theorem.

Unit-6
Evaluation of improper integrals and definite integrals involving sines and cosines, integration through a branch cut.

Unit-7
Logarithmic residues and Rouches theorem, the Argument Principle.

Unit-8
Linear fractional transformations, cross ratios, mappings of the half planes and circles, conformal mapping.

Unit-9
Condition under which a function is identically zero, Schwarz Reflection Principle, Analytic continuation, Riemann Surfaces.

Textbook(s)

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

Reference book(s)

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

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

Unit-1

Preliminaries of probability distributions, Laplace transforms, Laplace transforms of probability distributions of random variables, Simple random walk.

Unit-2

Stationary processes, Martingales (discrete).

Unit-3

Markov chains, Higher transition probability and its determinations, Sequence of chain-dependent trials, Classifications of States and chains.

Unit-4

Poisson Process and its properties.

Textbook(s)

1. Feller,W. *An Introduction to Probability Theory and its Applications*, II, (Wiley, 1998).
2. Medhi, J. *Stochastic Processes*, (Wiley Eastern Ltd., New Delhi, 1994).

Reference book(s)

1. Bhattacharyya, R. and Waymire, E. C. *Stochastic processes with applications*, (SIAM, 1990).

MI 502 Mathematical Programming (L3 -T1 -P0 -CH4 -CR 4)

Unit-1

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.

Unit-2

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.

Unit-3

Duality in linear programming, comparison of solutions of primal and its dual. Development of computer software for the solution of LPP using simplex.

Unit-4

Formulation of LP problem in revised simplex form. Computational procedure (algorithms). Advantage of revised simplex over simplex.

Unit-5
Introduction to dual simplex method along with its limitations. Development of computer software for the solution of LPP using Dual Simplex algorithm.

Unit-6
Importance of Integer programming problems. Gomory's All IPP technique. How to construct Gomory's constraint.

Unit-7 Game theory: Two-person zero-sum games, maximum criterion, dominance rules, mixed strategies, mini-max theorem, solutions of 2x2 and 2xm games.

Textbook(s)

1. Hadley, G. *Linear Programming* (Narosa Publishing House, New Delhi, 1987).
2. Kanti Swaroop, P.K. Jain and Mohan, M. *Operation Research*: *An Introduction* (S. Chand & Company, New Delhi, 1996).
3. Sharma, S. D. *Operations Research and Statistical Analysis* (Kedar Nath Ram Nath & Co., India, 1989).

Reference book(s)

1. Taha, H.A. *Operation Research*: An Itroduction (Macmilllan, New York,1992).
2. Kambo, N.S. *Mathematical Programming Techniques* (Affiated East West Press, New Delhi, 1990).
3. Luenberger, D.G. *Introduction to Linear and Nonlinear Programming* (Addison Wesley, Massachusetts, 1973).
4. Bazarra, M.S. and Shetty, C. M. *Nonlinear Programming Theory and Algorithms*, (John Wiley & Sons, New York, 1979).

MI 503 Advanced Numerical Analysis (L3 -T1 -P0 -CH3 -CR 4)

Unit-1
Iterative methods for Linear Systems: Classical iterative methods (Jacobi, Gauss-Seidel and successive over-relaxation methods).

Unit-2
Krylov subspace methods, Conjugate-Gradient (CG), BiConjugate-Gradient (BiCG), BiCG Stabilised (BiCGStab), Generalised Minimum Residual (GMRES). Preconditioning Techniques, parallel implementations.

Unit-3
Finite Difference method: Explicit and Implicit schemes, consistency, stability and convergence, Lax equivalence theorem. Numerical solutions of elliptic, parabolic and hyperbolic partial differential equations.

Unit-4
Approximate method of solution: Galerkin method, properties of Galerkin aproximations, Petrov-Galerkin method, Generalised Galerkin method.

Unit-5
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.

Textbook(s)

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 book(s)

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 540 Mathematical Methods in Finance (L3 -T1 -P0 -CH3 -CR 4)

Unit-1

An introduction to the basic concepts of financial markets. Various terms associated with Options. Different types of options. Payoff functions. Introduction to Martingale and the concept of fair price. (Proofs and technical details of stochastic calculus are beyond the scope of this course).

Unit-2

First principles, viz. no arbitrage, continuous compounding of risk free interest rates. Present value. Call-put parity. Bounds for present value of option price. Effect of expiry date and strike price on option valuation. Introduction to the concept of risk neutrality.

Unit-3

Discrete models in finance. Self financing strategy. Viable and complete market. Martingale based option pricing. CRR model and exact formulae for present value of European options based on a single asset.

Unit-4

Continuous time asset price model. ARCH / GARCH models for dynamically estimating volatility. Fitting these models using R. Exotic Options. . Approximation of expected option pay-off by Monte Carlo Simulation. Monte- Carlo Integration.

Unit-5

Introduction to Brownian Motion Process and Geometric Brownian motion process and Black -Scholes Model. Solution of a linear SDE.

Textbook(s)

1. Higham, D. J. *An Introduction to Financial Option Valuation* (Cambridge University Press, 2004).

Reference book(s)

1. Glasserman, P. *Monte Carlo Methods in Financial Engineering* (Springer, 2000).

MI 541 Fluid Mechanics (L3 -T1 -P0 -CH3 -CR 4)

Unit-1

Lagrarian and Eulerian methods, Velocity and acceleration, Particle path, Stream lines, Streak lines velocity potential, Steady and unsteady flows.

Unit-2

Conservation of mass and momentum, 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.

Unit-3

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,

Unit-4

Motion in two dimensions, 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.

Unit-5

Three dimensional flow, Irrotational motion, Weiss's theorem and its applications.

Unit-6

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

Textbook(s)

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 book(s)

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 -CH3 -CR 4)

Unit-1
Electrostatic force on charges, Coulombs Law, Electrostatic Field and Potential, Conservative force, Divergence and Curl of Electrostatic field, Gauss Law, Poisson and Laplace Equation.

Unit-2
Boundary conditions on Electrostatic field, Green's Function, Fourier series and Fourier Transform, Solution Electrostatic Poisson and Laplace Equation, Electrostatic Mirror Image.

Unit-3
Electrostatics in Media, Free and bound charges, Polarisation Vector, Permittivity and Susceptibility of media, Displacement Vector. Clausius-Mosotti Equation.

Unit-4
Moving charges and current, Conductors and Insulators, Current density, Magnetic effects of current, Bios-Savart Law, Magnetic field around an infinitely long current carrying wire, an infinite sheet and a solenoid, Divergence and Curl of Magnetic field, Amperes circuital Law. Megnetic Vector Potential.

Unit-5
Time varying electric and magnetic fields, Electromagnetic Induction, Faraday law, Lenz's law, Self and Mutual Inductance.

Unit-6
Maxwell Equations in free space and material media, Wave equation, Electromagnetic Waves, Plane wave solution, Transverse waves, Poynting Vector, Maxwell equations in conducting media, Attenuation of Electric and Magnetic fields.

Unit-7
Reflection, Refraction and Polarisation of Electromagnetic Plane waves, Brewster Angle, Fresnel's Equations.

Unit-8
Special Theory of Relativity, Lorentz Transformation and consequences, Minkowski Diagram, Four dimensional spacetime continuum, Four vector formulation of Maxwell Equations, Electromagnetic field Tensor.

Textbook(s)

1. Griffiths, D. J. *Introduction to Electrodynamics* (Pearson Education Limited, 2012).
2. Jackson, J. D. *Classical Electrodynamics* (Wiley Eastern Ltd., 1989).

Reference book(s)

1. Reitz, J. R., Milford, F. J. & Christy, R. W. *Foundations of Electromagnetic theory* (Narosa Publishing House, 1988).
2. Miah, M. A. W. *Fundamentals of Electrodynamics* (Tata McGraw Hill, 1986).
3. Laud, B. B. *Electromagnetics* (Wiley Eastern Ltd., 1990).

MI 543 Relativity **(L3 -T1 -P0 -CH3 -CR 4)**

Unit-1
Postulates of Special Theory of Relativity, Lorentz Transformation and consequences, Minkowski Diagram, Four dimensional spacetime continuum, Four vector formulation, Elementary properties of Tensors.

Unit-2
Rules of Combination of Tensors, Tensor Algebra, Inner and Outer Product Quotient Rule, Metric tensor and Conjugate Metric Tensors, Raising and lowering properties, Christofell symbols of first and second kind, Tranformation properties of Christofell symbols.

Unit-3
Tensor Analysis, Covariant Derivative of Tensors, Gradient, Divergence and Curl of Tensor, Geodesic Equation, Riemannian Tensor, Ricci Tensor, Bianchi Identities, Einstein Tensor.

Unit-4
Transition of Special to General Theory of Relativity, Principle of covariance, Equivalence Principle and consequences, Stress Energy Tensor, Einstein Field Equations and Newtonian limit.

Unit-5
Spherically symmetric solution to Einstein Field Equation in free space and in matter, Schwarzshild line element. Schwarzschild Black Holes.

Unit-6
Equation of Planetary Orbits, Crucial tests of General Theory of Relativity, Advance of Perihelion, Gravitational bending of light and Gravitational Redshift.

Unit-7
Cosmology: Large scale structure of Universe, Galactic Densities and the darkness of the Night Sky, Galactic Number Counts, Olber's paradox, Cosmological principles, Relativistic Universe and models.

Unit-8
Einstein and de-Sitter models of static universe, Dynamical Universe, Comoving time, Red Shifts and Horizons, Friedmann-Robertson-Walker line element, Open and Closed Universe, Hubbles law, Early Universe.

Textbook(s)

1. Narlikar, J.V. *An Introduction to Cosmology*, 3rd edition (Cambridge University Press, 2002).
2. Landau and Lifshitz, *Classical Theory of Fields* (Pergamon Press, 1975).

Reference book(s)

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

MI 544 Operations Research (L3 -T1 -P0 -CH3 -CR 4)

Unit-1
Definition and scope of operational research, different types of models.

Unit-2
Replacement model and Sequencing theory. Inventory problems and their analytical structure.

Unit-3
Economic lot size models with uniform rate of demand, with different rate of demand in different cycle**.**

Unit-4
Simple deterministic and stochastic model of inventory control; basic characteristics of queueing system.

Unit-5
Steady state solution of Markovian queueing model; M/M/1, M/M/1 with limited waiting space.

Unit-6
M/M/C, M/M/C with limited waiting space.

Textbook(s)

1. Sharma, J. K. *Operations Research: Theory and Applications* (Macmillan, 1997).

Reference book(s)

1. Taha, Humdy A. *Operations Research - An Introduction* (Prentice Hall of India, New Delhi, 1999).

MI 545 Elliptic Curves (L3 -T1 -P0 -CH4 -CH 4)
Prerequisite: MI 305

Unit-1
Projective Geometry: Homogeneous coordinates, projective plane, curve in projective plane, intersection of projective curves, Bezout's theorem.

Unit-2
Introduction to algebraic curves, singular and non-singular curves, geometry of cubic curves, elliptic curves, Weierstrass normal form of elliptic curves, Mordell-Weil group law on elliptic curve, explicit formulas for group law, Isogeny.

Unit-3
Points on elliptic curves of order two and three, points of finite order, Nagell-Lutz theorem and its applications.

Unit-4
Group of rational points on elliptic curve, height function, Mordell’s theorem, rank of elliptic curves, examples.

Unit-5
Elliptic curves over finite fields, Frobenius endomorphism, trace of Frobenius and number of points on elliptic curves.

Unit-6
Real and complex points on elliptic curves, periods of elliptic curves, lattice associated to elliptic curves.

Unit-7
Complex multiplication: Abelian extension of Q, algebraic points on cubic curves, Galois representation and complex multiplication.

Textbook(s)
1. Silverman, J.H. & Tate, J. *Rational Points On Elliptic Curves* (Springer-Verlag Indian Reprint, New Delhi 2010).
2. Washington, L. C. *Elliptic Curves: Number Theory and Cryptography* (CRC Press, USA, 2006).

Reference book(s)
1. Husemoller, D., *Elliptic Curves*, GTM vol. 111 (Springer-Verlag, New York, 2005).
2. McKean, M. & Moll, V. *Elliptic Curves,* (Cambridge University Press, 1999).

MI 546 Algebraic Number Theory (L3 -T1 -P0 -CH4 -CH 4)
Prerequisite: MI 305

Unit-1
Algebraic numbers and number fields, Discriminants, Norms and Trace.

Unit-2
Algebraic Integers, rings of integers, Integral Bases, Problems for quadratic and cubic cases.

Unit-3
Arithmetic of Number Fields: Quadratic Fields, Cyclotomic polynomials and fields.

Unit-4
Units in Number Rings, Dirichlet's Unit Theorem.

Unit-5
Ideal Theory: Norms of Ideals, fractional ideals.

Unit-6
Ideal Classes-The Class Group, Class Numbers of Quadratic Fields and Cyclotomic fields.

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

MI 547 Numerical Linear Algebra **(L3 -T1 -P0 -CH4 -CH 4)**

Unit -1
Fundamentals. Linear systems, LU decompositions, Gaussian elimination with partial pivoting, Banded systems, Positive definite systems, Cholesky decomposition. Vector and matrix norms,

Unit -2
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.

Unit -3
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.

Unit -4
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.

Textbook(s)
1. TrefethenL. N. and Bau, David. *Numerical Linear Algebra* (SIAM, 1997).
2. Watkins, D. S. *Fundamentals of Matrix Computation* (Wiley, 1991).

Reference book(s)
1. Golub, G. H. and Loan, C.F.Van. *Matrix Computation* (John Hopkins U. Press, Baltimore, 1996).
2. Stewart, G. W. *Introduction to Matrix Computations* (Academic Press, 1973).
3. Demmel, J.W. *Applied numerical linear algebra* (SIAM, Philadelphia, 1997).

MI 548 Mathematical Logic **(L3 -T1 -P0 -CH4 -CH 4)**

Unit-1
Zermelo-Fraenkel set theory, Ordinals and well-ordering, Axiom of choice cardinal Arithmetic.

Unit-2
Boolean algebra and proportional calculus. First order theories, validity, consistency, completeness.

Unit-3
Skolem-Iowenheim Theorem, compactness theorem, categoricity, Decidability; Godel's numbering. Godel's incompleteness theorems.

Unit-4

Propositional calculus, Truth on algebraic systems. The calculus of predicates. Model theory.

Textbook(s)

1. Cori, Rene and Lascar, Daniel., *Mathematical logic (*Oxford, 2001).

Reference book(s)

1. Halmos, P. R. *Naïve Set Theory* (Springer-Verlag, New York, 1974).

MI 549 Graph Theory **(L3 -T1 -P0 -CH4 -CH 4)**

Unit-1

Graphs: History, The Konigsberg Bridge Problem, Basic Ideas: Definitions of Graph, Sub Graph, Spanning and Induced Subgraph (with diagrams), Degree and Incidence, Multi and Pseudo Graphs, Diagraph. Isomorphism and Homeomorphism of graphs.

Operations on Graphs: Union, Intersection and Ring-Sum of graphs, addition and removal of Edges and Vertices.

Unit-2

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.

Unit-3

Trees: Characterizations of trees, Theorems on tree, Forest, Rooted Tree, Binary Tree, Spanning Tree, Fundamental Cycles (to construct spanning Tree).

Unit-4

Traversability: Definition of Eularian graph, Properties of Eulerian Graphs: Necessary and sufficient conditions, Definition of Hamiltonian graph, Properties of Hamiltonian Graphs: Necessary and sufficient conditions .

Structure-based Connectivity and bipartite graph and and its necessary and sufficient condition.
Some Applications: The shortest path problem, The chinese postman problem and Travelling Salesman Problem.

Unit-5

Coverings and Colourings: Covering, Independence and Domination, Colouring Vertices (Chromatic Number, 4, 5 and 6 – Colourable Graphs, k-Colourable Graph), Colouring edges, Chromatic Polynomials.

Unit-6

Planarity: The Utilities Problem, Plane and Planar Graph, Planar Graph Representation, Planarity Detection (Kuratowski's theorem), Duality, Thickness and Crossing Numbers.

Unit-7

Diagraphs: Connectivity, Traversibility, Directed Trees, More Diagraph Matrices, The principle of Directional Duality, Tournaments.

Unit-8
Matrices: The Adjacency Matrix, The Incedence Matrix, The Cycle Matrix, The Cut-set Matrix, The Path Matrix.

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

MI 550 Discrete Mathematics (L3 -T1 -P0 -CH4 -CH 4)

Unit-1
Set Theory: Sets and classes, Relations and Functions, Equivalence relations and Equivalence classes, Principle of mathematical induction, Recursive definitions.

Unit-2
Poset: Definitions and properties of poset, Chains and well-ordered sets.

Unit-3
Axiom of choice, Cardinal and ordinal numbers, Cantor's lemma, Set theoretic paradoxes.

Unit-4
Combinatorics: Permutation and combinations, Principles of addition and multiplication, Arrangements, Multinomial theorem, Partitions and allocations, Pigeonhole principle, Inclusion-exclusion principle. Generating functions, Recurrence relations.

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

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

MI 551 Introduction to Category Theory (L3 -T1 -P0 -CH4 -CR 4)
Prerequisites: MI 208, 305, 304.

Unit-1
Category, Functors and Natural Transformations: basic introductions and examples.
The notion of universality.

Unit-2
Representablity, and its connections with universality, Yoneda's Lemma and its consequences.
Limits, co-limits and their examples.

Unit-3
Algebras, internal algebras, matrices, internal relations, internal equivalence relations, internal groupoids, internal categories.

Unit-4
Adjoints and their examples, Characterising algebras through Beck's Monadicity Theorem.

Unit-5
A second visit to adjoints: Freyds Adjoint Functor Theorem and its applications to adjoints in algebra and topology.

Unit-6
Monoidal Categories, Introduction to Enriched Categories, Introduction to Abelian Categories.

Textbook(s)

1. Mac Lane, S. *Categories for the Working Mathematician*, 2nd ed. (Springer Verlag, New York, 1997).
2. Kelly, G. M. *Basic Concepts of Enriched Category Theory*, volume 64 (London Mathematical Society Lecture Notes, Cambridge University Press, 1982).

Reference Books:

1. Mac Lane, S. & Birkhofff, G. *Algebra*, 3rd ed. *(*Chelsea Pub. Co., New York, 1988).
2. Borceux, F. *Hand Book of Categorical Algebra-I: Basic Category Theory* (Cambridge University Press, Cambridge, 1994).

MI 552 Operator Theory I **(L3 -T1 -P0 -CH4 -CR 4)**

Unit-1
Uniform, strong and weak convergences.

Unit-2
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 operators.

Unit-3
Bounded operators on Hilbert spaces; adjoint operators; normal, unitary and self adjoint operators; spectral properties of bounded self adjoint linear operators.

Unit-4
positive operators and their square root; projection operators; spectral representation of a bounded self adjoint linear operator.

Unit-5
Spectral measure.

Unit-6
Spectral theorem for bounded normal operators.

Textbook(s)

1. Conway, J. B. *A course in Operator Theory* (AMS., GSM Vol. 21, 1999).
2. Kreyszig, E. *Introductory functional analysis with applications* (John Wiley and Sons, 1978).

Reference book(s)

1. Halmos, P. R. *Introduction to Hilbert spaces and theory of spectral multiplicity* (Chelsea Publishing Co., New York, 1957).
2. Abramovich, Y. A. and Aliprantis, C. D. *An Invitation to Operator Theory* (AMS, GSM Vol. 50, 2002).

MI 554 Advanced Algebra I **(L3 -T1 -P0 -CH4 -CR 4)**

Prerequisite: MI 305

Unit-1

Ideals in commutative rings, operations on ideals, extension and contraction of ideals, Nilradical and Jacobson radicals, prime spectrum of commutative rings.

Unit-2

Localization of commutative rings and their basic properties.

Unit-3

Noetherian and Artinian rings, examples.

Unit-4

Integral extensions, Dedekind domains.

Unit-5

Hilbert's Nullstellensatz, Noether's normalisation, valuation rings.

Unit-6

Modules: Elementary properties of modules, Quotient modules, module homomorphisms, Isomorphism theorems, Generation of modules, Direct sum of modules, finitely generated modules, free modules.

Unit-7

Tensor product of modules and properties, Exact sequences, projective and injective modules.

Unit-8

Modules over Principal Ideal Domain.

Textbook(s)

1. McDonalds, I. G. & Atiyah, M. F. *Introduction to Commutative Algebra* (Levant Books, Kolkata, 2007).
2. Dummit, D. S. & Foote, R. M. *Abstract Algebra* (Wiley-India, New Delhi, 2011).

Reference book(s)

1. Sharp, R. Y. *Step in Commutative Algebra* (Cambridge University Press, Cambridge, 2000).

2. Lang, S. *Algebra* (Springer, GTM Vol. 211, New Delhi, 2006).

MI 556 Quantum Mechanics I (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Inadequacy of classical mechanics, Specific Heat at low temperature, Dulong and Petit law, Amagat's experiment, Photoelectric effect, Properties of electromagnetic waves, Davisson and Garmer experiment.

Unit-2
Frank and Hertz Experiment, G.P. Thomspon experiment, Blackbody radiation, Wein's and Rayleigh-Jean's law, plack's quantum idea, de Broglie waves.

Unit-3
Heisenberg uncertainty principle, wave packet, phase velocity and group velocity. Time independent and time dependent schrodinger equation, interpretation of wave function.

Unit-4
Particle constrained in one dimension, in three dimension, potential well, rectangular potential barrier, theory of alpha decay.

Unit-5
Schordinger equations for Simple Harmonic Oscillator, Solution by the method of separation of variables, Quantisation of energy levels, Hermite polynomials.

Unit-6
Hydrogen atoms and orbitals, Lauguerre polynomials, Quantum Theory of Angular Momentum, Quantisation of angular momentum, Ladder operators, Spherical Harmonics.

Unit-7
Addition of angular momenta, Pauli spin matrices, Space quantisation, spin quantisation, Addition of orbital and spin angular momentum, Clebsch-Gordon coefficient.

Unit-8
Formal Structure of Quantum Mechanics, Postulates, Linear vector space, basis, quantum mechanical operators, Dirac bra and ket notation, unitary transformation, Matrix Mechanics.

Textbook(s)
1. Schiff, L. I. *Quantum Mechanics* (McGraw Hill, 1986).
2. Enderson, E. E. *Introduction to Modern Physics and Quantum Mechanics* (Macmillan India Ltd, 1979).
3. Ghatak, A. K. and Loknathan, S. *Quantum Mechanics* (Macmillan India Ltd, 1982).

Reference book(s)
1. Methews, P.M. and Venkatesan, K. *Quantum Mechanics* (Tata McGraw Hill, 1990).
2. Merzbacher, *Quantum Mechanics* (John Wiley & Sons, NY, 1970).
3. Dirac, P. A. M. *The Principles of Quantum Mechanics* (Oxford University Press, 1958).

MI 557 Mathematical Modelling-I (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Background of Mathematical Modelling, need and Techniques. Classification and its characteristics.

Unit-2
Autonomous System, Nonautonomous System, Sylvester criterion.

Unit-3
Liapunov's Theorems, Stability by Liapunov's Direct Method. Krasovskii's method.

Unit-4
Construction of Liapunov function for linear system with constant coefficients.

Unit-5
Test for stability based on first approximations, Two-dimensional nonlinear system and linearization technique.

Unit-6
Limit sets and Limit cycles, Extent of Asymptotic Stability, Lienard Equation.

Unit-7
Stability, Perturbation Theorems, Poincare's Linearization Theorem, Bifurcation and Chaos.

Textbook(s)

1. Glendinning, P. *Stability, Instability and Chaos* (Cambridge University Press, 1994).
2. Yoshizawa, T. *The Stability Theory by Liapunov's Second Method* (Mathematical Society of Japan, Tokyo, 1966).

Reference book(s)

1. Hahn, W., *Stability of Motion* (Springer Verlag, Berlin, 1967).
2. Salle J. La and Lefschetz, S. *Stability by Liapunov's Direct Mehtod* (Academic Press, New York, 1961).

MI 558 General Theory of Relativity (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Elementary properties of Tensors. Rules of Combination of Tensors, Tensor Algebra, Inner and Outer Product Quotient Rule, Riemannian space, Metric tensor and Conjugate Metric Tensors, Raising and lowering properties.

Unit-2
Parallel Transport, Christofell symbols of first and second kind, Tranformation properties of Christofell symbols, Covariant Derivative of Tensors, Gradient, Divergence and Curl of Tensors.

Unit-3
Geodesic Equation, Riemannian Tensor, Ricci Tensor, Bianchi Identities, Scalar Curvature, Einstein Tensor and their properties, Differential Manifolds.

Unit-4
Transition of Special to General Theory of Relativity, Principle of covariance, Equivalence Principle and consequences, Stress Energy Tensor, Einstein Field Equations and Newtonian limit.

Unit-5
Spherically symmetric solution to Einstein Field Equation in free space and in matter, Schwarzshild line element. Schwarzschild Singularity, Eddington-Finkelstein co-ordinates, Kruskal-Szekeres co-ordinates.

Unit-6
Linearised theory of gravity, weak field limit, Hilbert gauge and wave solution to Einstein Field Equations, Gravitational Waves, Polarisation properties, emission of gravitational waves.

Unit-7
Crucial tests of General Theory of Relativity, Advance of Perihelion, Gravitational bending of light, Gravitational Redshift, Shapiro delay.

Unit-8
Large scale structure of Universe, Cosmological principles, Einstein and de-Sitter models of static universe, Dynamical Universe, Comoving time, Red Shifts and Horizons, Friedmann-Robertson-Walker line element, Hubbles law, Elements of Quasi-Steady State Cosmology.

Textbook(s)

1. Narlikar, J.V. *An Introduction to Cosmology*, 3rd edition (Cambridge University Press, 2002).
2. Adler, R., Bazin M. & Schiffer, M. *Introduction to General Relativity* (McGraw Hill, 1975).

Reference book(s)

1. Landau and Lifshitz *Classical Theory of Fields* (Pergamon Press, 1975).
2. Dirac, P. A. M. *General Theory of Relativity* (Prentice Hall of India (reprinted), 2001).
3. Weinberg, S. *Gravitation and Cosmology* (John Wiley & Sons, 1972).
4. Kenyon, I. R. *General Relativity* (Oxford University Press, 1991).
5. Misner, C., Thorne, K.S. & Wheeler, J.A. *Gravitation* (W.H. Freeman, 1973).

MI 560 Sampling Techniques-I (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Introduction of Sampling techniques and methods of estimation.

Unit-2
Various sampling techniques: Simple random sampling with and without replacement, Stratified random sampling, optimal allocations, allocation problem, Systematic sampling, Two stage sampling, Multistage sampling, Multiphase sampling, Sequential sampling.

Unit-3
Methods of estimation: Ratio method of estimation, Regression method of estimation, Related estimation problems.

Unit-4
A survey description of sample surveys conducted in India.

Textbook(s)

1. Cochran, W. G. *Sampling Technique* (Wiley Eastern, New Delhi, 1977).
2. Sukhatme, P. V., Sukhatme, B. V., Sukhatme S., and Ashok, C. *Sampling Theory of Survey with Applications* (Iowa State University Press, Ames, Iowa, 1984).
3. Murthy, M. N. *Sampling Theory & Methods*, 2nd edition (Stat. Pub. Soc., Calcutta., 1977).

Reference book(s)

1. Mukhopadhyay, P. *Theory and Methods of Survey Sampling* (Prentice-Hall of India Pvt. Ltd, New Delhi, 1998).
2. Hansen, M. H., Hurwitz, H.N. and Madow, W. G. *Sample Survey Methods and Theory*, Vols. I and II, (Wiley, N.Y., 1953).
3. Lish, L. *Survey Sampling* (Wiley, N.Y., 1965).
4. Jensen, R. J. *Statistical Survey Techniques* (Wiley, N.Y., 1978).
2. Des Raj and Chandhok, P., *Sample Survey Theory* (Narosa Publishing House, New Dehi, 1998).

MI 562 Statistical Quality Control (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Statistical control of processes, Concept of quality and meaning of control, Various control charts.

Unit-2
Properties of control charts, Special procedures in process control.

Unit-3
Estimating process average, single, double and sequential sampling plans.

Unit-4
Natural tolerance limits and specification limits, OC and ASN functions, AOQL and ATI**.**

Unit-5
Acceptance sampling by variables, tolerance limits.

Textbook(s)

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., 1982).
3. Montgomery,D. C. *Introduction to Statistical Quality Control* (John Wiley, N.Y., 1985).

Reference book(s)

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)

Unit-1
Bivariate Moment Generating Functions, Characteristics Functions, Bivariate Normal Distributions and its Properties.

Unit-2
Multivariate Normal Distributions, Singular and non-singular Multivariate Distributions.

Unit-3
Marginal and Conditional Distributions, Distributions of Linear forms, and Quadratic forms

Unit-4
Multiple Regression and Correlation, Correlation coefficient of a Bivariate sample.

Unit-5
The distribution when the population coefficient is non-zero, Cochran's Theorem

Unit-6
Tests of hypotheses and confidence region, the asymptotic distribution of a sample correlation coefficient.

Unit-7
Fisher's z, Partial correlation coefficient, Multiple Logistic Regression.

Unit-8
Multinomial Distributions, Multivariate Multinomial Distributions.

Textbook(s)

1. Anderson, T. W. *An Introduction to Multivariate Analysis*, 2nd edition (Wiley, 1984).
2. Khirsagar, A. M. *Multivariate Analysis* (Marcell Dekker, New York).
3. Krishnaiah, P. R. (eds), *Some recent developments on real multivariate distributions*, *Development in Statistics*, Vol. I (Academic Press, New York, 1978).
4. Johnson N. L., and Kotz, S. *Continuous Multivariate Distributions* (John Wiley, New York).

Reference book(s)

1. Kendall, M. G. *Multivariate Analysis* (NY, Hamer Press, 1975).
2. Maxwell, A. E. *Multivariate Analysis in Behavioural Research* (Chapman & Hall, London 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).
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 edition (Wiley, 1993).

MI 565 Fuzzy Sets and Applications-I **(L3 -T1 -P0 -CH4 -CR 4)**

Unit-1
Fuzzy sets - basic definitions, α-level sets, convex fuzzy sets.

Unit-2
Basic operations on fuzzy sets, types of fuzzy sets

Unit-3
Cartesian products, algebraic products, bounded sum and difference, t-norms and t-conorms. Fuzzy sets in contrast of probability theory.

Unit-4
The extension principle - the Zadeh's extension principle, image and inverse image of fuzzy sets,

Unit-5
Fuzzy numbers, elements of fuzzy arithmetic.

Unit-6
Fuzzy relations and fuzzy graphs, composition of fuzzy relations, min-max composition and its properties, fuzzy equivalence relations, fuzzy relational equations, fuzzy graphs.

Textbook(s)

1. Klir, G. J. and Yuan, B. *Fuzzy Sets and Fuzzy Logic : Theory and Applications*, (Prentice Hall of India, New Delhi, 1997)

Reference book(s)

1. Zimmermann, H. J. *Fuzzy set theory and its Applications* (Allied publishers Ltd., New Delhi, 1991).

MI 566 Fourier Analysis **(L3 -T1 -P0 -CH4 -CR 4)**
Prerequisite: MI 306 Functional Analysis

Unit 1:
Fourier series: Orthogonal systems, Trigonometric system, Orthogonal polynomials, Genesis of the Fourier series.

Unit 2:
Convergence of Fourier series: Fejer mean and Cesaro mean, Convergence of the Fourier series, Fejer theorem, Uniqueness and convergence, Approximate identity, Fourier series of continuous and smooth functions.

Unit 3:
L^2 theory of Fourier series: Inversion formula and the Parseval identity.

Unit 4:
Fourier transforms, the Schwartz space,Plancherel formula, Maximal function and distributions, Tempered distribution,, Fourier analysis and filters. Bessel functions.

Unit 5
Fourier analysis and complex function theory: Paley Wiener's theorem, Tauberian theorem, Dirichlet problem.,Classical Hardy spaces F and M. Reisz theorem.

Textbook(s)

1. Katznelson, Y. *An Introduction to Harmonic Analysis* (Dover, New York, 1976).

Reference book(s)

1. Dym, I.H. and Mc Kean, H.P. *Fourier Series and Integrals* (Academic Press, 1985).
2. Folland G. B. *Fourier Analysis and Applications* (Brooks/Cole Mathematics Series, 1972).
3. Korner, T. *Fourier Analysis* (Cambridge, 1989).
4. Rudin, W. *Functional Analysis* (Tata Mc. Graw Hill, 1974).
5. Elias M. S. and Shakarchi, R. *Fourier Analysis An Introduction (*Princeton University Press, Princeton, 2004).

MI 567 Continuum Mechanics (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Analysis of Strain: Lagrangian and Eulerian finite strain tensor. Geometrical interpretation of the components of atrain. Strain quadric of Cauchy. Principall strains and invariants. General infinitesimal deformation. Saint-Venant's equations of compatibility.

Unit-2
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. Two dimensional problems-Plane stress. Generalised plane stress. Airy stress function.

Unit-3
Fundamental laws of continuum mechanics: Continuity equation, Equation of motion, Moment of momentum principle, Second law of thermodynamics. The Clausius-Duhem inequality.

Unit-4
Equations of Elasticity. Generalosed Hooks's law. Homogeneous isotropic media, Strain energy function and its connection with Hooke's law. Four basic elastic constants-Young's modulus, Poisson's ratio, modulus of rigidity, bulk modulus. Uniqueness of solution. Saint-Vernant's principle.

Unit-5
Fluids: Classification, constitutive equations, energy equation, dissipation of energy.

Textbook(s)

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

Reference book(s)

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

MI 568 Theory of Distribution and Sobolev Spaces (L3 -T1 -P0 -CH4 -CR4)

Unit -1
Test Function and distribution: Definition, operations with distributions, convolution of distributions, Fourier transform of tempered distributions.

Unit -2
Sobolev spaces: generalized derivatives, Definition and properties, extension theorem, imbedding and completeness theorem, fractional order Sobolev spaces, trace theory.

Unit -3
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 semi-linear elliptic BVP.

Textbook(s)

1. Adams, R.A. *Sobolev Spaces* (Academic Press, 1975).
2. Kesavan, S. *Topics in Functional Analysis and Applications* (Wiley Eastern Ltd., New Delhi, 1989).
3. Strihartz, Robert S. *A guide to Distribution Theory and Fourier Transforms, Studies in Advanced Mathematics (*CRC Press,USA,1994).

Reference book(s)

1. Oden, J.T. and Reddy, J.N. *An Introduction to Mathematical Theory of Finite Elements,* (Wiley Interscience, 1976).
2. Brennan, K. E. and Scott., R. *The Mathematical Theory of Finite Element Methods (*Springer-Verlag, Berlin, 1994).
3. Lieb. Elliot H. and Loss, M. *Analysis (*Narosa Publishing House, New Delhi, 1997).
4. Rudin, W. *Functional Analysis* (Tata Mc-Graw Hill, 1974).

MI 572 Operator Theory II (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Functional calculus and spectral mapping theorem for analytic functions; Riesz decomposition theorem.

Unit-2
Numerical range of an operator; spectral radius.

Unit-3
Subnormal and hyponormal operators.

Unit-4
Partial isometries; polar decomposition.

Unit-5
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, multiplication operator and differentiation operator.

Unit-6
Spectral representation of unitary and self adjoint linear operators.

Textbook(s)
1. Conway, J. B. *A course in Operator Theory* (AMS., GSM Vol. 21, 1999).
2. Kreyszig, E. *Introductory functional analysis with applications* (John Wiley and Sons, 1978).
3. Conway, J. B. *A course in Functional Analysis (*Springer Verlag, New York, 1985).

Reference book(s)
1. Halmos, P. R. *Introduction to Hilbert spaces and theory of spectral multiplicity* (Chelsea Publishing Co., New York, 1957).
2. Abramovich, Y. A. and Aliprantis, C. D. *An Invitation to Operator Theory* (AMS., GSM Vol. 50, 2002).

MI 573 Analytic Number Theory (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Arithmetical functions and Dirichlet multiplication, averages of arithmetical functions.

Unit-2
Elementary theorems on the distribution of primes, the prime number theorem, Chebyshev's functions and their relations.

Unit-3
Dirichlet's theorem for primes of the form *4n-1* and *4n+1*, distribution of primes in arithmetic progressions.

Unit-4
Quadratic residues and quadratic reciprocity law, applications of the reciprocity law, Gauss sums.

Unit-5
Dirichlet series, Euler products, Riemann zeta function and Dirichlet *L*-functions.

Unit-6
Introduction to partitions, geometric representation, generating functions, Euler's Pentagonal number theorem, Jacobi triple product identity, recursion formula for *p(n).*

Unit-7
Partition identities of Ramanujan.

Textbook(s)
1. Apostol, T. M. *Introduction to Analytic Number Theory*, Springer International Student Edition (Narosa Publishing House, New Delhi, 1993).
2. Hardy, G.H. and Wright, E. M. *An Introduction to the Theory of Numbers*, 4th Edition (Oxford University Press, 1960).

Reference book(s)
1. Niven, I. and Zuckerman, H. *An Introduction to the Theory of Numbers*, 5th Edition (Wiley Eastern, New Delhi, 2000).

2. Andrews, G.E. *Number Theory* (Hindustan Publishing Corporation, New Delhi, 1992).

MI 574 Advanced Algebra-II (L3 -T1 -P0 -CH4 -CR 4)
Prerequisite: MI 305

Unit-1
Field extensions: Algebraic, normal and separable extensions of field.

Unit-2
Splitting fields.

Unit-3
Automorphisms of extensions, the fundamental theorem of Galois theory.

Unit-4
Finite fields.

Unit-5
Primitive elements, norm and trace, cyclotomic fields, cyclic extension.

Unit-6
Solution of polynomial equations by radicals, Kummer theory.

Textbook(s)
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(s)
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

Unit-1
Time independent and time dependent schrodinger equation, interpretation of wave function. Particle constrained in three dimension, potential well, rectangular potential barrier, theory of alpha decay.

Unit-2
Schordinger equations for Simple Harmonic Oscillator, Solution by the method of separation of variables, Quantisation of energy levels, Hermite polynomials.

Unit-3
Hydrogen atoms and orbitals, Lauguerre polynomials, Quantum Theory of Angular Momentum, Quantisation of angular momentum, Ladder operators, Spherical Harmonics.

Unit-4
Addition of angular momenta, Pauli spin matrices, Space quantisation, spin quantisation, Addition of orbital and spin angular momentum, Clebsch-Gordon coefficient.

Unit-5
Formal Structure of Quantum Mechanics, Postulates, Linear vector space, basis, quantum mechanical operators, Dirac bra and ket notation, unitary transformation, Matrix Mechanics.

Unit-6
Time independent perturbation theory, variational method, WKB approximation, Time dependent perturbation theory, Quantum theory of scattering, motion in a magnetic field.

Unit-7
Relativistic quantum mechanics: Klein Gordon equation, equation of continuity and interpretation in Klein Gordon equation and its limitations.

Unit-8
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.

Textbook(s)

1. Schiff, L. I. *Quantum Mechanics* (McGraw Hill, 1986).
2. Enderson, E. E. *Introduction to Modern Physics and Quantum Mechanics* (Macmillan India Ltd, 1979).
3. Ghatak, A. K. & Loknathan, S. *Quantum Mechanics* (Macmillan India Ltd, 1982).
4. Bjorken, J. D. & Drell, S. D. *Relativistic Quantum Mechanics* (McGraw Hill, New York, 1964).

Reference book(s)

1. Methews, P.M. and Venkatesan, K. *Quantum Mechanics* (Tata McGraw Hill, 1990).
2. Merzbacher *Quantum Mechanics* (John Wiley & Sons, NY, 1970).
3. Dirac, P. A. M. *The Principles of Quantum Mechanics* (Oxford University Press, 1958).
4. Parthasarathy, R. *Relativistic Quantum Mechanics* (Alpha Science Int. Ltd., 2010).
5. Schwabl, F. *Advanced Quantum Mechanics* (Springer-Verlag, 2008).

MI 577 Mathematical Modeling II (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Fundamentals of Mathematical Modelling. Characteristics of Mathematical Models.

Unit-2
Single-species growth, Malthusian and Logistic growth models.

Unit-3
Gompertz and Weibull growth models. Examples of some Mortality Models

Unit-4
The general autonomous and Non-autonomous growth Model. Predation and parasitism.

Unit-5
Solutions of Lotka-Volterra Systems for predator-prey interactions, Increasing and diminishing returns, Perturbed models.

Unit-6
Existence of limit cycle for perturbed models, Intermediate predator-prey models, A generalized Gauss model.

Unit-7
Lotka-Volterra competition models, The competitive exclusion principle, Competition for fixed resources, Competition for renewable resources.

Unit-8
Lotka-Volterra Cooperation models, Kolmogorov Type models. Diffusion and pollution models, Models for fishery resources.

Textbook(s)

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

Reference book(s)
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)

Unit-1
Double Sampling, Cluster Sampling**,** Probability proportion to size with replacement sampling, varying probability without replacement sampling.

Unit-2
Hurwitz-Thomson estimator, Midzuno-Lahiri-Sen Sampling Strategy, Des Raj's, Murthy's Sampling strategies, etc.

Unit-3
Errors of Surveys: Sampling and non-sampling error.

Unit-4
Some problem of Inference under a fixed population set-up, Interpenetrating samples, Small area estimation.

Textbook(s)
1. Cochran, W. G. *Sampling Technique* (Wiley Eastern, New Delhi, 1977).
2. Sukhatme, P. V. Sukhatme, B. V., Sukhatme S., and Ashok, C., *Sampling Theory of Survey with Applications* (Iowa State University Press, Ames, Iowa, 1984).
3. Murthy, M. N. *Sampling Theory & Methods*, 2nd edition (Stat. Pub. Soc., Calcutta., 1977).

Reference book(s)

1. Mukhopadhyay, P. *Theory and Methods of Survey Sampling* (Prentice-Hall of India Pvt. Ltd, New Delhi, 1998).
2. Hansen, M. H., Hurwitz, H.N. and Madow, W. G. *Sample Survey Methods and Theory*, Vols. I and II (Wiley, N.Y., 1953).
3. Lish, L. *Survey Sampling* (Wiley, N.Y., 1965).
4. Jensen, R. J. *Statistical Survey Techniques* (Wiley, N.Y., 1978).
5. Des Raj and Chandhok, P. *Sample Survey Theory* (Narosa Publishing House, New Dehi, 1998).

MI 581 Stochastic Process –II **(L3 -T1 -P0 -CH4 -CR 4)**

Unit-1

Branching processes- Properties of generating functions of Branching processes, Probability of Extinction, Distribution of the total number of progeny.

Unit-2

Galton-Watson process. Introduction Brownian motion process.

Unit-3

Wiener process, first passage time distribution for Wiener process, Ornstein-Ulhenbech process.

Unit-4

Queueing systems, Single server queueing models (M/M/1/μ, M/M/1/k, M/M/μ/μ, etc.)

Textbook(s)

1. W. Feller *An Introduction to Probability Theory and its Applications*, II (Wiley, 1998).
2. Bhattacharyya, R. and Waymire, E. C. *Stochastic processes with applications* (SIAM, 1990).

Reference book(s)

1. Medhi, J. *Stochastic Processes* (Wiley Eastern Ltd., New Delhi, 1994).

MI 582 Reliability Theory **(L3 -T1 -P0 -CH4 -CR 4)**

Unit-1

Exponential failure model: properties of exponential distributions, estimation of mean life with complete samples.

Unit-2

Reliability estimation: Estimation of reliability in Stress-Strength Models, estimation with censored samples, estimation based on components of order statistics: k out of n.

Unit-3

Gamma and Weibull distributions (one, two and three parameters)

Unit-4
Estimation of complete samples, truncated and censored samples. An application of the Kaplan-Meier estimator and its extensions.

Unit-5
Reliability estimation of Normal and related distributions.

Unit-6
Reliability estimation: mixture distributions and competing risks.

Unit-7
Reliability of series / parallel systems : Series system with identical components

Unit-8
Reliability bounds - classical approach and - Bayesian approach.

Textbook(s)

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 book(s)

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)

Unit-1
Inference on parameters of Multivariate normal distributions, One population and Two Population cases.

Unit-2
Wishart Distributions, Hotellings T^2.

Unit-3
Discriminant analysis, Mahalanobis $D^{2.}$.

Unit-4
Testing general linear hypotheses: Estimation of parameters in multivariate linear regression, distribution of and , Computation of and .

Unit-5
Likelihood ratio criteria for testing linear hypotheses about regression coefficients, Moments of Likelihood ratio criterion.

Unit-6
Principal Components: Definition of Principal Components in the Population, Maximum likelihood Estimates of the Principal Components and their Variances.

Unit-7
Computation of the Maximum Likelihood Estimates of the Principal Components.

Unit-8
Canonical Correlation and Canonical Variables: Canonical Correlations and Variables in the Population, Estimation of Canonical Correlations and Variables, Computation. Cluster Analysis.

Textbook(s)
1. Anderson, T. W. *An Introduction to Multivariate Analysis*, 2nd Edition (Wiley, 1984).
2. Khirsagar, A. M. *Multivariate Analysis* (Marcell Dekker, New York).
3. Krishnaiah, P. R. *Some recent developments on real multivariate distributions*, Development in Statistics, Vols. I & II (Academic Press, New York, 1978).

Reference book(s)
1. Johnson, N. L. and Kotz, S. *Continuous Multivariate Distributions* (John Wiley, New York).
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, B. *Regression Analysis by Examples* (John Wiley, NY, 1977).
5. Johnson, R. A. and Wichern, D. W. *Applied Multivariate Statistical Analysis*, 3rd Ed, (PHI, 1998).

MI 585 Fuzzy Sets and Their Applications-II (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Fuzzy logic, fuzzy propositions, fuzzy quantifiers, linguistic variables, inference from conditional fuzzy propositions, compositional rule of inference.

Unit-2
Approximate reasoning - an overview of fuzzy expert systems, fuzzy implications and their selection, multi-conditional approximate reasoning, role of fuzzy relation equation.

Unit-3
An introduction to fuzzy control - fuzzy controllers, fuzzy rule base, fuzzy inference engine.

Unit-4
Fuzzification, defuzzification and the various defuzzification methods.

Unit-5
Decision making in fuzzy environment - individual decision making, multi-person decision making, multi-criteria decision making, multistage decision making, fuzzy ranking methods.

Unit-6
Fuzzy logic as a tool in soft computing.

Textbook(s)
1. Klir, G. J. and Yuan, B. *Fuzzy Sets and Fuzzy Logic : Theory and Applications* (Prentice Hall of India, New Delhi, 1997)

Reference book(s)
1. Zimmermann, H. J. *Fuzzy set theory and its Applications* (Allied publishers Ltd., New Delhi, 1991).

MI 586 Parallel Numerical Algorithms (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Fundamentals of Parallel computing. Parallel techniques and algorithms.

Unit-2
Theoretical models of parallel computation: Variants of the PRAM model. Performance of parallel algorithms.

Unit-3
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.

Unit-4
Graph algorithms: Connected components, colouring. Parallel algorithms on interconnection networks and other architectures. Limits to parallelisability. P-completeness.

Unit-5
Parallel algorithms for linear algebraic equations; Design of parallel algorithms for eigen value problem; parallel issues of factorization. Parallel implementation of classical iterative methods.

Unit-6
Parallel methods for ordinary and partial differential equations.

Textbook(s)
1. Quinn, Michael J. *Parallel computing theory and practice*, 2nd ed (Mc-Graw Hill, 2000).
2. Joseph, Jaja. *An introduction to parallel algorithms* (Addision Wesley, 1992).

Reference book(s)
1. Reif H.H. *Synthesis of parallel algorithms* (Morgan Kaufmann publishers, San Mateo, California, 2000).
2. Leighton, F.T. *Introduction to parallel algorithms and architectures: Arrays trees, Hypercubes (*Morgan Kaufmann publishers, San mateo, California, 2000).

MI 587 Finite Element Method (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Introduction: Basic concepts of process of discretization, subdivision, continuity, convergence, bounds, error. Principle and Laws. Cause and effects.

Unit-2
Finite Element Methods: Introduction, general idea of element configuration, approximation models or functions. Strain (Gradient)-Displacement (unknown) and stress-strain (constitutive) relationships, element equations. Energy methods, methods of wieghted residuals. Introduction to variational calculus.

Unit-3
One-dimensional Stress Deformation: Element configuration, local and global coordinates, interpolation functions, stress-strain relationship, element equations and assembling, direct stiffness method, formulation by Galerkin method.

Unit-4
One-dimensional flow: Theory and formulation, finite element formulation, variational approach, Galerkin method, boundary conditions.

Unit-5
Further Applications: One-dimensional time dependent flow: introduction to uncoupled and coupled problems, beam bending and beam-column, one-dimensional mass transport and one-dimensional stress wave propagation

Unit-6
Two and Three-dimensonal formulations: Introduction, two-dimensional formulation, triangular and quadrilateral elements, three-dimensional formulation, tetrahedron element, brick element

Unit-7
Applications: Potential, thermal, fluid and electrical flow: a brief theroy and their finite element formulations

Unit-8
Coding: Computer codes in Matlab/C/C++.

Textbook(s)

1. Desai, C. S. and Kundu, T. *Introductory Finite element method* (CRC Press, 2001).
2. Braess, D. and Schumaker, L. L. *Finite elements: theory, fast solvers and applications in solid mechanics (*Cambridge University Press, 2001).
3. Brenner, S. C. and Scott, L. R. *The mathematical theory of finite element methods*, (Springer, 2008).

Reference book(s)

1. Ciarlet, P. G. *The finite element method for elliptic problems* (North Holland, 1978).
2. Thome\'e, V. *Galerkin finite element methods for parabolic problems* (Springer, 1997).

MI 588 Applied Matrix Theory (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Review of basic linear algebra.

Unit-2
Canonical factorization, Q-forms.

Unit-3
Courant-Fischer minmax & related theorems. Perron-Frobenius theory. Matrix-stability.

Unit-4
Inequalities, g-inverse (A^-, A^m, A^+).

Unit-5
Drect, iterative, projection and rotation methods for solving linear systems & eigenvalue problems.

Unit-6
Applications

Textbook(s)

1. Datta, K. B. *Matrix and Linear Algebra* (PHI, 1991).
2. Watkins, D. S. *Fundamentals of Matrix Computation* (Wiley, 1991).
3. Golub, G. H. and Loan, C. F. Van. *Matrix Computation (*John Hopkin U. Press, Baltimore, 1996.)

Reference book(s)

1. Stewart, G. W. *Introduction to Matrix Computations* (Academic Press, 1973.)

MI 591 Computational Fluid Dynamics (L3 -T1 -P0 -CH4 -CR 4)

Unit-1
Basic equations of Fluid Dynamics. Analytical Aspects of PDE. Iterative methods – Stationary Methods. Krylov subspace methods.

Unit-2
Stationary Convection diffusion equations, Non-stationary 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 Conservative property.

Unit-3
Finite volume and finite difference methods. Convergence and stability analysis, Explicit and implicit methods, Stream function equation and boundary conditions, Solution for primitive variables. Finite volume method, Application to Euler equations, Upwind difference scheme, Viscous flow solutions, Total variation diminishing schemes, Godunov-type schemes.

Unit-4
Simple CFD Techniques, Lax-Wendroff Technique, Mac Cormack's Techniques, Staggered grid, SIMPLE Algorithm. Numerical Solutions of Navier-Stokes equations on collocated and on staggered grids.

Textbook(s)

1. Chung, T.J. *Computational fluid Dynamics* (Cambridge University Press, 2005).
2. Fletcher, C. A. J. *Computational Techniques for Fluid Dynamics, Volume 1 & 2*, (Springer Verlag, 1992).

Reference book(s)

1. Chow, C. Y. *Introduction to Computational Fluid Dynamics* (John Wiley, 1979).
2. Holt, M. *Numerical Methods in Fluid Mechanics* (Springer Verlag, 1977).
3. Wirz, H. J. and Smolderen, J. J. *Numerical Methods in Fluid Dynamics* (Hemisphere, 1978).
4. Anderson, J. D. *Computational Fluid Dynamics* (Mc-Graw Hill, 1995).
5. Anderson, D. A., Tannehill, J. C. and Pletcher, R. H. *Computational Fluid Dynamics and Heat Transfer* (McGraw Hill, 1984).

MI 593 Wavelets and Applications (L3 -T1 -P0 -CH4 -CR 4)

Unit 1

Introduncton: Reviews of Fourier analysis and L^p spaces, Wavelets and atomic decomposition of functions.

Unit 2

Multi resolution analysis: Multi-resolution signal decomposition, Multi-resolution analysis and the construction of wavelets, Examples of wavelets, QMF and fast wavelet transform.

Unit 3

Continuous Wavelet transform: Localization, Regularity and approximation properties of wavelets,Construction of compactly support wavelets, Orthonormal bases of compactly supported wavelets.

Unit 4:

Wavelets sampling techniques, Convergence of wavelet expansion.

Unit 5

Time frequency analysis: Time frequency analysis for signal processing, Application of wavelets in image and signal processing.

Textbook(s)

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

Reference book(s)

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

MI 594 Advanced Topology -I **(L3 -T1 -P0 -CH4 -CR 4)**

Unit-1
Nets and filters, convergenge in terms of nets and filters, ultrafilters and compactness.

Unit-2
Urysohn's Lemma, Tietze Extension theorem.

Unit-3
Theories of metrization, Urysohn metrization theorem.

Unit-3
Paracompactness, characterisation in regular spaces, metrization based on paracompactness.

Unit-4
Nagata-Smirnov theorem, Stone's theorem, Smirnov's metrization theorem.

Unit-5
Homotopy and the fundamental group, computation of the fundamental group of the circle.

Textbook(s)

1. Joshi, K. D. *Topology* (Wiley-Eastern, 1988).
2. Munkres, J. R. *Topology: A first course* (2/e) (Prentice-Hall, 2000).

Reference book(s)

1. Kelley, J. L. *General Topology* (Graduate texts in Mathematics, Vol. 27, Springer, 1991).
2. Willard, S. *General Topology* (Addision-Wesley, Reading, 1970).

MI 595 Numerical Solutions of ODE **(L3 -T1 -P0 -CH4 -CR 4)**

Unit -1
Review of some basic concept of Numerical Analysis, Basics of Initial Value Problem (IVP), Explicit and implicit single step Methods, Euler's method, Runge-Kutta methods.

Unit -2
System of differential equations, Adaptive numerical methods, Predator- Corrector methods, explicit and implicit multistep methods, stability analysis.

Unit -3
Higher order differential equations, Non-uniform step methods, Boundary value problems, Convergence of difference schemes.

Unit -4
Linear eigenvalue problems.

Textbook(s)

1. Jain, M. K., Iyenger S. R. K., and Jain, R. K. *Numerical Methods for Scientific and Engineering Computation* (Wiley Eastern, 1993).

2. Lambert, J. D. *Numerical methods for Ordinary Differential equations (*John Wiley & Sons, 1991).

Reference book(s)

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).
5. Otto, S.R. & Denier, J. P. *An Introduction to Programming and Numerical Methods in MATLAB* (Springer, 2009).

MI 596 Advanced Topology – II (L3 -T1 -P0 -CH4 -CR 4)

Unit-1

Uniformities, uniform continuity, product uniformities, metrisation.

Unit-2

Completeness and compactness in uniform spaces.

Unit-3

Topological groups, subgroups, quotient groups, homogeneous spaces, product groups.

Unit-4

Uniform structures in topological groups, complete groups, completion of topological groups.

Unit-5

Function spaces, point-wise convergence, uniform convergence, compact-open topology, k-spaces, equi-continuity, Ascoli theorem.

Textbook(s)

1. Joshi, K. D. *Topology* (Wiley-Eastern, 1988).
2. Munkres, J. R. *Topology: A first course* (2/e) (Prentice-Hall, 2000).

Reference book(s)

1. Kelley, J. L. *General Topology* (Graduate texts in Mathematics, Vol. 27, Springer, 1991).
2. Willard, S. *General Topology* (Addision-Wesley, Reading, 1970).
3. Engelking, R. *General Topology* (Polish Scientific Publishers, Warshaw, 1977).
4. Bourbaki, N. *Elements of Mathematics: General Topology*, Vols. I & II, (Springer-Verlag, 1988).

MI 597 Numerical Solutions to PDE (L3 -T1 -P0 -CH4 -CR 4)

Unit-1

Finite difference methods for Parabolic, Elliptic and Hyperbolic equations. Dirichlet, Neumann and Mixed problems.

Unit-2
Sparseness and the ADI method, Iterative methods for Laplace equation. Backward Euler, Crank-Nicolson schemes.

Unit-3
Stability, convergence and consistency analysis of finite difference methods, Lax's equivalence theorem.

Unit-4
Method of characteristics, Lax-Wendroff explicit method, CFL conditions, Wendroff implicit approximation.

Unit-5
Three dimensional elliptic problems.

Textbook(s)

1. Hoffman, J. D. *Numerical methods for Engineers and Scientists* (McGraw Hill, 2001).
2. Smith, G. D. *Numerical solutions to Partial Differential Equation (*Clarendon Press, Oxford, 1985.)
3. Johnson, C. *Numerical solution of Partial Differential equations by the Finite Element Method (*Cambridge University Press, 1987.)

Reference book(s)

1. Eriksson, K. et. al, *Computational Differential Equations* (Cambridge University Press, 1996).
2. Lapidus, L. and Pinder, G. F. *Numerical solutions of Partial Differential Equations in Science and Engineering (*John Wiley, 1982).
3. Langtangen, H. P. *Computational Partial Differential Equations (*Springer-Verlag, 1999.)
4. Jain, M. K., Iyenger, S. R. K. and Jain, R. K. *Numerical Methods for Scientific and Engineering Computation (*Wiley Eastern, 1993).
5. Jain, M. K., Iyenger, S. R. K. and Jain, R. K. *Computational Mathods for Partial Differential Equations (*Wiley Eastern, 1994).

MI 598 Algebraic Geometry **(L3 -T1 -P0 -CH4 -CR 4)**

Unit-1
Affine varieties defined over algebraically closed fields.

Unit-2
Projective varieties.

Unit-3
Rational mappings, bi-rational geometry.

Unit-4
Divisors, principal divisors especially on curves and surfaces.

Unit-5
Introduction to the language of schemes.

Unit-6
Riemann-Roch theorem for curves.

Textbook(s)

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(S)

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