M.Sc. MATHEMATICS

SYLLABUS UNDER CHOICE BASED CREDIT SYSTEM

(with effect from 2018-2019)

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	18MATP0101	Algebra	4	4	3	40	60	100
	18MATP0102	Real Analysis	4	4	3	40	60	100
	18MATP0103	Numerical Analysis	4	4	3	40	60	100
	18MATP0104	Differential Equations	4	4	3	40	60	100
	18MATP0105	Discrete Mathematics	4	4	3	40	60	100
Value added course	18GTPP0001	Gandhi in Everyday Life	2	2	--	50	--	50
		TOTAL	22					
	Semester – II							
Core Course	18MATP0206	Linear Algebra	4	4	3	40	60	100
	18MATP0207	Advanced Real Analysis	4	4	3	40	60	100
	18MATP0208	Mathematical Methods	4	4	3	40	60	100
	18MATP0209	Probability and Statistics	4	4	3	40	60	100
Electives		Non Major Elective	4	4	3	40	60	100
Value added course	18ENGP00C1	Communication and Soft Skills	2	2	--	50	--	50
		TOTAL	22					
	Semester – III							
Core Course	18MATP0310	Topology	4	4	3	40	60	100
	18MATP0311	Measure Theory	4	4	3	40	60	100
	18MATP0312	Stochastic Processes	4	4	3	40	60	100
Electives	18MATP03EX	Major Elective	4	4	3	40	60	100

Modular Course	18MATP03MX	Modular Course	2	2	--	50	--	50
Compulsory Non Credit Course	18MATP03F1	Extension/ Field Visit	--	2	--	50	--	50
Extension	18EXNP03V1	Village Placement Programme	2	--	--	50	--	50
		TOTAL	**20**					
	Semester – IV							
Core Course	18MATP0413	Complex Analysis	4	4	3	40	60	100
	18MATP0414	Functional Analysis	4	4	3	40	60	100
	18MATP0415	Classical Mechanics	4	4	3	40	60	100
Electives	18MATP04EX	Major Elective	4	4	3	40	60	100
	18MATP0416	Dissertation	6	12	--	75	75+50	200
Modular Course	18MATP04MX	Modular Course	2	2	--	50	--	50
Compulsory Non Credit Course	18MATP04F2	Extension/Field Visit	--	2	--	50	--	50
		TOTAL	**24**					
		GRAND TOTAL	**88**					

MAJOR ELECTIVES: (18MATP03EX)

Semester – III

1.18MATP03E1 Optimization Techniques
2.18MATP03E2 Control Theory
3.18MATP03E3 Optimal Control
4.18MATP03E4 Statistical Inference (Online)

Semester - IV

1. 18MATP04E5 Graph Theory
2. 18MATP04E6 Fractal Analysis
3. 18MATP04E7 Coding Theory
4. 18MATP04E8 Regression Analysis (Online)

MODULAR COURSES :
(18MATP03MX/18MATP04MX)

Semester – III

1. 18MATP03M1 Matlab & Latex
2. 18MATP03M2 Wavelet Analysis

Semester – IV

1. 18MATP04M3 Fuzzy Sets and Fuzzy Logic
2. 18MATP04M4 Neural Networks

ABSTRACT	
Course type	**Total number of Courses**
Core Course	16
Major Elective Course	02
Non-Major Elective Course	01
Modular Course	02
Compulsory Non Credit Course	02
Value added course	02
Extension	01

Core Course	Semester I	
18MATP0101	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.

(14 hours)

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

(12 hours)

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

(13 hours)

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

(12 hours)

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

(13 hours)

Text Book:

1. N. Herstein, **Topics in Algebra**, 2nd 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.

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc18_ma15
2. https://onlinecourses.nptel.ac.in/noc18_ma16

LECTURE SCHEDULE

Unit	Topics	No. hours
1	A counting principle	1
	Normal subgroups and quotient groups	3
	Homomorphisms	2
	Automorphisms	2
	Cayley's theorem	3
	Permutation groups	3
		Total 14
2	Another counting principle	2
	Sylow's theorems	4
	Direct product	3
	Finite abelian groups	3
		Total 12
3	Euclidean rings	3
	A particular Euclidean ring	2
	Polynomial rings	2
	Polynomials over the rational field	3
	Polynomial rings over commutative rings	3
		Total 13
4	Extension fields	4
	Roots of polynomials	3
	More about roots	1
	Finite fields	4
		Total 12
5	The elements of Galois theory	5
	Solvability by radicals	4
	Galois group over the rationals	4
		Total 13
		Grand Total 64

Core Course	Semester - I	
18MATP0102	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.

(13 hours)

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

(13 hours)

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 – Power series - Summation by parts - Absolute convergence - Addition and multiplication of series - Rearrangements.

(16 hours)

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

(11 hours)

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.

(11 hours)

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.

Web Resources:

1. http://nptel.ac.in/courses/109104124/
2. http://nptel.ac.in/courses/111101100/

LECTURE SCHEDULE

Unit	Topics	No. of Hours
1	The real and complex number systems: Introduction	1
	Ordered sets	2
	Fields - The real field	4
	The extended real number system - The complex field	3
	Euclidean spaces.	3
	Total	13
2	Finite - Countable and Uncountable sets	3
	Metric spaces.	3
	Compact sets	2
	Perfect sets	2
	Connected sets	3
	Total	13
3	Convergent sequences – Subsequences - Cauchy sequences	3
	Upper and lower limits	2
	Some special sequences	2
	Series - The number e - The root and ratio tests	3
	Power series - Summation by parts - Absolute convergence	3
	Addition and multiplication of series - Rearrangements.	3
	Total	16
4	Limits of functions - Continuous functions	3
	Continuity and compactness	2
	Continuity and connectedness	2
	Monotonic functions	2
	Infinite limits and limits at infinity.	2
	Total	11

5	The derivative of a real function	2
	Mean value theorems - The continuity of derivatives	2
	L'Hospital's rule - Derivatives of Higher order	3
	Taylor's theorem	2
	Differentiation of vector valued functions.	2
	Total	11
	Grand Total	64

Core Course **Semester – I**

18MATP0103 **NUMERICAL ANALYSIS** **Credits: 4**

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

Specific outcome of learning: The learner will be able to

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

Unit 1: Solving a system of simultaneous equations: Elimination method - The Gaussian elimination and Gauss -Jordan method - Iterative methods - Gauss Jacobi iteration- Gauss Seidel iteration- Relaxation method.

(13 hours)

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

(13 hours)

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 1/3rd rule - 3/8 rule - Weddles's rule - Errors in quadrature formula.

(13 hours)

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.

(13 hours)

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.

(12 hours)

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, 2.11
   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, 2000
   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.

Web Resources:

1. http://nptel.ac.in/courses/111107105/

LECTURE SCHEDULE

Unit	Topics	No. of Hours
1	Solving a system of simultaneous equations: Elimination method	1
	The Gaussian elimination	3
	Gauss -Jordan method	3
	Iterative methods - Gauss Jacobi iteration- Gauss Seidel iteration	4
	Relaxation method.	2
	Total	13
2	Interpolation and curve fitting: Lagrangian polynomials	3
	Divided differences	3
	Interpolation with cubic spline	2
	Least square approximation of functions.	2
	Total	13

3	Numerical differentiation and integration: Numerical differentiation- derivatives using Newton's forward and backward formula	3
	Derivatives using Striling's formula	2
	Trapezoidal rule	2
	Simpson's 1/3rd rule - 3/8 rule	2
	Weddles's rule	2
	Errors in quadrature formula.	2
	Total	13
4	Numerical solution of ordinary differential equations: The Taylor series method	3
	Picard's method	2
	Euler and modified Euler methods	2
	Runge - Kutta methods	4
	Milne's method - The Adams - Moulton method.	2
	Total	13
5	Numerical Solution of Partial Differential Equations: Introduction - Difference quotients	2
	Geometrical representation of partial differential quotients -	2
	Classification of partial differential equations - Elliptic equations .	2
	Solutions to Laplace's equation by Liebmann's iteration process	2
	Poisson's equations and its solutions	2
	Parabolic equations – Crank - Nicholson method - Hyperbolic equations	2
	Total	12
	Grand Total	64

Core Course	**Semester – I**	
18MATP0104	**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. (13 hours)

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

(12 hours)

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

(13 hours)

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.

(13 hours)

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.

(13 hours)

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

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc18_ma10

LECTURE SCHEDULE

Unit	Topics	No. of Hours
1	Systems of linear differential equations: Introduction - Systems of first order equations	2
	Existence and uniqueness theorem	2
	Fundamental matrix – Non - homogeneous linear systems	3
	Linear systems with constant coefficients	3
	Linear systems with periodic coefficients	3
	Total	13
2	Existence and uniqueness of solutions: Introduction - Successive approximations	3
	Picard's theorem	3
	Continuation and dependence of initial conditions	3
	Fixed point method.	3
	Total	12
3	Boundary value problem: Introduction - Strum Liouville problem	3
	Green's function	3
	Applications of boundary value problems	4
	Picard's theorem.	3
	Total	13
4	First order partial differential equations: Linear equations of the first order	2
	Pfafian differential equations	3
	Compatible systems – Charpit's method	3
	Jacobi's method	2
	Integral surface through a given circle.	3
	Total	13
5	Genesis of second order PDE: Classifications of second order PDE	2
	One dimensional wave equation – Vibrations of an infinite string - Vibrations of semi - infinite string	4

	Vibrations of a string of finite length (method of separation of variables)	3
	Heat conduction problem – Heat conduction of infinite rod case -	2
	Heat conduction of finite rod case.	2
	Total	13
	Grand Total	64

Core Course **Semester - I**
18MATP0105 **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.

(14 hours)

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.

(13 hours)

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.

(13 hours)

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 pseudoprimes - Wilson's theorem - The Fermat-Kraitchik factorization method.

(12 hours)

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.

(13 hours)

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. N. Robbins, **Beginning Number Theory**, 2nd Edition, Narosa Publishing House, New Delhi, 2007.

Web Resources:

1. https://www.tutorialspoint.com/discrete_mathematics/
2. home.iitk.ac.in/~arlal/book/mth202.pdf

LECTURE SCHEDULE

Unit	Topics	No. hours
1	counting principles – permutations, combinations of sets	4
	Pigeonhole principle	4
	The binomial theorem	3
	The multinomial theorem	3
		Total 14
2	The inclusion – exclusion principle	4
	Some number sequences	3
	Generating functions	3
	recurrence relations	3
		Total 13
3	Divisibility theory in the integers	4
	Primes and their distributions	3
	The Goldbach conjecture	3
	Related problems	3
		Total 13
4	The theory of congruence	3
	Linear congruence	4
	Fermat's Theorem	2
	factorization method	3
		Total 12
5	Number theoretic functions	3
	Euler's generalization of Fermat's theorem	3
	Primitive roots	4
	Related problems	2
		Total 12
		Grand Total 64

Core Course	**Semester – II**	
18MATP0206	**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 matrix form.
- decompose a given vector space into 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.

(14 hours)

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

(13 hours)

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

(13 hours)

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

(12 hours)

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

(12 hours)

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.

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc18_ma16

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Elementary basic concepts of vector spaces	4
	Linear independence and bases	4
	Dual spaces	6
		Total 14
2	The algebra of linear transformations	5
	Characteristic roots	4
	Matrices	4
		Total 13
3	Triangular forms	5
	Nilpotent transformations	5
	Jordan form	3
		Total 13
4	Inner product spaces	3
	Orthogonality	2
	Orthogonalization	2
	Orthogonal Complement	2
	Trace and Transpose	3
		Total 12
5	Hermitian Transformations	3
	Unitary and Normal Transformations	4
	Basic properties of quadratic forms	3
	Diagonalization of quadratic forms	2
		Total 12
		Grand Total 64

Core Course **Semester - II**
18MATP0207 **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.

(13 hours)

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.

(12 hours)

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. (13 hours)

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

(13 hours)

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

(13 hours)

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**, Wiley Eastern Ltd., New Delhi, 1985.
4. N. L. Carothers, **Real Analysis**, Cambridge University Press, UK, 2000.

Web Resources:

1. http://nptel.ac.in/courses/109104124/
2. https://onlinecourses.nptel.ac.in/noc18_ma10

LECTURE SCHEDULE

Unit	Topics	No. of Hours
1	Definition and existence of the integral	2
	Properties of the integral	3
	Integration and differentiation	3
	Integration of vector valued functions	3
	Rectifiable curves.	2
	Total	13
2	Discussion of Main problem	1
	Uniform convergence and continuity	2
	Uniform convergence and Integration - Uniform convergence and differentiation	4
	Equicontinuous families of functions	3
	The Stone-Weierstrass theorem.	2
	Total	12
3	Power series	1
	The exponential and Logarithmic functions - The trigonometric functions	4
	The algebraic completeness of the complex field	2
	Fourier Series	3
	The Gamma functions.	3
	Total	13
4	Linear transformations	4
	Differentiation	4
	The contraction principle	2
	The inverse function theorem.	3
	Total	13
5	The implicit function theorem	3
	The rank theorem	3
	Determinants	3
	Derivatives of higher order	2
	Differentiation of integrals.	2
	Total	13
	Grand Total	64

Core Course	Semester - II	
18MATP0208	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.

(13 hours)

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.

(12 hours)

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.

(12 hours)

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.

(14 hours)

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.

(13 hours)

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.

Web Sources:

1. http://nptel.ac.in/courses/111107103/
2. https://onlinecourses.nptel.ac.in/noc18_ma12

LECTURE SCHEDULE

Unit	Topics	No. of Hours
1	Integral equations: Types of integral equations - conversion of ordinary differential equation into integral equation.	2
	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.	3
	Solution of Homogeneous Fredholm integral equation of the second kind with separable kernels.	3
	Problems - Characteristic values and functions.	3
	Solutions of Fredholm integral equation of the second kind with separable kernels – Problems.	2
	Total	13
2	Method of successive approximations : Introduction - Iterated kernels or functions - Resolvent (or reciprocal) kernel.	2
	Solution of Fredholm integral equation of the second kind	2

	by successive substitutions.	
	Solution of Volterra integral equation of the second kind by successive approximations.	3
	Reciprocal functions Neumann series -Solutions of Volterra integral equation of the second kind when its kernel is of some particular form.	3
	Solution of Volterra equation of the second kind by reducing to differential equation.	2
	Total	12
3	Classical Fredholm theory – Introduction - Fredholm's first fundamental theorem	3
	Problems based on Fredholm's first fundamental theorem	3
	Fredholm's second fundamental theorem	3
	Fredholm's third fundamental theorem – Including proof.	3
	Total	12
4	Singular integral equations - The solution of Abel's integral equation	3
	Some general form of Abel's singular integral equation – Problem	3
	Applications of integral equation and Green's functions to ordinary differential equation – Green's function	3
	Conversion of a boundary value problem into Fredholm's integral equation	2
	Some special cases - Examples based on construction of Green's functions and problems.	3
	Total	14
5	Fourier Transforms - Definition- Inversion theorem	3
	Fourier sine and cosine transform	3
	Fourier transforms of derivatives	3
	Convolution theorem - Parsevel's relation for Fourier transform and problems on self-reciprocal.	4
	Total	13
	Grand Total	64

Core Course	Semester – II	
18MATP0209	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.

(13 hours)

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.

(14 hours)

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

(12 hours)

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.

(13 hours)

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.

(12 hours)

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

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc18_ma19
2. https://onlinecourses.nptel.ac.in/noc18_ma22

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Introduction to probability and distributions, The probability set function.	4
	Conditional probability and independence.	4
	Random variables of the discrete type - Random variables of the continuous type.	3
	Properties of the distribution function.	2
		Total 13
2	Expectation of a random variable, Some special expectations and Chebyshev's inequality.	4
	Some Special Distributions: The Binomial and related distributions, Poisson distribution and Uniform distribution.	3
	The Gamma and Chi-Square distributions, normal distribution, bivariate normal distribution.	4
	The beta distribution, Student's t- distribution and F-distribution.	3
		Total 14

3	Limiting Distributions: Convergence in distribution.	3
	Convergence in probability.	3
	Limiting moment generating function.	3
	The central limit theorem and related problems.	3
		Total 12
4	Estimation Theory: Introduction, Unbiased estimators, Efficiency, Consistency, Sufficiency and Robustness.	4
	The method of moments, the method of maximum likelihood and Bayesian estimation.	4
	Sufficient Statistics: Measure of quality of estimators.	3
	A sufficient statistic for a parameter and properties of a sufficient statistics.	2
		Total 13
5	Analysis of Variance: Introduction.	3
	One-way analysis of variance and Experimental design.	3
	Two-way analysis of variance without interaction.	3
	Two-way analysis of variance with interaction and related problems.	3
		Total 12
		Grand Total 64

Core Course **Semester – III**
18MATP0310 **TOPOLOGY** **Credits: 4**

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

Specific outcome of learning: The learner will be able to

- acquire knowledge about several constructions of topological spaces
- understand various properties of topological spaces
- recognize the properties of continuous functions on topological spaces
- understand connected, compact and normal topological spaces and their properties

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.

(14 hours)

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

(13 hours)

Unit 3: Connected spaces - Connected subspaces of the real line - Compact spaces - Compact subspaces of the real line.

(13 hours)

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

(10 hours)

Unit 5: Normal spaces - The Urysohn's lemma - The Urysohn's metrization theorem –Tietz extension theorem - The Tychonoff theorem.

(14 hours)

Text Book:

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, 3.2, 3.4, 3.5
Unit 4: Chapter 4: Sections 3.6, 4.1-4.2
Unit 5: Chapters 4: Sections 4.3, 4.4, 4.5, 4.6, Chapter 5: 5.1.

References:

1. G. F. Simmons, **Introduction to Topology and Modern Analysis**, Tata McGraw-Hill Education Pvt. Ltd., New Delhi, 2016.
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.

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Topological spaces	3
	Basis for a topology	3
	The order topology	2
	The product topology on X × Y	2
	The subspace topology	2
	Closed sets and limit	2
		Total 14

2	Continuous functions	5
	The product topology	4
	The metric topology	4
		Total 13
3	Connected spaces	3
	Connected subspaces of the real line	3
	Compact spaces	3
	Compact subspaces of the real line	4
		Total 13
4	Limit point compactness	3
	The countability axioms	4
	The separation axioms	3
		Total 10
5	Normal spaces	3
	The Urysohn's lemma	2
	The Urysohn's metrization theorem	3
	The Tietz extension theorem	3
	The Tychonoff theorem	3
		Total 14
		Grand Total 64

Core Course	Semester – III	
18MATP0311	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.

(12 hours)

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

(13 hours)

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.

(14 hours)

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 $L^p(\mu)$.

(13 hours)

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.

(12 hours)

Text Book:

1. G.de Barra, **Measure Theory and Integration,** Ist 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, 8.3,8.4

References:

1. H. L. Royden, **Real analysis**, 3rd 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.

Web Resources:

1. http://nptel.ac.in/courses/111101100/

LECTURE SCHEDULE

Unit	Topics	No. of Hours
1	Lebesgue outer measure	3
	Measurable sets	3
	Regularity - Measurable functions	3
	Borel and Lebesgue measurability.	3
	Total	12

2	Integration of non-negative functions	3
	The general integral	3
	Integration of series	3
	Riemann and Lebesgue integrals.	4
	Total	13
3	Measures and outer measures	3
	Extension of a measure -Uniqueness of the extension	4
	Completion of a measure	3
	Measure spaces	2
	Integration with respect to a measure.	2
	Total	14
4	The L^p Spaces	2
	Convex functions	3
	Jensen's inequality	2
	The inequalities of Holder and Minkowski	3
	Completeness of $L^p(\mu)$.	3
	Total	13
5	Signed measures and the decomposition	3
	The Jordan decomposition	3
	The Radon-Nikodym theorem	3
	Some applications of the Radon-Nikodym theorem	3
	Total	12
	Grand Total	64

Core Course — **Semester – III**
18MATP0312 — **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 queueing systems

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

(13 hours)

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.

(13 hours)

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.

(13 hours)

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.

(13 hours)

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

(12 hours)

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.

Web Resources:

1) https://nptel.ac.in/courses/111102014/
2) https://nptel.ac.in/courses/111103022/
3) https://onlinecourses.nptel.ac.in/noc18_ma19

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Definition of stochastic processes	3
	Markov chains and order of a Markov chain	4
	Higher transition probabilities	3
	Classification of states and chains.	3
		Total 13
2	Markov Process with discrete state space and Poisson process and related distributions	4
	Properties of Poisson process and Generalizations of Poisson processes	3
	Birth and death processes	3
	Continuous time Markov chains	3
		Total 13
3	Markov processes with continuous state space	4
	Weiner process and differential equations for it	3
	Kolmogrov equations and First passage time distribution for Weiner process	3
	Ornstein – Uhlenbech process	3
		Total 13
4	Branching Processes Properties of generating functions of Branching processes	4
	Distribution of the total number of progeny	3
	Continuous - Time Markov branching process	3
	Age dependent branching process Bellman-Harris process	3
		Total 13
5	Stochastic Processes in Queueing Systems	4
	Birth and death process in Queueing theory	4
	Non birth and death Queueing process	4
		Total 12
		Grand Total 64

Core Course	Semester – IV	
18MATP0413	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.

(14 hours)

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

(13 hours)

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

(13 hours)

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

(12 hours)

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

(12 hours)

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.

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Analytic Functions	4
	Harmonic functions	3
	Bilinear transformations	4
	Related problems	3
		Total 14
2	Power Series	3
	Maclaurin and Taylor Series	4
	Conformal mappings	3
	Related problems	3
		Total 13
3	Complex integration	4
	Curves- Parameterizations	3
	Line integral	3
	Related problems	3
		Total 13
4	Cauchy's integral formula	3
	Cauchy's inequality and applications	3
	Maximum modulus theorem	3
	Related problems	3
		Total 12
5	Laurent Series	3
	Classification of singularities	3

	Evaluation of real integrals	3
	Argument principle	3
		Total 12
		Grand Total 64

Core Course — **Semester – IV**

18MATP0414 — **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.

(14 hours)

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.

(13 hours)

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.

(13 hours)

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

(12 hours)

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.

(12 hours)

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.

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Norm on a linear space	4
	Quotient spaces	3
	Semi – inner product and sesquilinear form	3
	Banach spaces	4
		Total 14
2	Incomplete normed linear spaces	4
	Schauder basis and separability	3
	Heine-Borel theorem	3
	Best approximation theorems - Projection theorem.	3
		Total 13
3	Operators on normed linear spaces	4
	The space B(X,Y)	3
	Bessel's inequality	3
	Riesz-Fischer theorem	3
		Total 13
4	Hahn-Banach theorem	3
	The extension theorem	4

	Consequences on uniqueness of extension	2
	Separation theorem	3
		Total 12
5	Uniform boundedness principle	3
	Closed graph theorem	3
	Bounded inverse theorem	4
	Open mapping theorem	2
		Total 12
		Grand Total 64

Core Course **Semester - IV**
18MATP0415 **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.

(13 hours)

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

(13 hours)

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

(13 hours)

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

(13 hours)

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

(12 hours)

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.

Web Resources:

1. http://nptel.ac.in/courses/111107103/

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Introductory Concepts The mechanical system	4
	Generalized coordinates	3
	Constraints and Virtual work	3
	Energy and momentum	3
		Total 13
2	Lagrange's equations	3
	Derivation of Lagrange's equations	4
	Examples	3
	Integrals of the motion	3
		Total 13
3	Hamilton's principle	5
	Hamilton's equations	4
	Variational principles	4
		Total 13
4	Hamilton's principal function	4
	The Hamilton - Jacobi equation	5
	Separability	4
		Total 13

5	Canonical Transformations	3
	Differential forms and generating functions	3
	Special transformations	3
	Lagrange and Poisson brackets	3
		Total 12
		Grand Total 64

Core Course **Semester IV**
18MATP0416 **Dissertation** **Credits: 4**

Major Elective **Semester - III**
18MATP03E1 **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.

(14 hours)

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

(14 hours)

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.

(12 hours)

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

(12 hours)

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

(12 hours)

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.
3. Kanti Swarup, Gupta P. K. & Man Mohan, **Operations Research**, S. Chand & Sons, New Delhi, 1995.
   Unit 4: Chapter 28 (Sections 28.3, 28.5, 28.6)
   Unit 5: Chapter 28 (Sections 28.7, 28.8)

References:

1. J. K. Sharma, **Operations Research Theory & Applications**, Macmillan India Ltd., New Delhi, 2006.
2. G. Srinivasan, **Operations Research: Principles & Applications,** Prentice Hall of India, New Delhi, India, 2007.

Web Resources:

1. http://nptel.ac.in/courses/111107104/

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Convex set and convex function	3
	Simplex method	3
	Revised simplex method	3
	Duality concept, Dual simplex method	5
		Total 14
2	Branch – and Bound method	4
	Cutting plane method	3
	Zero – one integer problem	3
	Transportation problem, Assignment problem	4
		Total 14
3	Unimodel function, Fibonacci method	3
	Golden section and Quadratic interpolation methods	3
	Cubic interpolation, Direct root, Univariate methods	3
	Hooks and Jeeves, Fletcher – Reeves and Newton's methods	3
		Total 12
4	Lagranges multiplier method	2
	Kuhn-Tucker condition	2
	Hessian matrix method	2
	Wolfe's and Beal's method	6
		Total 12
5	Geometric programming polynomials	2
	Arithmetic Geometric inequality method	2
	Separable programming and Dynamic programming algorithm	5
	Solution of LPP by Dynamic Programming	3
		Total 12
		Grand Total 64

Major Elective | **Semester - III**
18MATP03E2 | **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

(14 hours)

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

(14 hours)

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

(12 hours)

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

(12 hours)

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

(12 hours)

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.

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Observability Linear systems	4
	Observability Grammian	3
	Constant coefficient systems and Reconstruction kernel	4
	Nonlinear Systems	3
		Total 14
2	Controllability Linear systems	3
	Controllability Grammian and Adjoint systems	4
	Constant coefficient systems and Steering function	3
	Nonlinear systems	4
		Total 14
3	Stability and Uniform stability	3
	Asymptotic stability of linear Systems	3
	Linear time varying systems	3
	Perturbed linear systems Nonlinear systems	3
		Total 12
4	Stabilization via linear feedback control	3
	Bass method	3
	Controllable subspace	3
	Stabilization with restricted feedback	3
		Total 12
5	Optimal control Linear time varying systems with quadratic performance criteria	3
	Matrix Riccati equation	3
	Linear time invariant systems	3
	Nonlinear Systems	3
		Total 12
		Grand Total 64

Major Elective	**Semester - III**	
18MATP0 3E3	**OPTIMAL CONTROL**	**Credits: 4**

Objective: To introduce basic theories and methodologies required for analyzing and designing optimal control of dynamical systems.

Specific outcome of learning:

- The learner will acquire skills to solve system via Euler – Lagrange equation
- Proficient in solving linear and nonlinear optimal control systems through calculus of variations
- Proficient in Linear Quadratic Optimal Control Systems
- Proficient in Pontryagin Minimum principle for solving optimal control systems
- Proficient in constrained optimal control problems

UNIT-I (Basic concepts)

Basic Concepts-Optimal of a function and functional-The Basic variational problems: Fixed –End time fixed-end state system, Euler-Lagrange equation, Different cases for Euler –Lagrange equation- Extrema of functions with conditions: Direct Method-Lagrange Multiplier Method.

(14 hours)

UNIT –II (Optimal control through Calculus of Variations)

Extrema of Functional with conditions-Variational approach to optimal control systems: Terminal Cost Problem-Different Types of Systems- Sufficient Condition- Summary of variational approach.

(14 hours)

UNIT-III (Linear Quadratic Optimal Control System)

Problem Formulation - Finite –Time Linear Quadratic Regulator-Analytic Solution to the Matrix Differential Riccatic Equation-Infinite- Time LQR System.

(12 hours)

UNIT-IV (Pontryagin Minimum Principle)

Constrained System- Pontryagin Minimum Principle- Necessary Conditions- Dynamic Programming: Principle of Optimality –Optimal control Using Dynamic Programming-Optimal Control of Continuous-Time Systems- The Hamilton – Jacobi- Bellman Equation- LQR System Using H-J-B Equation.

(12 hours)

UNIT-V (Constrained optimal control system)

Constrained Optimal Control-TOC of a Double Integral System- Fuel-Optimal Control Systems.

(12 hours)

Text Book:

1. D. S. Naidu: **Optimal Control Systems**, CRC Press, 2002.

    Unit-I: Chapter 2: Section: 2.1-2.3, 2.5
    Unit-II: Chapter 2: Sections: 2.6-2.8
    Unit-III: Chapter 3: Sections: 3.1-3.4
    Unit-IV: Chapter 6: Sections: 6.1-6.4 (except 6.3.3)
    Unit-V: Chapter 7: Sections: 7.1-7.3

References:

1. F.L.Lewis, **Optimal Control**, John Wiley & Sons, Inc., New York, NY, 1986
2. M.Gopal, **Modern Control System Theory**, 2nd Edition, New Age International, 1984.
3. E. B. Lee and L. Markus, Foundations of Optimal Control Theory, Robert E. Krteger Publishing Company, Florida, 1968.
4. Web link: https://onlinecourses.nptel.ac.in/noc17_ee11/preview
http://nptel.ac.in/syllabus/101108057/

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Basic Concepts-Optimal of a function and functional	4
	The Basic variational problems: Fixed –End time fixed-end state system	3
	Euler-Lagrange equation, Different cases for Euler –Lagrange equation	4
	Extrema of functions with conditions: Direct Method-Lagrange Multiplier Method.	3
		Total 14
2	Extrema of Functional with conditions	3
	Variantional approach to optimal control systems: Terminal Cost Problem	4
	Different Types of Systems- Sufficient Condition	4
	Summary of variational approach.	3
		Total 14
3	Problem Formulation	3
	Finite –Time Linear Quadratic Regulator	3
	Analytic Solution to the Matrix Differential Riccatic Equation	3
	Infinite- Time LQR System	3
		Total 12
4	Constrained System - Pontryagin Minimum Principle-Necessary Conditions	3
	Dynamic Programming: Principle of Optimality	3
	Optimal control Using Dynamic Programming-Optimal Control of Continuous-Time Systems- The Hamilton –Jacobi- Bellman Equation	3
	LQR System Using H-J-B Equation	3
		Total 12

5	Constrained Optimal Control	4
	TOC of a Double Integral System	4
	Fuel-Optimal Control Systems.	4
		Total 12
		Grand Total 64

Major Elective — **Semester III**

18MATP03E4 — **STATISTICAL INFERENCE** — **Credits: 4**

ABOUT THE COURSE:

This course aims at giving the foundation knowledge of Probability and Statistical Inference. In particular, it gives details of theory of Estimation and testing of hypothesis. Both theoretical aspect will be discussed and practical problems will be dealt with in great detail. This course will help students and practitioners of statistics at both UG and PG level. This course will also serve as a foundation course for students working on Machine Learning.

COURSE LAYOUT:

Week 1 : Revision of Probability, Different Discrete and Continuous Distributions
Week 2 : Functions of Random Variables and their distributions, T, Chi-sq, F distributions and their Moments
Week 3 : Introduction of statistics and the distinction between Data and its properties, and probabilistic models
Week 4 : Estimator and methods of estimation, Properties of an estimator: Consistency, Unbiasedness, Efficiency and Sufficiency
Week 5 : Neyman Factorization, Cramer-Rao Bound
Week 6 : Confidence Intervals, Concepts of hypothesis testing, Characteristics of Good Hypothesis, null and Alternative Hypotheses, Types of Errors

Week 7 : Inference on Population mean, Comparing two population means, Inference on Variance, Comparing two population variance
Week 8 : Neyman Pearson Lemma

SUGGESTED READING MATERIALS:

1) Probability and Statistics for engineers and scientists, Ed 4, Anthony J Hayter, Brroks/Cole, Cengage Learning.
2) Statistical Methods, R.J.Freund, W.J. Wilson and D.L Mohr, (Ed 3) Elsevier.
3) Mathematical Statistics: A Textbook, S. Biswas and G.L.Sriwastav, Narosa

Web Sources:
https://onlinecourses.nptel.ac.in/noc18_ma22/preview

Core Course	Semester - IV	
18MATP04E5	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 and their applications
- understand the applications of different parameters of a graph.
- understand the domination number and its real life applications.
- define different types of graphs and study its properties.

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

(14 hours)

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

(12 hours)

Unit 3: Independent sets and Matchings: Introduction – Vertex independent sets and Vertex covering – Edge independent sets – Matching and factors. Eulerian and Hamiltonian graphs: Introduction - Eulerian graphs - Hamiltonian graphs.

(13 hours)

Unit 4: Graph Colorings: Introduction - Vertex colorings - Critical graphs. Planarity: Introduction - Planar and Non Planar graphs - Euler formula and its consequences - K_5 and $K_{3,3}$ are non- planar.

(12 hours)

Unit 5: 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.

(13 hours)

Text Books:

1. R. Balakrishnan & K. Ranganathan, **A Text Book of Graph Theory,** Springer-Verlag New York, Inc, 2000.
   Unit 1: Chapter I: Sections:1.0 – 1.7
   Unit 2 : Chapter III : Sections: 3.0 – 3.2 ; Chapter IV: Sections: 4.0 – 4.4
   Unit 3 : Chapter V : Sections : 5.0 – 5.3 ; Chapter VI : Sections: 6.0 – 6.2
   Unit 4 : Chapter VII: Sections : 7.0 – 7.2 ; Chapter VIII : Sections: 8.0 – 8.3

2. Teresa W. Hayness, Stephen T. Hedetniemi, Peter J. Slater, & Marcel Dekker, **Fundamental of Domination in Graphs,** INC New York, 1998.
   Unit 5: Chapter 1, Chapter 2: Sections: 2.1-2.4

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.

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Basic results-Basic concepts	3
	sub graphs-degrees of vertices	3
	paths and connectedness- automorphism of simple graphs, line graphs	4
	Operations on graphs	4
		Total 14
2	Connectivity - Vertex cut and edge cut	3
	Connectivity and edge connectivity	3
	Trees – Definition - Characterization and simple properties -	3
	Centers and centroids – Counting the number of spanning trees - Cayley's formula	3
		Total 12
3	Independent sets and Matchings: Introduction	4
	Vertex independent sets and Vertex covering	3
	Edge independent sets – Matching and factors	3
	Eulerian and Hamiltonian graphs: Introduction, Eulerian graphs - Hamiltonian graphs	3
		Total 13
4	Graph Colorings: Introduction - Vertex colorings	3
	Critical graphs. Planarity: Introduction	3

	Planar and Non Planar graphs	3
	Euler formula and its consequences, K_5 and $K_{3,3}$ are non-planar.	3
		Total 12
5	Dominating sets in graphs - Various real life applications	4
	Bounds on the domination number -	3
	Bounds in terms of order - Degree and packing	3
	Bounds in terms of order and size	3
		Total 13
		Grand Total 64

Major Elective **Semester - IV**
18MATP03E6 **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 measure and box-counting dimension.
- recognize the Hausdorff and packing measures and dimensions.
- find the product and intersection of fractals.
- understand the self-similar and self-affine sets, and examples of number theory.
- recognize the concepts of fractal and Julia sets.

Unit 1: Mathematical background: Basic set theory-Functions and limits-Measures and mass distributions-Notes on probability theory. Box-counting dimensions: Box-counting dimensions-Properties and problems of box-counting dimension-Modified box-counting dimensions-Some other definitions of dimension.

(14 hours)

Unit 2: Hausdorff and packing measures and dimensions: Hausdorff measure- Hausdorff dimension- Calculation of Hausdorff dimension—simple examples- Equivalent definitions of Hausdorff dimension- and packing measures and dimensions-Finer definitions of dimension-Dimension prints-porosity. Techniques for calculating dimensions: Basic methods- Subsets of finite measure- Potential theoretic methods-Fourier transform methods.

(13 hours)

Unit 3: Local structure of fractals: Densities-Structure of 1-sets-Tangents to s-sets. Projections of fractals: Projections of arbitrary sets-Projections of s-sets of integral dimension-Projections of arbitrary sets of integral dimension. Products of fractals: Product formulae. Intersections of fractals: Intersection formulae for fractals-Sets with large intersection.

(12 hours)

Unit 4: Iterated function systems—self-similar and self-affine sets: Iterated function systems- Dimensions of self-similar sets- Some variations- Self-affine sets- Applications to encoding images-Zeta functions and complex dimensions. Examples from number theory: Distribution of digits of numbers- Continued fractions- Diophantine approximation.

(12 hours)

Unit 5: Graphs of functions: Dimensions of graphs- Autocorrelation of fractal functions. Iteration of complex functions—Julia sets: General theory of Julia sets- Quadratic functions—the Mandelbrot set- Julia sets of quadratic functions- Characterization of quasi-circles by dimension- Newton's method for solving polynomial equations. Random fractals: A random Cantor set- Fractal percolation.

(13 hours)

Text Book:

1. Kenneth J. Falconer, **Fractal Geometry: Mathematical Foundations and Applications**, John Wiley and Sons Ltd, Third edition, 2014.
   Unit 1: Chapter 1: Sections: 1.1 to 1.4, Chapter 2: Sections: 2.1 to 2.4.
   Unit 2: Chapter 3: Sections: 3.1 to 3.8, Chapter 4: Section: 4.1 to 4.4.
   Unit 3: Chapter 5: Sections: 5.1 to 5.3, Chapter 6: Sections: 6.1 to 6.3,
   Chapter 7: Sections: 7.1 only, Chapter 8: Sections: 8.1 to 8.2.
   Unit 4: Chapter 9: Sections: 9.1 to 9.6, Chapter 10: Sections: 10.1 to 10.3.
   Unit 5: Chapter 11: Sections 11.1 to 11.2, Chapter 14: Sections: 14.1 to 14.5,
   Chapter 15: Sections: 15.1 to 15.2.

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.
4. Michael F. Barnsley, **Fractals Everywhere**, Academic Press Professional, 1988.

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Measures and mass distributions	3
	Box-counting dimensions	4

	Properties and problems of box-counting dimension	4
	Modified box-counting dimensions	3
		Total 14
2	Hausdorff measure and dimension	3
	Packing measure and dimension	3
	Techniques for calculating dimensions	4
	Fourier transform methods	3
		Total 13
3	Local structure of fractals	3
	Projections of fractals	3
	Products of fractals	3
	Intersections of fractals	3
		Total 12
4	Self-similar and self-affine sets	4
	Applications to encoding images	2
	Zeta functions and complex dimensions	3
	Examples from number theory	3
		Total 12
5	Autocorrelation of fractal functions	4
	General theory of Julia sets	3
	Characterization of quasi-circles by dimension	3
	Random fractals	3
		Total 13
		Grand Total 64

Major Elective	**Semester -IV**	
18MATP03E7	**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.

(12 hours)

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.

(14 hours)

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.

(13 hours)

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

(13 hours)

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

(12 hours)

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.

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Communication channels	2
	Maximum likelihood decoding	2
	Hamming distance	3
	Nearest neighbourhood minimum distance decoding	3
	Distance of a code	2
		Total 12
2	Linear codes	2
	Self orthogonal codes	1
	Self dual codes	1
	Bases for linear codes	1
	Generator matrix and parity check matrix	3
	Enconding with a linear code	2
	Decoding of linear codes	2
	Syndrome decoding	2
		Total 14
3	The main coding theory problem	2
	lower bounds	1
	Sphere covering bound	2
	Gilbert Varshamov bound	1
	Binary Hamming codes	1
	q-ary Hamming codes	1
	Golay codes	1
	Singleton bound and MDS codes	2
	Plotkin bound	2
		Total 13
4	Definitions of cyclic codes	2
	Generator polynomials	3
	Generator matrix and parity check matrix	4
	Decoding of Cyclic codes	4
		Total 13
5	BCH codes	3
	Parameters of BCH codes	3
	Decoding of BCH codes	3
	Reed Solomon codes	3
		Total 12
		Grand Total 64

Major Elective **Semester IV**
18MATP04E8 **REGRESSION ANALYSIS** **Credits: 4**

COURSE INTRODUCTION:

Regression analysis is one of the most powerful methods in statistics for determining the relationships between variables and using these relationships to forecast future observations. The foundation of regression analysis is very helpful for any kind of modelling exercises. Regression models are used to predict and forecast future outcomes. Its popularity in finance is very high; it is also very popular in other disciplines like life and biological sciences, management, engineering, etc. In this online course, you will learn how to derive simple and multiple linear regression models, learn what assumptions underline the models, learn how to test whether your data satisfy those assumptions and what can be done when those assumptions are not met, and develop strategies for building best models. We will also learn how to create dummy variables and interpret their effects in multiple regression analysis; to build polynomial regression models and generalized linear models.

COURSE LAYOUT

Week 1 Simple Linear Regression (Part A, B, C)
Week 2 Simple Linear Regression (Part D, E)
Week 3 Multiple Linear Regression (Part A, B, C)
Week 4 Multiple Linear Regression (Part D)
Selecting the best regression equation (Part A, B)
Week 5 Selecting the best regression equation (Part C, D)
Week 6 Multicollinearity (Part A, B, C)
Week 7 Model Adequacy Checking (Part A, B, C)
Week 8 Test for influential observations
Transformations and weighting to correct model inadequacies (Part A)
Week 9 Transformations and weighting to correct model inadequacies (Part B, C)
Week 10 Dummy variables (Part A, B, C)
Week 11 Polynomial Regression Models (Part A, B, C)
Week 12 Generalized Linear Model (Part A, B)
Non-Linear Estimation

REFERENCE MATERIALS

1.Draper, N. R., and Smith, H. (1998), Applied Regression Analysis (3rd ed.), New York: Wiley.

2.Montgomery, D. C., Peck, E. A., and Vining, G. (2001), Introduction to Linear Regression Analysis (3rd ed.), Hoboken, NJ: Wiley.

Web Sources:
https://onlinecourses.nptel.ac.in/noc18_ma23/preview

Modular Course	**Semester - III**	
18MATP03M1	**MATLAB & LATEX**	**Credits: 2**

Objective: To impart the programming concepts of matlab and preparation of mathematical documents, articles using 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.

(6 hours)

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.

(6 hours)

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.

(6 hours)

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.

(7 hours)

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.

(7 hours)

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.

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Introduction: Starting, Closing matlab and Types of matlab windows.	1
	Data types, Assignment statements. System commands and mathematical operators.	1
	Saving and loading files and Workspace.	2
	Mathematical operators: Relational, binary and logical operators.	2
		Total 6
2	Handling of arrays: Creating and Accessing arrays.	1
	Mathematical operations on arrays: Addition, multiplication of single and multiple arrays. Relational and logical operations on arrays and operations on sets.	2
	Handling of matrices: Creating, Accessing, Length, Size, Maximum, Minimum, Mean, Expanding and reducing size.	2
	Reshaping, Shifting, Sorting, Special matrices, Mathematical operations on matrices.	2
		Total 7
3	Basic programming in MATLAB, M-File functions: Creating, Running and Handling.	2
	Variables, Types of functions, Cell arrays, Structures. File I/O handling.	2
	Graphics: 2D graphics and 3D graphics.	2
	Specialized graphs, Saving and printing figures.	1
		Total 7

4	Document layout and organization.	1
	Document class, Page style and Parts of the document.	1
	Text formatting and its offspring,	2
	What's different in latex 2 and basics of LaTeX file.	2
		Total 6
5	Commands and environments, command names and arguments, Environments and Declarations.	1
	Lengths, Special characters, Fragile commands, Table of contents, Fine tuning text.	2
	Word division, Labeling, referencing, displayed text and changing font.	1
	Centering and identifying, lists, generalized lists, theorem like declarations, tabular stops, boxes.	2
		Total 6
		Grand Total 32

Modular Course **Semester - III**

18MATP03M2 **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 of 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.

(14 hours)

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.

(13 hours)

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

(12 hours)

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.

(12 hours)

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.

(13 hours)

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 1.4, Chapter 2: Sections: 2.1 to 2.3,
   Chapter 3: Sections 3.1 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.

LECTURE SCHEDULE

Unit	Topics	No. hours
1	The New Mathematical Engineering	4
	Good Approximations	3
	Wavelets	4
	The Democratization of Arithmetic	3
		Total 14
2	Wavelet Matrices-Haar Wavelet Matrices	4
	the Space of Wavelet Matrices	3
	Wavelet Matrix Series and Discrete Orthonormal Expansions	4

	Related problems	3
		Total 13
3	One-Dimensional Wavelet Systems: Introduction-The Scaling Equation	3
	Wavelet Systems	3
	Multiwavelets and Lifting	3
	Related problems	3
		Total 12
4	Universal Scaling Functions	3
	Orthonormal Wavelet Systems-Flat Wavelets	3
	Polynomial Regular and Smooth Wavelets	3
	Fourier-Polynomial Wavelet Matrices.	3
		Total 12
5	Higher-Dimensional Wavelet Systems: Introduction-Scaling Functions-Scaling Tiles	3
	Orthonormal Wavelet Bases-Wavelet Data Compression	3
	Image Compression-Transform Image Compression Systems	3
	Multiresolution Audio Compression-Denoising Algorithms	4
		Total 13
		Grand Total 64

Modular Course — **Semester – IV**
18MATP04M3 — **FUZZY SETS AND FUZZY LOGIC** — **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 and operations on fuzzy sets and the relationship between different fuzzy sets
- Fuzzy logic and its application

Unit 1: Crisp sets- fuzzy sets basic types and basic concepts-Fuzzy sets versus crisp sets-additional Properties of alpha-cuts-b representations of Fuzzy sets, Extension principle for fuzzy sets-Operation on fuzzy sets- types of operations-fuzzy complements- fuzzy intersections t-forms fuzzy unions t- conforms-combinations of operations- aggregation operation.

Unit 2: 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 – applications.

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.

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Crisp sets- fuzzy sets basic types and basic concepts-Fuzzy sets versus crisp sets	4
	Additional Properties of alpha-cuts-b representations of Fuzzy sets, Extension principle for fuzzy sets-Operation on fuzzy sets	4
	Operation on fuzzy sets- types of operations-fuzzy complements	4
	Fuzzy intersections t-forms fuzzy unions t- conforms-combinations of operations- aggregation operation	4
		Total 16
2	Fuzzy Logic- Multivalve logic- fuzzy propositions- fuzzy quantifiers	4
	Linguistic Hedges- inference from conditional fuzzy propositions	4
	Inference from conditional and qualified propositions	4
	Inference from quantified propositions – applications	4
		Total 16
		Grand Total 32

Modular Course	Semester -IV	
18MATP04M4	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

Unit-1: Architectures: Introduction to Neural Network-Applications of neural network-Biological neural networks-Artificial neural networks-Functioning of artificial neural network-Neuron modeling. (16 hours)

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. (16 hours)

Text Books:

1. A. AntoSpiritusKingsly, **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

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Architectures: Introduction to Neural Network.	4
	Applications of neural network.	4
	Biological neural networks-Artificial neural networks.	4
	Functioning of artificial neural network-Neuron modeling.	4
		Total 16
2	Dynamic Neural Units (DNUs): Nonlinear models and dynamics	4
	Models of dynamic neural units	4
	Models and circuits of isolated DNUs	4
	Neuron with excitatory and inhibitory dynamics.	4
		Total 16
		Grand Total 32

Non Major Elective **Semester II**
18MATP02N1 **NUMERICAL AND STATISTICAL METHODS** **Credits 4**

Objective: To impart basic concepts and skills in the applications of various Numerical and Statistical Methods.

Specific outcome of learning:

- Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.
- Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations.
- Differentiate between the mean, the median, and the mode of data differentiate between the mean, the median, and the mode of dat
- Determine whether the correlation and regression are significant.
- Demonstrate an understanding of the basic concepts of probability and random variables.

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Unit 1: Curve Fitting: Methods of Least Squares- Fitting Straight Line- Fitting a Parabola – Fitting an Exponential Curve. Solution of Numerical and Transcendental Equations: The Bisection method- Method of False Position. Solution of Simultaneous Linear Algebraic Equations: Gauss Elimination Method- Gauss Jordan Method – Jacobi Method of Iteration – Gauss Seidal Method.

(14 hours)

Unit 2: Interpolation: Difference Tables – Newton's Forward and Backward Interpolation Formula for Equal Intervals – Lagrange's Interpolation Formula for Unequal Intervals. Numerical Integration: Trapezoidal Rule – Simpson's $1/3^{rd}$ Rule and Simpson's $3/8^{th}$ Rule.

(12 hours)

Unit 3: Frequency Distribution – Diagramatic Graphical Presentation of Frequency Distributions – Measures of Central Value – Arithmetic Mean – Median – Mode Geometric Mean – Harmonic Mean – Standard Deviation - Coefficient of Variance – Moments – Skewness – Kurtosis.

(13 hours)

Unit 4: Correlation – Scatter Diagram – Karl Pearson's Coefficient of Correlation – Correlation Coefficient for a Bivariate frequency Distribution – Rank Correlation Coefficient – Regression – Regression Lines.

(12 hours)

Unit 5: Probability – Introduction – Calculation of Probability – Conditional Probability – Bayes' Theorem – Mathematical Expectation – Theoretical Distributions – Binomial Distribution – Poisson Distribution.

(13 hours)

Text Books:

1. M.K. Venkataraman, **Numerical Methods in Science and Engineering**, 2/e, National Publishing Co., Madras, 1987, Unit 1 & Unit 2.

2. Arumugam S. Issac, **Statistics**, SCITech Publications, 2011, Unit 3: Chapters 1,2,3,4 Unit 4: Chapter 6 Unit 5: Chapter 11 Chapter 12- Secs 12.1-12.4, Chapter 13- Secs 13.1,13.2.

References:

1. M.K. Jain, S.R.K. Iyengar, R.K. Jain, **Numerical Methods for Scientific and Engineering Computation**, Willey Eastern Limited, 2003.
2. S.S. Sastry, **Introductory Methods of Numerical Analysis,** Prentice – Hall of India, 2010, 4th Edition.

LECTURE SCHEDULE

Unit	Topics	No. hours
1	Curve Fitting	4
	Solution of Numerical and Transcendental Equations	3
	Solution of Simultaneous Linear Algebraic Equations	4
	Related problems	3
		Total 14
2	Interpolation for equal interval	3
	Interpolation for unequal interval	3
	Numerical Integration	3
	Related problems	3
		Total 12
3	Frequency Distribution	3
	Measures of Central Value	4
	Standard Deviation - Coefficient of Variance	3
	Skewness – Kurtosis	3
		Total 13
4	Correlation	4
	Rank Correlation	3
	Regression	2
	Related problems	3
		Total 12
5	Probability	4
	Conditional Probability	3
	Theoretical Distributions	3
	Related problems	3
		Total 13
		Grand Total 64