THE GANDHIGRAM RURAL INSTITUTE (DEEMED TO BE UNIVERSITY)
GANDHIGRAM - 624302
(Ministry of Education, Govt. of India)
Accredited by NAAC with 'A' Grade (3rd cycle)

Department of Mathematics
M.Sc. Degree (Mathematics)
Revised Syllabus with effect from 2024 – 2025 onwards

CURRICULUM WITH OUTCOME BASED EDUCATION (OBE)

Name of the School	:	School of Sciences
Department	:	Department of Mathematics
Academic Programme offered	:	B.Sc. (Hons.) Mathematics, B.Sc. B.Ed. (4 year integrated) Mathematics, M.Sc. Mathematics and Ph.D. Mathematics

I. VISION :

- Science & Technology Enabled Rural Development through teaching and research in Mathematical Sciences

II. MISSION :

- Proficiency in research and teaching
- Research studies in International standards and to urge the need for practical significance

III. PROGRMME CODE : MATP

IV. PROGRAMME : M.Sc. Mathematics

V. PROGRAMME EDUCATIONAL OBJECTIVES (PEO) OF M.Sc. MATHEMATICS:

PEO1: Developing problem solving & computational skills in the advanced areas of Mathematics and its applied subjects.

PEO2: To create new theoretical and Mathematical concepts towards many real life problems

PEO3: Interpreting mathematical results through geometrical concepts.

PEO4: Creating competence to qualify National/international level exams.

PEO5: Ability to think innovatively to do research in high level in Mathematics and interdisciplinary fields.

GRADUATE ATTRIBUTES

GA1: Critical Thinking
GA2: Mathematical Modeling Ability
GA3: Solving Ability

VI. PROGRAMME OUTCOMES (PO)

PO 1: To pursue careers in education, business, industry, government etc., and getting teaching skills in Mathematics and research awareness in pure and applied field of Mathematics.

PO 2: Have the ability to do interdisciplinary research in science and engineering

PO 3: To demonstrate technical and soft skills through Mathematical knowledge to commensurate with global needs.

PO 4: To get employed in higher level institutes in national/ international standards

PO 5: Have the potential to meet out the challenges in modern technology

VII. PROGRAMME SPECIFIC OUTCOMES(PSO)

PSO1: Explain advanced concepts of algebra, real and complex analysis, measure theory, functional analysis and number theory.

PSO2: Succeed in solving problems in differential equations, mechanics, optimization theory, statistics and numerical analysis.

PSO3: Critique soft skills and computing skills for solving complex problems arising in Mathematics and other interdisciplinary fields.

PSO4: Identify the significance of mathematical and statistical thinking, training, and approach to problem solving, on a diverse variety of disciplines.

PSO5: Creating mathematical models for real-world problems.

Name of the Programme	M.Sc. Mathematics				
Year of Introduction	2008				
Year of Revision	2024				
Semester-wise Courses and Credit distribution	I	II	III	IV	Total
No. of Courses	6	8	7	6	27
No. of Credits	22	25	23	22	92

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	24MATP0101	Advanced Algebra	4	4	3	40	60	100
	24MATP0102	Real Analysis	4	4	3	40	60	100
	24MATP0103	Advanced Ordinary Differential Equations	4	4	3	40	60	100
	24MATP0104	Numerical Analysis	4	4	3	40	60	100
	24MATP0105	Discrete Mathematics	4	4	3	40	60	100
Foundation Course	24GTPP0001	Gandhi in Everyday Life	2	2	--	50	--	50
TOTAL			**22**					
	Semester – II							
Core Course	24MATP0206	Linear Algebra	4	4	3	40	60	100
	24MATP0207	Advanced Real Analysis	4	4	3	40	60	100
	24MATP0208	Partial differential Equations and Applications	4	4	3	40	60	100
	24MATP0209	Complex Analysis	4	4	3	40	60	100
	24MATP0210	Mathematical Methods	4	4	3	40	60	100
Electives	24MATP02GX	Generic Elective	3	3	3	40	60	100
Value Added Course	24MATP2VAX	Value Added Course	2	2	--	50	--	50
Skill Development Course	24ENGP00C1	Communication and Soft Skills	2	2	--	50	--	50
TOTAL			**25**					

	Semester – III							
Core Course	24MATP0311	Topology	4	4	3	40	60	100
	24MATP0312	Measure Theory	4	4	3	40	60	100
	24MATP0313	Probability and Statistics	4	4	3	40	60	100
	24MATP0314	Optimization Techniques	4	4	3	40	60	100
Electives	24MATP03DX	Discipline Centric Elective	3	3	3	40	60	100
Modular Course	24MATP03MX	Modular Course	2	2	--	50	--	50
Extension	24EXNP03V1	Village Placement Programme	2	--	--	50	--	50
TOTAL			**23**					
	Semester – IV							
Core Course	24MATP0415	Stochastic Processes	4	4	3	40	60	100
	24MATP0416	Functional Analysis	4	4	3	40	60	100
	24MATP0417	Graph Theory	4	4	3	40	60	100
	24MATP0418	Dissertation	6	12	--	75	75+50	200
Value Added Course	24GTPP00M1	Human values and Professional Ethics	2	2	--	50	--	50
Modular Course	24MATP04MX	Modular Course	2	2	--	50	--	50
TOTAL			**22**					
GRAND TOTAL			**92**					

DISCIPLINE CENTRIC ELECTIVES: (24MATP03DX)

Semester – III

1. 24MATP03D1 Classical Dynamics
2. 24MATP03D2 Control Theory
3. 24MATP03D3 Optimal Control
4. 24MATP04D4 Fractal Analysis
5. 24MAT P04D5 Coding Theory

VALUE ADDED COURSES: (24MATP02VAX)

1. 24MATP02VA1 Numerical Methods for Engineers
2. 24MATP02VA2 Mathematics for Competitive Examinations
3. 24MATP02VA3 Fuzzy Logic For Management Decision Making

MODULAR COURSES: (24MATP03MX/24MATP04MX)

Semester – III

1. 24MATP03M1 Field Theory
2. 24MATP03M2 Wavelet Analysis

Semester – IV

1. 24MATP04M3 Introduction to SciLab
2. 24MATP04M4 Neural Networks

ABSTRACT	
Course type	**Total number of Courses**
Core Course	17
Discipline Centric Elective	01
Generic Elective	01
Modular Course	02
Foundation Course	01
Extension	01
Human values and Professional Ethics	01
Skill Development Course	01
Dissertation	01
Value Added Course	01

<table>
<tr><td>Semester</td><td>I</td><td>Course Code</td><td colspan="2">24MATP0101</td></tr>
<tr><td>Course Title</td><td colspan="4">Advanced Algebra</td></tr>
<tr><td>No. of. Credits</td><td>4</td><td>No. of. contact hours per week</td><td colspan="2">4</td></tr>
<tr><td>New Course/ Revised Course</td><td>Revised Course</td><td>If revised, Percentage of Revision effected (Minimum 20%)</td><td colspan="2">30%</td></tr>
<tr><td>Category</td><td colspan="4">Core Course</td></tr>
<tr><td>Scope of the Course</td><td colspan="4">Advanced Skill</td></tr>
<tr><td>Cognitive Levels addressed by the course</td><td colspan="4">• Recognizing some advances of theory of groups (K1 Remember)
• Understanding automorphism group of a group, class equation of a group and the structure of finite abelian groups (K2-Understanding)
• Applying Sylow's Theorem to study the properties of groups. Using class equation to find the conjugacy classes in symmetric groups (K3-Applying)
• Examining the irreducibility of a polynomial (K4-Analyse)
• Investigating the structure of two isomorphic algebraic structures like groups, rings, fields (K5-Evaluate)
• Formulating some special types of rings, ideals (K6-Create)</td></tr>
<tr><td>Course Objective</td><td colspan="4">The Course aims to provide deep knowledge about various algebraic structures.</td></tr>
<tr><td>Unit</td><td colspan="3">Content</td><td>No. of. Hours</td></tr>
<tr><td>I</td><td colspan="3">A counting principle - Normal subgroups and quotient groups – Homomorphisms – Cauchy's theorem for abelian groups - Sylow's theorem for abelian groups - Correspondence theorem for groups – First isomorphism theorem</td><td>14</td></tr>
<tr><td>II</td><td colspan="3">Automorphisms – Inner automorphisms - Automorphism group of cyclic groups - Cayley's theorem – Applications - Permutation groups</td><td>12</td></tr>
<tr><td>III</td><td colspan="3">Another counting principle: Conjugate class - Class equation of a group – Applications - Cauchy's theorem - Sylow's theorems - Direct product of groups - Finite abelian groups.</td><td>13</td></tr>
<tr><td>IV</td><td colspan="3">Ideals and quotient rings – More ideals and quotient rings: Maximal ideals - Euclidean rings - G.C.D - Unique Factorization Theorem - A particular Euclidean ring - Fermat's theorem</td><td>12</td></tr>
<tr><td>V</td><td colspan="3">Polynomial rings - Division Algorithm- Polynomials over the rational field-Gauss' Lemma - Eisenstein Criterion - Polynomial rings over commutative rings - U.F.D.</td><td>13</td></tr>
<tr><td>References</td><td colspan="4">Text Book:
1. I. N. Herstein, Topics in Algebra, 2nd edition, John Wiley & Sons, Singapore, 2006.
Unit 1: Chapter 2: Sections 2.5, 2.6, 2.7
Unit 2: Chapter 2: Sections 2.8, 2.9, 2.10</td></tr>
</table>

	Unit 3: Chapter 2: Sections 2.11, 2.12, 2.13, 2.14 Unit 4: Chapter 3: Sections 3.4, 3.5, 3.7, 3.8, Unit 5: Chapter 3: Sections 3.9, 3.10, 3.11
	Reference Books: 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**, AMS, 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.
	E-Recourses: 1. https://onlinecourses.nptel.ac.in/noc18_ma15 2. https://onlinecourses.nptel.ac.in/noc18_ma16
Course Outcomes	On completion of the course students should be able to CO1: explain advances of the theory of groups. CO2: use Sylow's theorems in the study of finite groups. CO3: classify finite abelian groups using direct products CO4: formulate some special types of rings and their properties. CO5: check the irreducibility of polynomials.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	1	3
CO2	3	1	2	1	3
CO3	3	2	1	1	2
CO4	3	3	1	1	3
CO5	3	3	2	1	3

Semester	**I**	Course Code	**24MATP0102**
Course Title	**Real Analysis**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Core Course**		
Scope of the Course	Advanced Skill		

<table>
<tr><td>Cognitive Levels addressed by the course</td><td colspan="2">

Understanding the fundamentals of sets and axioms (K1 & K2-Remembering and understanding).
Understanding the geometry of metric spaces and identifying open, closed, connected and compact sets in metric spaces (K2 & K4 -Remembering and Analyzing).
Evaluating the limit of a sequence/series by analysing the convergence of the sequence/series (K4 & K5-Analyzing and Evaluating).
Applying open & closed set to study continuous and discontinuous functions (K3-Applying).
Identifying differentiable functions and evaluate its derivatives (K4 & K5 – Analyzing and Evaluating)

</td></tr>
<tr><td>Course Objective</td><td colspan="2">The Course aims to impart the concepts of sets and functions on metric spaces.</td></tr>
<tr><th>Unit</th><th>Content</th><th>No. of. Hours</th></tr>
<tr><td>I</td><td>The real and complex number systems: Introduction, Ordered sets – Fields - The real field - The extended real number system - The complex field - Euclidean spaces.</td><td>13</td></tr>
<tr><td>II</td><td>Basic Topology: Finite - Countable and Uncountable sets - Metric spaces - Compact sets - Perfect sets - Connected sets.</td><td>13</td></tr>
<tr><td>III</td><td>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.</td><td>16</td></tr>
<tr><td>IV</td><td>Continuity: Limits of functions - Continuous functions - Continuity and compactness - Continuity and connectedness - Monotonic functions - Infinite limits and limits at infinity.</td><td>11</td></tr>
<tr><td>V</td><td>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.</td><td>13</td></tr>
<tr><td rowspan="2">References</td><td colspan="2">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).</td></tr>
<tr><td colspan="2">Reference Books:
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.</td></tr>
</table>

	E-Recourses: 1. http://nptel.ac.in/courses/109104124/ 2. http://nptel.ac.in/courses/111101100/
Course Outcomes	On completion of the course students should be able to CO1: Discuss various axioms and properties of real and complex numbers. CO2: Identify the topological properties of sets in metric spaces. CO3: Compute the limits of convergent sequences/series. CO4: Identify the topological properties of functions defined on metric spaces. CO5: Evaluate the derivative of real valued functions.

Mapping of COs with POs

CO \ PO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	1
CO2	3	2	3	1	2
CO3	3	3	2	2	2
CO4	3	3	2	1	2
CO5	3	3	2	1	2

Semester	**I**	Course Code	24MATP0103
Course Title	**Advanced Ordinary Differential Equations**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	Revised Course	If revised, Percentage of Revision effected (Minimum 20%)	40%
Category	**Core Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Identify various basic concepts on differentiations(K1) • Use to model differential systems (K2) • To develop approximation methods and fixed point theorems to get solutions of differential equations (K3) • Extend the results to higher order differential calculus(K4)		
Course Objective	The Course aims to study in-depth concepts and applications of ordinary differential equations.		

Unit	Content	No. of. Hours
I	Existence and Uniqueness of Solutions: Introduction - Successive approximations - Picard's theorem - Continuation and dependence of initial conditions – Existence of Solutions in the large – Existence and Uniqueness for Systems - Fixed point method.	13

II	Differential Equations of Higher Order: Introduction – Higher order Equations – Linear Dependence and Wronskian – Basic Theory for linear Equations – Homogeneous Linear Equations with Constant Coefficients – Equations with Variable coefficients – Method of Variation of Parameters .	12
III	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 – Variation of Parameters.	13
IV	Solution in Power Series: Introduction – Second – order Linear Equations with Ordinary Points – Legendre Equations and Legendre Polynomials – Second – Order Equations with Regular Singular Points – Bessel's Functions.	13
V	Boundary value problem: Introduction - Strum Liouville problem - Green's function - Applications of boundary value problems - Picard's theorem.	13
References	**Text Book:** 1. S. G. Deo, V. Raghavendra, Rasmita Kar & V. Lakshmikantham, **Text book of Ordinary Differential Equations**, Third Edition, McGraw-Hill Education (India) Pvt. Ltd., New Delhi, 2016 Unit 1: Chapter 2: Sections 2.1 to 2.9 Unit 2: Chapter 4: Sections 4.1 to 4.2, 4.4 to 4.8 Unit 3: Chapter 5: Sections 5.1 to 5.9 Unit 4: Chapter 6: Sections 6.1 to 6.5 Unit 5: Chapter 8: Sections 8.1 to 8.5	
	Reference Books: 1. M.E. Taylor, **Introduction to Differential Equations** , AMS Indian Edition,2011. 2. Earl. A. Coddington, **An Introduction to Ordinary Differential Equations**, PHI Learning Pvt. Ltd., New Delhi, 2013. 3. G. F. Simmons, S. G. Krantz, **Differential Equations: Theory, Technique and Practice**, Tata McGraw Hill Book Company, New Delhi, India, 2007. 4. M. Barun, **Differential Equations and Their Applications**, 4th Edition, Springer,1993.	
	E-Recourses: 1. https://onlinecourses.nptel.ac.in/noc18_ma10 2. https://nptel.ac.in/courses/111/107/111107111/	
Course Outcomes	On completion of the course students should be able to CO1: analyze the existence and uniqueness of solutions of Differential Equations. CO2: solve higher order ODE using various techniques. CO3: analyze the existence and uniqueness of solutions of system of Differential Equations. CO4: solve differential equations using power series method. CO5: solve boundary value problems.	

Mapping of COs with POs

CO \ PO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	2	3
CO2	2	3	2	2	2
CO3	1	2	1	2	3
CO4	1	2	2	1	3
CO5	1	2	2	2	2

Semester	**I**	Course Code	**24MATP0104**
Course Title	**Numerical Analysis**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Core Course**		
Scope of the Course	Employability		
Cognitive Levels addressed by the course	• Knowing large number numerical calculations (K1) • Understanding numerical ability (K2) • Applying algorithms numerically (K3)		
Course Objective	The Course aims to develop skills to solve many physical problems in an effective and efficient manner using different numerical techniques.		

Unit	Content	No. of. Hours
I	Transcendental and polynomial equations: Rate of convergence Secant Method-Regula Falsi Method-Netwon Raphson Method- Muller Method and Chebyshev Method. Polynomial equations: Descartes' Rule of Signs-Iterative Methods: Birge-Vieta method, Bairstow's method Direct Method: Graeffe's root squaring method.	13
II	Interpolation and curve fitting: Lagrangian polynomials - Divided differences - Interpolation with cubic spline – Least square approximation of functions.	13
III	Numerical differentiation and integration: Numerical differentiation derivatives using Newton's forward and backward formula -Derivatives using Stirling's formula - Trapezoidal rule - Simpson's 1/3rd rule - 3/8 rule -Weddle's rule - Errors in quadrature formula.	13
IV	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

V	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
References	**Text Books:** 1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, **Numerical Methods for Scientific and Engineering Computation**, New Age International (p) Limited Publishers, New Delhi, Sixth Edition 2012. Unit 1: Chapter 2: Sections 2.5,2.9 2. Curtis. F. Gerald, Patrick & O. Wheatley, **Applied Numerical Analysis**, 5th Edition, Pearson Education, New Delhi, 2005 Unit 2: Chapter 3: Sections 3.1, 3.2, 3.3, 3.4, 3.7. 3. V. N. Vedamurthy & N. Ch. S. N. Iyengar, **Numerical Methods**, Vikas Publishing House, Pvt. Ltd., Noida, 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.	
	Reference Books: 1. R. L. Burden & J. Douglas Faires, **Numerical Analysis**, Thompson Books, USA, 2005. 2. P. Kandasamy, K. Thilagavathy & K. Gunavathi, **Numerical Methods**, S. Chand & company PVT. LTD.	
	E-Recourses: 1. http://nptel.ac.in/courses/111107105/	
Course Outcomes	On completion of the course students should be able to CO1: Apply different methods to solve the system of equations CO2: Realize the nature of different curves along with specified properties CO3: Utilize various types of integrals to solve many complicated problems CO4: Outline the methods to solve higher order differential equations CO5: Discuss various types of partial differential equations.	

<u>Mapping of COs with POs</u>

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	1	2
CO2	3	3	3	3	2
CO3	2	2	3	3	3
CO4	3	3	2	3	1
CO5	1	2	3	3	3

Semester	**I**	Course Code	**24MATP0105**
Course Title	**Discrete Mathematics**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Core Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Knowing the concepts of basic principles to solve the counting problems (K-1) • Understanding the permutation and combinatorial problem (K-2) • Applying Inclusion-exclusion principle to real life problems (K-3) • Evaluating number theoretical problems by using number theoretic functions (K-3)		
Course Objective	The Course aims to impart various concepts about permutations, combinations and theory of numbers.		

Unit	**Content**	**No. of. Hours**
I	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
II	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
III	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
IV	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
V	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.	12

<table>
<tr><td rowspan="3">References</td><td>Text Books:
1. Richard A. Brualdi, Introductory Combinatorics, 5th 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.</td></tr>
<tr><td>Reference Books:
1. S. Lipschutz & M. Lipson, Discrete Mathematics (Schaum's Outlines), Revised 3rd Edition, Tata McGraw-Hill Publishing Company, New Delhi, 2017.
2. J. Truss, Discrete Mathematics for Computer Scientists, Pearson Education Limited, England, 1999.
3. Tom. M. Apostol, Introduction to Analytic Number Theory, Springer, New Delhi, 1993.
4. Thomas Koshy, Elementary Number Theory, Elsevier, California, 2005.
5. N. Robbins, Beginning Number Theory, 2nd Edition, Narosa Publishing House, New Delhi, 2007.</td></tr>
<tr><td>E-Recourses:
1. https://www.tutorialspoint.com/discrete_mathematics/
2. home.iitk.ac.in/~arlal/book/mth202.pdf</td></tr>
<tr><td>Course Outcomes</td><td>On completion of the course students should be able to
CO1: Outline the ideas of permutations, combinations and its properties
CO2: Apply the permutations and combinations to solve problems
CO3: Predict the concepts of divisibility and related algorithms
CO4: Analyse the properties of congruence relations
CO5: Explain the number theoretic functions</td></tr>
</table>

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	1	2	1	2
CO3	2	2	1	2	2
CO4	2	2	1	2	2
CO5	2	2	1	2	2

Semester	**II**	Course Code	**24MATP0206**	
Course Title	**Linear Algebra**			
No. of. Credits	4	No. of. contact hours per week	4	
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--	
Category	**Core Course**			
Scope of the Course	Advanced Skill			
Cognitive Levels addressed by the course	• Recognizing some advances of vector spaces, inner product spaces and linear transformations (K1-Knowing). • Discussing certain canonical forms of vector spaces, visualizing linear transformations in matrix form, diagonalization of quadratic forms, dual spaces (K2-Understanding). • Using Gram-Schmidt Orthogonalization process to find an orthonormal basis (K3-Apply). • Examining the linear independence and orthogonality of set of vectors, dimension of vector spaces, linear transformations (K4-Analyse). • Constructing linearly independent sets, basis, subspaces, linear transformations in a vector space (K6-Create).			
Course Objective	The Course aims to introduce some important concepts of vector spaces.			
Unit	**Content**			**No. of. Hours**
I	Vector spaces: Elementary basic concepts – Homomorphisms-Quotient spaces – Direct sum- Subspace- Linear independence and bases – Dimension - Dual spaces – Annihilators			14
II	Linear Transformations: The algebra of linear transformations – Regular linear maps – rank of a linear transformation - Characteristic roots – Matrices: Matrix of a linear transformation – Linear transformation corresponding to a matrix – Algebra of matrices – Change of basis.			13
III	Canonical Forms: Triangular forms - Nilpotent transformations - A decomposition of vector spaces: Jordan form.			13
IV	Inner product spaces – Orthogonality – Orthogonalization - Orthogonal Complement – Trace and Transpose – Jacobson Lemma - Adjoints.			12
V	Hermitian - Unitary and Normal Transformations – Diagonalization - Real Quadratic forms – Sylvester's law of inertia.			12
References	**Text Book:** 1. I. 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.
	Reference Books: 1. Vivek Sahai & Vikas Bist, **Linear Algebra**, Narosa Publishing House, New Delhi, 2002. 2. A. R. Rao & P. Bhimashankaram, **Linear Algebra**, Hindustan Book Agency, New Delhi, 2000. 3. J. S. Golan, **Foundations of Linear Algebra**, Kluwer Academic publisher, Tel Aviv 1995. 4. Kenneth Hoffman & Ray Kunze, **Linear Algebra**, Prentice-Hall of India Pvt., New Delhi, 2004. 5. S. Kumaresan, **Linear Algebra: A Geometric Approach**, Prentice Hall of India, New Delhi, 2006.
	E-Recourses: 1. https://onlinecourses.nptel.ac.in/noc18_ma16
Course Outcomes	On completion of the course students should be able to CO1: Identify the advances of vector spaces and linear transformations. CO2: Analyse the concepts of linear algebra in geometric point of view. CO3: Visualize linear transformations as matrix form. CO4: Decompose a given vector space into certain canonical forms. CO5: Formulate several classes of linear transformations and their properties.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	1	3
CO2	3	3	3	1	3
CO3	3	3	2	1	3
CO4	3	2	2	1	3
CO5	3	3	3	1	3

Semester	**II**	Course Code	**24MATP0207**
Course Title	**Advanced Real Analysis**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Core Course**		

<table>
<tr><td>Scope of the Course</td><td colspan="2">Advanced Skill</td></tr>
<tr><td>Cognitive Levels addressed by the course</td><td colspan="2">Interpreting the geometry of integrals and evaluating the integral values (K4 & K5 – Analysing and Evaluating).
Understanding the concepts of uniform convergence and apply them to evaluate the derivatives and integrals (K2 & K3 -Remembering and Applying).
Understanding the concepts trigonometric functions and applying them to study Fourier series. (K2 & K3-Understanding and Applying).
Understanding the concepts of functions of several variables and evaluating the derivatives of multi-variable functions (K2 & K5 Understanding and Evaluating)
Applying Implicit function theorem to Identifying solutions of differential equations (K3 & K6 – Applying and Creating).</td></tr>
<tr><td>Course Objective</td><td colspan="2">The Course aims to introduce the concept of integration of real-valued functions, sequences and series of functions.</td></tr>
<tr><th>Unit</th><th>Content</th><th>No. of. Hours</th></tr>
<tr><td>I</td><td>The Riemann-Stieltjes integral: Definition and existence of the integral - Properties of the integral - Integration and differentiation - Integration of vector valued functions - Rectifiable curves.</td><td>13</td></tr>
<tr><td>II</td><td>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.</td><td>12</td></tr>
<tr><td>III</td><td>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.</td><td>13</td></tr>
<tr><td>IV</td><td>Functions of several variables: Linear transformations – Differentiation - The contraction principle - The inverse function theorem.</td><td>13</td></tr>
<tr><td>V</td><td>The implicit function theorem - The rank theorem – Determinants - Derivatives of higher order - Differentiation of integrals.</td><td>13</td></tr>
<tr><td rowspan="2">References</td><td colspan="2">Text Book:
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.</td></tr>
<tr><td colspan="2">Reference Books:
Tom M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, India, 1997.
G. F. Simmons, Introduction to Topology and Modern Analysis, 3rd Ed., McGraw- Hill, New Delhi, 2004.
S. C. Malik, Mathematical Analysis, Wiley Eastern Ltd., New Delhi, 1985.
N. L. Carothers, Real Analysis, Cambridge University Press, UK, 2000.</td></tr>
</table>

	E-Recourses: 1. https://nptel.ac.in/courses/111/106/111106053/ 2. https://nptel.ac.in/courses/111/106/111106153/
Course Outcomes	On completion of the course students should be able to CO1: Evaluate the integrals of a bounded function on a closed bounded interval. CO2: Compute the pointwise limit and Uniform limit of sequences of functions. CO3: Analyse the convergence of Fourier series CO4: Evaluate the derivative of functions of several variables CO5: Compute higher order derivatives for vector valued functions

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	1
CO2	3	3	2	2	2
CO3	3	3	2	1	2
CO4	3	3	2	2	2
CO5	3	3	2	1	2

Semester	**II**	Course Code	24MATP0208
Course Title	**Partial Differential Equations and Applications**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	New Course	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Core Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Identify various basic concepts on Partial Differential Equations (K1) • To study second order P.D.E and its Classifications (K2) • To study the results to Laplace's Equation, Wave Equation & Heat Equation(K4)		
Course Objective	The Course aims to study in-depth concepts and applications of partial differential equations.		

Unit	Content	No. of. Hours
I	First Order P.D.E: Curves and Surfaces - Genesis of First Order P.D.E. - Classification of Integrals - Linear Equations of the First Order - Pfaffian Differential Equations - Compatible Systems - Charpit's Method - Jacobi's Method.	13

II	Linear Integral Surfaces Through a Given Curve - Quasi-Linear Equations - Non-linear First Order P.D.E. Second Order P.D.E.: Genesis of Second Order P.D.E. - Classification of Second Order P.D.E.	12
III	Wave Equation: One-Dimensional Wave Equation - Vibrations of an Infinite String - Vibrations of a Semi-infinite String - Vibrations of a String of Finite Length (Method of separation of variables).	13
IV	Laplace's Equation: Boundary Value Problems - Maximum and Minimum Principles - The Cauchy Problem - The Dirichlet Problem for the Upper Half Plane - The Neumann Problem for the Upper Half Plane - The Dirichlet Interior Problem for a Circle - The Dirichlet Exterior Problem for a Circle - The Neumann Problem for a Circle - The Dirichlet Problem for a Rectangle - Harnack's Theorem .	13
V	Heat Equation: Heat Conduction Problem - Heat Conduction - Infinite Rod Case - Heat Conduction Finite Rod Case - Duhamel's Principle - Wave Equation - Heat Conduction Equation.	13
References	**Text Book:** 1. T. Amarnath, **An Elementary Course in Partial Differential Equations**, 2nd Ed, Narosa Publishing Company, 2010. Unit 1: Chapter 1: Sections 1.1 to 1.8 Unit 2: Chapter 1, 2: Sections 1.9 to 1.11 & 2.1,2.2 Unit 3: Chapter 2: Sections 2.3.1 to 2.3.5 Unit 4: Chapter 2: Sections 2.4.1 to 2.4.10 Unit 5: Chapter 2: Sections 2.5 to 2.6	
	Reference Books: 1. I. N. Snedden, **Elements of Partial Differential Equations**, Dover, 2006. 2. F. Treves, **Basic Linear Partial Differential Equations**, Dover, 2006. 3. A.K. Nandakumaran and P.S. Datti, **Partial Differential Equations**, Classical Theory with a Modern Touch, Cambridge University Press, 2020	
	E-Recourses: 1. https://onlinecourses.nptel.ac.in/noc18_ma10 2. https://nptel.ac.in/courses/111/107/111107111/	
Course Outcomes	On completion of the course students should be able to CO1: solve different types of first order partial differential equations. CO2: classify and solve second order partial differential equations. CO3: solve wave equations using different techniques. CO4: solve different forms of Laplace equations. CO5: solve heat equations and apply in real life problems.	

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	2
CO2	1	3	2	2	3
CO3	3	2	1	3	2
CO4	2	1	2	3	3
CO5	3	3	2	2	3

Semester	**II**	Course Code	**24MATP0209**
Course Title	**Complex Analysis**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Core Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Know the concept of bilinear transformations, power series, operations of power series, conformal mappings, singularities, and residues (K1). • Understand the importance of analytic functions, the uniform convergence of a series, the Cauchy's inequality and applications and argument principles (K2). • Apply the concept of the complex integration, Cauchy's integral formula to solve integral problems, maximum modulus principles, and the residue theorem to find integral values (K3). • Analyse the analyticity of a function (K4). • Evaluate the values of real integrals (K5).		
Course Objective	The Course aims to impart various concepts about the analytic functions in the complex plane.		

Unit	Content	No. of. Hours
I	Analytic Functions: Cauchy–Riemann equation – Analyticity - Harmonic functions - Bilinear transformations and mappings: Basic mappings - Linear fractional transformations.	14
II	Power Series: Sequences revisited - Uniform convergence - Maclaurin and Taylor Series - Operations on power series - Conformal mappings.	13
III	Complex Integration and Cauchy's Theorem: Curves – Parameterizations - Line Integrals - Cauchy's Theorem.	13

IV	Applications of Cauchy's Theorem: Cauchy's integral formula - Cauchy's inequality and applications - Maximum modulus theorem- Schwarz's Lemma.	12
V	Laurent series and the residue theorem: Laurent Series - Classification of singularities - Evaluation of real integrals - Argument principle- Rouche's Theorem- Open Mapping Theorem.	12
References	**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	
	Reference Books: 1. S. Ponnusamy, **Foundations of Complex analysis**, 2nd Edition, Narosa Pub., New Delhi, 2005. 2. V. Karunakaran, **Complex Analysis**, Narosa Publishing House, New Delhi, 2002. 3. R.V. Churchill & J. W. Brown, **Complex Variables & Applications**, 9th Edition, Mc. Graw Hill, New Delhi, 2021. 4. John. B. Conway, **Functions of One Complex Variable**, Springer-Verlag, New York, 1978. 5. Murray R. Spiegel, Seymour Lipschutz, John J. Schiller, Dennis Spellman, **Schaum's Outline of Complex Variables,** 2nd Edition, McGraw Hill, 2009. 6. Lars. V. Ahlfors, **Complex Analysis**, 3rd edition, McGraw Hill book company, International Edition, Singapore, 1979.	
	E-Recourses: 1. https://nptel.ac.in/courses/111/106/111106141/ 2. https://nptel.ac.in/courses/111/103/111103070/	
Course Outcomes	On completion of the course students should be able to do CO1: Explain about analytic function and transformations CO2: Examine power series of analytic function CO3: Discuss the concept of complex integration CO4: Apply Cauchy's theorem to evaluate contour integrals CO5: Classify the singularities and residues of complex functions	

Mapping of COs with POs

CO \ PO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	1	2
CO2	3	2	2	1	2
CO3	3	2	2	1	2
CO4	3	2	2	1	1
CO5	2	3	2	3	3

Semester	**II**	Course Code	**24MATP0210**
Course Title	**Mathematical Methods**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Core Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Knowing different methods of transformations (K1) • Understanding the in-build techniques of calculations (K2) • Applying various transformations to reality (K3)		
Course Objective	The Course aims to learn various integral equations, transformation techniques and its applications.		

Unit	**Content**	**No. of. Hours**
I	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
II	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
III	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.	13
IV	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

V	Functionals – Euler's equation – Solutions of Euler's equation – Geodesics – Isoperimetric problems – Several dependent variables – Functionals involving higher order derivatives.	13
References	**Text Books:** 1. M. D. Raisinghania, **Integral Equations and boundary value Problems**, Third Revised Edition, S. Chand & Company Ltd. New Delhi, 2010. 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 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 McGraw Hill, New Delhi, 1972. Unit 4: Chapter 2, Section 2.1-2.6, 2.9, 2.10. 3. B.S. Grewal, **Higher Engineering Mathematics**, 39th edition, Khanna publishers, New Delhi, 2016. Unit 5: Chapter 33.1-33.8	
	Reference Books: 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.	
	E-Recourses: 1. http://nptel.ac.in/courses/111107103/ 2. https://onlinecourses.nptel.ac.in/noc18_ma12 3. http://nptel.ac.in/courses/111107103/	
Course Outcomes	On completion of the course students should be able to CO1: Apply the various concepts of integral equations in various problems CO2: Discuss the solutions of various integral equations CO3: Assess various theorems with proof techniques that will motivate to develop further CO4: Create different functions based on applications CO5: Apply different transformation techniques in solving problems.	

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	2	3
CO2	3	3	3	2	3
CO3	1	1	3	2	3
CO4	2	3	2	3	2
CO5	3	2	1	3	3

Semester	**III**	Course Code	**24MATP0311**
Course Title	**Topology**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Core Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Recognizing topological spaces, basis, subspace topology, continuous functions, countability axioms, separation axioms (K1- Knowing). • Understanding box topology, product topology, metric topology (K2-Understading). • Applying results of topology to determine the connectedness, compactness of topological spaces. (K3-Applying). • Investigating the connectedness and compactness in Real line (K4 - Analyse). • Building new topological spaces, connected spaces, compact spaces, normal spaces, regular spaces and Hausdorff space from the existing topological spaces (K6 - Create)		
Course Objective	The Course aims to introduce the fundamental concepts of topology and study the properties of topological spaces.		

Unit	**Content**	**No. of. Hours**
I	Topological spaces -Basis for a topology - The order topology - The product topology on X × Y – The subspace topology - Closed sets and limit.	14
II	Continuous functions - The product topology - The metric topology.	13
III	Connected spaces - Connected subspaces of the real line - Compact spaces - Compact subspaces of the real line.	13
IV	Limit point compactness - The countability and separation axioms: The countability axioms - The separation axioms.	12
V	Normal spaces - The Urysohn's lemma - The Urysohn's metrization theorem –Tietz extension theorem - The Tychonoff theorem.	12
References	**Text Book:** 1. James R. Munkres, **Topology**, 2nd Edition, Pearson Education, Delhi, 2006. Unit 1: Chapter 2: Sections 2.1- 2.6 Unit 2: Chapter 2: Sections 2.7-2.10 Unit 3: Chapter 3: Sections 3.1, 3.2, 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. **Reference Books:** 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, 2011. 5. K. D. Joshi, **Introduction to General Topology**, New Age International Pvt. Ltd, New Delhi, 1983. 6. J. L. Kelly, **General Topology,** Springer-Verlag, New York, 1975 7. James Dugundji**, Topology,** Allyn and Bacon INC, Boston, 1966.
	E-Recourses: 1. https://nptel.ac.in/courses/111/106/111106054/
Course Outcomes	On completion of the course students should be able to do CO1: Discuss several constructions of topological spaces CO2: Analyse various properties of topological spaces CO3: Apply properties of continuous functions on topological spaces CO4: Examine connected, compact, and normal topological spaces and their properties CO5: Demonstrate various theorems on Normal Topological spaces

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	1	2
CO2	3	3	3	1	3
CO3	3	3	3	2	2
CO4	3	3	3	1	2
CO5	2	3	2	1	2

Semester	III	Course Code	24MATP0312
Course Title	**Measure Theory**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Core Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Understanding the basic concepts of measurable sets and measurable functions by applying open sets (K2 & K3 – Understanding and Applying). • Interpreting geometrically the Lebesgue integration and evaluate it (K4 & K5 –Analysing and Evaluating). • Understanding the Lebesgue integration on general spaces by applying Lebesgue		

	integration on real line. (K3 & K6-Applying and Creating). • Understanding the concepts convergence of Lebesgue integrable functions(K1 & K2 – Remembering and Understanding) • Generalising the concept of Lebesgue measure (K6 – Creating).	
Course Objective	The Course aims to introduce the fundamentals of measure and integration on the real line.	
Unit	**Content**	**No. of. Hours**
I	Measure on the real line: Lebesgue outer measure - Measurable sets – Regularity - Measurable functions - Borel and Lebesgue measurability.	12
II	Integration of functions of a real variable: Integration of non-negative functions - The general integral - Integration of series - Riemann and Lebesgue integrals.	13
III	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
IV	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
V	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
References	**Text Book:** 1. G.de Barra, **Measure Theory and Integration**, New Age International Publishers, New Delhi, 2003. Unit 1: Sections 2.1-2.5. Unit 2: Sections 3.1- 3.4. Unit 3: Sections 5.1- 5.6. Unit 4: Sections 6.1- 6.5. Unit 5: Sections 8.1-8.4.	
	Reference Books: 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, 2007. 3. Paul. R. Halmos, **Measure Theory**, Springer, New York, 2009 4. E. Hewitt & K. R. Stromberg, **Real and Abstract Analysis**, Wiley Verlag, 1966.	
	E-Recourses: **1.** http://nptel.ac.in/courses/111101100/	
Course Outcomes	On completion of the course students should be able to do CO1: Outline the concept of Lebesgue measure and integration. CO2: Interpret the geometric meaning of measurable functions and integration. CO3: Formulate the relationships between Riemann and Lebesgue integrals. CO4: Describe the applications of measure theory in other branches of Mathematics. CO5: Apply the techniques of measure theory to evaluate integrals.	

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	1	2
CO2	3	2	2	2	2
CO3	3	3	2	1	2
CO4	3	2	1	2	2
CO5	3	2	2	1	1

Semester	**III**	Course Code	**24MATP0313**
Course Title	**Probability and Statistics**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	Revised Course	If revised, Percentage of Revision effected (Minimum 20%)	40%
Category	**Core Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• K1: Knowing the concepts of probability, random variables, and distribution • K2: Understanding the properties of moment generating functions • K3: Applying central limit theorem for limiting problems in statistics • K4: Analyzing various probability distributions • K5: Evaluating estimations through various methods		
Course Objective	The Course aims to learn the advanced theory of probability and some statistical techniques.		

Unit	Content	No. of. Hours
I	Random variables and its Distributions: Introduction-Random Variable-Types of Random Variables-Probability Mass Function, Probability Density Function and Probability Distribution- Distribution Function-Functions of Random Variables and their Distributions.	12
II	Expectation, Variance and Other Moments of Random Variable : Introduction-Expected value of a random variable-Properties of expected value-Conditional Expectation-Variance and covariance of Random variables-Properties of variance-Conditional Variance-Theorems on Mean and Variance : Cauchy-Schwartz Inequality-Chebyshev's Inequality-Marko's Inequality-Moments of Random variable-Moment Generating function-Factorial Moment Generating function- Joint Moment Generating function-	14

	Characteristics of Moment Generating function-Cumulant and Cumulant Moment Generating function- Properties of Moment Generating function-Characteristic function- Characteristic function of k-dimensional random variables-Properties of Characteristic function.	
III	Convergence in probability-Weak Law of Large number-Strong Law of Large Numbers-Central Limit Theorem-Binomial distribution: Definition and origin-First four moments of the Binomial distribution-Generating functions of the Binomial distribution- Applications of Binomial distribution-Poisson distribution: Definition and applications-First four moments of the Poisson distribution-Generating functions of the Poisson distribution-Fitting of Poisson distribution-Normal distribution: Definition and remarks-Moments and Generating functions of Normal distribution-Fitting of Normal distribution-Properties of Normal distribution.	13
IV	Method of Estimation: Introduction-Maximum Likelihood (ML) Method-Properties of ML Estimators-Method of Least Squares-Properties of Least squares Estimator-Method of Moment-Method of Minimum Chi-square-Bayes method of Estimation.	12
V	Interval Estimation: Introduction-Method of construction of Confidence Interval- Pivotal-Method to find Confidence Interval-Confidence interval using large sample-Statistical Method of Confidence Interval-Confidence interval using Chebyshev's Inequality-Uniformly most accurate (UMA) Confidence Interval-Unbiased Confidence Interval-Confidence interval for the difference of two Means-Confidence interval for the Difference of two proportions.	13
References	**Text Book:** 1. K. C. Bhuyan, **Probability Distribution Theory and Statistical Inference**, New Central Book Agency Pvt. Ltd., London, 2015. Unit.1 Section 2.1-2.6, Unit.2 Section 3.1-3.19 (Except 3.15, 3.16) Unit.3 Section 3.21-3.24, Section 7.1-7.4, 8.1-8.4-16.1-16.3, 16.5 Unit.4 Section 33.1-33.8. Unit.5 Section 35.1-35.6.	
	Reference Books: 1. Robert V. Hogg & Allen T. Craig, **Introduction to Mathematical Statistics**, 7th Edition, Pearson Education, Singapore, 2012. 2. Irwin Miller & Marylees Miller, **John E. Freund's Mathematical Statistics**, 8th Edition, Pearson Education, New Delhi, 2013. 3. John E. Freund, **Mathematical Statistics**, 5th edition, Prentice Hall India, 1994. 4. S.M. Ross, **Introduction to Probability Models**, Academic Press, India, 2014.	

	E-Recourses: 1. https://onlinecourses.nptel.ac.in/noc18_ma19 2. https://onlinecourses.nptel.ac.in/noc18_ma22
Course Outcomes	On completion of the course students should be able to CO1: Explain the basic concepts of probability and its properties. CO2: Construct the probability distribution of a random variable, based on a real-world situation, and use it to compute expectation and variance. CO3: Compute probabilities based on practical situations using the binomial, normal and other distributions. CO4: Evaluate the limiting process of distributions and solve related problems. CO5: Constructing confidence intervals for ML estimators

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	2	2	2
CO2	1	3	1	3	2
CO3	2	3	2	2	2
CO4	2	3	1	2	2
CO5	1	3	1	2	2

Semester	III	Course Code	**24MATP0314**
Course Title	**Optimization Techniques**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	Revised Course	If revised, Percentage of Revision effected (Minimum 20%)	30%
Category	Core Course		
Scope of the Course	• Advanced Skill • Entrepreneurship		

Cognitive Levels addressed by the course	• Knowing the basic properties of convex function, Linear and non-linear programming Fibonacci method – Golden Section Method, Multi-dimensional constrained optimization and Dynamic Programming (K1). • Understanding the cutting plane method, Transportation and Assignment problems, direct root method, Hooks and Jeeves method (K2). • Applying the Revised simplex method – Duality concept – Dual simplex methods to solve linear programming problems. Applying Lagrange's multiplier method – Kuhn- Tucker conditions to solve the constrained non-linear programming problems (K3). • Testing whether the solution is unique or not for one dimensional optimization using convexity (K4). • Investigating the Non-linear programming problems in different type of optimizations methods (K5). • Formulating some new iterative algorithms to solve Non-linear programming problems by using classical differential calculus(K6).	
Course Objective	The Course aims to impart the mathematical modelling skills through different methods of optimization.	
Unit	Content	No. of. Hours
I	Introduction to convex set and convex function – Linear Programming problems: Simplex method – Revised simplex method – Duality concept – Dual simplex method.	14
II	Integer Linear Programming: Branch – and Bound method – cutting plane method – Zero – one integer problem – Transportation and Assignment problems.	14
III	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
IV	Non- linear programming and optimization: Multivariable constrained optimization with equality constraints - constrained optimization with inequality constraints – Kuhn-Tucker conditions with non - negative constraints – quadratic programming problem - Wolfe's modified simplex method – Beal's method.	12
V	Dynamic Programming: Characteristics of Dynamic programming problems – Solving LLP by Dynamic Programming - Separable Programming Algorithm - Geometric programming - Geometric - Arithmetic mean inequality.	12

<table>
<tr><td rowspan="3">References</td><td>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 25 (Sections 25.6, 25.7), Chapter 26 (Sections 26.2, 26.5)
Unit 5: Chapter 15 (Sections 15.1, 15.6)
Chapter 25 (Section 26.7), Chapter 26 (Section 27.1)</td></tr>
<tr><td>Reference Books:
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.
3. Frederick S. Hillier, Gerald J. Lieberman, Bodhibroto Nag, Preetam Basu, Introduction to Operations Research, 11th Ed, Tata McGraw Hill, 2021.</td></tr>
<tr><td>E- Resources:
1. http://nptel.ac.in/courses/111107104/</td></tr>
<tr><td>Course Outcomes</td><td>On completion of the course students should be able to do
CO1: Formulate Linear Programming problems and determine its solutions CO2: Discuss Integer Linear Programming problems
CO3: Compute one dimensional optimization and Multidimensional unconstrained optimization problems
CO4: Apply Multi-dimensional constrained optimization problems in Industries.
CO5: Expertise in solving Geometric and Dynamic Programming problems</td></tr>
</table>

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	1	3	2	3	3
CO2	1	3	2	3	3
CO3	2	3	2	3	3
CO4	1	3	2	3	3
CO5	2	3	2	3	3

Semester	**IV**	Course Code	24MATP0415
Course Title	**Stochastic Processes**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	20%
Category	**Core Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Knowing about the stochastic processes, higher transition probabilities and stochastic processes in queuing systems (Knowing-K1) • Understanding the in-depth knowledge about stationary stochastic processes and Markov chains. (Understanding - K2) • Applying the concept of Markov processes to real life problems. (Applying – K3) • Analyses the solving technique for stochastic processes in queuing systems. (Analysing – K4) • Create new problems in queuing theory models. (Creating – K6)		
Course Objective	The Course aims to introduce a wide variety of stochastic processes and their applications.		

Unit	**Content**	**No. of. Hours**
I	Random variables and stochastic processes: Generating functions - Stochastic processes: An Introduction - Markov chains: Definition and examples - Higher transition probabilities-Generalization of independent Bernoulli trials: sequence of chain - dependent trials-Classification of states and chains - Determination of higher transition probabilities.	13
II	Markov process with discrete state space: Poisson process and its extensions - Poisson process - Poisson process and related distributions - Generalizations of Poisson process - Birth and death processes.	13
III	Markov processes with continuous state space: Introduction - Brownian motion - Weiner process - Differential equations for a Wiener Process - Kolmogrov equations - First passage time distribution for Weiner process - Ornstein - Uhlenbech process.	13
IV	Branching Processes: Introduction – Properties of generating functions of Branching processes – Distribution of the total number of progeny – Continuous –Time Markov branching process.	13
V	Applications in stochastic models: Queueing systems and models – Birth and death processes in queueing theory: Markovian models – Reliability models.	12
References	**Text Book:** 1. J. Medhi, **Stochastic Processes**, New Age International Private limited, New Delhi, 4th Edition, 2017. Unit 1: Chapter 1: Sections 1.1 & 1.5, Chapter 2: Sections 2.1- 2.5.	

	Unit 2: Chapter 3: Sections 3.1 - 3.4. Unit 3: Chapter 4: Sections 4.1 - 4.6. Unit 4: Chapter 9: Sections 9.1, 9.2, 9.4, 9.7. Unit 5: Chapter 10: Sections 10.1, 10.2, 10.5.
	Reference Books: 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, 2011. 3. G. Grimmett& D. Stirzaker, **Probability and Random Processes**, 3rd Ed., Oxford University Press, New York, 2001.
	E-Recourses: 1. https://nptel.ac.in/courses/111102014/ 2. https://nptel.ac.in/courses/111103022/ 3. https://onlinecourses.nptel.ac.in/noc18_ma19
Course Outcomes	On completion of the course students should be able to do CO1: Discuss about Stationary Stochastic Processes and Markov chains. CO2: Distinguish the Markov Process with discrete state space and continuous state space CO3: Demonstrate Brownian Motions and its properties CO4: Outline branching processes and age dependent branching process CO5: Apply stochastic processes in queuing systems

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	2	3
CO2	2	2	2	3	2
CO3	2	2	3	2	2
CO4	1	2	2	3	3
CO5	2	3	2	3	3

Semester	**IV**	Course Code	**24MATP0416**
Course Title	**Functional Analysis**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Core Course**		
Scope of the Course	Advanced Skill		

Cognitive Levels addressed by the course	• Know the concept of normed linear spaces, bounded linear operators, the difference between Schauder basis and Hamel basis, separability (K1). • Understand the importance of normed linear spaces, Hiene-Borel theorem and Riesz lemma, Hahn-Banach extension theorem (K2). • Apply the concept of norm in various other fields of Mathematics (K3). • Analyse the boundedness of different kinds of operators (K4). • Evaluate the norm of different kinds of operators (K5). • Create new theoretical concept (K6).	
Course Objective	The Course aims to introduce basics of functional analysis with special emphasis on Hilbert and Banach space theory.	
Unit	**Content**	**No. of. Hours**
I	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
II	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
III	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
IV	Hahn-Banach theorem and its consequences - The extension theorem- Consequences on uniqueness of extension - Separation theorem	12
V	Uniform boundedness principle - Its consequences - Closed graph theorem and its consequences - Bounded inverse theorem - Open mapping theorem - A stability result for operator equations.	12
References	**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.	
	Reference Books: 1. G. F. Simmons, **Introduction to Topology and Modern Analysis**, Tata McGraw-Hill Education Pvt. Ltd., New Delhi, 2016. 2. H. Siddiqi, **Functional Analysis with Applications**, Tata McGraw-Hill Pub., New Delhi, 1986. 3. S. Ponnusamy, **Foundations of Functional Analysis**, Narosa Publishing House, New Delhi, 2008.	

	4. Kreyszig, **Introductory Functional Analysis with Applications**, John Wiley & Sons, New York, 2006. 5. S. Kesavan, **Functional Analysis**, 2^{nd} Edition, Hindustan Book Agency, 2022. 6. Rami Shakarchi, **Functional Analysis**, Princeton Lectures in Analysis, 2013.
	E-Recourses: 1. https://nptel.ac.in/courses/111/106/111106147/
Course Outcomes	On completion of the course students should be able to do CO1: Outline the normed linear spaces and Banach spaces CO2: Discuss about the completion of normed linear spaces CO3: Apply various operators on Banach spaces CO4: Demonstrate the consequences of Hahn-Banach theorem CO5: Critique the closed graph theorem and stability result for operator

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	2
CO2	3	2	2	3	2
CO3	3	2	3	3	2
CO4	3	2	3	2	2
CO5	3	3	2	2	2

Semester	**IV**	Course Code	**24MATP0417**
Course Title	**GRAPH THEORY**		
No. of. Credits	4	No. of. contact hours per week	4
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Core Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Knowing different types of graphs (K1) • Understanding connectivity, independent sets and matching of graphs (K2) • Applying graph coloring and planarity to study the properties of graphs (K4) • Examining various bounds on domination number of graphs (K5)		
Course Objective	The course aims to impart the different concepts of theory of graphs.		
Unit	**Content**		**No. of. Hours**

I	Basic results - Basic concepts - Sub graphs - Degrees of vertices - Paths and connectedness - Automorphism of simple graphs – line graphs - Operations on graphs.	14
II	Connectivity - Vertex cut and edge cut - Connectivity and edge connectivity. Trees – Definition - Characterization and simple properties - Counting the number of spanning trees - Cayley's formula-Application: Prism's Algorithm-Dijsktra Algorithm	12
III	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
IV	Graph Colorings: Introduction - Vertex colorings - Critical graphs. Planarity: Introduction - Planar and Non Planar graphs - Euler formula and its consequences - K5 and K3,3 are non- planar.	12
V	Dominating sets in graphs - Bounds on the domination number - Bounds in terms of order, Degree and packing	13
References	Text Books: 1. R. Balakrishnan & K. Ranganathan, **A Text Book of Graph Theory**, Springer-Verlag New York, 2000. Unit 1: Chapter I: Sections:1.0 – 1.7 Unit 2: Chapter III : Sections: 3.0 – 3.2 ; Chapter IV: Sections: 4.0 – 4.2,4.4-4.5 4.7 Unit 3: Chapter V : Sections : 5.0 – 5.3 ; Chapter VI : Sections: 6.0 – 6.2; Chapter VII: 7.9 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: 2.1-2.2	
	Reference Books: 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., New York, 1976.	
	E-Recourses: 1. https://nptel.ac.in/courses/111/106/111106050/ 2. https://nptel.ac.in/courses/111/106/111106102/	
Course Outcomes	On completion of the course students should be able to do CO1: Identify various operations on graphs. CO2: Classify different types of graphs and their applications. CO3: Analyse the applications of different parameters of a graph. CO4: Predict the domination number and apply in real life problems. CO5: Compare different types of graphs and study its properties.	

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	1	3
CO2	1	3	2	3	2
CO3	2	3	3	2	2
CO4	3	2	1	3	3
CO5	3	3	3	2	1

Semester	**III**	Course Code	**24MATP03D1**
Course Title	**Classical Dynamics**		
No. of. Credits	3	No. of. contact hours per week	3
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Discipline Centric Elective**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• To know the concepts of mechanical system, potential and kinetic energies, Lagrangian function and momentum, generating functions, Hamilton - Jacobi equation (K1) • Understanding how to formulate differential equations of motion of a system and to solve by variational principle, Hamilton's principle, and the derivation of HJB equations (K2, K3) • Lagrange's equations apply to solve physical problems and the Hamilton–Jacobi method employees to solve problems of differential equation in three-dimensional space (K3) • To analyse about the variational principles, differential forms, generating functions, canonical transformations, and special transformations (K4)		
Course Objective	The Course aims to study the system dynamics via non-relativistic theories and methods.		

Unit	Content	No. of. Hours
I	Introductory Concepts: The mechanical system - Generalized coordinates - Constraints - Virtual work - Energy and momentum.	10
II	Lagrange's equations: Derivation of Lagrange's equations - Examples - Integrals of the motion.	10
III	Hamilton's Equations: Hamilton's principle – Hamilton's equations.	10

IV	Hamilton - Jacobi theory: Hamilton's principal function - The Hamilton - Jacobi equation.	9
V	Canonical Transformations: Differential forms and generating functions - Lagrange and Poisson brackets.	9
References	**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 4.2 Unit 4: Sections 5.1 to 5.2 Unit 5: Sections 6.1 & 6.3. **Reference Books:** 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**, Addison Wesley, USA, 2002. **E-Recourses:** 1. http://www.damtp.Cam.ac.uk/user/tong/dynamics.html	
Course Outcomes	On completion of the course students should be able to do CO1: Discuss the basic concepts of nonrelativistic classical dynamics CO2: Apply Lagrange's equations to solve related mechanical problems CO3: Analyse variational principle, Hamilton principle and Hamilton's equations CO4: Explain the derivation and application of Hamilton-Jacobi Equations CO5: Demonstrate the canonical transformations, Lagrange and Poisson brackets expressions	

Mapping of COs with POs

CO \ PO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	3	2	3
CO2	3	3	2	2	3
CO3	3	3	2	1	3
CO4	1	3	2	2	2
CO5	2	2	1	3	3

Semester	**III**	Course Code	**24MATP03D2**
Course Title	**Control Theory**		
No. of. Credits	3	No. of. contact hours per week	3
New Course/ Revised	--	If revised, Percentage of Revision effected	--

Course		(Minimum 20%)	
Category	**Discipline Centric Elective**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Learning to know observability, controllability, stability problems of linear and nonlinear control systems (K1) • Understanding to design controllability and observability Gramian matrix for the linear and nonlinear system (K2) • Apply the stability and stabilization for the various linear and nonlinear physical systems (K3) • To analyse the uniform stability, asymptotic stability and optimal control of linear time varying, perturbed system and nonlinear systems. (K4) • To design stabilization via linear feedback control for the unstable system (K6)		
Course Objective	The Course aims to introduce basic theories and methodologies required for analysing and designing advanced control systems.		

Unit	Content	No. of. Hours
I	Observability: Linear systems – Observability Grammian – Constant coefficient systems – Reconstruction kernel – Nonlinear Systems	10
II	Controllability: Linear systems – Controllability Grammian – Adjoint systems – Constant coefficient systems – Steering function – Nonlinear systems	10
III	Stability: Stability – Uniform stability – Asymptotic stability of linear Systems - Linear time varying systems – Perturbed linear systems – Nonlinear systems.	10
IV	Stabilizability: Stabilization via linear feedback control – Bass method – Controllable subspace –Stabilization with restricted feedback.	9
V	Optimal Control: Linear time varying systems with quadratic performance criteria – Matrix Riccati equation – Linear time invariant systems – Nonlinear Systems	9

References	**Text Book:** 1. K. Balachandran & J. P. Dauer, **Elements of Control Theory,** Narosa, New Delhi, 1999.
	Reference Books: 1. R. Conti, **Linear Differential Equations and Control**, Academic Press, London, 1976. 2. R.F. Curtain and A.J. Pritchard, **Functional Analysis and Modern Applied Mathematics**, Academic Press, New York, 1977. 3. J. Klamka, **Controllability of Dynamical Systems**, Kluwer Academic Publisher, Dordrecht, 1991.
	E-Recourses: 1. https://ocw.mit.edu/resources/res-6-010-electronic-feedback-systems-spring-2013/ course-videos/ 2. https://nptel.ac.in/courses/108101037/

Course Outcomes	On completion of the course students should be able to do CO1: Analyse linear and nonlinear control systems CO2: Evaluate observability problems of linear and nonlinear systems CO3: Analyse the stability of linear and nonlinear systems CO4: Apply the stability theory in control systems CO5: Model the optimal control problems in science & engineering

Mapping of COs with POs

CO \ PO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	1	2	2
CO2	3	2	1	2	3
CO3	1	2	1	3	2
CO4	3	2	1	2	3
CO5	2	1	3	1	3

Semester	**III**	Course Code	**24MATP03D3**
Course Title	**Optimal Control**		
No. of. Credits	3	No. of. contact hours per week	3
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Discipline Centric Elective**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Learning to know optimal of a function/functional, basic variational problems, estrema of functions/functionals, (K1) • Understanding to design matrix Riccati equation, Pontryagin minimum principle, HJB equation (K2) • LQR problem using HJB equation, Fuel optimal control system (K3) • To analyse the constrained optimal control (K4) • To design optimal control of system using dynamic programming (K6)		
Course Objective	The Course aims to introduce basic theories and methodologies required for analyzing and designing optimal control of dynamical systems.		

Unit	**Content**	**No. of. Hours**
I	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.	10

II	Extrema of Functional with conditions-Variational approach to optimal control systems: Terminal Cost Problem-Different Types of Systems-Sufficient Condition- Summary of variational approach.	10
III	Problem Formulation - Finite –Time Linear Quadratic Regulator-Analytic Solution to the Matrix Differential Riccatic Equation-Infinite- Time LQR System.	9
IV	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.	10
V	Constrained Optimal Control-TOC of a Double Integral System- Fuel-Optimal Control Systems.	9
References	**Text Book:** 1. D. S. Naidu: **Optimal Control Systems**, CRC Press, 2002. Unit 1: Chapter 2: Section: 2.1-2.3, 2.5 Unit 2: Chapter 2: Sections: 2.6-2.8 Unit 3: Chapter 3: Sections: 3.1-3.4 Unit 4: Chapter 6: Sections: 6.1-6.4 (except 6.3.3) Unit 5: Chapter 7: Sections: 7.1-7.3	
	Reference Books: 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.	
	E-Recourses: 1. https://onlinecourses.nptel.ac.in/noc17_ee11/preview 2. http://nptel.ac.in/syllabus/101108057/	
Course Outcomes	On completion of the course students should be able to do CO1: Determine the solutions of control system via Euler – Lagrange equation CO2: Apply calculus of variations to solve the linear and nonlinear optimalcontrol systems CO3: Outline the Linear Quadratic Optimal Control Systems CO4: Employ Pontryagin Minimum principle for solving optimal control systems CO5: Evaluate the solutions of constrained optimal control problems	

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	1	2	2
CO2	3	2	3	2	3
CO3	2	2	3	3	2
CO4	3	2	3	2	3
CO5	2	3	3	2	3

Semester	**III**	Course Code	**24MATP03D4**
Course Title	**Fractal Analysis**		
No. of. Credits	3	No. of. contact hours per week	3
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Discipline Centric Elective**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Knowing the Basic set theory, Functions and limits, Measures and mass distributions, Properties and problems of box-counting dimension (K1). • Understanding the Hausdorff measure, Hausdorff dimension, Calculation of Hausdorff dimension and Techniques for calculating dimensions, self-similar and self-affine sets, and examples of number theory (K2). • Applying the 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 (K3). • Recognize the concepts of fractal and Julia sets (K4). • Investigating the product and intersection of fractals and Newton's method for solving polynomial equations (K5).		
Course Objective	The Course aims to introduce the basic mathematical techniques of fractal geometry for diverse applications.		

Unit	**Content**	**No. of. Hours**
I	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.	10
II	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 method.	10
III	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.	10
IV	Iterated function systems—self-similar and self-affine sets: Iterated function systems- Dimensions of self-similar sets- Some variations- Self-affine sets-	9

	Applications to encoding images-Zeta functions and complex dimensions. Examples from number theory: Distribution of digits of numbers- Continued fractions- Diophantine approximation.	
V	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.	9
References	**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, 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.	
	Reference Books: 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.	
	E-Recourses:	
Course Outcomes	On completion of the course students should be able to do CO1: Outline the basic concepts of measure and box-counting dimension. CO2: Identify the Hausdorff and packing measures and dimensions. CO3: Determine the product and intersection of fractals. CO4: Explain the self-similar and self-affine sets, and examples of number theory. CO5: Analyse the concepts of fractal and Julia sets.	

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	1	3	2	3	3
CO3	3	3	1	3	2
CO4	2	3	3	3	3
CO5	3	2	1	3	3

Semester	**II**	Course Code	24MAT P04D5
Course Title	**Coding Theory**		
No. of. Credits	3	No. of. contact hours per week	3
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Discipline Centric Elective**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Describing the fundamentals of error detection, correction and decoding techniques in communication channels (K1 – Knowing) • Estimate the various bounds for the linear codes and explain the Hamming codes, Golay codes (K2 – Understanding) • Applying Syndrome decoding technique to decode linear codes (K3- Applying) • Constructing BCH codes using generator polynomials, generating matrix and parity check matrix (K6-Create)		
Course Objective	The Course aims to introduce the elements of coding theory and its applications		

Unit	Content	No. of. Hours
I	Error detection, correction and decoding: Communication channels – Maximum likelihood decoding – Hamming distance – Nearest neighbourhood minimum distance decoding – Distance of a code.	10
II	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.	10
III	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.	10
IV	Cyclic codes: Definitions – Generator polynomials – Generator matrix and parity check matrix – Decoding of Cyclic codes.	9
V	Special cyclic codes: BCH codes – Parameters of BCH codes – Decoding of BCH codes – Reed Solomon codes.	9
References	**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.	

	Reference Books: 1. S. Lin &D. J. Costello, Jr.**, Error Control Coding: Fundamentals and Applications**, Prentice-Hall, Inc., New Jersey, 1983.Vera Pless**, Introduction to the Theory of Error Correcting Codes**, Wiley, New York, 1982. 2. E. R Berlekamp, **Algebriac Coding Theory**, Mc Graw-Hill, 1968. 3. H. Hill**, A First Course in Coding Theory**, OUP, 1986.
	E-Recourses: https://nptel.ac.in/courses/117106031
Course Outcomes	On completion of the course students should be able to do CO1: Discuss the basic concepts of coding theory. CO2: Analyse the importance of finite fields in the design of codes. CO3: Predict and correct the errors occur in communication channels with the help of methods of coding theory. CO4: Apply the tools of linear algebra to construct special type of codes. CO5: Apply algebraic techniques in designing efficient and reliable data transmission methods.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	3	2
CO2	3	3	3	1	3
CO3	3	3	3	2	2
CO4	3	3	3	2	1
CO5	3	3	1	3	2

Semester	**III**	Course Code	24MATP03M1
Course Title	**Field Theory**		
No. of. Credits	2	No. of. contact hours per week	2
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Modular Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Recognize some advances in fields and Galois theory (K1- Remember) • Understand splitting fields and finite fields (K2 – Understanding) • Describe the Galois groups and solvability of groups (K1- Remember)		

Course Objective	The course aims to introduce the elements of extension fields, finite fields and Galois theory	
Unit	**Content**	**No. of. Hours**
I	Extension fields – Algebraic extensions - Roots of polynomials – Remainder theorem – Splitting fields - More about roots – Simple extension - Finite fields.	16
II	The elements of Galois theory – Galois group – Theorem on Symmetric polynomials – Normal Extension – Fundamental theorem of Galois theory - Solvability by radicals – Solvability of groups -Abel's theorem - Galois group over the rationals.	16
References	**Text Book:** I. N. Herstein, **Topics in Algebra**, 2nd edition, John Wiley & Sons, Singapore, 2006. Unit 1: Chapter 5: Sections 5.1, 5.3, 5.5 & Chapter 7: Section 7.1 Unit 2: Chapter 5: Sections 5.6, 5.7, 5.8.	
	Reference Books: 1. John. B. Fraleigh, **A First Course in Abstract Algebra**, 7th Edition, Addison-Wesley, New Delhi, 2003. 2. Steven Roman, **Field Theory**, Springer, New York, 1995. 3. John M. Howie, **Fields and Galois Theory**, Springer Verlag, London, 2006. 4. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul, **Basic Abstract Algebra**, Cambridge University Press, USA, 1986. 5. D. S. Dummit & R. M. Foote, **Abstract Algebra,** John Wiley, New York, 1999.	
	E-Recourses: https://nptel.ac.in/courses/111106145	
Course Outcomes	On completion of the course students should be able to CO1: understand the extension fields and related results CO2: explain the Galois groups and solvability by radicals CO3: classify the finite fields	

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	1	3	2	2	3
CO2	2	1	3	1	2
CO3	2	2	2	3	1

Semester	**III**	Course Code	**24MATP03M2**
Course Title	**Wavelet Analysis**		
No. of. Credits	3	No. of. contact hours per week	3
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--

Category	**Modular Course**	
Scope of the Course	Advanced Skill	
Cognitive Levels addressed by the course	• K-1. Knowing the basic concepts of Wavelets, Approximation and the Perception of Reality, Information Gained from Measurement, Functions and their Representations, Multi-resolution Representation, Positional Notation for Numbers, Music Notation as a Metaphor for Wavelet Series, Wavelet Phase Space. • K-2. Identifying the Algebra and Geometry of Wavelet Matrices, Wavelet Matrices-Haar Wavelet Matrices, The Algebraic and Geometric structure of the Space of Wavelet Matrices. • K-3. Classifying One-Dimensional Wavelet Systems such as the Scaling Equation and Wavelet Systems. Investigating Multi-wavelets and Lifting. • K-4. Realizing the Examples of One-Dimensional Wavelet Systems with Universal Scaling Functions • K-5. Recognizing the concepts of Higher-Dimensional Wavelet Systems and Understanding Compression.	
Course Objective	The Course aims to impart skills in the various applications of wavelet analysis.	
Unit	**Content**	**No. of. Hours**
I	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.	16
II	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- One-Dimensional Wavelet Systems: Introduction-The Scaling Equation-Wavelet Systems-Recent Developments: Multiwavelets and Lifting.	16
References	**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.	

	Reference Books: 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.
	E-Recourses: https://web.iitd.ac.in/~sumeet/WaveletTutorial.pdf
Course Outcomes	On completion of the course students should be able to do CO1: Describe the basic concepts of Wavelets CO2: Identify the Algebra and Geometry of Wavelet Matrices CO3: Classify One-Dimensional Wavelet Systems CO4: Determine the solutions of One-Dimensional Wavelet Systems CO5: Analyze the concepts of Higher-Dimensional Wavelet Systems

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	2	3	1
CO2	1	3	3	1	3
CO3	3	2	1	3	3
CO4	2	1	2	2	3
CO5	2	3	2	3	2

Semester	**IV**	Course Code	**24MATP04M3**
Course Title	**Introduction to SciLab**		
No. of. Credits	3	No. of. contact hours per week	3
New Course/ Revised Course	New Course	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Modular Course**		
Scope of the Course	Skill Development		
Cognitive Levels addressed by the course	• Remembering basic tools on SciLab(K-1) • Creating real variables, complex numbers and matrices (K-6) • Computing matrix operations (K-5) • Creating 2D graphs using functions (K-6)		
Course Objective	The Course aims to make an overview of Scilab features.		

Unit	Content	No. of. Hours
I	Overview of Scilab- How to get started with Scilab - Getting help from Scilab demonstrations and macros – The Console – The Editor – Batch Processing- Creating Real Variables - Elementary mathematical functions – Booleans – Complex Numbers – Integers – Floating Points – Strings – Dynamic Variables- Matrices – Create Matrices of Real Variables – Accessing Elements of Matrices- Matrices are dynamic – Elementwise Operations- Conjugate transpose and non-conjugate transpose - Multiplication of two vectors Comparing two real matrices - Issues with floating point integers - More on elementary functions - Higher-level linear algebra features	16
II	Looping and branching: The if , select , for and while break and continue statements- Functions - Defining functions - Function libraries - Managing output arguments- Levels in the call stack - The return statement - Debugging functions with pause - Plotting - 2D plot - Contour plots - Titles, axes and legends - Export.	16
References	**Text Book:** 1. Michael Baudin, **Introduction to Scilab**, The Scilab Consortium, Digiteo, 2010.	
	Reference Books: 1. Stephen L. Campbell, Jean-Philippe Chancelier, Ramine Nikoukhah, **Modeling and Simulation in Scilab/Scicos with Scicos Lab** 4.4, Springer-Verlag New York, 2006. 2. Eike Rietsch, **An Introduction to Scilab from a Matlab User's Point of View**, INRIA, France, 2010.	
	E-Recourses: 1. http://www.openeering.com/scilab_tutorials	
Course Outcomes	On completion of the course students should be able to CO1: perform arithmetic operations on real numbers, complex numbers and matrices CO2: solve system of linear equations CO3: construct loop and functions for iterative problems CO4: apply SciLab tools in numerical simulations of mathematical modelling CO5: plot graph of functions	

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	3	3
CO2	3	2	2	3	2
CO3	3	1	3	2	1
CO4	2	3	2	2	3
CO5	3	1	2	3	2

Semester	**IV**	Course Code	**24MATP04M4**
Course Title	**Neural Networks**		
No. of. Credits	3	No. of. contact hours per week	3
New Course/ Revised Course	--	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	**Modular Course**		
Scope of the Course	Advanced Skill		
Cognitive Levels addressed by the course	• Know the concept of Neural Network and its various types, Functioning of artificial neural network and Neuron modelling. • Understand the concept of Dynamic Neural Units, Models, and circuits of isolated DNUs.		
Course Objective	The Course aims to introduce the main fundamental principles and techniques of neural network systems and investigate the principal neural network models and applications.		
Unit	**Content**		**No. of. Hours**
I	Architectures: Introduction to Neural Network-Applications of neural network-Biological neural networks-Artificial neural networks-Functioning of artificial neural network-Neuron modelling.		16
II	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
References	**Text Book:** 1. A. Anto Spiritus Kingsly, **Neural network and fuzzy logic control**, Anuradha Publications, Chennai, 2009. 2. Madan M. Gupta, Liang Jin & Noriyasu Homma, **Static and dynamic neural networks**, A John Wiley and sons, INC., Publication, 2003. Unit 1: Chapters 1: Sections: 1.1—1.6.2 –Text book 1 Unit 2: Chapters 8: Sections: 8.1—8.3—Text book 2		
	Reference Book: **1.** James A. Anderson, **An Introduction to Neural Networks**, The MIT Press, Cambridge 1995		
	E-Recourses: https://www.cs.jhu.edu/~phi/ai/slides-2019/lecture-neural-networks.pdf		
Course Outcomes	On completion of the course students should be able to do CO1: Explain various types of neural networks and its implementations CO2: Design nonlinear models and dynamics of neurons CO3: Analyze Neural Networks and its applications in information theory		

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	1	2	2
CO2	3	2	1	2	3
CO3	2	3	1	2	2

Semester	**II**	Course Code	**24MATPO2VA1**
Course Title	**Numerical Methods For Engineers**		
No. of. Credits	**2**	No. of. contact hours per week	**2**
New Course/ Revised Course	New Course	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	Valued Added Course		
Scope of the Course	• Skill Development		
Cognitive Levels addressed by the course	• Remembering the basic rules of finding the square and square root of numbers (K-1) • Understanding the Vedic Sutras and apply them to find Square and square root of numbers. (K-2 & K-3) • Remembering the basic rules of finding the cube and cubic root of numbers (K-1) • Understanding the Vedic Sutras and apply them to find Cube and Cubic root of numbers. (K-2 & K-3)		
Course Objective	The Course aims to impart skills on solving numerical problems.		

Unit	Content	No. of. Hours
I	Introduction & Approximations : Motivation and Applications- Accuracy and precision-Truncation and round-off errors- Binary Number System- Error propagation- Linear Systems and Equations - Matrix representation- Cramer's rule- Gauss Elimination- Matrix Inversion- LU Decomposition-Linear Systems and Equations - Iterative Methods- Relaxation Methods- Eigen Values.	16
II	Algebraic Equations: Bracketing Methods -Introduction to Algebraic Equations-Bracketing methods: Bisection, Reguli-Falsi- Algebraic Equations: Open Methods Secant- Fixed point iteration- Newton-Raphson- Multivariate Newton's method-Numerical Differentiation-Numerical differentiation- error analysis- higher order formulae - Integration and Integral Equations Trapezoidal rules-Simpson's rules- Quadrature.	16

References	**Text Book:** 1. S. K. Gupta, **Numerical Methods for Engineers,** New Age International, 1995
	Reference Book: 1. S.C. Chapra and R. P. Canale, **Numerical Methods for Engineers,** 5th Ed., McGraw Hill, 2006.
	E- Resources: 1. https://nptel.ac.in/courses/127/106/127106019/
Course Outcomes	On completion of the course students should be able to CO1: solve system of equations using various methods CO2: solve algebraic equations using various methods CO3: compute differentiation and integration approximately.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	1	2	3
CO2	1	1	2	3	2
CO3	2	2	1	2	3

Semester	**II**	Course Code	24MATP02VA2
Course Title	**Mathematics For Competitive Examinations**		
No. of. Credits	**2**	No. of. contact hours per week	**2**
New Course/ Revised Course	New Course	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	Valued Added Course		
Scope of the Course	• Skill Development		
Cognitive Levels addressed by the course	• Remembering the basic rules of number system and fractions and apply them to solve simplification problems (K-1 & K-3) • Understanding the Polynomials, quadradic equations, sequence and series and apply them to solve problems in competitive exams. (K-2 & K-3) • Analyse profit /loss in a particular investment (K-4) • Understanding the Vedic Sutras and apply them to find Cube and Cubic root of numbers. (K-2 & K-3)		
Course Objective	The Course aims to impart skills on solving numerical problems.		

Unit	Content	No. of. Hours
I	Number system-Fraction-Simplification- Approximate values-Inequalities-Polynomials-Quadradic equations-Sequence and Series.	16
II	Average-Ratio and Proportions-Problems related to ages-Percentage-Profit and Loss-Partnership-Simple interest and Compound interest-Time and Work	16
References	**Text Book:** 1. Gautam Puri, **Quantitative Aptitude for Competitive Examinations**, G K Publications Pvt Ltd, Noida, 2017.	
	Reference Book: 1. R.S. Agarwal, **Quantitative Aptitude**, Revised and Enlarged Edition, S. Chand & Company Ltd., New Delhi, 2017.	
Course Outcomes	On completion of the course students should be able to CO1: solve problems related to number systems, fractions, inequalities and sequence and series. CO2: solve problems related to ratio and proportions, ages and percentage. CO3: Solve problems related to simple interest and compound interest and time and work.	

Mapping of COs with POs

CO \ PO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	1	2	3
CO2	1	2	2	1	2
CO3	1	2	1	2	3

Semester	II	Course Code	24MATP02VA3
Course Title	**Fuzzy Logic For Management Decision Making**		
No. of. Credits	2	No. of. contact hours per week	2
New Course/ Revised Course	New Course	If revised, Percentage of Revision effected (Minimum 20%)	--
Category	Value Added Course		
Scope of the Course	• Basic Skill		

<table>
<tr><td>Cognitive Levels addressed by the course</td><td colspan="2">Understanding various definitions of fuzzy sets, membership functions and identify.
basic standard operations such as complement, union, intersection, composition, and other operations in Fuzzy Set theory(K-1).
Applying fuzzy concepts to solve real life problems and using fuzzy relations to create fuzzy Graphs(K-3).
Deriving the characteristics and classifying the fuzzy relation(K-4).</td></tr>
<tr><td>Course Objective</td><td colspan="2">Describe the fuzzy logic and connectives, interface, propositions and quantifiers, the decision making, fuzzy ranking method, fuzzy linear programming problems.</td></tr>
<tr><td>Unit</td><td>Content</td><td>No. of. Hours</td></tr>
<tr><td>I</td><td>Fuzzy Logic: Fuzzy Logic and Fuzzy Propositions, Fuzzy Connectives, Fuzzy Interface, Fuzzy Propositions, Fuzzy Quantifiers.</td><td>16</td></tr>
<tr><td>II</td><td>Decision Making in Fuzzy Environment: Introduction, Individual Decision Making, Multiperson Decision Making, Multicriteria Decision Making, Fuzzy Ranking Method, Fuzzy Linear Programming.</td><td>16</td></tr>
<tr><td rowspan="2">References</td><td colspan="2">Text Book:
1. Sudhir K. Pundir, Rimple Pundir, Fuzzy Sets and Their Applications, 8th Edition, Pragati Prakashan Educational Publishers, Meerut, 2016,
Unit I: Chapter 7: Sections: 7.13-7.17
Unit II: Chapter 10: Sections: 10.1-10.6</td></tr>
<tr><td colspan="2">Reference Books:
1. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer, New York, 2005.
2. G. J. Klir and B. Yuan, Fuzzy Sets and Fuzzy Logic, Prentice-Hall India, 1995.</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">At the end of the course learner will be able to
CO1: Recognize the Concept of Fuzzy Sets and its Properties.
CO2: Compute Decision Making in Fuzzy Environment Problems.</td></tr>
</table>

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	2	1	3
CO2	1	2	3	1	1