M.Sc. Mathematics

Syllabus

(with effect from June 2015)

DEPARTMENT OF MATHEMATICS
The Gandhigram Rural Institute – Deemed University
Gandhigram – 624 302 Tamil Nadu

M.Sc. MATHEMATICS

SYLLABUS UNDER CHOICE BASED CREDIT SYSTEM

(with effect from 2015-2016)

Category	Course Code	Course Title	Number of Credits	Lecture Hours per week	Exam Duration (Hours)	Marks		
						C.F.A	E.S.E	Total
	Semester – I							
Core Course	15MATP0101	Algebra	4	4	3	40	60	100
	15MATP0102	Real Analysis	4	4	3	40	60	100
	15MATP0103	Numerical Analysis	4	4	3	40	60	100
	15MATP0104	Differential Equations	4	4	3	40	60	100
	15MATP0105	Discrete Mathematics	4	4	3	40	60	100
Compulsory Non Credit Course	15GTPP0001	Gandhi in Everyday Life	--	2	--	50		50
		TOTAL	20					
	Semester – II							
Core Course	15MATP0206	Linear Algebra	4	4	3	40	60	100
	15MATP0207	Advanced Real Analysis	4	4	3	40	60	100
	15MATP0208	Mathematical Methods	4	4	3	40	60	100
	15MATP0209	Probability and Statistics	4	4	3	40	60	100
Electives		Non Major Elective	4	4	3	40	60	100
Compulsory Non Credit Course	15ENGP00C1	Communication and Soft Skills	--	2	--	50		50
		TOTAL	20					
	Semester – III							
Core Course	15MATP0310	Complex Analysis	4	4	3	40	60	100
	15MATP0311	Topology	4	4	3	40	60	100
	15MATP0312	Measure Theory	4	4	3	40	60	100
	15MATP0313	Differential Geometry	4	4	3	40	60	100
Electives	15MATP03EX	Major Elective	4	4	3	40	60	100

Modular Course	15MATP03MX	Modular Course	2	2	--	50	--	50
Compulsory Non Credit Course	15MATP03F1	Extension/ Field Visit	--	2	--	50	--	--
Extension	15EXNP03V1	Village Placement Programme	2	--	--	50	--	50
TOTAL			24					
	Semester – IV							
Core Course	15MATP0414	Functional Analysis	4	4	3	40	60	100
	15MATP0415	Graph Theory	4	4	3	40	60	100
	15MATP0416	Classical Mechanics	4	4	3	40	60	100
	15MATP0417	Stochastic Processes	4	4	3	40	60	100
Modular Course	15MATP04MX	Modular Course	2	2	--	--	--	--
	15MATP0418	Dissertation	6	12	--	75	75+50	200
Compulsory Non Credit Course	15MATP04F2	Extension/Field Visit	--	2	--	50	--	--
TOTAL			24					
GRAND TOTAL			88					

MAJOR ELECTIVES: (15MATP03EX)

Semester – III

1.15MATP03E1 Optimization Techniques
2.15MATP03E2 Control Theory
3.15MATP03E3 Commutative Algebr
4. 15MATP03E4 Coding Theory
5. 15MATP03E5 Fractal Analysis

MODULAR COURSES :
(15MATP03MX/15MATP04MX)

Semester – III

1. 15MATP03M1 Matlab & Latex
2. 15MATP03M2 Wavelet Analysis

Semester – IV

1. 15MATP04M1 Fuzzy logic and its Applications
2. 15MATP04M2 Neural Networks

Core Course	Semester I	
15MATP0101	ALGEBRA	Credits: 4

Objective: To provide deep knowledge about various algebraic structures.

Specific outcome of learning: The learner will be able to

- recognize some advances of the theory of groups.
- use Sylow's theorems in the study of finite groups.
- formulate some special types of rings and their properties.
- recognize the interplay between fields and vector spaces.
- apply the algebraic methods for solving problems.

Unit 1: A counting principle - Normal subgroups and quotient groups – Homomorphisms – Automorphisms - Cayley's theorem - Permutation groups.

Unit 2: Another counting principle - Sylow's theorems - Direct product - Finite abelian groups.

Unit 3: Euclidean rings - A particular Euclidean ring - Polynomial rings - Polynomials over the rational field - Polynomial rings over commutative rings.

Unit 4: Extension fields - Roots of polynomials - More about roots - Finite fields.

Unit 5: The elements of Galois theory - Solvability by radicals - Galois group over the rationals.

Text Book:

1. N. Herstein, **Topics in Algebra**, 2^{nd} edition, John Wiley & Sons, Singapore, 2006.

Unit 1: Chapter 2: Sections 2.5, 2.6, 2.7, 2.8, 2.9, 2.10
Unit 2: Chapter 2: Sections 2.11, 2.12, 2.13, 2.14
Unit 3: Chapter 3: Sections 3.7, 3.8, 3.9, 3.10, 3.11
Unit 4: Chapter 5: Sections 5.1, 5.3, 5.5 & Chapter 7: Section 7.1
Unit 5: Chapter 5: Sections 5.6, 5.7, 5.8

References:

1. John. B. Fraleigh, **A First Course in Abstract Algebra**, 7th Edition, Addison-Wesley, New Delhi, 2003.
2. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul, **Basic Abstract Algebra**, Cambridge University Press, USA, 1986.
3. Charles Lanski, **Concepts in Abstract Algebra**, American Mathematical Society, USA, 2010.
4. M. Artin, **Algebra**, Prentice-Hall of India, New Delhi, 1991.
5. D. S. Dummit & R. M. Foot, **Abstract Algebra,** John Wiley, New York, 1999.

Core Course	Semester - I	
15MATP0102	REAL ANALYSIS	Credits: 4

Objective: To impart abstract concepts of real valued functions in detail.

Specific outcome of learning: The learner will acquire in-depth knowledge of

- various axioms and properties of real and complex numbers
- sets with its abstract properties
- sequences and series along with its properties
- existence of limit of functions
- existence of derivative of real valued functions

Unit 1: The real and complex number systems: Introduction, Ordered sets – Fields - The real field - The extended real number system - The complex field - Euclidean spaces.

Unit 2: Basic Topology: Finite - Countable and Uncountable sets - Metric spaces - Compact sets - Perfect sets - Connected sets.

Unit 3: Numerical Sequences and Series: Convergent sequences – Subsequences - Cauchy sequences - Upper and lower limits - Some special sequences – Series - The number e - The root and ratio tests - Fourier series - Summation by parts - Absolute convergence - Addition and multiplication of series - Rearrangements.

Unit 4: Continuity: Limits of functions - Continuous functions - Continuity and compactness - Continuity and connectedness - Monotonic functions - Infinite limits and limits at infinity.

Unit 5: Differentiation: The derivative of a real function - Mean value theorems - The continuity of derivatives - L'Hospital's rule - Derivatives of Higher order - Taylor's theorem - Differentiation of vector valued functions.

Text Book:

1. Walter Rudin, **Principles of Mathematical Analysis,** 3rd Edition, McGraw – Hill International Book Company, Singapore, (1982).

   Units 1-5: Chapters: 1 – 5 (Including Appendix of chapter 1).

References:

1. Tom M. Apostol, **Mathematical Analysis**, Narosa Publishing House, New Delhi, 1997.
2. G. F. Simmons, **Introduction to Topology and Modern Analysis**, McGraw- Hill, New Delhi, 2004.
3. R. G. Bartle & D.R. Sherbert, **Introduction to Real Analysis**, John Wiley & Sons, New York, 1982.
4. Kenneth A. Ross, **Elementary Analysis: The theory of Calculus**, Springer, New York, 2004.
5. N. L. Carothers, **Real Analysis**, Cambridge University Press, UK, 2000.
6. S. C. Malik, **Mathematical Analysis**, Willey Eastern Ltd., New Delhi, 1985.
7. K. R. Stromberg, **An Introduction to Classical Real Analysis,** Wadsworth, 1981.

Core Course	Semester – I	
15MATP0103	NUMERICAL ANALYSIS	Credits: 4

Objective: To develop skills to solve many physical problems in an effective and efficient manner.

Specific outcome of learning:

- To understand different methods to solve the system of equations
- To realize the nature of different curves along with specified properties
- To tackle various types of integrals to solve many complicated problems
- Students can understand the method to solve higher order differential equations
- Students can understand different solutions of various types of specified equations.

Unit 1: Solving set of equations: Elimination method - The Gaussian elimination and Gauss -Jordan method (Except algorithms) - Iterative methods - Gauss Jacobi iteration- Gauss Seidel iteration (only problems).

Unit 2: Interpolation and curve fitting: Lagrangian polynomials - Divided differences - Interpolation with cubic spline – Least square approximation.

Unit 3: Numerical differentiation and integration: Numerical differentiation- derivatives using Newton's forward and backward formula - Derivatives using Striling's formula - Trapezoidal rule - Simpson's $1/3^{rd}$ rule - 3/8 rule - Weddles's rule - Errors in quadrature formula.

Unit 4: Numerical solution of ordinary differential equations: The Taylor series method – Picard's method - Euler and modified Euler methods – Runge - Kutta methods - Milne's method - The Adams - Moulton method.

Unit 5: Numerical Solution of Partial Differential Equations: Introduction - Difference quotients - Geometrical representation of partial differential quotients - Classification of partial differential equations - Elliptic equations - Solutions to Laplace's equation by Liebmann's iteration process - Poisson's equations and its solutions - Parabolic equations – Crank - Nicholson method - Hyperbolic equations.

Text books:

1. Curtis. F. Gerald, Patrick & O. Wheatley, **Applied Numerical Analysis,** 5th Edition, Pearson Education, New Delhi, 2005.

   Unit 1: Chapter 2: Sections 2.3, 2.4, 2.10.

   Unit 2: Chapter 3: Sections 3.1, 3.2, 3.3, 3.4, 3.7.

2. V. N. Vedamurthy & N. Ch. S. N. Iyengar, **Numerical Methods,** Vikas publishing house, Pvt. Ltd.,1998.

   Unit 3: Chapter 9: Sections 9.1 to 9.4, 9.6 to 9.12.

   Unit 4: Chapter 11: Sections 11.4 to 11.20.

   Unit 5: Chapter 12: Sections 12.1 to 12.9.

References:

1. M. K. Jain, S. R. K. Iyengar & R. K. Jain, **Numerical Methods for Scientific and Engineering Computation,** 3rd Edition, Wiley Eastern Edition, New Delhi, 2003.
2. R. L. Burden & J. Douglas Faires, **Numerical Analysis,** Thompson Books, USA, 2005.

Core Course	Semester – I	
15MATP0104	DIFFERENTIAL EQUATIONS	Credits: 4

Objective: To study in-depth concepts and applications of differential equations.

Specific outcome of learning: The learner will be able to

- Solve higher order and system of differential equations of different types.
- Finding the solutions of differential equation with initial and boundary conditions.
- Solving higher order partial differential equations using various methods.
- Identify, analyze and subsequently solve physical situations whose behavior can be described by ordinary differential equations.
- Choose the appropriate techniques from Calculus and Analytical Geometry to generate and explain exact and qualitative solutions of differential equations.

Unit 1: Systems of linear differential equations: Introduction - Systems of first order equations - Existence and uniqueness theorem - Fundamental matrix – Non - homogeneous linear systems - Linear systems with constant coefficients - Linear systems with periodic coefficients.

Unit 2: Existence and uniqueness of solutions: Introduction - Successive approximations - Picard's theorem - Continuation and dependence of initial conditions – Fixed point method.

Unit 3: Boundary value problem: Introduction - Strum Liouville problem - Green's function - Applications of boundary value problems - Picard's theorem.

Unit 4: First order partial differential equations: Linear equations of the first order – Pfafian differential equations – Compatible systems – Charpit's method – Jacobi's method – Integral surface through a given circle.

Unit 5: Genesis of second order PDE: Classifications of second order PDE – One dimensional wave equation – Vibrations of an infinite string - Vibrations of semi - infinite string - Vibrations of a string of finite length (method of separation of variables) – Heat conduction problem – Heat conduction of infinite rod case - Heat conduction of finite rod case.

Text Books:

1. S. G. Deo, V. Lakshmikantham & V. Raghavendra, **Ordinary Differential Equations**, Second Edition, Tata Mc Graw-Hill publishing company Ltd, New Delhi, 2004.
   Unit 1 : Chapter 4: Sections 4.1 to 4.8.
   Unit 2 : Chapter 5 : Sections 5.1 to 5.6, 5.9
   Unit 3 : Chapter 7 : Sections 7.1 to 7.5.

2. T. Amarnath, **An Elementary Course in Partial Differential Equations**, Narosa Publishers, New Delhi, 1997.
   Unit 4: Chapter 1: Sections 1.4 to 1.9
   Unit 5: Chapter 2: Sections 2.1, 2.2, 2.3.1, 2.3.2, 2.3.3, 2.3.5, 2.5.1, 2.5.2.

References:

1. Earl. A. Coddington, **An Introduction to Ordinary Differential Equations**, Dover Publications, inc., 1990.
2. G. F. Simmons, S. G. Krantz, **Differential Equations: Theory, Technique and Practice**, Tata McGraw Hill Book Company, New Delhi, India, 2007.
3. Clive R. Chester, **Techniques in Partial Differential Equations**, McGraw-Hill, 1970

Core Course	Semester - I	
15MATP0105	DISCRETE MATHEMATICS	Credits: 4

Objective: To impart various concepts about permutations, combinations and theory of numbers.

Specific outcome of learning:

- The learner will gain knowledge of permutations, combinations and its properties
- The learner will acquire knowledge of applications of permutations and combinations
- The learner will acquire concepts of divisibility and related algorithms
- The learner will become proficient in congruence properties
- The learner will acquire knowledge of number theoretic functions

Unit 1: Four basic counting principles - Permutations of sets - Combinations (subsets) of sets - Permutations of multi sets - Combinations of multi sets - Pigeonhole principle: simple form - strong form - Pascal's triangle - The binomial theorem - Unimodality of binomial coefficients - The multinomial theorem - Newton's binomial theorem.

Unit 2: The inclusion – exclusion principle – Combinations with repetition - Derangements – Permutations with forbidden positions – Some number sequences – Generating functions – Exponential generating functions – Solving linear homogeneous recurrence relations and non-homogeneous recurrence relations.

Unit 3: Divisibility theory in the integers: Early number theory - The division algorithm - The greatest common divisor - The Euclidean algorithm - The Diophantine equation. Primes and their distributions: The fundamental theorem of arithmetic - The sieve of Eratosthenes - The Goldbach conjecture.

Unit 4: The theory of congruence: Basic properties of congruence - Linear congruence and the Chinese Reminder Theorem - Fermat's Theorem: Fermat's little theorem and pseudo primes - Wilson's theorem - The Fermat - Kraitchik factorization method.

Unit 5: Number theoretic functions: The sum and number of divisors - The Mobius inversion formula. Euler's generalization of Fermat's theorem: Euler's Phi function - Euler's theorem - Some properties of Phi function. Primitive roots: The order of an integer modulo n - Primitive roots for primes - Composite numbers having primitive roots.

Text Books:

1. Richard A. Brualdi, **Introductory Combinatorics**, 5 th edition, Pearson Education Inc, England, 2010.
   Unit 1: Chapter 2: Sections 2.1 - 2.5. Chapter 3: Sections 3.1, 3.2. Chapter 5: Sections 5.1 – 5.5.
   Unit 2: Chapter 6: Sections 6.1 - 6.4. Chapter 7: Sections 7.1 -7.5.
2. David M. Burton, **Elementary Number Theory**, 6th Edition, Tata McGraw Hill, New Delhi, 2006.
   Unit 3: Chapter 2: Sections 2.1 - 2.5, Chapter 3: Sections 3.2 - 3.3.
   Unit 4: Chapter 4: Sections 4.2, 4.4, Chapter 5: Sections 5.2 - 5.4.
   Unit5: Chapter 6: Sections 6.1, 6.2, Chapter 7: Sections 7.2, 7.3,
   Chapter 8: Sections 8.1 - 8.3.

References:

1. C. Berg, **Principles of Combinatorics**, Academic Press, New York, 1971.
2. S. Lipschutz & M. Lipson, **Discrete Mathematics**, Tata McGraw-Hill Publishing Company, New Delhi, 2006.
3. J. Truss, **Discrete Mathematics for Computer Scientists**, Pearson Education Limited, England, 1999.
4. Tom. M. Apostol, **Introduction to Analytic Number Theory**, Springer, New Delhi, 1993.
5. Thomas Koshy, **Elementary Number Theory**, Elsevier, California 2005.
6. I. N. Robbins, **Beginning Number Theory**, 2nd Edition, Narosa Publishing House, New Delhi, 2007.

Core Course	Semester – II	
15MATP0206	LINEAR ALGEBRA	Credits: 4

Objective: To introduce some important concepts of vector spaces.

Specific outcome of learning: The learner will be able to

- recognize some advances of vector spaces and linear transformations.
- understand the concepts of linear algebra in geometric point of view.
- visualize linear transformations as a matrix form.
- decompose a given vector space in to certain canonical forms.
- formulate several classes of linear transformations and their properties.

Unit 1: Vector spaces: Elementary basic concepts - Linear independence and bases - Dual spaces.

Unit 2: Linear Transformations: The algebra of linear transformations - Characteristic roots – Matrices.

Unit 3: Canonical Forms: Triangular forms - Nilpotent transformations - A decomposition of vector spaces: Jordan form.

Unit 4: Inner product spaces – Orthogonality – Orthogonalization - Orthogonal Complement – Trace and Transpose.

Unit 5: Hermitian - Unitary and Normal Transformations - Quadratic forms: Basic properties of quadratic forms – Diagonalization of quadratic forms.

Text Book:

1. N. Herstein, **Topics in Algebra**, 2nd Edition, John Wiley & Sons, Singapore, 1993.
   Unit 1: Chapter 4: Sections 4.1, 4.2, 4.3.
   Unit 2: Chapter 6: Sections 6.1, 6.2, 6.3.
   Unit 3: Chapter 6: Sections 6.4, 6.5, 6.6.
   Unit 4: Chapter 4: Section 4.4, Chapter 6: Sections 6.8.
   Unit 5: Chapter 6: Sections 6.10, 6.11.

References:

1. Vivek Sahai & Vikas Bist, Linear **Algebra**, Narosa Publishing House, 2002.
2. A. R. Rao & P. Bhimashankaram., **Linear Algebra**, Tata Mc Graw Hill. 1992.
3. J. S. Golan, **Foundations of linear Algebra**, Kluwer Academic publisher, 1995.
4. Kenneth Hoffman & Ray Kunze, **Linear Algebra**, Prentice-Hall of India Pvt., 2004.
5. S. Kumaresan, **Linear Algebra: A Geometric Approach**, Prentice Hall of India, 2006.
6. Jin Ho Kwak & Sungpyo Hong, **Linear algebra**, Birkhauser, 2004.

Core Course | Semester - II
15MATP0207 | ADVANCED REAL ANALYSIS | Credits: 4

Objective: To introduce the concept of integration of real-valued functions, sequences and series of functions.

Specific outcome of learning: The learner will acquire in-depth knowledge about

- integrals of a bounded function on a closed bounded interval
- sequences and series of functions and uniformity in its convergence
- various mathematical functions
- finding the derivative of functions of multiple variables
- higher order derivatives for vector valued functions

Unit 1: The Riemann-Stieltjes integral: Definition and existence of the integral - Properties of the integral - Integration and differentiation - Integration of vector valued functions - Rectifiable curves.

Unit 2: Sequences and series of functions: Discussion of Main problem - Uniform Convergence - Uniform convergence and continuity - Uniform convergence and Integration - Uniform convergence and differentiation - Equicontinuous families of functions - The Stone-Weierstrass theorem.

Unit 3: Some special functions: Power series - The exponential and Logarithmic functions - The trigonometric functions - The algebraic completeness of the complex field - Fourier Series - The Gamma functions.

Unit 4: Functions of several variables: Linear transformations – Differentiation - The contraction principle - The inverse function theorem.

Unit 5: The implicit function theorem - The rank theorem – Determinants - Derivatives of higher order - Differentiation of integrals.

Text Book:

1. Walter Rudin, **Principles of Mathematical Analysis,** 3rd Edition, McGraw – Hill International Book Company, Singapore, 1982.

   Unit 1: Chapter 6, Unit 2: Chapter 7, Unit 3 : Chapter 8. Unit 4, 5: Chapter 9.

References:

1. Tom M. Apostol, **Mathematical Analysis**, Narosa Publishing House, New Delhi, India, 1997.
2. G. F. Simmons, **Introduction to Topology and Modern Analysis**, 3rd Ed., McGraw- Hill, New Delhi, 2004.
3. S. C. Malik, **Mathematical Analysis**, Willey Eastern Ltd., New Delhi, 1985.
4. N. L. Carothers, **Real Analysis**, Cambridge University Press, UK, 2000.

Core Course	Semester - II	
15MATP0208	MATHEMATICAL METHODS	Credits: 4

Objective: To learn various integral equations, transformation techniques and its applications.

Specific outcome of learning:

- To understand the various concepts of integral equations
- Students can develop their skills to find the solutions of various integral equations
- To understand various theorems with proof techniques that will motivate to develop further
- Students can understand different functions based on applications
- To understand different transformation techniques.

Unit 1: Integral equations: Types of integral equations - conversion of ordinary differential equation into integral equation - Method of converting initial value problem into a Volterra integral equation - Boundary value problem - Method of converting a boundary value problem into a Fredholm integral equation – Solution of Homogeneous Fredholm integral equation of the second kind with separable kernels - Problems - Characteristic values and functions - Solutions of Fredholm integral equation of the second kind with separable kernels – Problems.

Unit 2: Method of successive approximations : Introduction - Iterated kernels or functions - Resolvent (or reciprocal) kernel - Solution of Fredholm integral equation of the second kind by successive substitutions - Solution of Volterra integral equation of the second kind by successive approximations - Reciprocal functions Neumann series - Solutions of Volterra integral equation of the second kind when its kernel is of some particular form - Solution of Volterra equation of the second kind by reducing to differential equation.

Unit 3: Classical Fredholm theory – Introduction - Fredholm's first fundamental theorem - Problems based on Fredholm's first fundamental theorem - Fredholm's second fundamental theorem - Fredholm's third fundamental theorem – Including proof.

Unit 4: Singular integral equations - The solution of Abel's integral equation - Some general form of Abel's singular integral equation - Problem- Applications of integral equation and Green's functions to ordinary differential equation – Green's function- Conversion of a boundary value problem into Fredholm's integral equation - Some special cases - Examples based on construction of Green's functions and problems.

Unit 5: Fourier Transforms - Definition- Inversion theorem - Fourier sine and cosine transform - Fourier transforms of derivatives - Convolution theorem - Parsevel's relation for Fourier transform and problems on self-reciprocal.

Text Books:

1. M. D. Raisinghania, **Integral Equations and boundary value Problems**, Third Revised edition, S. Chand & Company Ltd. New Delhi.
   Unit I: Chapter 2 Sections 2.1 to 2.6 and Chapter 3 Sections 3.1 to 3.3
   Unit 2: Chapter 5 Sections 5.1 to 5.15
   Unit 3: Chapter 6.1 to 6.5
   Unit 4: Chapter 8, Section 8.1 to 8.6, chapter 11 Section 11.1 to 11.8
2. I. N. Sneddon, **The use of Integral Transform**, Tata Mc Graw Hill, New Delhi, 1974.

References:

1. J. K. Goyal & K. P. Gupta, **Laplace and Fourier Transforms,** 12th Edition, Pragati Prakashan Meerukt, 2000.
2. W. V. Lovitt, **Linear Integral equations,** Dover Publications, New York, 1950.

Core Course	Semester – II	
15MATP0209	PROBABILITY AND STATISTICS	Credits: 4

Objective: To learn the advanced theory of probability and some statistical techniques.

Specific learning outcome: The learner will become proficient in

- Understanding the basic concepts of probability and its properties.
- Constructing the probability distribution of a random variable, based on a real-world situation, and use it to compute expectation and variance.
- Computing probabilities based on practical situations using the binomial normal and other distributions.
- Understanding the limiting process of distributions and solve related problems.
- Identifying situations where one-way ANOVA is and is not appropriate.

Unit 1: Introduction to probability and distributions - The probability set function - Conditional probability and independence - Random variables of the discrete type - Random variables of the continuous type - Properties of the distribution function.

Unit 2: Expectation of a random variable - Some special expectations - Chebyshev's inequality. Some Special Distributions: The Binomial and related distributions - The Poisson distribution - The Uniform distribution - The Gamma and Chi-Square distributions - The normal distribution - The bivariate normal distribution - The beta distribution - Student's t- distribution - F-distribution.

Unit 3: Limiting Distributions: Convergence in distribution - Convergence in probability - Limiting moment generating function - The central limit theorem.

Unit 4: Estimation Theory: Introduction - Unbiased estimators – Efficiency – Consistency – Sufficiency – Robustness - The method of moments - The method of maximum likelihood - Bayesian estimation. Sufficient Statistics: Measure of quality of estimators - A sufficient statistic for a parameter - Properties of a sufficient statistics.

Unit 5: Analysis of Variance: Introduction - One-way analysis of variance - Experimental design - Two-way analysis of variance without interaction - Two-way analysis of variance with interaction.

Text Books:

1. Robert V. Hogg & Allen T. Craig, **Introduction to Mathematical Statistics**, 5th Edition, Pearson Education, Singapore, 2002.

Unit 1: Chapter1: Sections 1.1 to 1.7
Unit 2: Chapter 1: Sections 1.8 to 1.10, Chapter 3: Sections 3.1 to 3.5, Chapter 4: Section 4.4
Unit 3: Chapter 5: Sections 5.1 to 5.5
Unit 4: Chapter 7: Sections 7.1 to 7.3

2. Irwin Miller & Marylees Miller, **John E. Freund's Mathematical Statistics**, 6th Edition, Pearson Education, New Delhi, 2002.
   Unit 2: Chapter 6: Section 6.2,
   Unit 4: Chapter 10: Sections 10.1 to 10.9
   Unit 5: Chapter 15: Sections 15.1 to 15.5

References:

1. Marek Fisz, **Probability Theory and Mathematical Statistics**, John Wiley, 1963.
2. John E. Freund, **Mathematical Statistics**, 5 th edition, Prentice Hall India, 1994.
3. S.M. Ross, **Introduction to Probability Models**, Academic Press, India, 2000

Core Course	Semester – III	
15MATP0310	COMPLEX ANALYSIS	Credits: 4

Objective: To impart various concepts about the analytic functions in the complex plane.

Specific outcome of learning:

- The learner will acquire knowledge of analytic function and transformations
- The learner will gain knowledge of power series of analytic function
- The learner will acquire concepts of complex integration
- The learner will become proficient in applications of Cauchy's theorem
- The learner will acquire knowledge of singularities and residues

Unit 1: Analytic Functions: Cauchy–Riemann equation – Analyticity - Harmonic functions - Bilinear transformations and mappings: Basic mappings - Linear fractional transformations.

Unit 2: Power Series: Sequences revisited - Uniform convergence - Maclaurin and Taylor Series - Operations on power series - Conformal mappings.

Unit 3: Complex Integration and Cauchy's Theorem: Curves – Parameterizations - Line Integrals - Cauchy's Theorem.

Unit 4: Applications of Cauchy's Theorem: Cauchy's integral formula - Cauchy's inequality and applications - Maximum modulus theorem.

Unit 5: Laurent series and the residue theorem: Laurent Series - Classification of singularities - Evaluation of real integrals - Argument principle.

Text Book:

1. S. Ponnusamy & Herb Silverman, **Complex Variables with Applications**, Birkhauser, Boston, 2006

   Unit 1: Chapter 5: Sections 5.1, 5.2, 5.3, Chapter 3: Sections 3.1, 3.2
   Unit 2: Chapter 6: Sections 6.1, 6.2, 6.3, 6.4 Chapter 11: Section 11.1
   Unit 3: Chapter 7: Sections 7.1, 7.2, 7.3, 7.4
   Unit 4: Chapter 8: Sections 8.1, 8.2, 8.3

Unit 5: Chapter 9: Sections 9.1, 9.2, 9.3, 9.4

References:

1. S. Ponnusamy, **Foundations of Complex analysis**, 2 nd edition , Narosa Pub., 2005.
2. T. W. Gamlelin, **Complex Analysis**, Springer-Verlag, New York, 2001.
3. V. Karunakaran, **Complex Analysis**, Narosa Publishing House, New Delhi, 2002.
4. R.V. Churchill & J. W. Brown, **Complex Variables & Applications**, Mc.Graw Hill, 1990.
5. John. B. Conway, **Functions of One Complex Variable**, Narosa Pub. House, 2002.
6. Elias M. Stein & Rami Shakarchi, **Complex analysis**, Princeton University Press, 2003.
7. B. P. Palka, **An Introduction to Complex Function Theory**, Springer-Verlag, New York 1991.
8. Lars. V. Ahlfors, **Complex Analysis**, 3rd edition, McGraw Hill book company, International Edition 1979.

Core Course Semester – III
15MATP0311 TOPOLOGY Credits: 4

Objective: To introduce the fundamental concepts of topology and investigate properties of topological spaces.

Specific outcome of learning: The learner will acquire knowledge about

- Various topological properties of sets
- The properties of continuous functions on different topological spaces
- Connected and compact topological spaces and its properties
- Various axioms satisfied by topological spaces
- Various theorems on normal spaces and complete metric spaces

Unit 1: Topological spaces-Basis for a topology - The order topology - The product topology on $X \times Y$ – The subspace topology - Closed sets and limit.

Unit 2: Continuous functions - The product topology - The metric topology .

Unit 3: Connected spaces - Connected subspaces of the real line - Components and local connectedness - Compact spaces - Compact subspaces of the real line

Unit 4: Limit point compactness-Local compactness- The countability and separation axioms: The countability axioms - The separation axioms - Normal spaces.

Unit 5: The Urysohn's lemma - The Urysohn's metrization theorem-The Tychonoff theorem: The Tychonoff theorem - Complete metric spaces and function spaces: Complete metric spaces.

Text Book:

1. James R. Munkres, **Topology**, 2nd Edition, Pearson Education, Delhi, 2006.

Unit 1: Chapter 2: Sections 2.1- 2.6

Unit 2: Chapter 2: Sections 2.7-2.10

Unit 3: Chapter 3: Sections 3.1- 3.5

Unit 4: Chapter 4: Sections 3.6, 3.7, 4.1-4.3

Unit 5: Chapters 4: Sections 4.4, 4.5, Chapter 5: 5.1, Chapter 7: Sections 7-1.

References:

1. G. F. Simmons, **Introduction to Topology and Modern Analysis**, International Student Edition, New Delhi, 2005.
2. B. Mendelson, **Introduction to Topology**, CBS Publishers, Delhi, 1985.
3. Sze- Tsen Hu, **Introduction to General Topology**, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1966.
4. S. Lipschutz, **General Topology**, **Schaum's Series**, McGraw-Hill New Delhi, 1965.
5. K. D. Joshi, **Introduction to General Topology**, New Age International Pvt. Ltd, 1983.
6. J. L. Kelly, **General Topology**, Springer-Verlag, New York, 1975
7. James Dudunji, **Topology**, Allyn and Bacon, New Delhi, 1966.

Core Course Semester – III
15MATP0312 MEASURE THEORY Credits: 4

Objective: To introduce the fundamentals of measure and integration on the real line.

Specific outcome of learning: The learner will be able to

- recognize the concept of Lebesgue measure and integration.
- describe of geometric meaning of measurable functions and integration.
- formulate the relationships between Riemann and Lebesgue integrals.
- describe the importance and applications of measure theory in other branches of Mathematics.
- apply the techniques of measure theory to evaluate integrals.

Unit 1: Measure on the real line: Lebesgue outer measure - Measurable sets – Regularity - Measurable functions - Borel and Lebesgue measurability.

Unit 2: Integration of functions of a real variable: Integration of non-negative functions - The general integral - Integration of series - Riemann and Lebesgue integrals.

Unit 3: Abstract measure spaces: Measures and outer measures - Extension of a measure - Uniqueness of the extension - Completion of a measure - Measure spaces - Integration with respect to a measure.

Unit 4: Inequalities and the L^p Spaces: The L^p Spaces - Convex functions - Jensen's inequality - The inequalities of Holder and Minkowski - Completeness of $L^p(\mu)$.

Unit 5: Signed Measures and their derivatives: Signed measures and the decomposition - The Jordan decomposition - The Radon-Nikodym theorem - Some applications of the Radon-Nikodym theorem.

Text Book:

1. G.de Barra, **Measure Theory and Integration,** I[st] Edition, New Age International Publishers, 2003.

   Unit 1 : Sections 2.1, 2.2, 2.3, 2.4, 2.5
   Unit 2 : Sections 3.1, 3.2, 3.3, 3.4
   Unit 3 : Sections 5.1, 5.2, 5.3, 5.4, 5.5, 5.6
   Unit 4 : Sections 6.1, 6.2, 6.3, 6.4, 6.5
   Unit 5 : Sections 8.1, 8.2, 8.3

References:

1. H. L. Royden, **Real analysis**, 3[rd] Ed., Prentice Hall of India, New Delhi, 2005.
2. I. K. Rana, **An Introduction to Measure and Integration**, Narosa Publishing House, New Delhi, 1999.
3. D.L. Cohn, **Measure Theory**, Birkhauser, Switzerland,1980.
4. E. Hewitt & K. R. Stromberg, **Real and Abstract Analysis**, Wiley Verlag, 1966.

Core Course Semester III

15MAT0313 DIFFERENTIAL GEOMETRY Credits: 4

Objective: To introduce the concepts of space curves, surfaces and their properties.

Specific outcome of learning: The learner will acquire more knowledge about

- The problems and properties of curves and surfaces based on vector methods in geometrical view point
- Fundamental existence theorem for space curves
- Representation of a surface
- Canonical geodesic equations
- Geodesic curvature

Unit 1: Theory of space curves: Unique parametric representation of a space curve - Arc-length - tangent and osculating plane - principal normal and binormal - curvature and torsion - contact between curves and surfaces - osculating circle and osculating sphere - locus of centres of spherical curvature.

Unit 2: Tangent surfaces - Involutes and evolutes – Betrand curves - Spherical indicatrix - Intrinsic equations of space curves - Fundamental existence theorem for space curves - Helices.

Unit 3: The first fundamental form and local intrinsic properties of a surface: Definition of a surface - Nature of points on a surface - Representation of a surface - Curves on surfaces - Tangent plane and surface normal - The general surfaces of revolution – Helicoids - Metric on a surface - The first fundamental form - Direction coefficients on a surface.

Unit 4: Families of curves - Orthogonal trajectories - Double family of curves - Isometric correspondence - Intrinsic properties - Geodesics on a surface: Geodesics and their differential equations - Canonical geodesic equations - Geodesics on surface of revolution - Normal property of geodesics - Differential equations of geodesics using normal property.

Unit 5: Existence theorems - Geodesic parallels - Geodesic polar coordinates - Geodesic curvature - Gauss-Bonnet theorem-Gaussian curvature.

Text Book:

1. D. Somasundaram, **Differential Geometry: A first course**, Narosa Publishing House, New Delhi, India, 2005.
   Unit 1: Sections 1.3-1.7, 1.10-1.12
   Unit 2: Sections 1.13-1.18
   Unit 3: Sections 2.2-2.10
   Unit 4: Sections 2.11-2.15, 3.2-3.6
   Unit 5: Sections 3.7-3.12

Reference:

1. T.J. Willmore, **An Introduction to Differential Geometry,** Oxford University Press, New Delhi, 2006.
2. J. N. Sharma & A. R. Vasistha, **Differential Geormetry**, Kedar Nath Ram Nath, Meerut, 1998.

Modular Course	Semester - III

15MATP03M1 **MATLAB & LATEX** Credits: 2

Objective: To impart the programming concepts of matlab and latex.
Specific outcome of learning: The learner will be

- Able to use Matlab for interactive computations.
- Able to draw 2D and 3D graphs.
- Able to applying programming techniques to solve problems at advanced level.
- Understand richness of Latex rather than using M.S word for documentation.
- Proficient in documentation using mathematical symbols, graphs and tables.
-

Unit 1: Introduction – Starting - Closing matlab – Types of matlab windows – Data types - Assignment statements. System commands and mathematical operators: Saving and loading files – Workspace – Mathematical operators – Relational, binary and logical operators.
Unit 2: Handling of arrays: Creating - Accessing arrays - Mathematical operations on arrays: Addition, multiplication of single and multiple arrays – Relational and logical operations on arrays – Operations on sets. Handling of matrices: Creating – Accessing – Length - Size – Maximum – Minimum - Mean – Expanding and reducing size – Reshaping – Shifting – Sorting – Special matrices - Mathematical operations on matrices.
Unit 3: Basic programming in MATLAB - M-File functions: Creating – Running - Handling variables - Types of functions - Cell arrays - Structures. File I/O handling. Graphics: 2D graphics – 3D graphics – Specialized graphs – Saving and printing figures.
Unit 4: Document layout and organization – Document class - Page style - Parts of the document - Text formatting - TeX and its offspring, what's different in latex 2 and basics of LaTeX file.
Unit 5 : Commands and environments-command names and arguments – Environments - Declarations - Lengths - Special characters - Fragile commands - Table of contents - Fine – Tuning text - Word division - Labeling, referencing, displayed text – Changing font - Centering and identifying, lists, generalized lists, theorem like declarations, tabular stops, boxes.

Text Books:

1. Y. Kirani Singh & B. B. Chaudhuri, **MATLAB Programming**, Prentice-Hall of India Pvt. Ltd, New Delhi, 2008.
2. Desmond. J. Higham & Nicholas J. Hiham, **MATLAB Guide,** 2nd edition, SIAM, 2005.

Reference:

1. H. Kopka & P. W. Daly, **A Guideline to LaTeX** , Third edition, Addison – Wesley, London, 1999.

15MATP03M2 WAVELET ANALYSIS Credits: 2

Objective: To impart skills in the various applications of wavelet analysis.

Specific outcome of learning: The learner will acquire skills to

- understand the basic concepts of Wavelets
- identify the Algebra and Geometry of Wavelet Matrices
- classify One-Dimensional Wavelet Systems
- realize the Examples of One-Dimensional Wavelet Systems
- recognize the concepts Higher-Dimensional Wavelet Systems

Unit 1: The New Mathematical Engineering: Introduction-Trial and Error in the Twenty-First Century-Active Mathematics-The Three types of Bandwidth-Good Approximations: Approximation and the Perception of Reality-Information Gained from Measurement-Functions and their Representations-Wavelets: A Positional Notation for Functions: Multiresolution Representation-The Democratization of Arithmetic: Positional Notation for Numbers-Music Notation as a Metaphor for Wavelet Series-Wavelet Phase Space.

Unit 2: Algebra and Geometry of Wavelet Matrices: Introduction-Wavelet Matrices-Haar Wavelet Matrices-The Algebraic and Geometric structure of the Space of Wavelet Matrices- Wavelet Matrix Series and Discrete Orthonormal Expansions.

Unit 3: One-Dimensional Wavelet Systems: Introduction-The Scaling Equation-Wavelet Systems-Recent Developments: Multiwavelets and Lifting.

Unit 4: Examples of One-Dimensional Wavelet Systems: Introduction to the Examples-Universal Scaling Functions-Orthonormal Wavelet Systems-Flat Wavelets-Polynomial Regular and Smooth Wavelets-Fourier-Polynomial Wavelet Matrices.

Unit 5: Higher-Dimensional Wavelet Systems: Introduction-Scaling Functions-Scaling Tiles-Orthonormal Wavelet Bases-Wavelet Data Compression: Understanding Compression-Image Compression-Transform Image Compression Systems-Wavelet Image Compression-Embedded Coding and the Wavelet-Difference-Reduction Compression Algorithm-Multiresolution Audio Compression-Denoising Algorithms.

Text Book:

1. Howard L. Resnikoff Raymond & O. Wells, Jr., **Wavelet Analysis- The Scalable Structure of Information,** Springer, New Delhi, 2004.
   Unit 1: Chapter 1: Sections: 1.1 to 3.4
   Unit 2:.Chapter 2: Sections: 4.1 to 4.5
   Unit 3: Chapter 5: Sections: 5.1 to 5.4
   Unit 4: Chapter 6: Sections: 6.1 to 6.6
   Unit 5: Chapter:7: Sections 7.1 to 7.4, Chapter 13: Sections: 13.1 to 13.7

References:

1. L.Prasad & S.S.Iyengar, **Wavelet Analysis with Applications to Image Processing,** CRC Press, New York, 1997.
2. Geroge Buchman, Lawrence Narichi, & Edward Beckenstein, **Fourier and Wavelet Analysis**, Springer-Verlag, New York, Inc-2000.

Core Course	Semester – IV	
15MATP0414	FUNCTIONAL ANALYSIS	Credits: 4

Objective: To introduce basics of functional analysis with special emphasis on Hilbert and Banach space theory.

Specific outcome of learning:

- The learner will become proficient in normed linear spaces and Banach spaces
- The learner will acquire knowledge of completion of normed linear spaces
- The learner will acquire concepts of operators on Banach spaces
- The learner will gain knowledge of consequences of Hahn-Banach theorem
- The learner will acquire knowledge of consequences of closed graph theorem and stability result for operator

Unit 1: Norm on a linear space - Examples of normed Linear spaces - Seminorms and quotient spaces - Product space and graph norm - Semi – inner product and sesquilinear form - Banach spaces.

Unit -2: Incomplete normed linear spaces - Completion of normed linear spaces - Some properties of Banach spaces - Baire category theorem (statement only) - Schauder basis and separability - Heine-Borel theorem and Riesz lemma - Best approximation theorems - Projection theorem.

Unit 3: Operators on normed linear spaces - Bounded operators - Some basic results and examples - The space B(X,Y) - Norm on B(X,Y) - Riesz representation theorem - Completeness of B(X,Y) - Bessel's inequality - Fourier expansion and Parseval's formula - Riesz-Fischer theorem.

Unit 4: Hahn-Banach theorem and its consequences - The extension theorem – Consequences on uniqueness of extension - Separation theorem.

Unit 5: Uniform boundedness principle - Its consequences - Closed graph theorem and its consequences - Bounded inverse theorem - Open mapping theorem - A stability result for operator equations.

Text Book:

1. M. Thamban Nair, **Functional Analysis - A First Course**, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.

    Unit 1: Chapter 2: Sections 2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.6, 2.2

    Unit 2: Chapter 2: Sections 2.1, 2.2.2, 2.2.3, 2.3 - 2.6.

    Unit 3: Chapter 3: Sections 3.1, 3.1.1, 3.2, 3.2.1, 3.3, 3.4.1,

    Chapter 4: Sections 4.2, 4.3, 4.4.

    Unit 4: Chapter 5: Sections 5, 5.1 - 5.4.

    Unit 5: Chapter 6: Sections 6.1, Chapter 7: Sections 7.1, 7.2, 7.3, 7.3.1.

References:

1. B. V. Limaye, **Functional Analysis**, New Age International Pvt. Ltd, 1996.
2. H. Siddiqi, **Functional Analysis with Applications**, Tata McGraw-Hill Pub., 1986.
3. S. Ponnusamy, **Foundations of Functional Analysis**, Narosa Publishing House, 2002.
4. Kreyszig, **Introductory Functional Analysis with Applications**, John Wiley & Sons, 2006.

Core Course	Semester - IV	
15MATP0415	GRAPH THEORY	Credits: 4

Objective: To impart the different concepts of theory of graphs.

Specific outcome of learning: The learner will be able to

- Understand various operations on graphs
- Know different types of graphs with applications
- Understand the applications of different parameters of a graph.
- Understand the domination number with real life applications.
- Motivate to introduce different types of graphs with parameter with applications.

Unit 1: Basic results - Basic concepts - Sub graphs - Degrees of vertices - Paths and connectedness - Automorphism of simple graphs - line graphs - Operations on graphs - Application to chemistry.

Unit 2: Connectivity - Vertex cut and edge cut - Connectivity and edge – Blocks – Trees – Definition - Characterization and simple properties - Centers and centroids – Counting the number of spanning trees - Cayley's formula.

Unit 3: Eulerian and Hamiltonian graphs: Introduction - Eulerian graphs - Hamiltonian graphs - Vertex colorings - Critical graphs - Triangle free graphs. Planarity: Introduction - Planar and Non Planar graphs - Euler formula and its consequences - K_5 and $K_{3,3}$ are non- planar.

Unit 4: Dominating sets in graphs - Various real life applications - Bounds on the domination number - Bounds in terms of order - Degree and packing - Bounds in terms of order and size.

Unit 5: Conditions on the dominating set: Introduction- Independent dominating sets - Total dominating sets - Connected dominating sets - Dominating cliques - Paired dominating sets - Applications.

Text Books:

1. R. Balakrishnan & K. Ranganathan, **A Text Book of Graph Theory,** Springer-Verlag New York, Inc. (Units 1-3), 2012.
2. Teresa W. Hayness, Stephen T. Hedetniemi, Peter J. Slater, & Marcel Dekker, **Fundamental of Domination in Graphs,** INC New York, 1998.
   Unit 4: Chapter 1, Chapter 2 (Sections 2.1-2.4)
   Unit 5: Chapter 6 (Sections 6.1 - 6.6)

References:

1. F. Harary, **Graph Theory**, Addison-Wesley, Reading Mass., 1969
2. J. A. Bondy and U. S. R. Murty, **Graph theory with applications,** The MacMillan Press Ltd., 1976.

Core Course	Semester - IV

15MATP0416 **CLASSICAL MECHANICS** **Credits: 4**

Objective: To study the system dynamics via non-relativistic theories and methods.

Specific outcome of learning:

- The learner will become proficient in the basic concepts of nonrelativistic classical dynamics
- Proficient in derivation and application of Lagrange's equations
- Proficient in variational principle, Hamilton principle and Hamilton's equations
- Proficient in derivation and application of Hamilton-Jacobi equations
- Proficient in canonical transformations, Lagrange and Poisson brackets expressions

Unit 1: Introductory Concepts: The mechanical system - Generalized coordinates - Constraints - Virtual work - Energy and momentum.

Unit 2: Lagrange's equations: Derivation of lagrange's equations - Examples - Integrals of the motion.

Unit 3: Hamilton's Equations: Hamilton's principle – Hamilton's equations – Other variational principles.

Unit 4: Hamilton - Jacobi theory: Hamilton's principal function - The Hamilton - Jacobi equation - Separability.

Unit 5: Canonical Transformations: Differential forms and generating functions - Special transformations - Lagrange and Poisson brackets.

Text Book:

1. Donald T. Greenwood, **Classical Dynamics**, 3rd Edition, Prentice-Hall Private Limited, New Delhi, 1990.

   Unit 1: Sections 1.1 to 1.5
   Unit 2: Sections 2.1 to 2.3
   Unit 3: Sections 4.1 to 4.3
   Unit 4: Sections 5.1 to 5.3
   Unit 5: Sections 6.1 to 6.3

References:

1. P. N. Singhal and S. Sareen, **A Text Book on Mechanics**, Anmol Publications Pvt., Ltd., New Delhi, 2000.
2. Goldstein, Charles Poole, John Safko, **Classical Mechanics**, Pearson Education , 2002.

Core Course Semester – IV

15MATP0417 STOCHASTIC PROCESSES Credits: 4

Objective: To introduce a wide variety of stochastic processes and their applications.

Specific outcome of learning:

- The learner will acquire in-depth knowledge about stationary stochastic processes and Markov chains.
- Proficient in Markov Process with discrete state space
- Proficient in Markov processes with continuous state space
- Proficient in Branching processes and age dependent branching process
- Proficient in solving stochastic processes in queuing systems

Unit 1: Definition of stochastic processes – Markov chains: Definition- order of a markov chain – Higher transition probabilities – classification of states and chains.

Unit 2: Markov Process with discrete state space: Poisson process and related distributions – Properties of Poisson process - Generalizations of Poisson processes – Birth and death processes – Continuous time Markov chains.

Unit 3: Markov processes with continuous state space: Introduction - Brownian motion – Weiner process and differential equations for it - Kolmogrov equations – First passage time distribution for Weiner process – Ornstein – Uhlenbech process.

Unit 4: Branching Processes: Introduction – Properties of generating functions of Branching processs – Distribution of the total number of progeny – Continuous - Time Markov branching process - Age dependent branching process: Bellman-Harris process.

Unit 5: Stochastic Processes in Queueing Systems: Concepts – Queueing model M/M1 – transient behavior of M/M/1 model – Birth and death process in Queueing theory : M/M/1 – Model related distributions – M/M/∞ - M/M/S/S – Loss system - M/M/S/M – Non birth and death Queueing process : Bulk queues – $M^{(x)}/M/1$

Text Book:

1. J. Medhi, **Stochastic Processes**, 2nd Edition, New age international Private limited, New Delhi, 2006.
   Unit 1: Chapter 2: Sections 2.1 - 2.3, Chapter 3: Sections 3.1- 3.4.
   Unit 2: Chapter 4: Sections 4.1 - 4.5.
   Unit 3: Chapter 5: Sections 5.1 - 5.6.
   Unit 4: Chapter 9: Sections 9.1, 9.2, 9.4, 9.7.
   Unit 5: Chapter 10: Sections 10.1 - 10.5.

References:

1. K. Basu, **Introduction to Stochastic Process**, Narosa Publishing House, New Delhi, 2003.
2. Goswami & B. V. Rao, **A Course in Applied Stochastic Processes**, Hindustan Book Agency, New Delhi, 2006.
3. G. Grimmett & D. Stirzaker, **Probability and Random Processes**, 3rd Ed., Oxford University Press, New York, 2001.

15MATP04M1 FUZZY LOGIC AND ITS APPLICATIONS Credits: 2

Objective: To develop many problem solving skills in fuzzy system.

Specific outcome of learning: The learner will be able to understand

- The different concepts of fuzzy sets
- The various operations on fuzzy sets
- Different fuzzy numbers
- The relationship between different fuzzy sets
- Fuzzy quantifiers and Linguistic Hedges

Unit 1: Crisp sets- fuzzy sets basic types and basic concepts-Fuzzy sets versus crisp sets- additional Properties of alpha-cults-b representations of Fuzzy sets, Extension principle for fuzzy sets

Unit 2: Operation on fuzzy sets- types of operations-fuzzy complements- fuzzy intersections t-forms fuzzy unions t- conforms-combinations of operations- aggregation operation.

Unit 3: Fuzzy numbers - Linguistic values - Arithmetic operations on intervals - Arithmetic operations on Fuzzy numbers- lattice of Fuzzy numbers- Fuzzy equations.

Unit 4: Fuzzy relations - Crisp versus fuzzy relations- projections and cylindrical extensions- binary Fuzzy relations- binary relations on a single set- Fuzzy equivalence relation- Fuzzy compatibility relations.

Unit 5: Fuzzy Logic - Multivalve logic- fuzzy propositions- fuzzy quantifiers- Linguistic Hedges - inference from conditional fuzzy propositions - inference from conditional and qualified propositions- inference from quantified propositions.

Text Book:

1. George J.Klir & Bo Yunan, **Fuzzt sets and Fuzzy logic Theory & applications**, PHI Learning Private Limited- New Delhi 2013.

References:

1. Bandemer. H & W. Nather, **Fuzzy Data Analysis,** Kluwer, Boston, New York 1992.

15MATP04M2 **NEURAL NETWORKS** **Credits: 2**

Objective: To introduce the main fundamental principles and techniques of neural network systems and investigate the principal neural network models and applications.

Specific outcome of learning: The learner will acquire in-depth knowledge of

- Neural Network-Applications of neural network
- Nonlinear models and dynamics
- Dynamical behavior of DNN
- Hopfield dynamic neural network
- Conditions for equilibrium points in DNN

Unit-1: Architectures: Introduction to Neural Network-Applications of neural network-Biological neural networks-Artificial neural networks-Functioning of artificial neural network-Neuron modeling.

Unit-2: Dynamic Neural Units (DNUs): Nonlinear models and dynamics-Models of dynamic neural units-Models and circuits of isolated DNUs-Neuron with excitatory and inhibitory dynamics.

Unit-3: Neuron with multiple nonlinear feedback-Dynamic temporal behavior of DNN-Nonlinear analysis for DNUs.

Unit-4: Continuous-time dynamic neural networks: Dynamic neural network structures: An introduction-Hopfield dynamic neural network (DNN) and its implementation-Hopfield dynamic neural networks (DNNs) as Gradient-like systems.

Unit-5: Modifications of Hopfield dynamic neural networks-Other DNN models-Conditions for equilibrium points in DNN.

Text Books:

1. A. Anto Spiritus Kingsly, **Neural network and fuzzy logic control**, Anuradha publications, Chennai, 2009.
2. Madan M. Gupta, Liang Jin & Noriyasu Homma, **Static and Dynamic neural networks**, A John Wiley and sons, INC., Publication, 2003.

Unit 1: Chapters: 1.1—1.6.2 –Text book 1
Unit 2: Chapters: 8.1—8.3—Text book 2
Unit3: Chapters: 8.4—8.6—Text book 2
Unit 4: Chapters: 9.1—9.3—Text book 2
Unit 5: Chapters: 9.4—9.6—Text book 2

References:

1. JaceK M. Zurada, **Introduction to Artificial Neural Systems**, Jaico Publishing House, Chennai, 2006.
2. Kevin L. Priddy & Paul E. Keller, **Artificial Neural Networks,** PHI Learning Private Limited, New Delhi, 2009.
3. Elaine Rich &Kevin Knight, **Artificial Intelligence**, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2005.
4. S. Rajasekaran & G. A. Vijayalakshmi Pai, **Neural Networks**, Fuzzy Logic and Genetic Algorithms synthesis and applications, PHI Learning Private Limited, New Delhi, 2008.

Core Course
15MATP0418 DISSERTATION Credits: 6

Major Elective Semester - III
15MATP03E1 OPTIMIZATION TECHNIQUES Credits: 4

Objective: To impart the mathematical modelling skills through different methods of optimization.

Specific outcome of learning: The learner will become proficient in solving mathematical models through different optimization techniques

- The learner will become capable in solving Linear Programming problems
- The learner will become skillful in solving Integer Linear Programming problems
- The learner will become competent in solving one dimensional optimization and Multidimensional unconstrained optimization problems
- The learner will become knowledgeable in solving Multi-dimensional constrained optimization problems
- The learner will become proficient in solving Geometric and Dynamic Programming problems

Unit 1: Introduction to convex set and convex function – Linear Programming problems: Simplex method – Revised simplex method – Duality concept – Dual simplex method.

Unit 2: Integer Linear Programming: Branch – and Bound method – cutting plane method – Zero – one integer problem – Transportation and Assignment problems.

Unit 3: Unimodel function – one dimensional optimization: Fibonacci method – Golden Section Method – Quadratic and Cubic interpolation methods – Direct root method – Multidimensional unconstrained optimization: Univariate Method – Hooks and Jeeves method – Fletcher – Reeves method - Newton's method.

Unit 4: Multi-dimensional constrained optimization: Lagranges multiplier method – Kuhn-Tucker conditions – Hessian Matrix Method – Wolfe's method – Beal's method.

Unit 5: Geometric programming polynomials – Arithmetic Geometric inequality method – Separable programming – Dynamic Programming: Dynamic programming algorithm – solution of LPP by Dynamic Programming.

Text Books:

1. H. A. Taha, **Operations Research – An Introduction**, 8th Edition, Prentice – Hall of India, New Delhi, 2006.
   Unit 1: 3.3, 4.4, 7.1, 7.2
   Unit 2: Chapter 5 and Section 9.2
2. S. S. Rao, **Engineering Optimization**, 3rd Edition, New Age International Pvt. Ltd., Publishers, Delhi, 1998.
   Unit 3: Chapter 5 (Sections 5.1 – 5.12), Chapter 6 (Sections 6.4, 6.6, 6.12.2, 6.13)
   Unit 4: Chapter 2 (Sections 2.4, 2.5)
   Unit 5: Chapters 8 & 9.

References:

1. J. K. Sharma, **Operations Research Theory & Applications**, Macmillan India Ltd., New Delhi, 2006.
2. Kanti Swarup, Gupta P. K. & Man Mohan, **Operations Research**, S. Chand & Sons, New Delhi, 1995.
3. G. Srinivasan, **Operations Research: Principles & Applications**, Prentice Hall of India, New Delhi, India, 2007.

Major Elective	Semester - III

15MATP03E2 CONTROL THEORY Credits: 4

Objective: To introduce basic theories and methodologies required for analyzing and designing advanced control systems.

Specific outcome of learning:

- The learner will acquire skills to solve observability problems of linear and nonlinear systems
- Proficient in solving linear and nonlinear control systems
- Proficient in stability analysis of linear and nonlinear systems
- Proficient in stabilization of control systems
- Proficient in optimal control problems

Unit 1: Observability: Linear systems – Observability Grammian – Constant coefficient systems – Reconstruction kernel – Nonlinear Systems

Unit 2: Controllability: Linear systems – Controllability Grammian – Adjoint systems – Constant coefficient systems – Steering function – Nonlinear systems

Unit 3: Stability: Stability – Uniform stability – Asymptotic stability of linear Systems - Linear time varying systems – Perturbed linear systems – Nonlinear systems

Unit 4: Stabilizability: Stabilization via linear feedback control – Bass method – Controllable subspace –Stabilization with restricted feedback

Unit 5: Optimal Control: Linear time varying systems with quadratic performance criteria – Matrix Riccati equation – Linear time invariant systems – Nonlinear Systems

Text Book:

1. K. Balachandran & J. P. Dauer, **Elements of Control Theory,** Narosa, New Delhi, 1999.

References:

1. Linear Differential Equations and Control by R.Conti, Academic Press, London, 1976.
2. Functional Analysis and Modern Applied Mathematics by R.F.Curtain and A.J.Pritchard, Academic Press, New York, 1977.
3. Controllability of Dynamical Systems by J.Klamka, Kluwer Academic Publisher, Dordrecht, 1991.

Major Elective Semester – III

15MATP03E3 COMMUTATIVE ALGEBRA Credits: 4

Objective: To introduce the advanced concepts of commutative algebra.

Specific outcome of learning: The learner will
- acquire knowledge about special algebraic structures and their properties.
- be proficient in the theory of Modules.
- understand the methods of decomposition of rings.
- be able to formulate the special types of rings and their properties.
- be able to solve problem related to commutative algebra.

Unit 1: Rings and ring homomorphism's – ideals – Extension and Contraction, modules and module homomorphism – exact sequences.

Unit 2: Tensor product of modules – Tensor product of algebra – Local properties – extended and contracted ideals in rings of fractions.

Unit 3: Primary Decomposition – Integral dependence – The going-up theorem – The going down theorem – Valuation rings.

Unit 4: Chain conditions – Primary decomposition in Noetherian rings.

Unit 5: Artin rings – Discrete valuation rings – Dedekind domains – Fractional ideals.

Text Book:
1. Atiyah, M., MacDonald, I.G., **Introduction to Commutative Algebra**, Addison-Wesley, Massachusetts 1969.
   Unit 1 : Chapter 1, Chapter 2 (up to page 23)
   Unit 2 : Chapter 2 (pages 24 – 31), Chapter 3.
   Unit 3 : Chapters 4, 5.
   Unit 4 : Chapters 6, 7.
   Unit 5 : Chapters 8, 9.

References:

1. H.Matsumura, **Commutative ring theory**, Cambridge University Press, 1986.
2. N.S. Gopalakrishnan, **Commutative Algebra**, Oxonian Press Pvt. Ltd, New Delhi, 1988.
3. R.Y.Sharp, **Steps in Commutative Algebra,** Cambridge University Press, 1990.

Major Elective Semester -III

15MATP03E4 **CODING THEORY** Credits: 4

Objective: To introduce the elements of coding theory and its applications.

Specific outcome of learning: The learner will be able to

- recognize the basic concepts of coding theory.
- understand the importance of finite fields in the design of codes.
- detect and correct the errors occur in communication channels with the help of methods of coding theory.
- apply the tools of linear algebra to construct special type of codes.
- use algebraic techniques in designing efficient and reliable data transmission methods.

Unit 1: Error detection, Correction and decoding: Communication channels – Maximum likelihood decoding – Hamming distance – Nearest neighbourhood minimum distance decoding – Distance of a code.

Unit 2: Linear codes: Linear codes – Self orthogonal codes – Self dual codes – Bases for linear codes – Generator matrix and parity check matrix – Enconding with a linear code – Decoding of linear codes – Syndrome decoding.

Unit 3: Bounds in coding theory: The main coding theory problem – lower bounds - Sphere covering bound – Gilbert Varshamov bound – Binary Hamming codes – q-ary Hamming codes – Golay codes – Singleton bound and MDS codes – Plotkin bound.

Unit 4: Cyclic codes: Definitions – Generator polynomials – Generator matrix and parity check matrix – Decoding of Cyclic codes.

Unit 5: Special cyclic codes: BCH codes – Parameters of BCH codes – Decoding of BCH codes – Reed Solomon codes.

Text Book:

1. San Ling and Chaoping Xing , **Coding Theory: A first course**, Cambridge University Press, 2004.

   Unit 1 : Sections 2.1, 2.2, 2.3, 2.4, 2.5

   Unit 2 : Sections 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8

   Unit 3 : Sections 5.1, 5.2, 5.3, 5.4, 5.5,

   Unit 4 : Sections 7.1, 7.2, 7.3, 7.4

   Unit 5 : Sections 8.1, 8.2

References:

1. S. Lin &D. J. Costello, Jr., **Error Control Coding: Fundamentals and Applications**, Prentice-Hall, Inc., New Jersey, 1983.
2. Vera Pless, **Introduction to the Theory of Error Correcting Codes**, Wiley, New York, 1982.
3. E. R Berlekamp, **Algebriac Coding Theory**, Mc Graw-Hill, 1968.
4. H. Hill, **A First Course in Coding Theory**, OUP, 1986.

Major Elective	Semester - III

15MATP03E5 **FRACTAL ANALYSIS** **Credits: 4**

Objective: To introduce the basic mathematical techniques of fractal geometry for diverse applications.

Specific learning outcome The learner will able to

- understand the basic concepts of fractals and measure
- recognize the space of fractals and fractal dimension
- find the Hausdorff, box-counting and other dimensions
- understand the self-similar sets properties of fractals
- recognize the concepts fractal interpolation

Unit 1: Fractals and Measures: Introduction to Fractals – History of Fractals – Fractal Examples: The Triadic Cantor Set – The Sierpinski Gasket – A space of Strings – The Koch Curve – Heighway's Dragon – Measures and Mass Distributions: Examples of Measures – Notes on Probability Theory – Topological Dimension.

Unit 2: The Space of Fractals and Fractal Dimension : The Contraction Mapping Theorem – The Hausdorff Metric – The Metric Space (H(X), *h*): The Place Where Fractals Live – Iterated Functions Systems – Contraction Mappings on the Space of Fractals – Fractal Dimension – The Box-Counting Theorem – The Theoretical Determination of the Fractal Dimension – The Experimental Determination of the Fractal Dimension.

Unit 3: Hausdorff, Box-Counting and Other Dimensions : Hausdorff Measure – Hausdorff Dimension – Calculation of Hausdorff Dimension-Simple Examples – Equivalent Definition of Hausdorff Dimension – Finer Definitions of Dimension – Box-Counting Dimensions – Properties and Problems of Box-Counting Dimension – Modified Box-Counting Dimensions – Packing Measures and Dimensions – Some Other Definitions of

Dimension – Techniques for Calculating Dimensions: Basic Methods – Subsets of Finite Measure – Potential Theoretic Methods – Fourier Transform Methods.

Unit 4: Self-Similar Sets, Similarity Dimensions and Divider Dimensions: Ratio Lists – Iterated Function Schemes – Dimension of Self-Similar Sets – Some Variations – Self-affine Sets – Applications to Encoding Images – Determination of Similarity Dimensions: The Cantor Set – The Koch Curve – The Quadratic Koch Curve – The Koch Island – The Sierpinski Gasket and Carpet – The Menger Sponge – The Structured Walk Technique and the Divider Dimension.

Unit 5: Fractal Interpolation Functions and Graphs of Functions : Interpolation Functions – Fractal Interpolation Functions – The Fractal Dimension of Fractal Interpolation Functions – Collage Theorem for IFS – Dimensions of Graphs – The Weierstrass Function – Self-affine Curves – Autocorrelation of Fractal Functions.

Text Books:

1. Kenneth J. Falconer, **Fractal Geometry: Mathematical Foundations and Applications**, John Wiley and Sons, 2003.
2. Michael F. Barnsley, **Fractals Everywhere**, Academic Press Professional, 1988.

References:

1. G. A. Edgar, **Measure, Topology and Fractal Geometry**, Springer – New York, 2008.
2. Kenneth J. Falconer, **The Geometry of Fractals Sets**, Cambridge University Press, Cambridge, 1985.
3. Paul S. Addison, **Fractals and Chaos: An Illustrated Course**, Overseas Press, 2005.