DEPARTMENT OF MATHEMATICS

ANNA UNIVERSITY, CHENNAI

VISION

We, at the Department of Mathematics, Anna University, Chennai, shall strive constantly to

- Achieve excellence in the field of Computer Science and Information Technology with strong Mathematical foundation by providing high quality teaching, research and training in Computer Science and all related Engineering fields to our students where they can significantly contribute to our society in all aspects
- Contribute to the quality Personnel Development in Computer Science / Information Technology through our effective Masters Programmes

MISSION

- To provide determined computer science background to the students to hone their skills with best-in-class emerging technologies across the globe
- To imbibe a spirit of innovations in computers, information technologies and mathematical sciences
- To popularize and to project the proper perspective of Computer Science with essential Mathematical modelling by undertaking sponsored research and provide consultancy services in educational and industrial relevant areas

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M.Sc. MATHEMATICS (2 years)

REGULATIONS - 2023

CHOICE BASED CREDIT SYSTEM

1. **PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):**

I. To make the students in mastering in the fields of Mathematics and prepare them for higher research or to take up professional careers in Mathematical Science.

II. To provide the students with solid foundation in both fundamentals of Mathematics and modern Mathematical Theory with deeper insight on the powerful methods and techniques that can be used within Mathematics and its areas of applications.

III. To train students with logical and analytical thinking so as to comprehend, analyze, design and provide solutions for the real life problems.

IV. To inculcate the students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate Mathematical aspects to broader social context.

V. To provide students an academic environment to develop excellence in leadership qualities, practice ethical codes and guidelines, and achieve life-long learning needed for a successful professional career.

2. **PROGRAMME OUTCOMES (POs):**

After going through the two years of study, our Mathematics Post-Graduates will exhibit :

PO1: An ability to independently carry out research /investigation and development work to solve practical problems;

PO2: An ability to write and present a substantial technical report/document;

PO3: An ability to demonstrate a degree of mastery over Mathematics .The mastery is at a level higher than the requirements in the bachelor program of Mathematics;

PO4: An ability to continue professional development and learning as a life-long activity;

PO5: An ability to apply various tools and techniques to improve the efficiency of the system;

PO6: An ability to function in a multi-disciplinary team in a professional and ethical manner.

3. PEO / PO Mapping:

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
I	3	3	3	3	3	3
II	3	3	3	3	3	3
III	3	2	3	3	2	3
IV	3	3	3	3	3	3
V	3	3	3	3	3	2

4. Mapping of Course Outcome and Programme Outcome

		Course Name	PO01	PO02	PO03	PO04	PO05	PO06
YEAR 1	**Semester 1**	Abstract Algebra	**3**	**3**	**3**	**3**	2	2
		Real Analysis	3	3	3	3	2	2
		Ordinary Differential Equations	3	3	3	3	2	2
		Probability and Random Processes	2.4	2.2	2.4	2.2	2	-
		Graph Theory	3	3	3	2	3	3
		Object Oriented Programming and Data Structures	3	3	3	3	2	2
		Object Oriented Programming and Data Structures Laboratory	-	-	-	-	-	-
	Semester 2	Advanced Calculus	3	3	3	3	2	2
		Classical Mechanics	3	3	3	2	3	3
		Complex Analysis	3	3	3	3	2	2
		Linear Algebra	1.8	1.4	3	2.2	1.4	3
		Partial Differential Equations	3	3	3	3	2	2
		Mathematical Statistics	2.2	2.2	2.2	2.2	2.2	-
		Computational Laboratory	3	3	3	3	2	2
YEAR 2	**Semester 3**	Continuum Mechanics	3	2.8	3	3	2.6	3
		Functional Analysis	3	3	3	3	2	2
		Integral Transforms and Calculus of Variations	3	2.2	2.4	2	1	1
		Numerical Analysis	2	2	3	3	1.8	2
		Topology	3	3	3	3	2	2
		Elective I	3	3	3	3	2	2
		Computational Laboratory	-	-	-	-	-	-
	Semester 4	Elective II	3	3	3	3	2	2
		Elective III	3	3	3	3	2	2
		Project Work	3	3	3	3	2	2

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M.Sc. MATHEMATICS (2 years)

REGULATIONS - 2023

CHOICE BASED CREDIT SYSTEM

CURRICULUM AND SYLLABUS FOR SEMESTERS I TO IV

SEMESTER I

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MT3101	Abstract Algebra	PCC	4	4	0	0	4
2.	MT3102	Real Analysis	PCC	4	4	0	0	4
3.	MT3103	Ordinary Differential Equations	PCC	3	3	0	0	3
4.	MT3104	Probability and Random Processes	PCC	4	4	0	0	4
5.	MT3105	Graph Theory	PCC	3	3	0	0	3
6.	MT3106	Object Oriented Programming and Data Structures	PCC	3	3	0	0	3
PRACTICAL								
7.	MT3111	Object Oriented Programming and Data Structures Laboratory	PCC	4	0	0	4	2
			TOTAL	**25**	**21**	**0**	**4**	**23**

SEMESTER II

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MT3201	Advanced Calculus	PCC	3	3	0	0	3
2.	MT3202	Classical Mechanics	PCC	3	3	0	0	3
3.	MT3203	Complex Analysis	PCC	4	4	0	0	4
4.	MT3204	Linear Algebra	PCC	3	3	0	0	3
5.	MT3205	Partial Differential Equations	PCC	4	4	0	0	4
6.	MT3206	Mathematical Statistics	PCC	3	3	0	0	3
PRACTICAL								
7.	MT3211	Computational Laboratory using Python and R (Statistical Methods Laboratory)	PCC	4	0	0	4	2
			TOTAL	**24**	**20**	**0**	**4**	**22**

Attested

SEMESTER III

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MT3301	Continuum Mechanics	PCC	3	3	0	0	3
2.	MT3302	Functional Analysis	PCC	3	3	0	0	3
3.	MT3303	Integral Transforms and Calculus of Variations	PCC	3	3	0	0	3
4.	MT3304	Numerical Analysis	PCC	3	3	0	0	3
5.	MT3305	Topology	PCC	3	3	0	0	3
6.		Professional Elective – I	PEC	3	3	0	0	3
PRACTICAL								
7.	MT3311	Computational Laboratory	PCC	4	0	0	4	2
			TOTAL	**22**	**18**	**0**	**4**	**20**

SEMESTER IV

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Professional Elective - II	PEC	3	3	0	0	3
2.		Professional Elective – III	PEC	3	3	0	0	3
PRACTICAL								
3.	MT3411	Project Work	EEC	24	0	0	24	12
			TOTAL	**30**	**6**	**0**	**24**	**18**

Total No. of Credits: 83

PROFESSIONAL CORE COURSES (PCC)

Sl. No.	Course Code	Course Title	Periods per week			Credits	Semester
			L	T	P		
1.	MT3101	Abstract Algebra	4	0	0	4	1
2.	MT3102	Real Analysis	4	0	0	4	1
3.	MT3103	Ordinary Differential Equations	3	0	0	3	1
4.	MT3104	Probability and Random Processes Processes	4	0	0	4	1
5.	MT3105	Graph Theory	3	0	0	3	1
6.	MT3106	Object Oriented Programming and Data Structures	3	0	0	3	1
7.	MT3111	Object Oriented Programming and Data Structures Laboratory	0	0	4	2	1
8.	MT3201	Advanced Calculus	3	0	0	3	2
9.	MT3202	Classical Mechanics	3	0	0	3	2

10.	MT3203	Complex Analysis	4	0	0	4	2
11.	MT3204	Linear Algebra	3	0	0	3	2
12.	MT3205	Partial Differential Equations	4	0	0	4	2
13.	MT3206	Mathematical Statistics	3	0	0	3	2
14.	MT3211	Computational Laboratory (Using Python and R)	0	0	4	2	2
15.	MT3301	Continuum Mechanics	3	0	0	3	3
16.	MT3302	Functional Analysis	3	0	0	3	3
17.	MT3303	Integral Transforms and Calculus of Variations	3	0	0	3	3
18.	MT3304	Numerical Analysis	3	0	0	3	3
19.	MT3305	Topology	3	0	0	3	3
20.	MT3311	Computational Laboratory	0	0	4	2	3
					Total Credits	62	

PROFESSIONAL ELECTIVE COURSE (PEC)

S. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MT3001	Advanced Analysis	PEC	3	3	0	0	3
2.	MT3002	Differential Topology	PEC	3	3	0	0	3
3.	MT3003	Fixed Point Theory	PEC	3	3	0	0	3
4.	MT3004	Functional Analysis and its Applications to Partial Differential Equations	PEC	3	3	0	0	3
5.	MT3005	Geometric Function Theory	PEC	3	3	0	0	3
6.	MT3006	Mathematical Aspects of Finite Element Method	PEC	3	3	0	0	3
7.	MT3007	Theory of Wavelets	PEC	3	3	0	0	3
8.	MT3008	Number Theory	PEC	3	3	0	0	3
9.	MT3009	Number Theory and Cryptography	PEC	3	3	0	0	3
10.	MT3010	Fuzzy Set Theory	PEC	3	3	0	0	3
11.	MT3011	Finite Element Method	PEC	3	3	0	0	3
12.	MT3012	Finite Volume Method	PEC	3	3	0	0	3
13.	MT3013	Fluid Mechanics	PEC	3	3	0	0	3
14.	MT3014	Numerical Solutions of Partial Differential Equations	PEC	3	3	0	0	3
15.	MT3015	Mathematical Finance	PEC	3	3	0	0	3
16.	MT3016	Mathematical Programming	PEC	3	3	0	0	3
17.	MT3017	Networks, games and Decisions	PEC	3	3	0	0	3

18.	MT3018	Queueing and Reliability Modeling	PEC	3	3	0	0	3
19.	MT3019	Stochastic Processes	PEC	3	3	0	0	3
20.	MT3020	Advanced Graph Theory	PEC	3	3	0	0	3
21.	MT3021	Algorithmic Graph Theory	PEC	3	3	0	0	3
22.	MT3022	Boundary Layer Theory	PEC	3	3	0	0	3
23.	MT3023	Data Structures	PEC	3	3	0	0	3
24.	MT3024	Design and Analysis of Algorithms	PEC	3	3	0	0	3
25.	MT3025	Discrete Mathematics	PEC	3	3	0	0	3
26.	MT3026	Formal Languages and Automata Theory	PEC	3	3	0	0	3
27.	MT3027	Introduction to Algebraic Topology	PEC	3	3	0	0	3
28.	MT3028	Introduction to Lie Algebras	PEC	3	3	0	0	3
29.	MT3029	Analysis of Heat and Mass Transfer	PEC	3	3	0	0	3
30.	MT3030	Theory of Elasticity	PEC	3	3	0	0	3
31.	MT3031	Nonlinear Science	PEC	3	3	0	0	3
32.	MT3032	Dynamical Systems	PEC	3	3	0	0	3
33.	MT3033	Fractional Calculus	PEC	3	3	0	0	3
34.	MT3034	Statistical learning	PEC	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1	MT3411	Project Work	0	0	24	12	4
				Total Credits:		**16**	

SUMMARY

	M.Sc. MATERIALS SCIENCE (FT)					
	Subject Area	**Credits per Semester**				**Credits Total**
		I	**II**	**III**	**IV**	
1.	**FC**	00	00	00	00	**00**
2.	**PCC**	23	22	17	00	**62**
3.	**PEC**	00	00	03	06	**09**
4.	**EEC**	00	00	00	12	**12**
	Total Credit	**23**	**22**	**20**	**18**	**83**

MT3101 **ABSTRACT ALGEBRA** **L T P C**
4 0 0 4

OBJECTIVES:

- To start with the basic axioms defining a group and then move on to special groups like symmetric groups, cyclic groups, the notion of a subgroup, homomorphism between groups
- To know about more concepts and results like isomorphism theorems, group actions on sets and their applications
- To introduce rings and ideals, their properties
- To learn about a special type of rings, namely polynomial rings with coefficients in a field
- To introduce fields and field extensions and study their properties

UNIT I GROUPS 12

Basic Axioms, Examples of groups - Dihedral Groups, Symmetric groups, Matrix Groups, The Quaternion Group, Homomorphisms and isomorphisms, Subgroups-subgroup criterion, centralizers and normalizers, cyclic groups and cyclic subgroups, Cosets, normal subgroups, quotient groups, Lagrange's theorem.

UNIT II MORE ON GROUPS 12

Isomorphism theorems, permutation groups, Group Actions, Permutation Representations, Cayley's Theorem, The Class Equation, conjugacy in Sn, Sylow's Theorem

UNIT III RINGS 12

Basic definitions, Examples-polynomial rings, matrix rings, Ring homomorphisms, ideals, quotient rings, first isomorphism theorem for rings, principal ideal, maximal ideal, prime ideal, their properties Euclidean domains, principal ideal domains, unique factorization domains.

UNIT IV POLYNOMIAL RINGS 12

Polynomial Rings, Polynomial Rings over fields, Polynomial Rings that are Unique Factorization Domains, Irreducibility Criteria.

UNIT V FIELDS 12

Fields, Field Extensions, simple extensions, Algebraic extensions, classical Straight-Edge and compass constructions, splitting fields and algebraic closures, the fundamental theorem of algebra

TOTAL: 60 PERIODS

OUTCOMES:

CO1: Students would have learnt the basics of group theory and some important results like Lagrange's theorem.

CO2: Students would have learnt how to use isomorphism between groups to classify certain groups, and study properties of groups using class equation and Sylow's theorem.

CO3: The basics of ring theory, including the knowledge of Euclidean domains, PIDs and UFDs would have been imparted to the students.

CO4: Students will be knowledgeable about division algorithm for polynomial rings over a field and about different irreducibility criteria for polynomials.

CO5: Students would have learnt about field extensions and some important applications of field extensions.

REFERENCES

1. Artin M., "Algebra", Pearson Education, Second Edition, Harlow, 2011.
2. Dummit D. S. , Foote R. M., "Abstract Algebra", John-Wiley & Sons, Third Edition, New York, 2004.
3. Herstein I.N., "Topics in Algebra", John Wiley & Sons, Second Edition, New York, 2006
4. Lang S., "Algebra", Springer, Third Edition, New York, 2002.

Attested

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg	**3**	**3**	**3**	**3**	**2**	**2**

MT3102 REAL ANALYSIS L T P C
4 0 0 4

OBJECTIVES

- Real Analysis is the fundamental behind almost all other branches of Mathematics.
- The aim of the course is to make the students understand the basic concepts of Real analysis.
- To introduce uniform convergence and uniform continuity of sequences and series of functions.
- To introduce a few concepts of measure theory.
- To introduce Riemann and Lebesgue integrability concepts.

UNIT I METRIC SPACES, CONTINUITY AND DIFFERENTIABILITY 12

Metric spaces - Connectedness and Compactness – Characterization of connectedness in the real line - Limit of functions– Continuity of functions - Continuity and Compactness – Continuity and Connectedness – Differentiability – Mean value theorem – Continuity of derivatives.

UNIT II RIEMANN-STIELTJES INTEGRAL 12

Definition and existence of the integral - Properties of the integral - Integration and Differentiation.

UNIT III SEQUENCES AND SERIES OF FUNCTIONS 12

Pointwise convergence - Uniform convergence - Uniform convergence and continuity - Uniform convergence and Integration, Uniform Convergence and differentiation. Equi-continuous families of functions, Weierstrass and Stone-Weierstrass theorem.

UNIT IV MEASURE AND MEASURABLE SETS 12

Lebesgue Outer Measure - Measurable sets - Regularity - Measurable functions - Abstract Measure - Outer Measure Extension of a Measure – Measure spaces.

UNIT V LEBESGUE INTEGRAL 12

Integrals of simple functions - Integrals of Non-Negative functions - Fatou’s Lemma, Lebesgue monotone convergence theorem - The General Integral - Riemann and Lebesgue Integrals - Integration with respect to a general measure –Lebesgue dominated convergence theorem.

Attested

TOTAL: 60 PERIODS

OUTCOMES

CO1: The students will be able to get a deeper understanding of limits, continuity and differentiability.

CO2: The students should be able to gain another perspective of integral through the Riemann-Stieltjes integral.

CO3: The students should be able to identify the convergence of sequences and series of functions.

CO4: The students will be able to understand the methods of Decomposing signed measures which have applications in probability theory and Functional Analysis.

CO5: The students get introduced to the approach of integration via measure, rather than measure via integration. The students will be able to understand the treatment of Integration in the sense of both Riemann and Lebesgue.

REFERENCES

1. Avner Friedman, "Foundations of Modern Analysis", Hold Rinehart Winston, New York,1970.
2. Carothers, N.L, "Real Analysis", Cambridge University Press, 2000.
3. de Barra,G. "Measure Theory and Integration", New Age International Pvt. Ltd, Second Edition, New Delhi, 2013.
4. Kumaresan, S., "Topology of metric spaces", Narosa Publishing House Pvt. Ltd., Second Edition, New Delhi, 2011.
5. Rana I. K., "An Introduction to Measure and Integration", Narosa Publishing House Pvt.Ltd., Second Edition, New Delhi, 2007.
6. Royden H. L., Patrick Fitzpatrick, "Real Analysis", Pearson Publication, Fourth Edition, New York, 2018.
7. Rudin, W., "Principles of Mathematical Analysis", Tata McGraw-Hill Education, Third Edition, Singapore,2013.
8. Tom M. Apostol, Mathematical Analysis, Second Edition, Narosa Publishing House Pvt. Ltd., 2002,

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3103 ORDINARY DIFFERENTIAL EQUATIONS **L T P C**
3 0 0 3

OBJECTIVES

- To introduce the methods of solving linear higher order ordinary differential equations.
- To enable the students understand the existence conditions for solution of boundary valueproblems.
- To introduce the stability aspects of linear and nonlinear systems.
- To demonstrate power series solutions for Legendre equation.
- To discuss the series solution for Bessel equation.

UNIT I LINEAR EQUATIONS 9

Higher order equations - Linear independence - Wronskian - Variation of parameters – Systems of Linear differential equations - Existence and uniqueness theorem.

UNIT II EXISTENCE THEOREM AND BOUNDARY VALUE PROBLEMS 9

Successive approximations - Picard's theorem - Boundary Value problems - Sturm – Liouville problem - Green's Functions.

UNIT III STABILITY 9

Autonomous systems - The phase plane - Critical points and stability for linear systems - Stability by Liapunov's direct method - Simple critical points of non-linear systems.

UNIT IV LEGENDRE EQUATION 9

Power series solutions - Second order linear equations with ordinary points - Legendre equation - Legendre polynomials - Rodrigue's formula - Recurrence relations - Orthogonality.

UNIT V BESSEL EQUATION 9

Second order equations with regular singular points - Series solution - Bessel Equation Bessel functions of first kind - Recurrence relations - Orthogonality.

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course, the students will be able to

CO1: formulate and solve linear higher order ordinary differential equations.

CO2: analyze the existence of solutions for boundary value problems.

CO3: investigate the stability aspects of autonomous linear and nonlinear systems.

CO4: apply power series solutions to second order linear equations with ordinary points.

CO5: obtain the series solutions to second ions with regular singular points.

REFERENCES

1. Birkhoff, G. and Rota, G. C., "Ordinary Differential Equations", John Wiley & Sons, 4th Edition, New York, 1989.
2. Deo S.G., Lakshmikantham V. and Raghavendra V. "Text Book of Ordinary Differential Equations", Tata McGraw-Hill Publishing Company Ltd., Third Edition, New Delhi, 2015.
3. Elsgolts L., "Differential equation and the calculus of variations", MIR Publications, Moscow, 1980.
4. Gorge F. Simmons, Differential Equations with Applications and Historical Notes, Second Edition, McGraw Hill, 2017, NewDelhi
5. Krantz S. G., "Differential Equations, Theory, Technique and Practice", CRC Press, Second Edition, Dubuque, 2014.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

MT3104 PROBABILITY AND RANDOM PROCESSES

L	T	P	C
4	0	0	4

OBJECTIVES

- To understand the basic probability concepts and the basics of random variables with emphasis on the standard discrete and continuous distributions
- To understand the basic probability concepts with respect to two dimensional random variables along with the relationship between the random variables
- To learn the different modes of convergence of random variables along with the significance of the Central Limit Theorem
- To learn the classifications of random processes with emphasis on stationarity of various orders and Markov Chains
- To learn the basics of Markov processes, Birth and Death processes Poisson process and its variants

UNIT I PROBABILITY AND RANDOM VARIABLES 12

Basic Probability Concepts – Random variables – Moments and Moment Generating Function – Binomial, Geometric, Poisson, Uniform, Exponential, Gamma and Normal Distributions – Functions of a Random Variable

UNIT II TWO DIMENSIONAL RANDOM VARIABLES 12

Joint Distributions – Marginal Distributions – Transformation of Random Variables and their distributions – Computing Probabilities and Expectations by Conditioning – Correlation – Linear Regression – Regression Curves

UNIT III LIMIT THEOREMS 12

Modes of Convergence – Markov, Chebyshev's and Jensen's inequalities – Weak and Strong Laws of Large numbers – Kolmogorov's inequality – Central Limit Theorem (Independent and identically distributed Random Variables)

UNIT IV MARKOV CHAINS 12

Stochastic Processes – Classification – Markov Chain – Transition Probability Matrix – Chapman Kolmogorov Equations – Classification of states – First Passage Times – Stationary Distribution.

UNIT V MARKOV PROCESSES 12

Markov process – Poisson process– Birth and Death process – Pure Birth process – Pure Death process – Limiting Probabilities – Non-Homogeneous Poisson process – Compound Poisson process

TOTAL: 60 PERIODS

OUTCOMES

CO1: To analyze the performance in terms of probabilities and distributions achieved by the determined solutions.

CO2: To be familiar with some of the commonly encountered two dimensional random variables and be equipped for a possible extension to multivariate analysis along with the understanding of the relationship between random variables.

CO3: To appreciate various types of Stationarity with focus on Discrete parameter Markov chains.

CO4: To understand the various modes of Convergence of random variables and the importance of the Central Limit Theorem.

CO5: To gain proficiency in the concepts of Poisson process and its variants.

REFERENCES

1. Sheldon M. Ross, Introduction to probability models, Academic press Inc., (An Imprint of Elsevier), Eleventh Edition 2014
2. Vijay K. Rohatgi, and A.K. Md. Ehsanes Saleh, An introduction to Probability and Statistics, John Wiley & Sons, Inc., Second Edition, 2008

3. Karlin S and Taylor H.M. A first course in Stochastic processes, Academic Press, Second Edition, 1975 (An Imprint of Elsevier)
4. Medhi J. Stochastic Processes, New Age International (P) Ltd., New Delhi, Third Edition 2009
5. Hwei Hsu, "Schaum's Outline of Theory and Problems of Probability, Random variables and Random Processes, McGraw Hill Education, 3rd Edition, New Delhi, 2017.
6. Yates, R.D. and Goodman D.J., Famolari D. "Probability and Stochastic Processes, John Wiley and Sons, 3rd Edition, New Jersey, 2014.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	-
CO2	3	3	3	2	2	-
CO3	2	2	3	2	2	-
CO4	2	2	2	3	2	-
CO5	2	2	2	2	3	-
Avg.	**2.4**	**2.2**	**2.4**	**2.2**	**2**	**-**

MT3105 GRAPH THEORY **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce graph models and their basic concepts.
- To elaborate the importance of connectivity and traversability in graphs.
- To provide structural characterization of graphs with matching and perfect matching.
- To give exposure to graph coloring.
- To give structural understanding of planar graphs.

UNIT I INTRODUCTION TO GRAPH 9
Graphs and simple graphs - Graph isomorphism - Incidence and adjacency matrices – subgraphs – Vertex degrees - Paths and connection - Cycles - Trees - Cut edges and bonds - Cut vertices – The Shortest Path Problem - The Connector Problem.

UNIT II CONNECTIVITIY AND TRAVERSIBILITY 9
Connectivity - Whitney's theorems - Blocks - Applications of connectivity - Euler's tour – Hamilton Cycles - The Chinese Postman Problem - The Traveling Salesman Problem (only a brief introduction on these problems.)

UNIT III MATCHING 9
Matching - Matchings and covering in bipartite graphs - Perfect matchings - Independent sets.

UNIT IV COLORING 9
Vertex chromatic number - k-critical graphs - Brook's theorem - Chromatic polynomials - Girth and Chromatic number.

UNIT V PLANAR GRAPHS 9
Planar graphs - Euler's formula - Kurtowski's theorem - Five color theorem.

TOTAL: 45 PERIODS

OUTCOMES:
At the end of the course, students will be able to
CO1: Understand the graph models and their utilities.
CO2: Use graph traversability in solving application problems.
CO3: Apply graph matching ideas in various matching related problems.
CO4: Apply graph coloring ideas in solving partition related problems.
CO5: Apply graph planarity ideas in solving application problems.

REFERENCES

1. Balakrishnan R. and Ranganathan K., "A Text Book of Graph Theory", Springer- Verlag, 2012.
2. Bezhad M., Chartrand G. and Lesneik Foster L., "Graphs and Digraphs", Wadsworth International Group, 1979.
3. Bondy J. A. and Murty U.S. R.,"Graph theory with Applications", Elsevier North-Holland 1976.
4. Douglas B. West, "Introduction to Graph Theory", Prentice Hall of India, New Delhi, 2002.
5. Harary F., "Graph Theory", Narosa Publishing House, New Delhi, 2001.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	3	3
CO2	3	3	3	2	3	3
CO3	3	3	3	2	3	3
CO4	3	3	3	2	3	3
CO5	3	3	3	2	3	3
Avg.	**3**	**3**	**3**	**2**	**3**	**3**

MT3106 OBJECT ORIENTED PROGRAMMING AND DATA STRUCTURES **L T P C**
3 0 0 3

OBJECTIVES
- The language accommodates several programming paradigms, including object-oriented programming, generic programming, and the traditional procedural programming.
- Teaches object-oriented design and explores techniques for building modular, efficient and robust systems.
- To understand the concepts of linear and non-linear data structures.
- To get an idea about suitability of data structures for an object oriented design application development.
- To learn some fundamental algorithm design strategies and how to analyze an algorithm.

UNIT I OBJECT ORIENTED PROGRAMMING FUNDAMENTALS 9
Data Types- Control Structures-Reference Variables-Operators- Arrays-Data Abstraction – Encapsulation – Class – Object – Constructors – Copy Constructor-Destructor- Static members – Constant members – Member functions –friend function.

UNIT II OBJECT ORIENTED PROGRAMMING - ADVANCED FEATURES 9

Pointers – 'this' Pointer –String Handling – Polymorphism – Function Overloading – Operator Overloading – Dynamic Memory Allocation. – Templates – Class template – Function template – Inheritance – Virtual Functions – Abstract class – File Handling-Exception Handling.

UNIT III LINEAR DATA STRUCTURES 9

Abstract Data Types (ADTs) – List ADT – Array-Based Implementation – Linked List – Doubly-Linked Lists – Circular Linked List – Stack ADT – Implementation of Stack – Applications – Queue ADT – Priority Queues – Queue Implementation – Applications.

UNIT IV NON-LINEAR DATA STRUCTURES 9

Trees – Binary Trees – Tree Traversals – Expression Trees – Binary Search Tree –– Linear Probing– Quadratic Probing-Applications.

UNIT V SORTING AND SEARCHING TECHNIQUES 9

Insertion Sort – Quick Sort – Heap Sort – Hashing- Hash Functions – Separate Chaining – Open Addressing – Double Hashing – Rehashing -Merge Sort –Linear Search – Binary Search.

TOTAL: 45 PERIODS

OUTCOMES

CO1: Students will be able to design and write computer programs that are correct, simple, clear, efficient, well organized, and well documented.

CO2: Students will be able to apply programming skills in the areas of pure, applied mathematics and related areas and will understand the hardware and software aspects of computer systems that support application software development.

CO3: Point out various representations of data structures.

CO4: Suggest and use appropriate linear/non-linear data structures operations for solving a given problem.

CO5: Apply various algorithm design techniques and analysis.

REFERENCES

1. H. M. Deitel and P. J. Deitel, "C++ How to Program", Prentice Hall of India Pvt. Ltd., New Delhi, 10th Edition, 2010.
2. Bjarne Stroustrup, "The C++ Programming Language", Pearson Education, 2005.
3. Robert Lafore, "Object Oriented Programming in Microsoft C++", Pearson Education, Fourth Edition, 2010.
4. Balaguruswamy E., "Object Oriented Programming with C++", Tata McGraw Hill, New Delhi, Fourth Edition, 2007.
5. Adam Drozdek, "Data Structures and Algorithms in C++", 4th Edition, Cengage Learning, Boston, 2012.
6. Ellis Horowitz, SartajSahni, and Dinesh Mehta, "Fundamentals of Data structures in C++",Galgotia Publications, New Delhi — 2009.
7. Langsam Y., Augenstein M. and Tenenbaum A. M. — " Data Structures using C and C++.",(Second Edition) Prentice Hall of India, New Delhi – 2015.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3111 OBJECT ORIENTED PROGRAMMING AND DATA STRUCTURES LABORATORY

L T P C
0 0 4 2

1. Arithmetic operations using array of objects and dynamic data members.
2. Function template and class template implementation.
3. Implementation of constructor and destructor.
4. Overloading the operators to do arithmetic operations on objects.
5. Implementation of run time polymorphism.
6. Implementation of derived class which has direct access to both its own and public members of the base class.
7. Overloading stream operators.
8. File I/O operations.
9. Illustration of a data structure using dynamic objects.
10. Implementation of Sparse matrix operations using arrays.
11. Implementation of Stacks and Queues using arrays.
12. Implementation of Single linked, Double linked and Circular lists.
13. Implementation of Linked stacks , Linked queues and Priority queues
14. Implementation of Graph traversal algorithms.
15. Implementation of Hash table
16. Implementation of Sorting algorithms

TOTAL: 60 PERIODS

OUTCOMES

On successful completion of this Laboratory course students will be able to:

CO1: Implement object oriented programming concepts.
CO2: Understand the hardware and software aspects of computer systems that support Application software development.
CO3: Implement various representations of data structures.
CO4: Use appropriate linear and non-linear data structures operations for a given problem.
CO5: Apply various algorithm techniques and analysis outputs efficiency.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3201 **ADVANCED CALCULUS** **L T P C**
3 0 0 3

OBJECTIVES:

The main objectives of teaching Advanced Calculus are

- To educate the students on the basic concepts of partial differentiation and applications.
- To provide the student with the skills of vector calculus operations which are needed for further study in mathematics.
- To provide the student with the skills necessary to apply in solving practical problems.
- To provide the student with the critical thinking skills required to solve problems.

UNIT I PARTIAL DIFFERENTIATION 9

Functions of several variables - Homogeneous functions - Total derivative - Higher order Derivatives, Equality of cross derivatives - Differentials - Directional Derivatives.

UNIT II IMPLICIT FUNCTIONS AND INVERSE FUNCTIONS 9

Implicit functions - Higher order derivatives - Jacobians - Dependent and independent variables-The inverse of a transformation – Inverse function theorem – Change of variables – Implicit function theorem - Functional dependence – Simultaneous equations.

UNIT III TAYLOR'S THEOREM AND APPLICATIONS 9

Taylor's theorem for functions of two variables - Maxima and Minima of functions of two and three variables – Lagrange Multipliers.

UNIT IV LINE AND SURFACE INTEGRALS 9

Definition of line integrals - Green's theorem - Applications - Surface integrals - Gauss theorem-Verification of Green's and Gauss theorems.

UNIT V TRANSFORMATION AND LINE INTEGRALS IN SPACE 9

Change of variables in multiple integrals - Definition of line integrals in space - Stoke's theorem - Verification of Stoke's theorem.

TOTAL: 45 PERIODS

OUTCOMES:

After the completion of this course, students will be able to

CO1: Get a strong theoretical foundation on calculus of several variables and obtain derivative of multivariable functions by using appropriate rules.
CO2: Understand the concepts behind the Jacobians and its uses in defining the derivatives.
CO3: Understand the Taylor's theorem and its applications in solving optimization problems.
CO4: Define the integral of scalar and Vector functions over a surface by generalization of area of surface and Compute surface integrals of vector fields by developing the notion of integral.
CO5: Use Greens, Divergence and Stokes theorems by combining vector differential calculus and vector integral calculus.

REFERENCES

1. Kaplan W., "Advanced Calculus", Addison Wesley, Fifth Edition, Boston, 2003.
2. Widder D.V., "Advanced Calculus", Prentice Hall of India, Second Edition, New Delhi, 2002.
3. James Stewart, Daniel Clegg and Saleem Watson, "Multivariable Calculus", 9th Edition, Cengage Learning, Boston, 2015.
4. Carlos Polanzo, "Advanced Calculus", Bentham Science Publishers Pvt Ltd., Singapore, 2019.

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CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3202 CLASSICAL MECHANICS **L T P C**
3 0 0 3

OBJECTIVES

- To introduce the kinematics of objects in motion.
- To demonstrate the methods of dynamics in space.
- To give the methods of solution to the motion of macroscopic objects from projectiles to machinery as well as astronomical objects on the qualitative structure of phase space.
- To introduce the Lagrangean and Hamiltonian structure of mechanics.
- To enable the students apply the Hamiltonian methods of solving dynamical systems.

UNIT I KINEMATICS 9

Kinematics of a particle and a rigid body - Moments and products of inertia - Kinetic energy - Angular momentum.

UNIT II METHODS OF DYNAMICS IN SPACE 9

Motion of a particle - Motion of a system - Motion of a rigid body.

UNIT III APPLICATIONS OF DYNAMICS IN SPACE 9

Motion of a rigid body with a fixed point under no forces - Spinning top - General motion of top.

UNIT IV EQUATIONS OF LAGRANGE AND HAMILTON 9

Lagrange's equation for a particle - Simple dynamical system - Hamilton's equations.

UNIT V HAMILTONIAN METHODS 9

Natural Motions - Space of events - Action - Hamilton's principle - Phase space - Liouville's theorem.

TOTAL: 45 PERIODS

OUTCOMES :

At the end of the course, the students will be able to

CO1: Deal with kinematics of objects in motion.
CO2: Derive the equations of motion of a particle, a system and that of a rigid body.
CO3: Apply the dynamics in space to motion of rigid bodies.
CO4: Derive the Lagrangean and Hamiltonian equations of motion.
CO5: Solve dynamical systems using the Hamiltonian method.

REFERENCES
1. Berger V.D. and Olsson M.G., “Classical Mechanics - a modern perspective”, Tata McGraw Hill International, New York, 1995.
2. Bhatia V.B., “Classical Mechanics with introduction to non-linear oscillations and chaos”, Narosa Publishing House, New Delhi, 1997.
3. David Morin, “Introduction to Classical Mechanics with problems and solutions”, Cambridge University Press, New Delhi, 2008.
4. Goldstein, H., Classical Mechanics, Third Edition, Pearson, New Delhi, 2011.
5. Greenwood D. T., “Principles of Dynamics”, Prentice Hall of India Pvt. Ltd., New Delhi, 1988.
6. Rana N.C. and Joag P.S., “Classical Mechanics”, Tata McGraw Hill, New Delhi, 2001.
7. Sankara Rao K. “Classical Mechanics”, Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
8. Synge L. and Griffith B.A., “Principles of Mechanics”, Nabu Press, New York, 2015.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	3	3
CO2	3	3	3	2	3	3
CO3	3	3	3	2	3	3
CO4	3	3	3	2	3	3
CO5	3	3	3	2	3	3
Avg.	**3**	**3**	**3**	**2**	**3**	**3**

MT3203 COMPLEX ANALYSIS L T P C
4 0 0 4

OBJECTIVES
- To introduce analytic functions.
- To introduce the basic analogous of complex line integral, Cauchy theorem.
- To get introduced to integration via residues.
- To introduce and emphasize on Riemann mapping theorem and Hadamard’s theorem.
- To introduce the fundamental concepts of entire and meromorphic functions.

UNIT I COMPLEX FUNCTIONS 12
Limit – Continuity - Analytic function – Polynomials – Rational functions – Power series – Abel limit theorem – Conformal mapping – Bilinear transformation.

UNIT II COMPLEX INTEGRATION 12
Line integrals - Cauchy’s theorem for rectangle - Cauchy’s theorem for disk - Integral formula – Local properties of analytic functions - Schwartz lemma - Maximum Modulus principle.

UNIT III CALCULUS OF RESIDUES 12
Homology - Homologous form of Cauchy’s theorem - Calculus of Residues - Contour integration through residues.

UNIT IV DOMAIN CHANGING MAPPINGS AND HARMONIC FUNCTIONS 12

Conformality - Normal family - Riemann mapping theorem – Harmonic Functions - Properties – The mean-value property - Poisson's Formula - Schwarz's theorem - Harnack's principle.

UNIT V MEROMORPHIC AND ENTIRE FUNCTIONS 12

Meromorphic functions –Mittag Leffler's theorem - Partial fraction - Infinite product - Canonical Product - Gamma Functions - Jensen's formula - Order and Genus of an Entire function - Hadamard's theorem.

TOTAL: 60 PERIODS

OUTCOMES

CO1: The student will get good foundation on complex analysis as well as motivation at advanced level.
CO2: The student will gain an insight into integrating complex functions through Cauchy's theorem.
CO3: The student will be able to integrate complex functions through residues.
CO4: The student will be able to get in-depth understanding of harmonic functions.
CO5: The student will get a thorough understanding of entire functions.

REFERENCES

1. Conway J.B., "Functions of one Complex variables", Springer International Student Edition, Second Edition, New York, 2000.
2. Lars V. Ahlfors, "Complex Analysis", McGraw Hill International, Indian Edition, 2017.
3. Kumaresan, S. A Pathway to Complex Analysis, Techno Wold Publication, Kolkata, 2022
4. Mathews J.H. and Howell R.W., "Complex Analysis for Mathematics and Engineering", Narosa Publishing House, Third Edition, New Delhi, 1998.
5. Ponnusamy S., Foundations of Complex Analysis, Narosa Publishing House, Second Edition, New Delhi, 2018.
6. E.M.Stein and Rami Shakarchi, "Complex Analysis", Princeton University Press, 2003.
7. R.A.Silverman, "Complex Analysis with Applications", Dover Publications, 1986.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg	**3**	**3**	**3**	**3**	**2**	**2**

MT3204 LINEAR ALGEBRA L T P C
3 0 0 3

OBJECTIVES

- To get a strong background of finite dimensional vector space and linear transformations.
- To analyse the linear functional through characteristic values and polynomials.
- To learn about various invariant subspaces and primary decomposition theorem.
- To study about various canonical forms to solve matrix equations.
- To introduce the idea of distance or length into vector spaces via a much richer structure inner product spaces.

UNIT I VECTOR SPACES AND LINEAR TRANSFORMATIONS 9

Vector Spaces – Subspaces – Bases and Dimension– Computations Concerning Subspaces - Linear transformations – The Algebra of Linear transformations – isomorphism – Representation of transformations by matrices.

UNIT II LINEAR FUNCTIONALS AND ANNIHILATING POLYNOMIALS 9

Linear Functionals – The Double Dual – Transpose of Linear Transformation – Characteristic Values - Annihilating Polynomials.

UNIT III DIRECT SUM AND THE PRIMARY DECOMPOSITION THEOREM 9

Invariant Subspaces – Direct-Sum Decomposition – Invariant Direct Sums -The primary Decomposition Theorem.

UNIT IV CANONICAL FORMS 9

Triangular Form – Nilpotent Transformations – Jordan form.

UNIT V INNER PRODUCT SPACES 9

Inner products - Inner product spaces - Linear Functionals and Adjoints, - Unitary Operators - Normal Operators.

TOTAL: 45 PERIODS

OUTCOMES

CO1: The students would have developed their knowledge and understanding of the concepts of linear algebra.

CO2: Students will be able to find out matrices corresponding to linear transformations.

CO3: .Students will analyse the linear transformations on various subspaces.

CO4: Students will understand various methods of canonical forms and utilize in solving system of equations.

CO5: Students will learn about the inner product spaces and its algebraic properties.

REFERENCES

1. Kinkaid,D, and Chenny. W, Linear Algebra: Theory and Applications, 2nd edition , Brooks/Cole: Cengage Learning, 2013.
2. Halmos P.R., “Finite - dimentional Vector spaces”, Courier Dover Publications, New York, 2017.
3. Herstein I.N.,” Topics in Algebra” Wiley Eastern Limited, Second Edition, New York, 2008.
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5. Kumaresan S., “Linear Algebra: A Geometric Approach”, Prentice Hall of India, New Delhi, 2014.
6. Strang G., “Linear Algebra and its applications: Thomson Brooks”, Cengage learning, 4th Edition, New Delhi, 2017.
7. Williams G., “Linear Algebra and its applications”, Jones and Bartlett India pvt Ltd. 9th Indian Edition, New Delhi, 2019.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	2	1	3
CO2	2	1	3	2	2	3
CO3	2	2	3	2	1	3
CO4	2	1	3	2	1	3
CO5	2	2	3	3	2	3
Avg.	**1.8**	**1.4**	**3**	**2.2**	**1.4**	**3**

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MT3205 PARTIAL DIFFERENTIAL EQUATIONS

	L	T	P	C
	4	0	0	4

OBJECTIVES

- To introduce the methods of solving first order partial differential equations.
- To enable the students classify the second and higher order partial differential equations.
- To demonstrate the methods of solving initial value problems in vibrating strings.
- To display the methods of solving one and two dimensional diffusion equations.
- To discuss the methods of solving boundary value problems involving Laplace equation.

UNIT I FIRST ORDER EQUATIONS 12

Formation of Partial Differential Equations – Lagrange's equation - Integral surfaces passing through a given curve - Surfaces orthogonal to a given system of surfaces - Compatible system of equations - Charpit's method.

UNIT II SECOND AND HIGHER ORDER EQUATIONS 12

Classification of second order Partial Differential Equations - Reduction to canonical form – Adjoint operators - Higher order Homogeneous and Non-homogeneous Partial Differential Equations with constant coefficients.

UNIT III HYPERBOLIC EQUATIONS 12

One-dimensional wave equation - Initial value problem - D'Alembert's solution - Riemann - Volterra solution - Vibrating string - Variables Separable solution - Forced vibrations - Solutions of Non-homogeneous equation - Vibration of a circular membrane.

UNIT IV PARABOLIC EQUATIONS 12

Diffusion equation - Method of Separation of variables: Solution of one and two dimensional Diffusion equations in Cartesian coordinates and Solution of Diffusion equation in cylindrical and spherical polar coordinates.

UNIT V ELLIPTIC EQUATIONS 12

Boundary value problems – Dirichlet problem for a rectangle and a circle – Neumann problem for a rectangle - Properties of harmonic functions.

TOTAL: 60 PERIODS

OUTCOMES

At the end of the course, the students will be able to

CO1: solve various types of first order partial differential equations

CO2: classify the second and higher order partial differential equations

CO3: solve initial value problems in vibrating strings

CO4: solve one-dimensional and two-dimensional diffusion equations

CO5: solve boundary value problems involving Laplace equation.

REFERENCES

1. Dennemeyer R., "Introduction to Partial Differential Equations and Boundary Value Problems", Tata McGraw Hill Book Company, New York, 1968.
2. Haberman R, "Applied Partial Differential Equations with Fourier Series and Boundary Value Problems", Pearson Education Inc., Fifth Edition, Harlow, 2013.
3. Pinsky M.A., "Partial Differential Equations and Boundary Value Problems", Tata McGraw Book Company, Third Edition, Rhode Island, 2011.
4. Sankara Rao K., "Introduction to Partial Differential Equations", Prentice Hall of India,New Delhi, 2010.
5. Sneddon I.N., "Elements of Partial Differential Equations", Courier Corporation, New York,2006.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3206 MATHEMATICAL STATISTICS

L	T	P	C
3	0	0	3

OBJECTIVES

- To understand the basic concepts of sampling distributions and statistical properties of point and interval estimators.
- To apply the small / large sample tests through Testing of hypothesis
- To understand the correlation and regression concepts in empirical statistics
- To understand the concept of analysis of variance and use them to investigate factorial dependence
- To appreciate the classical multivariate methods and computational techniques.

UNIT I SAMPLING DISTRIBUTIONS AND ESTIMATION THEORY 9

Sampling distributions – Characteristics of good estimators – Method of Moments – Maximum Likelihood Estimation – Bayesian Estimation – Interval estimates for mean, variance and proportions.

UNIT II TESTING OF HYPOTHESIS 9

Type I and Type II errors – Tests based on Normal, t, χ^2 and F distributions for testing of mean, variance and proportions – Tests for Independence of attributes and Goodness of fit.

UNIT III CORRELATION AND REGRESSION 9

Method of Least Squares – Linear Regression – Normal Regression Analysis – Normal Correlation Analysis – Partial and Multiple Correlation – Multiple Linear Regression.

UNIT IV DESIGN OF EXPERIMENTS 9

Analysis of Variance – One-way and two-way Classifications – Completely Randomized Design – Randomized Block Design – Latin Square Design – **2^2 Factorial Design.**

UNIT V MULTIVARIATE ANALYSIS 9

Mean Vector and Covariance Matrices – Partitioning of Covariance Matrices – Combination of Random Variables for Mean Vector and Covariance Matrix – Multivariate, Normal Density and its Properties – Principal Components: Population principal components – Principal components from standardized variables.

TOTAL:45 PERIODS

OUTCOMES

On successful completion of this course students will be able to:
CO1: Demonstrate knowledge of and properties of statistical models in common use
CO2: Apply the basic principles underlying statistical inference (estimation and hypothesis testing)
CO3: Be able to construct tests and estimators and derive their properties
CO4: Demonstrate knowledge of applicable large sample theory of estimators and tests.
CO5: Recognize the importance of Multivariate analysis in various practical applications

REFERENCES

1. Gupta S.C. and Kapoor V.K.," Fundamentals of Mathematical Statistics", Sultan Chand & Sons, Eleventh Edition, New Delhi, 2019.
2. Johnson R.A. and Wichern D.W., "Applied Multivariate Statistical Analysis", Pearson Education, Sixth Edition, Harlow, 2015.
3. Miller I. And Miller M., "John E. Freund's Mathematical Statistics with applications", Pearson Education, Eighth Edition, Asia, 2014.
4. Devore J.L. "Probability and Statistics for Engineering and the Sciences",Cengage Learning, Ninth Edition, 2020.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	-
CO2	2	3	2	2	2	-
CO3	2	2	3	2	2	-
CO4	2	2	2	3	2	-
CO5	2	2	2	2	3	-
Avg.	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**	**-**

MT3211 COMPUTATIONAL LABORATORY USING PYTHON AND R (Statistical Methods Laboratory)

L T P C
0 0 4 2

INTRODUCTION: Python Interpreter – Program execution – Interactive prompt – IDLE User Interface.

UNIT I TYPES AND OPERATIONS: Python object types – Numeric types – Dynamic typing – String fundamentals – Lists – Dictionaries - Tuples – Type objects.

UNIT II STATEMENTS AND SYNTAX: Python statements - Assignments – Expressions – if Tests – while Loops - for Loops – Iterations – Comprehensions.

UNIT III FUNCTIONS AND GENERATORS: Function basics – Scopes – Arguments – Recursive functions – Anonymous functions – lambda – Generator functions -

UNIT IV MODULES AND PACKAGES: Python program structure – Module Imports – Standard library modules – Packages – Namespaces.

UNIT V STANDARD PACKAGES: NumPy – Matplotlib – SciPy – SymPy – Pandas.

FILES: Opening files – Reading and writing files – Text files – Binary files.

Implementation of the following problems using Python programming:

1. Simple programs to understand the concepts.
2. Familiarizing conditional, control and repetition statements.
3. Implementation of functions, recursive functions.
4. Defining and handling structures, array of structures and union.
5. Implementation of packages - GUI Programming .
6. Creating and processing data files.
7. Plotting Probability distributions
8. Analyzing probability distributions to verify the limit theorems

TOTAL: 60 PERIODS

Implementation of the following problems using Statistical Packages:

CO1: Classification and tabulation of data and Graphical and diagrammatic presentation of data.

CO2: Perform calculations that measure the central tendency and dispersion of data and Implementation of measures of Skewness, moments and kurtosis.

CO3: Determination of point and interval estimates.

CO4: Solving linear regression, polynomial regression and non-linear regression based problems and solving multiple regression and correlation analysis based problems.

CO5: Solving the problems based on Time series analysis and forecasting and implementing statistical quality control charts.

REFERENCES:

1. Christian Hill, "Learning Scientific Programming with Python", Cambridge University Press, 2016.
2. Allen Downey, 'Python for Software Design", Cambridge University Press, 2009.
3. Mark Lutz, "Learning Python", O'Reilly Media, 2013.
4. Tony Gaddis, "Starting out with Python", Pearson, 2017.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3301 **CONTINUUM MECHANICS** **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce the indicial notations and fundamentals of tensor algebra for continuum mechanics.
- To enable the students understand the kinematics of a continuum in material and spatial descriptions.
- To introduce the concept of stress tensor and its properties.
- To demonstrate the infinitesimal theory of linear isotropic elastic materials.
- To discuss the flow of Newtonian viscous fluids.

UNIT I TENSORS **9**

Summation Convention –Indicial notations and manipulations - Tensor - Components of a tensor.

UNIT II KINEMATICS OF A CONTINUUM **9**

Material and Spatial descriptions - Material derivative - Deformation - Principal Strain - Rate of deformation - Conservation of mass - Compatibility conditions.

UNIT III STRESS TENSOR **9**

Stress vector and tensor - Components of a stress tensor – Symmetry of stress tensor - Principal Stresses – Equations of motion - Boundary conditions – Integral formulation of general principals of mechanics.

UNIT IV LINEAR ELASTIC SOLIDS **9**

Isotropic linear elastic solids – Elastic Constants - Equations of infinitesimal theory - Examples of elastodynamics and elastostatics.

UNIT V NEWTONIAN VISCOUS FLUIDS **9**

Equations of hydrostatics - Newtonian fluid - Boundary conditions - Stream lines – Examples of laminar flows - Vorticity vector - Irrotational flow.

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course, the students will be able to

CO1: understand the concept of tensors and apply tensor algebra in Continuum Mechanics.
CO2: understand the Kinematics of a continuum.
CO3: Derive the equations of the basic principles of continuum mechanics.
CO4: Derive the equations of the infinitesimal theory of elasticity and solve in specific applications.
CO5: Derive the equations of motion of linear viscous fluids and solve in specific geometries.

REFERENCES

1. Chandrasekaraiah D.S. and Loknath Debnath, "Continuum Mechanics", Academic Press, Boston, 2014.
2. Chung T.J., "Continuum Mechanics", Prentice Hall, London, 1988.
3. Hunter S.C., "Mechanics of Continuous Media", Ellis Harwood Series, Chichester, 1983.
4. Lai W.M., Rubin D. and Krempel E., "Introduction to Continuum Mechanics", Butterworth-Heinemann, 4th Edition, Burlington, 2009.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	1	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
Avg.	**3**	**3**	**3**	**3**	**2.6**	**3**

MT3302 **FUNCTIONAL ANALYSIS** **L T P C**
3 0 0 3

OBJECTIVES

- To teach the fundamentals of Functional Analysis.
- The topics include Hahn-Banach theorem, Open mapping theorem, Closed graph theorem, Riesz-Representation theorem etc.
- To introduce inner product spaces and Hilbert spaces.
- To study the properties of operators on Hilbert spaces.
- To introduce fixed point theorem and spectral theorem.

UNIT I BANACH SPACES **9**

Normed spaces - Banach Spaces - Definition and Examples –Properties of normed spaces- Finite dimensional spaces – Compactness and finite dimension -Linear transformations – Continuous linear transformation – Normed spaces of operators – Dual spaces.

UNIT II FUNDAMENTAL THEOREMS IN NORMED LINEAR SPACES **9**

Hahn-Banach theorem –Adjoint operator – Reflexive spaces – Baire's category theorem – Uniform boundedness theorem – Strong and weak convergence - Open mapping theorem - Closed graph theorem.

UNIT III HILBERT SPACES **9**

Inner product spaces - Hilbert Spaces - Definition and Properties - Schwarz inequality – Orthogonal complements and direct sums– Projection - Orthonormal sets and sequences - Bessel's inequality - Gram–Schmidt orthogonalization process.

UNIT IV OPERATOR ON A HILBERT SPACE **9**

Representational of functional on Hilbert spaces –Riesz-Representation theorem –Hilbert adjoint of an operator - Self-adjoint operators - Normal and unitary operators.

UNIT V SPECTRAL AND FIXED POINT THEOREMS **9**

Banach fixed point theorem – Applications of Banach theorem to differential and integral equations - Spectral theorem in finite dimensional spaces.

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course,

CO1: The student will be familiar with the concepts on Normal Linear Spaces, Banach Spaces and Linear Transformations;

CO2: The student will be able to understand the four fundamental theorems of Functional Analysis;

CO3: The student will be thorough with Inner Product Spaces, Hilbert Spaces and Orthonormalization process;

CO4: The student will be able to understand operators on Hilbert space.

CO5: The student will be able to apply the fixed point theorem to solve differential equations and will be familiar with finite dimensional spectral theorems.

REFERENCES

1. Bollobas B., "Linear Analysis", Cambridge University Press, Indian Edition, New York,1999.
2. Coffman C. and Pedrick G., "First Course in Functional Analysis", Prentice-Hall of India, New Delhi,1995.
3. Conway J.B., "A Course in Functional Analysis", Springer-Verlag, New York, 2008.
4. Kreyszig E.," Introductory Functional Analysis with Applications, John Wiley & Sons, New York, 2007.
5. Kumaresan S., and Sukumar. D., Functional Analysis A First Course, Narosa, New Delhi 2021
6. Limaye B. V., "Functional Analysis", New Age International Ltd Publishers, Third Edition, New Delhi, 2014.

7. Nair M.T., “Functional Analysis, A First course”, Prentice Hall of India, New Delhi, 2010.
8. Simmons G.F., ”Introduction to Topology and Modern Analysis”, Tata McGraw Hill Pvt. Ltd., New Delhi, 2017.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3303 INTEGRAL TRANSFORMS AND CALCULUS OF VARIATIONS L T P C
3 0 0 3

OBJECTIVES

- To familiarize the students in the field of ordinary and partial differential equations to solve boundary value problems associated with engineering applications.
- To introduce integral transform techniques.
- To show the application of integral transforms for solution of linear ODEs and standard PDEs.
- To expose the students to variational formulation and numerical integration techniques
- To demonstrate solution methodology for the variational problems.

UNIT I LAPLACE TRANSFORMS 12

Transforms of elementary functions - Unit step and Dirac delta functions - Properties -Differentiation and integration of transforms - Periodic functions - Initial & final value theorems - Inverse Laplace transforms - Convolution theorem - Error function and its properties - Bessel functions - Transform of Error and Bessel functions.

UNIT II FOURIER TRANSFORMS 12

Fourier integral representation - Fourier transform pairs - Properties - Fourier sine and cosine transforms - Transforms and inverse transforms of elementary functions - Convolution theorem - Transforms of derivatives.

UNIT III APPLICATIONS OF TRANSFORMS 12

Application of Laplace Transforms - Evaluation of integrals - Solution of Linear ODE - Applications of Fourier Transforms – wave equation - Heat equation on infinite and semi-infinite line - Potential problems in half-plane.

UNIT IV VARIATIONAL PROBLEMS 12

Variation of a functional and its properties - Euler’s equations - Functionals with several arguments - Higher order derivatives - Functionals dependent on functions of several independent variables - Variational Problems in Parametric form.

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UNIT V MOVING BOUNDARIES AND DIRECT METHODS IN VARIATIONAL PROBLEMS **12**

Variation problems with a movable boundary for functionals dependent on one and two functions - One-sided variations - Constraints - Isoperimetric Problems - Direct Methods in Variational Problems - Rayleigh-Ritz method and Kantorovich method.

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course, the students will be able to

CO1: develop the mathematical models of applied mathematics and mathematical physics.

CO2: understand integral transform techniques.

CO3: apply integral transforms for solving linear ODEs and standard PDEs.

CO4: give variational formulation of any differential equation.

CO5: solve different variational problems.

REFERENCES

1. Andrews, L.C. and Shivamoggi, B.K., "Integral Transforms for Engineers", Prentice Hall of India, New Delhi, 2003.
2. Churchill, R.V, "Operational Mathematics", Mc-Graw Hill Company, 3rd Edition, New York, 1972.
3. Elsgolc, L.D., "Calculus of Variations", Dover Pub. Inc., New York, 2007.
4. Elsgolts,L., "Differential equations and the Calculus of Variations", University Press of the Pacific, Moscow, 2003.
5. Gupta, A.S., "Calculus of Variations with Applications", Prentice Hall of India, New Delhi, 2003.
6. Lokenath Debnath and Dambaru Datta, Integral Transforms and Their Applications, Chapman & Hall, Second Edition, Boca Raton, 2007.
7. Sneddon, I.N., "The use of Integral Transforms", Tata Mc-Graw Hill, New Delhi, 1979.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	1	1
CO2	3	3	3	2	1	1
CO3	3	2	2	2	1	1
CO4	3	2	2	2	1	1
CO5	3	2	2	2	1	1
Avg.	**3**	**2**	**2**	**2**	**1**	**1**

MT3304 NUMERICAL ANALYSIS **L T P C**
3 0 0 3

OBJECTIVES

- The aim of the course is to make the students understand the mathematical concepts of numerical methods, their implementation and analysis.
- To introduce the concept of differentiation and integration through numerical methods.
- To introduce approximation techniques for polynomials.
- To introduce various numerical methods for solving ordinary differential equations.
- To introduce various numerical methods for solving partial differential equations.

UNIT I SYSTEMS OF LINEAR EQUATIONS AND ALGEBRAIC EIGENVALUE PROBLEMS 9

Direct method: Gauss elimination method - Error analysis - Iterative methods: Gauss-Jacobi and Gauss-Seidel - Convergence considerations - Eigenvalue problem: Power method.

UNIT II INTERPOLATION, DIFFERENTIATION AND INTEGRATION 9

Interpolation: Lagrange's and Newton's forward interpolations - Errors in interpolation-Numerical differentiation by finite differences - Numerical Integration: Trapezoidal, Simpson's and Error in quadratures.

UNIT III APPROXIMATION OF FUNCTIONS 9

Norms of functions - Best Approximations: Least squares polynomial approximation – Approximation with Chebyshev polynomials - Piecewise Linear & Cubic Spline approximation.

UNIT IV ORDINARY DIFFERENTIAL EQUATIONS 9

Single-step methods: Euler's method - Taylor series method - Runge-Kutta method of fourth order for first order equations - Multistep methods: Adams-Bashforth and Milne's methods – Stability considerations - Linear Two point BVPs: Finite difference method.

UNIT V PARTIAL DIFFERENTIAL EQUATIONS 9

Elliptic equations: Five point finite difference formula in rectangular region - Truncation error; One dimensional Parabolic equation: Explicit and Crank-Nicholson schemes; Stability of the above schemes - One-dimensional Hyperbolic equation: Explicit scheme.

TOTAL: 45 PERIODS

OUTCOMES

CO1: The students will be able to understand, analyze and solve various problems arising in Science and Engineering Numerically.

CO2: The students will be able to solve differentiation and integration problems numerically.

CO3: The students will be able to approximate functions using least square method, cubic spline technique etc.

CO4: The students will be able to solve ordinary differential equations through a variety of numerical techniques.

CO5: The students will be able to undertake the study of advanced courses like Numerical solution of Partial Differential Equations, Functional Analysis and its applications to Partial Differential Equations.

REFERENCES

1. Atkinson K.E., "An Introduction to Numerical Analysis", Wiley, New York, 1989.
2. Brian Bradie., "A Friendly Introduction to Numerical Analysis", Pearson Education, First Edition, New Delhi, 2007.
3. Conte S.D. and Carl de Boor, "Elementary Numerical Analysis", Tata McGraw-Hill Publishing Company, Third Edition, Mexico, 2005.
4. Endre Süli and David Mayers: An Introduction to Numerical Analysis. Cambridge University Press, 2006.
5. Froberg C.E, "Introduction to Numerical Analysis", Addison-Wesley Publishing Company, Second Edition, New York, 1969.
6. Isaacson E. and Keller, H.B., "Analysis of Numerical Methods", Dover Publication, New York, 1994.
7. Iserles, A., "A first course in the Numerical Analysis of Differential Equations", Cambridge University press, New Delhi, 2010.
8. Jain M.K., Iyengar S.R.K. and Jain R.K., "Numerical Methods for Scientific and Engineering", New Age International Pub. Co., Third Edition, New Delhi, 2012.
9. Kincaid D. and Chenney W., "Numerical Analysis: Mathematics of Scientific Computing", AMS, University Press, Third Edition, Hyderabad, 2009.
10. Philips G.M and Taylor P.J., "Theory and Applications of Numerical Analysis", Elsevier, Second Edition, New Delhi, 2006.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	1	2
CO2	2	2	3	3	2	2
CO3	2	2	3	3	2	2
CO4	2	2	3	3	2	2
CO5	2	2	3	3	2	2
Avg.	**2**	**2**	**3**	**3**	**2.2**	**2**

MT3305 TOPOLOGY L T P C
3 0 0 3

OBJECTIVES

- To introduce the basic notion of a topological space.
- To introduce the concept of continuous mappings between topological spaces.
- To introduce the basics of connectedness and compactness of a topological space.
- To introduce the countability and separation axioms.
- To give an introduction to Urysohn metrization theorem and Tychonoff theorem.

UNIT I TOPOLOGICAL SPACES 9

Topological spaces - Basis for a topology - Product topology on finite Cartesian products – Subspace topology – Quotient topology.

UNIT II CLOSED SETS AND CONTINUOUS FUNCTIONS 9

Closed sets and Limit points - Continuous functions - Homeomorphism - Metric Topology – Uniform limit theorem.

UNIT III CONNECTEDNESS AND COMPACTNESS 9

Connected spaces - Components - Path components - Compact spaces - Limit point compactness - Local compactness.

UNIT IV COUNTABILITY AND SEPARATION AXIOMS 9

Countability axioms – T1-spaces - Hausdorff spaces – Regular spaces – Completely regular spaces - Normal spaces.

UNIT V URYSOHN LEMMA AND TYCHONOFF THEOREM 9

Urysohn lemma - Urysohn metrization theorem - Imbedding theorem - Tietze extension theorem - Tychonoff theorem.

TOTAL : 45 PERIODS

OUTCOMES

CO1: The students will get good foundation for future study in analysis and in geometry.
CO2: The students will be able to know more about topological spaces and their properties.
CO3: The students will get in-depth knowledge on topological properties through connected spaces.
CO4: The students will be able to distinguish between different spaces.
CO5: The students will be able to relate different spaces through Urysohn lemma and such.

Attested

REFERENCES
1. Dugundji J., “Topology”, University Book Stall, New Delhi,1990.
2. Joshi K. D., “Introduction to General Topology”, New Age International, New Delhi,2000.
3. Kelly J.L., “General Topology”, Van Nostrand, Toronto, 1955.
4. Munkres J.R., “Topology”, Pearson, Second Edition, New Delhi, 2015.
5. Murdeshwar M.G., “General Topology”, Wiley Eastern, Second Edition, New Delhi, 1990.
6. Simmons G.F., “Introduction to Topology and Modern Analysis”, Tata McGraw Hill, International Student Edition, Singapore, 1983.
7. C.Adams and R.Franzosa, “Introduction to Topology: Pure and Applied”, Pearson, 2007.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3311 COMPUTATIONAL LABORATORY L T P C
0 0 4 2

OBJECTIVE

- To have exposure and usage to software packages such as MATLAB, SPSS and TORA for mathematical computations in Numerical methods, Statistics and Operations research respectively.

C or C++ PROGRAMS

1. Program on Matrix manipulation
2. Program to solve a system of linear equations using Gauss Elimination method
3. Program to solve a system of linear equations using Seidel method
4. Program to solve a system of linear equations using Gauss Jordan method
5. For a given matrix, find the eigenvalue and eigenvector using Power Method

MATLAB PROGRAMS

6. Newton’s Forward and Backward Method
7. Newton’s Divided Difference
8. Simpson 1/3 and 3/8 Method
9. Program on ordinary differential equation
10. Program on Quadratic Equations 26
11. Splines
12. 2D Graphs
13. 3D Graphs
14. Program on Statistical Data Analysis
15. Program to Animation

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TORA

16. Program on Simplex method
17. Program on transportation model
18. Program on linear programming
19. Program on Big M method
20. Program on Integer Programming
21. Program on Graph Theory (Traversal)

TOTAL: 60 PERIODS

REFERENCES:

1. Duane C. Hanselman, Bruce L. Littlefield, "Mastering MATLAB 7", Pearson Education, NewJersey, 2011.
2. Rudra Pratap, "Getting Started with MATLAB", Oxford University Press, New York, 2010.
3. Raj Kumar Bansal, Ashok Goel, Manoj Kumar Sharma, "MATLAB and Its Applications in Engineering", Pearson Education, New Delhi, 2012.
4. Taha, H.A."Operations Research: An Introduction", Pearson Education, Tenth Edition, India, 2017.

MT3001 ADVANCED ANALYSIS

L	T	P	C
3	0	0	3

(Prerequisite: An introductory course in Real Analysis)

OBJECTIVES:

- Real Analysis is the fundamental behind almost all other branches of Mathematics.
- The aim of the course is to make the students understand the basic and advanced concepts of Real analysis.
- To introduce the concept of differentiation through measures.
- To introduce the Fourier transforms and its properties.
- To introduce the concept of Holomorphic Fourier transforms.

UNIT I SPACES 9

Convex functions and inequalities – The spaces – Approximation by continuous functions Trignometric Series completeness of trigonometric system.

UNIT II COMPLEX MEASURES 9

Total variation - Absolute continuity, Consequences of the Radon-Nikodym theorem – Bounded linear functionals - The Riesz representation theorem.

UNIT III DIFFERENTIATION AND PRODUCT SPACES 9

Derivatives of measures - The fundamental theorem of calculus - Differentiable transformations - Measurability on Cartesian Products-Product measures-Fubini's Theorem - Convolutions.

UNIT IV FOURIER TRANSFORMS 9

Attested

Formal properties - The inversion theorem - The Plancheral theorem - The Banach algebra L1.

UNIT V HOLOMORPHIC FOURIER TRANSFORMS **9**

Introduction - Two theorems of Paley and Wiener - Quasi-analytic classes - The Denjoy Carleman theorem.

TOTAL: 45 PERIODS

OUTCOMES

CO1: The students get introduced to the classical Banach spaces.

CO2: The students will get good understanding of methods of decomposing signed measures which has applications in probability theory and Functional Analysis.

CO3: The students will be able to use measure theory for differentiation.

CO4: The students will get good understanding of Fourier Transform and its Holomorphic extensions.

CO5: The students will be able to analyze Holomorphic Fourier Transforms.

REFERENCES

1. Avner Friedman, "Foundations of Modern Analysis", Hold Rinehart Winston, New York, 1970.
2. De Barra G., "Measure Theory and Integration", New Age International Pvt. Ltd, Second Edition, New Delhi, 2013.
3. Rana I. K., "An Introduction to Measure and Integration", Narosa Publishing House, Second Edition, New Delhi, 2007.
4. Walter Rudin, "Real and Complex Analysis", Tata McGraw-Hill, Third Indian Edition, New Delhi, 2017.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	3	3	3	3	2	2

MT3002 DIFFERENTIAL TOPOLOGY

L T P C
3 0 0 3

(Prerequisite: Topology and Advanced Calculus)

OBJECTIVES

- To introduce smooth manifolds and to do calculus on manifolds.
- To introduce manifolds with boundary and intersection theory.
- To introduce the concept of orientation and oriented intersection theory.
- To introduce the Hopf degree theorem.
- To introduce the concept of integration on manifolds.

UNIT I MANIFOLDS AND SMOOTH MAPS **9**

Definitions, derivatives and tangents, inverse function theorem, immersions, submersions, transversality, Homotopy and stability, Sard's theorem

UNIT II TRANSVERSALITY AND INTERSECTION 9

Manifolds with boundary, one manifolds, Transversality, intersection theory mod 2.

UNIT III ORIENTED INTERSECTION THEORY 9

Orientation, Oriented intersection number, Lefschetz fixed point theorem.

UNIT IV HOPF DEGREE THEOREM 9

Poincare Hopf index theorem, isotopy lemma, Hopf degree theorem.

UNIT V INTEGATION ON MANIFOLDS 9

Exterior algebra, differential forms, integration on manifolds.

TOTAL: 45 PERIODS

OUTCOMES

CO1: Students will have a thorough knowledge of differential topology. Manifolds appear in many areas like mathematics, physics and students will be able to solve problems involving manifolds.

CO2: The students will gain an understanding of manifolds with boundary.

CO3: The students will get more knowledge on orientation intersection theory.

CO4: The students will gain a thorough understanding of Hopf Degree theorem.

CO5: The students will be able to perform integration on manifolds.

REFERENCES

1. John W Milnor, “Topology from a Differentiable Viewpoint”, Princeton University Press, New Jersey, 1997.
2. Shastri A.R, Elements of Differential Topology, CRC Press, Boca Raton, 2011.
3. Victor Guillemin and Alan Pollack, “Differential topology”, Prentice-Hall, New Jersey, 1974.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3003 FIXED POINT THEORY L T P C
3 0 0 3

(Prerequisite: Real Analysis and Functional Analysis)

OBJECTIVES

- To identify self-maps for which at least one element is left invariant.
- To introduce hyperconvex spaces and fixed point structures.
- To introduce condensing mapping and continuous mapping in hyperconvex spaces.
- To introduce contraction mappings.
- To introduce asymptotically non expansive mappings.

UNIT I CONTRACTION AND CONTRACTIVE MAPPINGS 9

Banach's Contraction principle - Extensions of Banach's principle – The Caristis-Ekeland Principle - Equivalents of the Caristi-Ekeland Principle – Fixed point theorems for contractive mappings.

UNIT II HYPERCONVEX SPACES AND NORMAL STRUCTURES IN METRIC SPACES 10

Hyperconvexity - Properties of hyperconvex spaces - Approximate fixed points - Normal structures in metric spaces - Structure of the fixed point set - Continuous mappings on hyperconvex spaces.

UNIT III CONTINUOUS MAPPING ON BANACH SPACES 10

Brouwer's theorem - Schauder's Theorem - Stability of Schauder's Theorem - Condensing mappings.

UNIT IV NONEXPANSIVE MAPPINGS 8

Uniformly convex spaces - Basic theorems for non-expansive mappings - Asymptotically non expansive mappings - Asymptotically regular mappings - Demiclosedness principle.

UNIT V SET VALUED MAPPINGS 8

Set valued contractions – Common fixed point theorems for set valued contractions – Fixed point theorems for set valued continuous mappings.

TOTAL: 45 PERIODS

OUTCOMES

CO1: The student will be able to apply fixed point theory in various branches of applied mathematics.
CO2: The student will gain more in-depth understanding of metric spaces and hyperconvex spaces.
CO3: The student will be able to apply continuous mappings in hyperconvex spaces.
CO4: The student will be able to further apply contraction mappings and fixed point theorems.
CO5: The student will have a thorough understanding of some more fixed point theorems and their applications.

REFERENCES

1. Deimling K., "Nonlinear Functional Analysis", Springer–Verlag, New York,1985.
2. Istratescu V. I., "Fixed Point theory: An Introduction", Reidel Publishing Company, Boston,1981.
3. Mohamed A. Khamsi & William A. Kirk, "An Introduction to Metric Spaces and Fixed Point Theory", John Wiley & Sons, New York, 2001.
4. Smart D.R., "Fixed Point Theory", Cambridge University Press, Cambridge, 1980.
5. Zeidler E., "Nonlinear Functional Analysis and its applications", Vol. I, Springer-Verlag, New York,1986.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

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MT3004 FUNCTIONAL ANALYSIS AND ITS APPLICATIONS TO PARTIAL DIFFERENTIAL EQUATIONS **L T P C 3 0 0 3**

(Prerequisite: Functional Analysis and Partial Differential Equations)

OBJECTIVES

- The aim of the course is to make the students understand the functional analysis concepts and techniques used in partial differential equations.
- To introduce Sobolev Spaces and their properties.
- To find weak solutions to elliptic boundary value problems.
- To introduce finite element method and the analysis of the method.
- To introduce semigroups in Hilbert spaces.

UNIT I DISTRIBUTION THEORY 9

Distributions - operations with distributions - support and singular support – convolutions - fundamental solutions.

UNIT II SOBOLEV SPACES 9

Basic properties - approximation by smooth functions and consequences - imbedding theorems - Rellich-Kondrasov compactness theorems - trace spaces - dual spaces - trace theory.

UNIT III WEAK SOLUTIONS OF ELLIPTIC EQUATIONS 9

Abstract variational results (Lax-Milgram lemma, Babuska-Brezzi theorem) - existence and uniqueness of weak solutions for elliptic boundary value problems (Dirichlet, Neumann problems) - regularity results.

UNIT IV GALERKIN METHODS 9

Galerkin method - maximum principles - eigenvalue problems - introduction to the mathematical theory of the finite element method.

UNIT V EVOLUTION EQUATIONS 9

Unbounded operators - exponential map - C0-semigroups -Hille-Yosida theorem – contraction semigroups in Hilbert spaces - applications to the heat wave.

TOTAL: 45 PERIODS

OUTCOMES

CO1: The course, apart from providing a thorough understanding of the functional analytic concepts and techniques used in partial differential equations, will enable them to solve the partial differential equations of various problems arising in Science and Engineering.

CO2: The student will gain more understanding of Sobolev spaces, trace spaces etc.

CO3: The student will be able to solve various elliptic boundary value problems.

CO4: The student will be able to find solutions to partial differential equations through Galerkin's finite element method.

CO5: The student will be in a position to apply the technique to the heat wave problem.

REFERENCES

1. Evans L. C., “Partial Differential Equations, Graduate Studies in Mathematics” AMS University Press, Hyderabad,2009.
2. Kesavan, S., “Topics in Functional Analysis and Applications”, New Age International Ltd., New Delhi, 2008.
3. McOwen R.C., “Partial differential Equations”, Pearson Education, New Delhi,2003.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3005 GEOMETRIC FUNCTION THEORY (Prerequisite: Complex Analysis)

L T P C
3 0 0 3

OBJECTIVES

- The advanced level of Complex Analysis has been introduced and an expertise treatment is provided on Subordination, General Extremal problems and Integral transforms.
- To introduce primitive variational method.
- To introduce the concept of subordination.
- To introduce extremal problems and properties.
- To introduce the coefficient conjecture.

UNIT I ELEMENTARY THEORY OF UNIVALENT FUNCTIONS 9

Area theorem - Growth and distortion theorems - Coefficient estimates - Convex and Starlike functions - Close to convex functions – Spiral-like functions - Typically real functions.

UNIT II VARIATIONAL METHODS 9

Primitive variational method - Growth of integral means - Odd Univalent functions – Asymptotic Bieberbach conjecture.

UNIT III SUBORDINATION 9

Basic principles - Coefficient inequalities - Sharpened forms of the Schwartz lemma - Majorization - Univalent subordinate functions.

UNIT IV GENERAL EXTREMAL PROBLEMS 9

Functionals of linear spaces - Representation of linear functionals - Extreme points and support points- Properties of extremal functions – Extreme points of S, Extreme points of Σ.

UNIT V COEFFICIENT CONJECTURE 9

Preliminaries – Proof of the Coefficient Conjecture.

TOTAL: 45 PERIODS

OUTCOMES

CO1: The course equips the students with theory of Univalent functions and related mathematical concepts based on the same.
CO2: The students will have a thorough understanding of univalent functions.
CO3: The students will gain knowledge in subordination and univalent subordinate functions.
CO4: The students will get an understanding in solving extremal problems.
CO5: The students will get introduced to the concept of coefficient conjecture.

REFERENCES

1. Goodman A.W., "Univalent Functions", Vol. 1 , Polygonal Publishing House, New Jersey, 1983.
2. Peter L. Duren, "Univalent Functions", Springer Verlag, New York, 1983.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3006 MATHEMATICAL ASPECTS OF FINITE ELEMENT METHOD **L T P C**
(Prerequisite: Functional Analysis) **3 0 0 3**

OBJECTIVES

- The aim of the course is to make the students understand the mathematical aspects of finite element method required for solving partial differential equations.
- To introduce Sobolev Spaces and their properties.
- To introduce the concept of variational formulation of elliptic and parabolic boundary value problems.
- To introduce various element methods.
- To introduce higher dimensional variational problems.

UNIT I BASIC CONCEPTS 9

Weak formulation of Boundary value problems - Ritz-Galerkin approximation - Error estimates - Piecewise polynomial spaces - Finite Element Method - Relationship to difference.

UNIT II SOBOLEV SPACES 9

Review of Lebesgue integration theory - Weak derivatives - Sobolev norms and associated spaces - Inclusion relations and Sobolev's inequality - Trace theorems.

UNIT III VARIATIONAL FORMULATIONS 9

Projections onto subspaces and Riesz representation theorem - Symmetric and non-symmetric variational formulation of elliptic and parabolic boundary value problems - Lax-Milgram theorem – Error estimates for general finite element approximation.

UNIT IV CONSTRUCTION OF FINITE ELEMENT SPACE AND APPROXIMATION THEORY IN SOBOLEV SPACES 9

The Finite element - Triangular finite elements - Lagrange element - Hermite element, Rectangular elements - Interpolant - Averaged Taylor polynomials - Error representation - Bounds for the Interpolation error.

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UNIT V HIGHER DIMENSIONAL VARIATIONAL PROBLEMS 9

Higher-dimensional examples - Variational formulation and approximation of Poisson's and Neumann equations - Coercivity of the variational problem - Elliptic regularity estimates – Variational approximations of general Elliptic and Parabolic problems.

TOTAL: 45 PERIODS

OUTCOMES

CO1: The students will be in position to tackle complex problems involving partial differential equations arising in the mathematical models of various problems in Science and Engineering by finite element techniques.

CO2: The student will gain more understanding of Sobolev spaces.

CO3: The student will have more knowledge about variational formulations of elliptic and parabolic boundary value problems.

CO4: The student will get to know about different element methods and be able to find error estimates for different methods.

CO5: The student will be able to extend the knowledge to higher dimensional variational problems.

REFERENCES

1. Brenner S. and Scott R., "The Mathematical Theory of Finite Element Methods", Springer-Verlag, New York, 2008.
2. Ciarlet P.G., "The Finite Element Methods for Elliptic Problems", North Holland, Amsterdam,1978.
3. Claes Johnson, "Numerical Solutions of Partial Differential Equations by the Finite Element Method", Cambridge University Press, New York,1994.
4. Thomee V., "Galerkin Finite Element Methods for Parabolic Problems", Lecture Notes in Mathematics, Vol.1054, Springer-Verlag, Berlin,1984.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3007 THEORY OF WAVELETS L T P C
3 0 0 3

OBJECTIVES

- To revise Fourier analysis and continuous time convolution.
- To introduce the notions of wavelet transforms, Time frequency analysis.
- To introduce multi-resolution analysis and wavelets.
- Also to introduce the more specialized topics like compactly supported wavelets.
- To introduce cardinal splines and spline wavelets.

UNIT I FOURIER ANALYSIS 9

Fourier and inverse Fourier transforms - Continuous time convolution and the delta function – Fourier transform of square integrable functions - Poisson's summation formula.

UNIT II WAVELET TRANSFORMS AND TIME-FREQUENCY ANALYSIS 9

The Gabor transform - Short time Fourier transforms and the uncertainty principle - The integral wavelet transform - Diadic Wavelets and inversions - Frames.

UNIT III MULTI RESOLUTION ANALYSIS AND WAVELETS 11

The Haar wavelet construction - Multi resolution analysis - Riesz basis to orthonormal basis – Sealing function and scaling identity - Construction of wavelet basis.

UNIT IV COMPACTLY SUPPORTED WAVELETS 10

Vanishing moment's property - Meyer's wavelets - Construction of a compactly supported wavelet - Smooth wavelets.

UNIT V CARDINAL SPLINES AND SPLINE WAVELETS 6

Cardinal spline spaces - B-splines - computation of cardinal splines - spline wavelets – Exponential decay of spline wavelets.

TOTAL: 45 PERIODS

OUTCOMES

CO1: The students will be able to thoroughly handle Fourier analysis.
CO2: Students would be trained to handle "Wavelets", which is a versatile tool with rich mathematical content and has great potential for applications in engineering.
CO3: The student will be equipped for constructing wavelets.
CO4: The student will be able to construct compactly supported wavelets.
CO5: The student will get introduced to spline wavelets and their properties.

REFERENCES

1. Chan Y.T., "Wavelet Basics", Kluwer Academic Publishers, Boston, 1995.
2. Chui C.K., "An introduction to Wavelets", Academic Press, San Diego, 1992.
3. Pathak R.S.,, "The Wavelet Transform", Atlantis Press/World Scientific, Paris, 2009.
4. Wojtaszczyk P., "A mathematical introduction to Wavelets", London Mathematical Society Student Texts 37, Cambridge University Press, Cambridge, 1997.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3008 **NUMBER THEORY** **L T P C**
3 0 0 3

OBJECTIVES

- To introduce the concept of divisibility
- To introduce congruences and the Chinese Remainder theorem
- To introduce what is a public-key cryptography and the use of primitive roots power residues and quadratic residues
- To introduce some functions of number theory like greatest integer function, arithmetic functions and mobius inversion formula
- To introduce diophantine equations and Farey Fractions

UNIT I DIVISIBILITY **9**

Introduction - Divisibility - Primes - The binomial theorem.

UNIT II CONGRUENCES **9**

Congruences - Solutions of congruences - The chinese - Remainder theorem - Techniques of numerical calculation.

UNIT III APPLICATION OF CONGRUENCE AND QUADRATIC RECIPROCITY **9**

Public - Key cryptography - Prime power moduli - Prime modulus - Primitive roots and power residues - Quadratic residues - The Gaussian reciprocity law.

UNIT IV FUNCTIONS OF NUMBER THEORY **9**

Greatest integer function - Arithmetic functions - Mobius inversion formula - Recurrence functions Combinational number theory.

UNIT V DIOPHANTINE EQUATIONS AND FAREY FRACTIONS **9**

The equations ax + by = c Pythagorean triangle - Shortest examples - Farey sequences Rational approximations.

TOTAL: 45 PERIODS

OUTCOMES

CO1: The student would have learnt to solve divisibility problems using binomial theorem
CO2: Students would have learnt some techniques of numerical calculations using congruences
CO3: Students will be able to apply the Gaussian reciprocity law in public-key cryptography
CO4: Students will have a good foundation in combinatorial number theory
CO5: The students will be able to solve some diophantine equations and some special cases of Fermat's Last theorem.

REFERENCES

1. Bressoud D., Wagon S., "A Course in Computational Number Theory", Key College Publishing, New York, 2000.
2. Graham R.L., Knuth D.E. and Patashnik O., "Concrete Mathematics", Addison-Wesley, Second Edition, New Jersey, 2017.
3. Niven I., Zuckerman H.S., and Montgomery H.L., "An introduction to the theory of numbers", John Wiley & Sons Pvt., Ltd., Fifth Edition, Singapore, 2013.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3009 NUMBER THEORY AND CRYPTOGRAPHY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To introduce the mathematics needed in cryptography, like time estimation for doing mathematical operations
- To introduce more advanced topics like finite fields and multiplicative generators
- Students will be introduced to crypto systems
- To introduce pseudo primes and simple tests for primality
- To introduce elliptic curves and advanced primality tests

UNIT I INTRODUCTION TO NUMBER THEORY 9

Time estimates for doing arithmetic - Divisibility and the Euclidean algorithm - Congruences - Modular exponentiation - Some applications to factoring.

UNIT II QUADRATICS RESIDUES AND RECIPROCITY 9

Finite Fields - Multiplicative generators - Quadratic residues and reciprocity.

UNIT III CRYPTOSYSTEMS 9

Some simple cryptosystems - Digraph transformations - Enciphering Matrices - Affine enciphering transformations RSA - Discrete Log - Diffie-Hellman key exchange - The Massey - Omura cryptosystem - Digital Signature standard - Computation of discrete log.

UNIT IV PRIMALITY AND FACTORING - I 9

Pseudoprimes - Strong pseudoprimes - Solovay-Strassen Primality test - Miller - Rabin test - Rho method.

UNIT V PRIMALITY AND FACTORING – II 9

Elliptic Curves - Elliptic Curve Cryptosystems -Elliptic curve primality test- Elliptic Curve factoring - Pollard's p - 1 method - Elliptic curve reduction modulo n.

TOTAL: 45 PERIODS

OUTCOMES

CO1: The students would have learnt to assess and improve computer algorithms required for public key cryptography.

CO2: Students would be able to apply quadratic reciprocity law in number theory and cryptography

CO3: The students will know about different types of crypo systems and will be able to compute discrete log

CO4: Students will be able to apply Solovay-Strassen Primality test , Miller - Rabin test and Rho method.

CO5: Students will be able to able to deal with elliptic curve cryptosystems and would have learnt some advanced factoring methods

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3010 **FUZZY SET THEORY** **L T P C**
3 0 0 3

OBJECTIVES

- To define the basic ideas and entities in fuzzy set theory.
- To introduce the various types of operations on fuzzy sets.
- To extend the idea of operations on fuzzy sets to fuzzy numbers.
- To discuss the concepts and properties of relations on fuzzy sets.
- To learn how to obtain a fuzzy relation equation and its solution procedure.

UNIT I FUZZY SETS VARSUS CRISP SETS 9

Fuzzy sets-Basic types - Fuzzy sets - Basic concepts - Additional properties of Alpha-cuts Representations of fuzzy sets - Extension principle for fuzzy sets.

UNIT II OPERATIONS ON FUZZY SETS 9

Types of operations - Fuzzy complements - Fuzzy intersections: t-norms - Fuzzy unions: t- co-norms Combinations of operations.

UNIT III FUZZY ARITHMETIC 9

Fuzzy numbers - Linguistic variables - Arithmetic operations on Intervals - Arithmetic operations on fuzzy numbers.

UNIT IV FUZZY RELATIONS 9

Crisp and fuzzy relations - Projections and cylindric extensions - Binary fuzzy relations - Binary relations on a single set - Fuzzy equivalence relations - Fuzzy compatibility relations - Fuzzy ordering relations - Sup-i composition and inf-wi compositions of Fuzzy relations.

UNIT V FUZZY RELATION EQUATIONS 9

Partition - Solution method - Fuzzy relation equations based on sup-i compositions and infwi compositions.

TOTAL: 45 PERIODS

OUTCOMES

CO1: It helps to understand the basics of fuzzy sets and its properties.
CO2: It gives a clear idea of various types of operations on fuzzy sets.
CO3: It extends the essence of operations on fuzzy sets to fuzzy numbers.
CO4: It paves way to define the concepts and properties of relations on fuzzy sets.
CO5: It helps to obtain the fuzzy relation equation and its solution procedure.

REFERENCES

1. Dubois D. and Prade H., “Fuzzy sets and systems, Theory and Applications”, Academic Press, New York,1997.
2. Ganesh, M.,” Introduction to Fuzzy sets and Fuzzy logic”, Prentice Hall, New Delhi, 2006.
3. George J. Klir and Yuan B., “Fuzzy Sets and Fuzzy Logic, Theory and Applications”, Pearson, New Delhi , 2015.
4. Kaufmann A.,” Introduction to the theory of Fuzzy Subsets Vol. I Fundamental Theoretical Elements”, Academic Press, Orlando, 1985.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3011 **FINITE ELEMENT METHOD** **L T P C**
3 0 0 3

OBJECTIVES

- To introduce the integral formulations and variational methods of solving boundary value problems
- To enable the students understand various steps in the finite element method of solution.
- To demonstrate finite element method of solution to time-dependent problems in one-dimension
- To discuss the finite element method of solution to time-dependent problems in two-dimensions
- To analyze various measures of errors, convergence and accuracy of solution.

UNIT I INTEGRAL FORMULATIONS AND VARIATIONAL METHODS 9

Weighted integral and weak formulations of boundary value problems - Rayleigh-Ritz method - Method of weighted residuals.

UNIT II FINITE ELEMENT ANALYSIS OF ONE-DIMENSIONAL PROBLEMS 9

Discretization of the domain - Derivation of element equations - Connectivity of elements - Imposition of boundary conditions - Solution of equations.

UNIT III EIGENVALUE AND TIME DEPENDENT PROBLEMS IN ONE DIMENSION 9

Formulation of eigenvalue problem - Finite element models - Applications of semi discrete finite element models for time-dependent problems - Applications to parabolic and hyperbolic equations.

UNIT IV FINITE ELEMENT ANALYSIS OF TWO-DIMENSIONAL PROBLEMS 10

Interpolation functions - Evaluation of element matrices - Assembly of element equations – Imposition of boundary conditions - Solution of equations - Applications to parabolic and hyperbolic equations.

UNIT V FINITE ELEMENT ERROR ANALYSIS 8

Interpolation Functions - Numerical Integration and Modeling Considerations - Various measures of errors - Convergence of solution - Accuracy of solution.

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course, the students will be able to
CO1: construct integral formulations of boundary value problems
CO2: implement Finite Element Method for one-dimensional problems
CO3: formulate eigenvalue problems and time-dependent problems in one-dimension
CO4: implement finite element method to time dependent problems in two-dimensions
CO5: perform the finite element error analysis.

REFERENCES

1. Buchanen G.R. and Rudhramoorthy R., "Finite Element Analysis - Schaum's Outline Series",Tata McGraw Hill, New Delhi, 2006.
2. Huttan D.V., "Fundamentals of Finite Element Analysis", Tata McGraw Hill, New Delhi, 2005.
3. Reddy J.N., "An Introduction to the Finite Element Method", Tata Mc-Graw Hill, New York,2017.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

Attested

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MT3012 **FINITE VOLUME METHOD** **L T P C**
3 0 0 3

OBJECTIVES

- To introduce the ideas of conservation laws and governing equations of fluid flows.
- To demonstrate the finite volume method for diffusion and convection-diffusion problems.
- To present the solution algorithms for momentum equations.
- To exhibit the finite volume methods of solving unsteady flows.
- To extend the ideas to problems in complex geometries.

UNIT I CONSERVATION LAWS AND BOUNDARY CONDITIONS 9

Governing equation of fluid flow: Mass - Momentum and Energy equations - Equation of state; Navier-Stokes equations for a Newtonian fluid - Conservative form of equations of fluid flow - Differential and integral forms of the transport equation - Classification of PDE's and fluid flow equations - Viscous fluid flow equations - Transonic and supersonic compressible flows.

UNIT II FINITE VOLUME METHOD FOR DIFFUSION & CONVECTION-DIFFUSION PROBLEMS 9

FVM for Diffusion Problems: one-dimensional steady sate diffusion - Two-dimensional diffusion and three-dimensional diffusion problems; FVM for Convection-Diffusion problems: one-dimensional steady state convection- diffusion - central differencing schemes for one - Dimensional convection diffusion - Upwind differencing scheme - Hybrid differencing scheme - Higher-order differencing scheme for convection - Diffusion problems - TVD schemes.

UNIT III SOLUTION ALGORITHMS FOR PRESSURE-VELOCITY LINKED EQUATIONS 9

Staggered grid - momentum equations - SIMPLE, SIMPLER, SIMPLEC algorithms – PISO algorithm -Solution of discretised equation: Multigrid techniques.

UNIT IV FINITE VOLUME METHOD FOR UNSTEADY FLOWS 9

One-dimensional unsteady heat conduction: Explicit - Crank-Nicolson - fully implicit schemes - Implicit method for two and three dimensional problems - transient convection - Diffusion equation and QUICK differencing scheme - Solution procedures for unsteady flow calculations and implementation of boundary conditions.

UNIT V METHOD WITH COMPLEX GEOMETRIES 9

Body-fitted co-ordinate grids for complex geometries - Cartesian Vs. Curvilinear grids difficulties in Curvilinear grids - Block-structured grids - Unstructured grids and discretisation in unstructured grids - Discretisation of the diffusion term - Discretisation of convective term - Treatment of source terms - Assembly of discretised equations - Pressure-velocity coupling in unstructured meshes - Staggered Vs. co-located grid arrangements - Face velocity interpolation method to unstructured meshes.

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course, the students will be able to
CO1: understand the conservation laws and governing equations of fluid flows.
CO2: apply finite volume method for diffusion and convection-diffusion problems.
CO3: solve momentum equations after discretizing.
CO4: learn the finite volume methods of solving unsteady flows.
CO5: use finite volume methods to solve problems in complex geometries.

REFERENCES

1. Ferziger J.H and Peric. M, "Computational methods for Fluid Dynamics", Springer, Third Edition,New Delhi, 2005.
2. Chung T.J., "Computational Fluid Dynamics", Cambridge University Press, Leiden, 2010.
3. Suhas V. Patankar, "Numerical Heat Transfer and Fluid Flow", Taylor & Francis, Ohio, 2007.

4. Versteeg H.K. and Malalasekera W. “An Introduction to Computational Fluid Dynamics: TheFinite Volume Method”, Pearson Education, Second Edition, Harlow, 2008.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3013 FLUID MECHANICS L T P C
3 0 0 3

OBJECTIVES:

- To give a comprehensive overview of basic concepts of fluid mechanics.
- To introduce the concepts in kinematics and kinetics of fluid flows.
- To enable the students to understand the two-dimensional flows in various geometries.
- To introduce the hydrodynamical aspects of conformal transformation.
- To demonstrate various viscous fluid flows.

UNIT I KINEMATICS OF FLUIDS IN MOTION 9

Real and Ideal fluids – Velocity - Acceleration – Streamlines – Pathlines – Steady & unsteady flows – Velocity potential – Vorticity vector – Local and particle rates of change – Equation of continuity – Conditions at a rigid boundary.

UNIT II EQUATIONS OF MOTION OF A FLUID 9

Pressure at a point in a fluid – Boundary conditions of two inviscid immiscible fluids – Euler’sequations of motion – Bernoulli’s equation – Some potential theorems – Flows involving axial symmetry.

UNIT III TWO DIMENSIONAL FLOWS 9

Two-Dimensional flows – Use of cylindrical polar co-ordinates – Stream function, complex potential for two-dimensional flows, irrotational, incompressible flow –Complex potential for standard two dimensional flows –Two dimensional image systems – Milne-Thomson circle theorem – Theorem of Blasius.

UNIT IV CONFORMAL TRANSFORMATION AND ITS APPLICATIONS 9

Use of conformal transformations – Hydrodynamical aspects of conformal mapping - Schwarz Christoffel transformation – Vortex rows.

UNIT V VISCOUS FLOWS 9

Stress – Rate of strain – Stress analysis – Relation between stress and rate of strain – Coefficient of viscosity – Laminar flow – Navier-Stokes equations of motion – Some problems in viscous flow.

Attested

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course, the students will be able to

CO1: understand the concepts of kinematics and kinetics of fluid mechanics.

CO2: derive the governing equations of fluid flows.

CO3: solve the fluid flows in two-dimensional and axisymmetric geometries.

CO4: apply conformation transformation to fluid flows.

CO5: solve the viscous fluid flow problems in different geometries.

REFERENCES

1. Batchelor. G.K. " An introduction to Fluid Dynamics" ,Cambridge University Press, Cambridge, 2013.
2. Frank Chorlton, "Textbook of Fluid Dynamics", CBS Publishers, New Delhi, 1985.
3. Milne Thomson L.M., "Theoretical Hydrodynamics", Dover Publications, Fifth Edition, New York,2013.
4. White F.M., "Fluid Mechanics", McGraw-Hill, Eighth Edition, New Delhi, 2017.
5. White F.M., "Viscous Fluid Flow", McGraw-Hill, New York, 2011.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	3
CO2	3	3	3	3	3	3
CO3	3	3	2	2	3	3
CO4	3	3	2	3	2	3
CO5	3	3	3	3	3	3
Avg.	**3**	**3**	**2.6**	**2.8**	**2.6**	**3**

MT3014 NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS **L T P C**
3 0 0 3

OBJECTIVES

- To make the students understand the numerical methods of solving partial differential equations.
- To introduce the methods of solving one-dimensional parabolic equations.
- To demonstrate the methods of solving two-dimensional parabolic equations.
- To display the methods of solving hyperbolic equations.
- To reveal the ideas of solving elliptic equations.

UNIT I LINEAR SYSTEMS OF EQUATIONS 9

Iterative methods for solving large linear systems of algebraic equations: Jacobi, Gauss-seidel and S.O.R methods - Conditions for convergence of them - Methods for accelerating convergence: Lyusternite's & Aitken's methods - Optimum acceleration parameter for S.O.R method.

Attested

UNIT II ONE DIMENSIONAL PARABOLIC EQUATIONS 9

Explicit and Crank-Nicolson Schemes for $u_t = u_{xx}$ Weighted average approximation – Derivative boundary conditions - Truncation errors - Consistency, Stability and convergence - Lax Equivalence theorem.

UNIT III MATRIX NORMS & TWO DIMENSIONAL PARABOLIC EQUATION 9

Vector and matrix norms - Eigenvalues of a common tridiagonal matrix - Gerischgorin's theorems - Stability by matrix and Fourier-series methods – Rachford A.D.I. methods.

UNIT IV HYPERBOLIC EQUATIONS 9

First order quasi-linear equations and characteristics - Numerical integration along a characteristic - Lax-Wendroff explicit method - Second order quasi-linear hyperbolic equation - Characteristics - Solution by the method of characteristics.

UNIT V ELLIPTIC EQUATIONS 9

Solution of Laplace and Poisson equations in a rectangular region - Finite difference in Polar coordinate Formulas for derivatives near a curved boundary when using a square mesh - Discretisation error - Mixed Boundary value problems.

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course, the students will be able to

CO1: learn various numerical methods of solving partial differential equations.

CO2: solve one-dimensional parabolic equations using explicit and implicit schemes.

CO3: solve two-dimensional parabolic equations and analyze the stability of the schemes.

CO4: understand the methods of solving hyperbolic equations.

CO5: solve elliptic equations in Cartesian and Polar coordinates.

REFERENCES

1. Mitchel A.R. and Griffiths S.D.F., "The Finite Difference Methods in Partial Differential Equations", John Wiley and sons, New York, 1980.
2. Morton K.W., Mayers, D.F., "Numerical Solutions of Partial Differential Equations", Cambridge University Press, Cambridge, 2005.
3. Iserles A., "A first course in the Numerical Analysis of Differential Equations", Cambridge University press, New Delhi, 2010.
4. Smith G.D., "Numerical Solution of Partial Differential Equations", Oxford University Press, New York, 1995.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3015 **MATHEMATICAL FINANCE** **L T P C**
3 0 0 3

OBJECTIVES

- To understand the basic probability concepts in association with random variables and significance of the Central Limit theorem with respect to the Brownian motion
- To understand the basic concepts of present value and accumulated value and apply these concepts toward solving more complicated financial problems and complex annuity problems
- To appreciate the Arbitrage theorem in the context of the Black – Scholes formula.
- To obtain a practical knowledge on the Portfolio selection problem
- To understand option pricing with respect to various options via multi-period binomial models.

UNIT I PROBABILITY AND RANDOM VARIABLES 9

Probability and Events - Conditional probability - Random Variables and Expected values - Covariance and Correlation - Normal Random Variables - Properties of Normal Random Variables – Central Limit theorem - Geometric Brownian Motion as a limit of simpler models - Brownian motion.

UNIT II PRESENT VALUE ANALYSIS AND ARBITRAGE 9

Interest rates - Present value analysis - Rate of return - Continuously varying interest rates – Pricing contracts via Arbitrage - An example in options pricing.

UNIT III ARBITRAGE THEOREM AND BLACK-SCHOLES FORMULA 9

The Arbitrage theorem – Multi-period binomial model - Black-Scholes formula - Properties of Black - Scholes option cost - Delta Hedging Arbitrage Strategy - Pricing American put options.

UNIT IV EXPECTED UTILITY 9

Limitations of arbitrage pricing - Valuing investments by expected utility - The portfolio section problem- Capital assets pricing model - Rates of return - Single period and geometric Brownian motion.

UNIT V EXOTIC OPTIONS 9

Barrier options - Asian and look back options - Monte Carlo Simulation - Pricing exotic option by simulation - More efficient simulation estimators - Options with non-linear pay offs – pricing approximations via multi-period binomial models.

TOTAL: 45 PERIODS

OUTCOMES

CO1: To demonstrate a comprehensive understanding of the probability concepts
CO2: To locate and use information to solve problems in interest theory and financial engineering
CO3: To know the main features of models commonly drawn from industry and financial firms in order
CO4: To explore arbitrage strategy To understand and appraise utility and effectiveness in option pricing
CO5: To simulate appropriate models treating Exotic options

REFERENCES

1. Sheldon M. Ross, “An Elementary Introduction to Mathematical Finance”, Cambridge University Press, Third Edition, Cambridge, 2011.
2. Steven Roman, “Introduction to the Mathematics of finance”, Springer-Verlag Second Edition, New York, 2012.
3. Williams, R.J., “Introduction to the Mathematics of finance”, AMS Universities Press (India) Pvt. Ltd, New Delhi, 2006.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	1
CO2	2	3	3	2	1	1
CO3	2	2	3	2	2	2
CO4	2	1	2	3	2	2
CO5	2	1	1	2	3	3
Avg.	**2.2**	**1.8**	**2.2**	**2.2**	**1.8**	**1.8**

MT3016 MATHEMATICAL PROGRAMMING **L T P C**
3 0 0 3

OBJECTIVE

To provide knowledge and training using optimization techniques under limited resources for the engineering and business problems.

- To formulate and solve linear programming problems using graphical method, Simplex method and its variants
- To learn advanced Linear programming methods using Duality
- Exposure to Integer programming methods
- Understanding of Non-linear programming tools
- To learn Dynamic programming technique for realistic problems

UNIT I LINEAR PROGRAMMING 9

Assumptions and Formulation of linear programming problem – Graphical method – Solutions to LPP using simplex algorithm – Two phase method – Big-M method – Transportation and Assignment problems.

UNIT II ADVANCED LINEAR PROGRAMMING 9

Duality – Dual simplex method – Revised simplex method – Bounded variable technique.

UNIT III INTEGER PROGRAMMING 9

Cutting plane algorithm – Branch and bound technique – Applications of Integer programming – Capital Budgeting – Fixed-Charge Problem

UNIT IV NON-LINEAR PROGRAMMING 9

Unconstrained one variable and multi variable optimization, KKT Conditions, Constrained optimization, Quadratic programming

UNIT V DYNAMIC PROGRAMMING 9

Principle of optimality – Forward and backward recursive equations – Deterministic dynamic programming applications.

TOTAL: 45 PERIODS

OUTCOMES

CO1: Prepares the student to model various real life situations as Optimization problems and effect their solution through Mathematical Programming techniques

CO2: Students will gain familiarity with some of the well-known optimization techniques and their applicability in a real setting

CO3: Students will gain awareness on the usefulness and limitations of optimization

CO4: An ability to visualize and use optimization tools to the exposed ideas is attained

CO5: Students will be able to apply the technique to real life situations

REFERENCES

1. Taha, H.A., "Operations Research: An Introduction", Pearson Education, India, Tenth Edition, New Delhi, 2019.
2. Ravindran A., Phillips D.T. and Solberg,J.J., "Operations Research –Principles and Practice", Wiley Indian Edition, Second Edition, New Delhi, 2007.
3. Sharma, J.K. "Operations Research: Theory and Applications", Trinity Press, New Delhi, 2017
4. Frederick S.Hillier, Gerald J. Lieberman, Bodhibrata Nag and Preetam Kantiswarup, "Introduction to Operations Research", McGraw Hill Education, Boston, 2017.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	2
CO2	3	3	2	2	1	1
CO3	3	3	3	2	1	1
CO4	3	3	2	2	1	1
CO5	3	3	2	2	3	3
Avg.	**3**	**3**	**2.2**	**2**	**1.6**	**1.6**

MT3017 NETWORKS, GAMES AND DECISIONS **L T P C**
3 0 0 3

OBJECTIVES

- To introduce the certain algorithms for solving the network models
- Exposure to different project management techniques like PERT and CPM
- To familiarize with the various aspects of game theory which involves decision
- To introduce the students to the idea of making decision for problems involving various alternatives
- To get an idea of certain topics on Optimization techniques.

UNIT I NETWORK MODELS 9

Scope and definition of network models – Minimal spanning tree algorithm – Shortest-route problem – Maximal – flow Model.

UNIT II CPM AND PERT 9

Network representation – Critical path (CPM) computations – Construction of the time schedule – Linear programming formulation of CPM – PERT calculations.

UNIT III GAME THEORY 9

Optimal solution of two-person zero-sum games – Mixed strategies – Graphical solution of (2xn) and (mx2) games – Solution of mxn games by linear programming.

UNIT IV DECISION ANALYSIS 9

Decision making under certainty: analytic hierarchy process (AHP) – Decision making under risk – Decision under uncertainty.

UNIT V MARKOVIAN DECISION PROCESS 9

Scope of the Markovian decision problem – Finite stage dynamic programming model – Infinite stage model – Linear programming solution.

TOTAL: 45 PERIODS

OUTCOMES

CO1: It helps in formulating many practical problems in the framework of Networks.

CO2: It helps the students understand that CPM is a deterministic method whereas PERT uses a probabilistic model which deals with unpredictable activities.

CO3: It enables the students to identify competitive situations which can be modeled and solved by game theoretic formulations

CO4: It moulds the students to make decisions for various realtime problem subject to uncertainty and risk.

CO5: It offers interesting techniques to quantity and effectively obtain the solution of various decision making situations.

REFERENCES

1. Taha,H.A., “Operations Research: An Introduction”, Pearson Education Limited, Tenth Edition, New Delhi, 2019.
2. Hillier F.S., Lieberman G.J., Nag, Basu,“Introduction to Operations Research”,TataMc-Graw Hill, Ninth Edition, NewDelhi,2017.
3. Winston W.L., “Operations Research”, Brooks/Cole Cengage Learning, Fourth Edition, Belmont, 2003.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	2
CO2	2	3	2	2	2	2
CO3	2	2	3	2	2	2
CO4	1	2	2	3	2	2
CO5	1	2	2	3	3	3
Avg.	**1.8**	**2.2**	**2.2**	**2.4**	**2.2**	**2.2**

Attested

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MT3018 **QUEUEING AND RELIABILITY MODELING** **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce the basic concept of Markovian queueing systems.
- To analyze the advance Markovian queues such as bulk input, batch service and priority queues.
- To familiarize the non-Markov queues and their performance measures.
- To study the system reliability and hazard function for series and parallel systems.
- To implement Markovian Techniques for availability and maintainability which opens up new avenues for research.

UNIT I MARKOVIAN QUEUES 9

Steady State Analysis - Single and multiple channel queues - Erlang's formula - Queues with unlimited waiting space-Finite source queues.

UNIT II ADVANCED MARKOVIAN QUEUES 9

Bulk input model-Bulk service model-Erlangian models-Priority queue discipline.

UNIT III NON-MARKOVIAN QUEUES 9

M/G/1 queueing model-Pollaczek-Khintchine formula-Steady-state system size probabilities-Waiting time distributions-Generalization of Little's formula-Busy period analysis of M/G/1queue.

UNIT IV SYSTEM RELIABILITY 9

Reliability and hazard functions - Exponential, normal, Weibull and Gamma failure distributions - Time-dependent hazard models, Reliability of series and parallel systems.

UNIT V MAINTAINABILITY AND AVAILABILITY 9

Maintainability and Availability functions - Frequency of failures - Two unit parallel system with repair –k out of n systems.

TOTAL:45 PERIODS

OUTCOMES

CO1: The students are equipped to evaluate the various system performance measures for basic queueing systems.
CO2: Implementation of mathematical technique to study the priority and non-priority queues.
CO3: Students will be able to formulate the various kinds of Non-Markovian queueing models.
CO4: Students can analyze reliability of the systems for various probability distributions.
CO5: Students will be able to formulate problems using the maintainability and availability and analyse by using theoretical approach.

REFERENCES

1. Balagurusamy E.,"Reliability Engineering",TataMcGraw Hill Publishing Company Ltd., New Delhi, 2010.
2. Charles E. Ebeling, "An Introduction to Reliability and Maintainability Engineering", Waveland, Illinois, 2010.
3. ShortleJ.F, Gross ,Thompson J.M, Harris C.M., "Fundamentals of Queueing Theory", John Wiley and Sons, NewYork, 2018.
4. Govil A.K., "Reliability Engineering", Tata-Mc Graw Hill Publishing Company Ltd., New Delhi, 1983.
5. Kleinrock. L., "Queueing Systems: Volume 1", John Wiley and Sons, NewYork,1975.
6. Medhi J, "Stochastic models of Queueing Theory", Academic Press, Elsevier, Amsterdam, 2003.
7. Thomas G.Robertazzi, Computer Networks and Systems: Queueing Theory and Performance Evaluation, Springer-Verlag,3rd Edition, New Delhi, 2013.

Attested

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	1
CO2	2	3	2	2	1	1
CO3	3	2	3	1	2	2
CO4	2	2	1	3	2	2
CO5	1	1	2	2	3	3
Avg.	**2.2**	**2.2**	**2**	**2**	**1.8**	**1.8**

MT3019 STOCHASTIC PROCESSES **L T P C**
3 0 0 3

OBJECTIVES

- To understand the basic concepts of stochastic processes and be able to develop and analyze the stochastic models that capture the significant features of the probability models in order to predict the short and long term effects in the system.
- To Learn and model the renewal processes and study its theorems and their behavior.
- To understand the combination of renewal processes and Markov process.
- To understand the concept of branching processes and its nature. Also, to learn the variety of models in branching process.
- To find the nature of Wiener process and study its properties.

UNIT I MARKOV AND STATIONARY PROCESSES 9

Specification of Stochastic Processes - Stationary Processes - Poisson Process - Generalizations – Birth and Death Processes-Martingales.

UNIT II RENEWAL PROCESSES 9

Renewal processes in continuous time - Renewal equation Stopping time Wald's equation - Renewal theorems – Delayed and Equilibrium renewal processes - Residual and excess lifetimes-Renewal reward process – Alternating renewal process.

UNIT III MARKOV RENEWAL AND SEMI–MARKOV PROCESSES 9

Definition and preliminary results- Markov renewal equation-Limiting behavior - First passage time.

UNIT IV BRANCHING PROCESSES 9

Generating functions of branching processes - Probability of extinction - Distribution of the total number of progeny - Generalization of classical Galton - Watson process - Continuous time Markov branching process.

UNIT V MARKOV PROCESSES WITH CONTINUOUS STATE SPACE 9

Brownian motion – Wiener process – Diffusion and Kolmogorov equations-First passage time distribution for Wiener process.

TOTAL: 45 PERIODS

OUTCOMES

After the completion of the course, the students will be able to

CO1: Understand and characterize the random phenomena and model a stochastic system.

CO2: Connect the real life situation and renewal processes.

CO3: Obtain the knowledge about the advanced studies of renewal processes.

CO4: Understand stochastic population models through branching processes.

CO5: Obtain the knowledge about Wiener processes

REFERENCES

1. MedhiJ., “Stochastic Processes”, New Age International, Fourth Edition, New Delhi, 2017.
2. Narayan Bhat U.and Gregory K. Miller, “Elements of Applied Stochastic Processes”, Wiley–Inter science, Third Edition, Hoboken, 2002.
3. Karlin S “A First Course in Stochastic Processes”, Academic Press, New York, 2014.
4. Cox D.R . and Miller, H.D., ”The theory of Stochastic Process”, Methuen, London, 1965.
5. Ross S.M., ”Stochastic Processes”, Wiley, Second Edition, New York, 1996.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	-
CO2	2	3	3	1	1	1
CO3	2	3	3	2	1	1
CO4	2	2	2	3	1	1
CO5	2	1	1	2	3	3
Avg.	**2.2**	**2.2**	**2.2**	**2**	**1.4**	**1.2**

MT3020 ADVANCED GRAPH THEORY L T P C 3 0 0 3

OBJECTIVE

- To introduce edge coloring of graphs as well as line graphs and their relation.
- To provide exposure on Graph Ramsey Theory.
- To demonstrate the importance of computing eigenvalues of graphs in relevance to understand the structural property of graphs.
- To introduce the connectedness concept in digraphs.
- To provide exposure to the special class of digraph tournaments and their structural property.

UNIT I LINE GRAPHS AND EDGE-COLORING 9

Edge coloring, Characterization of Line Graphs.

UNIT II RAMSEY THEORY 9

Ramsey’s Theorem - Ramsey Numbers - Graph Ramsey Theory - Sperner’s Lemma and Bandwidth.

UNIT III EIGENVALUES OF GRAPHS 9

The Characteristic Polynomial - Linear Algebra of Real Symmetric Matrices - Eigenvalues and Graph Parameters - Eigenvalues of Regular Graphs - Strongly Regular Graphs.

UNIT IV CONNECTEDNESS IN DIGRAPHS 9

Digraphs - Connected and Disconnected digraphs - Strong digraphs - Digraphs and matrices.

UNIT V TOURNAMENTS 9

Properties of tournaments - Hamiltonian tournaments - Score Sequences.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, students will be able to

CO1: Able to apply edge coloring idea in solving real world problems relevant to partitioning.
CO2: Able to apply graph Ramsey theory principles in solving combinatorial problems.
CO3: Able to compute eigenvalues of graphs and use them for structural studies.
CO4: Able to understand connectedness in digraphs in various applications of digraphs.
CO5: Able to apply graph tournament ideas in solving game tournament related problems.

REFERENCES

1. Bela Bollabas, "Extremal Graph Theory", Dover Publications, New York, 2004.
2. Bezhad M., Chartrand G., Lesneik Foster L., "Graphs and Digraphs", Wadsworth InternationalGroup, Boston, 1981.
3. Douglas B. West, "Introduction to Graph Theory", Pearson Education India, New Delhi, 2015.
4. Jorgen Bang-Jensen and Gregory Gutin, "Digraphs – Theory, Algorithms and Applications",Springer-Verlag, London, 2010.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	2	3
CO2	3	2	3	3	2	3
CO3	3	2	3	3	2	3
CO4	3	2	3	3	2	3
CO5	3	2	3	3	2	3
Avg.	3	2	3	3	2	3

MT3021 ALGORITHMIC GRAPH THEORY **L T P C**
3 0 0 3

OBJECTIVES

- To introduce fundamental Graph Algorithms.
- To provide exposure to planarity algorithm and Network flow algorithm.
- To introduce Graph Traversal problems.
- To give exposure to graph coloring problems.
- To introduce NP-Completeness of some graph problems.

UNIT I INTRODUCTION TO GRAPHS AND ALGORITHMIC COMPLEXITY 9

Introduction to graphs - Introduction to algorithmic complexity - Adjacency matrices and Adjacency lists – Depth first searching - Optimum weight spanning trees - Optimum branching - Enumeration of spanning-trees - Fundamental of circuits of graphs - Fundamental cut-sets of a graph - Connectivity.

UNIT II PLANAR GRAPHS AND NETWORK FLOW 9

Basic properties of planar graphs - Genus, crossing-number and thickness - Characterizations of planarity – Planarity testing algorithm - Networks and flows - Maximizing the flow in a network - Menger's theorems and connectivity - Minimum cost flow algorithm.

UNIT III GRAPH TRAVERSALS AND MATCHINGS 9

Matching - Maximum matching - Perfect Matching - Maximum-Weight matching - Eulerian graphs - Finding Eulerian circuits. Counting Eulerian circuits - Chinese postman problem - Hamiltonian tours - Some elementary existence theorems - Finding all Hamiltonian tours by matricial products - Traveling salesman problem.

UNIT IV GRAPH COLOURING 9

Dominating sets, independent sets and cliques - Edge Coloring - Vertex Coloring - Chromatic polynomials – Five colour theorem - Four colour theorem.

UNIT V GRAPH PROBLEMS AND INTRACTABILITY 9

Introduction to NP - Completeness - Class P and Class NP- NP-Completeness and Cook's theorem – Vertex cover problem - Problems of Independent set and clique - Problems of Hamiltonian paths and circuits and the Traveling Salesman problem - Problems concerning the coloring of graphs.

TOTAL : 45 PERIODS

OUTCOMES

At the end of the course, students will be able to

CO1: Apply fundamental graph algorithms to solve certain optimization problems.

CO2: Apply network flow algorithm and planarity testing algorithms in real world application problems.

CO3: Use Eulerian circuit algorithm to solve certain traversal problems.

CO4: Use graph coloring ideas in Graph partitioning and scheduling related problems.

CO5: Understand the challenges in designing efficient algorithms to solve various graph problems.

REFERENCES

1. Balakrishnan R., Ranganathan K., "A text book of Graph Theory", Springer Science & Business Media, 2012.
2. Douglas B. West, "Introduction to Graph Theory", Prentice Hall of India, 2002.
3. Gibbons. A., "Algorithmic Graph Theory", Cambridge University Press, 1999.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	3
CO2	3	3	3	3	2	3
CO3	3	3	2	3	2	3
CO4	3	3	3	3	2	3
CO5	3	3	3	3	2	3
Avg.	**3**	**3**	**2.8**	**3**	**2**	**3**

MT3022 **BOUNDARY LAYER THEORY** **L T P C**
3 0 0 3

(Prerequisite: Continuum Mechanics)

OBJECTIVES

- To give a comprehensive overview of the boundary layer theory
- To apply the theory to all areas of fluid mechanics with emphasis on the laminar flow pastbodies
- To derive the boundary layer equations and study their properties
- To obtain exact and approximate solutions for specific boundary layer flows
- To enable the students understand the turbulent boundary layer flows.

UNIT I DERIVATION AND PROPERTIES OF NAVIER-STOKES EQUATIONS 9

Description of flow fields - Continuity and momentum equations - General stress state - State of deformation - Relation between stresses and deformation - Stokes hypothesis - Derivation of N-S equations - Similarity laws - Limiting cases.

UNIT II EXACT SOLUTIONS OF NAVIER - STOKES EQUATIONS 9

Steady plane flows- Couette - Poiseuille flows - Plane stagnation point flow - Steady axisymmetric flows - Hagen - Poiseuille flow - Flow between two concentric rotating cylinders - Axisymmetric stagnation flow - First and second Stokes problems.

UNIT III PROPERTIES AND EXACT SOLUTIONS OF BOUNDARY LAYER EQUATIONS 9

Boundary layer equations - Wall friction, separation and displacement - Dimensional Representation - Friction drag - Plate boundary layer- Compatibility conditions at the wall - Similar solutions of the boundary layer equations - Integral relations of the boundary layer.

UNIT IV APPROXIMATE METHODS FOR SOLVING BOUNDARY LAYER EQUATIONS 9

Integral methods - Comparison between approximate and exact solutions - Boundary layer control - Continuous suction and blowing- Two dimensional and Axisymmetric boundary layers.

UNIT V FUNDAMENTALS OF TURBULENT FLOWS 9

Turbulent flow - Introduction - Mean motion and fluctuations - Basic equations for the mean motion - Boundary layer equations for plane flows - Prandtl's mixing length theory.

TOTAL : 45 PERIODS

OUTCOMES

At the end of the course, the students will be able to
CO1: derive the governing equations of any flow problem
CO2: determine the exact solutions for flows in specific geometries
CO3: formulate the boundary layer flows and analyze their properties
CO4: demonstrate the exact and approximate methods of solutions of boundary layer flows and
CO5: distinguish between laminar and turbulent boundary layer flows.

REFERENCES

1. Batchelor. G.K. " An introduction to Fluid Dynamics" ,Cambridge University Press, Cambridge, 2000.
2. Schlichting.H and Gersten. K, "Boundary Layer Theory", Springer- Verlag, New Delhi, 2016.
3. Yuan. S.W. ,"Foundations of Fluid Mechanics", Prentice- Hall, New Delhi, 1988.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3023 DATA STRUCTURES L T P C
3 0 0 3

OBJECTIVES

- The emphasis of this course is on the organization of information, the implementation of common data structures such as arrays, stacks, queues, linked lists, binary trees, heaps, balanced trees and graphs.
- The course explores the implementation of these data structures (both array-based and linked representations) and examines classic algorithms that use these structures for tasks such as sorting, searching and hashing.

UNIT I STACKS AND RECURSION 9

Arrays : Array as an ADT, One-dimensional Arrays, Two-dimensional Array and Muti-dimensional Arrays - Structures and Unions - Stacks in C: Definition, Representation, Infix to Postfix conversion, Evaluating Postfix expression - Recursion in C.

UNIT II QUEUES AND LISTS 9

Queue and its sequential representation, Linked lists : Operations on Linked list, Linked Implementation of stack and queue, Lists in C, Circular linked lists.

UNIT III TREES 9

Binary Trees: Operations on Binary tree, Applications - Binary tree representation - Representing Lists as binary trees - Trees and their Applications.

UNIT IV SORTING & SEARCHING 9

Sorting: General background - Exchange sorts - Selection and Tree sorting - Insertion sorts – Merge and Radix sorts.

Searching : Basic search Technique - Sequential search, Indexed Sequential search and Binary Search - Tree searching.

UNIT V GRAPH AND THEIR APPLICATIONS 9

Graphs - Representation and their Application - Linked Representation of Graphs – Graph Traversal: DFS - BFS and Spanning Forest.

TOTAL : 45 PERIODS

OUTCOMES

CO1: Students will be able to understand the abstract properties of various data structures.

CO2: Students will be able to implement data structures in more than one manner and recognize the advantages and disadvantages of the same in different implementations.

CO3: Students will be able to compare the efficiency of algorithms in terms of both time and space.

REFERENCES

1. Langsam.Y, Augenstein, M. and Tanenbaum, A.M., “Data Structures using C and C++”,Prentice Hall of India, Second edition, New Delhi, 2015.
2. Michael T. Goodrich, Roberto Tamassia, David M. Mount,”Data Structures and Algorithms in C++”, Wiley, Second Edition, New Jersey, 2011.
3. Kruse C.L., Lenny B.P. and Tonto C.L., “Data Structures and Program Design in C”,Prentice Hall, New Jersey, 2006.
4. Ellis Horowitz, Sartaj Sahni and Dinesh Mehta, “Fundamentals of Data Structures in C++”, Silicon Press, Fifth edition, New Jersey, 2008.
5. Larry R Nyhoff, “ADTs, Data Structures and Problem Solving with C++”, Pearson Education, Second Edition, Taiwan, 2005.
6. Michael Main and Walter Savitch, “Data Structures and Other Objects using C++”, Addison Wesley, Fourth Edition, Boston, 2010.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	3	3	3	3	2	2

MT3024 DESIGN AND ANALYSIS OF ALGORITHMS **L T P C**
3 0 0 3

OBJECTIVES

- To introduce asymptotic notations and growth of functions for understanding of running time ofalgorithms.
- To explain the design of sorting algorithms with correctness and complexity.
- To provide details of design, correctness and the complexity of fundamental Graph Algorithms.
- To introduce string matching algorithms with correctness and complexity.
- To explain classification of problems based on the computational complexity.

UNIT I ANALYZING ALGORITHMS **9**

Algorithms – Analyzing algorithms – Designing algorithms – Growth of functions – Recurrences.

UNIT II SORTING Attested **9**

Insertion sort – Quick sort – Divide and Conquer – Mergesort – Heapsort – Lower bounds for sorting.

UNIT III GRAPH ALGORITHMS 9

Representations of graphs – Breadth-first search – Depth-first search – Minimum spanning tree – The algorithms of Kruskal and Prim – Shortest paths – Dijkstra's algorithm.

UNIT IV STRING MATCHING 9

The naïve string-matching algorithm – String matching with finite automata – The Knuth-Morris – Prattalgorithm.

UNIT V NP COMPLETENESS 9

Representation of polynomials – Polynomial time – The complexity class NP - NP completeness – Reducibility – NP complete problems.

TOTAL : 45 PERIODS

OUTCOMES

At the end of the course, students will be able to

CO1: Describe the complexity of algorithm with appropriate asymptotic notations.

CO2: Use efficient sorting algorithms with comparison as the basic operation for solving sorting problems.

CO3: Use the fundamental graph algorithms in solving optimization problems.

CO4: Use efficient string matching algorithms in string matching problems.

CO5: Able to recognize the complexity class of the given computational problems.

REFERENCES

1. Baase S., "Computer Algorithms: Introduction to Design and Analysis", Addison and Wesley, 2nd Edition, Massachusetts, 1993.
2. Cormen T.H., Leiserson C.E. and Rivest R.L., "Introduction to Algorithms", Prentice Hall of India, 2nd Edition, New Delhi, 2004.
3. Levitin A., "Introduction to the Design & Analysis of Algorithms", Pearson Education Pvt. Ltd., Third Edition, New Delhi, 2012.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3025 **DISCRETE MATHEMATICS** **L T P C**
3 0 0 3

OBJECTIVES

- To introduce Mathematical logic and their use in formal proofs.
- To provide introduction to integer algorithms and their applications.
- To give exposure to fundamental counting principles in combinatorics.
- To explain the method of solving reccurence relations.
- To introduce Boolean algebra and its use in designing Boolean circuits.

UNIT I LOGIC **9**

Propositions - Implications - Equivalence - Normal Forms - Predicates and Quantifiers - Nested Quantifiers - Methods of Proof - Mathematical Induction.

UNIT II NUMBER THEORY **9**

The Integers and Division - Integers and Algorithms - Applications of Number Theory.

UNIT III COUNTING **9**

The Basis of Counting - The Pigeonhole Principle - Permutations and Combinations - Binomial Coefficients - Generalized Permutations and Combinations - Generating Permutations and Combinations - Inclusion - Exclusion - Applications of Inclusion - Exclusion.

UNIT IV RECURRENCE RELATIONS **9**

Solving Recurrence Relations - Divide-and-Conquer Algorithms and Recurrence Relations - Generating Functions.

UNIT V BOOLEAN ALGEBRA **9**

Boolean Functions - Representing Boolean Functions - Logic Gates - Minimization of Circuits.

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course, students will be able to
CO1: Validate the logical arguments and the formal proof of theorems
CO2: Apply integer algorithms in solving number theoretic problems.
CO3: Apply the basic counting techniques in solving combinatorial related problems.
CO4: Solve reccurence relations which appear in various applications.
CO5: Apply Boolean laws to design optimal circuits.

REFERENCES

1. Grimaldi R.P., "Discrete and Combinatorial Mathematics", Pearson Education Pvt. Ltd., Fifth Edition, Singapore, 2004.
2. Rosen K.H., "Discrete Mathematics and its Applications", Tata McGraw-Hill PublishingCompany Ltd., Seventh Edition, New York, 2011.
3. Scheincreman E.R., "Mathematics – A Discrete Introduction", Brooks/Cole., Boston, 2013.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

Attested

MT3026 FORMAL LANGUAGES AND AUTOMATA THEORY **L T P C**
3 0 0 3

OBJECTIVES:
- To introduce finite state automata as language acceptor of regular sets.
- To introduce context free grammars and context free languages and their normal forms.
- To introduce pushdown automata as the language acceptor of context-free language.
- To demonstrate Turing machine as a mathematical model of language acceptor of recursively enumerable language and computer of computing number theoretic functions.
- To elaborate the Chomsky hierarchy among the formal languages.

UNIT I REGULAR SETS AND FINITE STATE AUTOMATA 9
Finite state automata - Deterministic and non-deterministic model - Languages accepted by Finite State Automata - Regular Expression - Pumping Lemma for regular set.

UNIT II CONTEXT FREE LANGUAGES 9
Grammar - Context Free Grammars - Derivation trees - Simplification of context - Free grammar (only Construction and no proof of equivalence of grammars) - Chomsky normal Form - Greibach Normal Form.

UNIT III PUSH DOWN AUTOMATA AND PROPERTIES OF CONTEXT FREE LANGUAGES 9
Pushdown automata - Push down automata and Context free languages - Pumping lemma for context free languages.

UNIT IV TURING MACHINE AND UNDECIDEABILITY 9
Turing Machine model - Computational languages and functions - Modifications of Turing machines (only description, no proof for theorems on equivalence of the modification) - Problems - Properties of recursive and recursively enumerable languages - Universal Turing Machine and the undecidable problem.

UNIT V THE CHOMSKY HIERARCHY 9
Regular grammar - Unrestricted grammar - Context Sensitive languages - Linear bounded automata – Relation between classes of languages.

TOTAL: 45 PERIODS

OUTCOMES:
At the end of the course, students will be able to
CO1: Design finite state automata to accept regular sets.
CO2: Form context free grammar to generate context free language and able to obtain its normal form.
CO3: Design pushdown automata to accept a context free language.
CO4: Design Turing machine to accept recursive enumerable language, to compute number theoretic functions and able to understand the limitation of Turing computing model.
CO5: Understand overall set theoretical relationship among formal languages.

REFERENCES

1. Hopcroft, J.E., Rajeev Motwani and Ullman, J.D. “Introduction to Automata Theory, Languages, and Computation”, Pearson Education, Second Edition, 2000.
2. Hopcroft J.E. and Ullman J.D. “Introduction to Automata Theory, Languages and Computation”, Narosa Publishing House, 2002.
3. Mishra K.L.P and Chandrasekaran. N, “Theory of Computer Science: Automata, Languages and Computation”, Prentice Hall of India, Third Edition, 2008.
4. Peter Linz, “An Introduction to Formal Languages and Automata”, Narosa Publishing House, Fourth Edition, 2012.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3027 INTRODUCTION TO ALGEBRAIC TOPOLOGY **L T P C**
3 0 0 3

OBJECTIVES

- To introduce the notion of homotopy
- To introduce the notion of the fundamental group of a space and to see some applications
- To introduce Van Kampen's theorem and see some simple applications
- To introduce covering spaces and to understand the connection between covering spaces and the fundamental group of the base space of a covering space
- To learn about the classification of covering spaces

UNIT I HOMOTOPY **9**

Homotopy and Homotopy type, contractible spaces, retraction and deformation, Homotopy extension property.

UNIT II THE FUNDAMENTAL GROUP **9**

Fundamental groups, the Fundamental group of the circle, applications- Brouwer fixed point theorem in dimension 2.

UNIT III VAN KAMPEN THEOREM **9**

Free product of groups, Van Kampen theorem, simple applications.

UNIT IV COVERING SPACES **9**

Covering projections, Homotopy lifting property, relations with fundamental group.

UNIT V MORE ON COVERING SPACES **9**

The classification of covering spaces, covering transformations.

TOTAL: 45 PERIODS

OUTCOMES

CO1: The students would have learnt about homotopy between maps and homotopically equivalent spaces
CO2: Students would have learnt about fundamental groups and simple applications like the Brouwer fixed point theorem in dimension 2
CO3: Students will be able to compute fundamental groups of spaces using Van Kampen's theorem
CO4: Students would have understood in detail about covering spaces
CO5: The students will have an understanding of covering transformations and regular coverings

REFERENCES
1. Hatcher A.," Algebraic topology", Cambridge University Press, New York 2002.
2. Rotman J.J., "An introduction to algebraic topology, Graduate text in Mathematics 119", Springer-Verlag, New York, 1988.
3. Spanier E.H., "Algebraic topology", Springer-Verlag, paper-back, New York,1994.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	2	3
CO2	2	2	3	3	2	3
CO3	2	2	3	2	3	2
CO4	3	2	3	2	2	2
CO5	3	3	3	3	3	3
Avg.	**2.4**	**2.2**	**3**	**2.4**	**2.4**	**2.6**

MT3028 INTRODUCTION TO LIE ALGEBRAS **L T P C**
3 0 0 3

(Pre-requisites: Abstract Algebra and Linear Algebra)

OBJECTIVES
- To introduce the notion of a Lie algebra with suitable examples
- To introduce the notion of a subalgebra, ideal of a Lie algebra and homomorphism between Liealgebras
- To introduce some special types of Lie algebras like solvable and nilpotent Lie algebras
- To learn about semi-simple Lie algebras
- To understand the representations of sl(2,F)

UNIT I LIE ALGEBRAS **9**
The notion of a Lie algebra, Linear Lie algebras, Lie algebras of derivations.

UNIT II IDEALS AND HOMOMORPHISMS **9**
Ideals, homomorphisms and representations, automorphisms.

UNIT III SOLVABLE AND NILPOTENT LIE ALGEBRAS **9**
Solvability, nilpotency, Engel's theorem, Lie's theorem, Cartan's criterion.

UNIT IV SEMISIMPLE LIE ALGEBRAS **11**
Semi-simple Lie algebra, Killing form, criterion for semi-simplicity, Schur's lemma, Weyl's theorem.

UNIT V REPRESENTATIONS OF sl(2,F) **7**
Weights and maximal vectors, classification of irreducible modules.

TOTAL: 45 PERIODS

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

OUTCOMES
CO1: Students would have learnt the basic axioms defining a Lie algebra
CO2: Students will be knowledgeable about ideals, homomorphisms and the representations of a Liealgebra
CO3: Students would have learnt about solvable and nilpotent Lie algebras in detail
CO4: Students will have a good understanding of semi-simple Lie algebras
CO5: Student would have a thorough understanding of the irreducible representations of sl(2,F)

REFERENCES

1. Erdmann K., Wildon M. J., "Introduction to Lie Algebras", Springer-Verlag, London, 2006.
2. Hall B., "Lie Groups, Lie Algebras, and Representations. An Elementary Introduction, Graduate Texts in Mathematics 222" , Springer-Verlag, Cham, 2015.
3. Humphreys J. E.," Introduction to Lie Algebras and Representation Theory, Graduate Texts in Mathematics 9" ,Springer-Verlag, New York,1997.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	2	2
CO2	2	2	3	2	2	2
CO3	2	2	3	2	3	2
CO4	2	2	3	3	2	3
CO5	3	3	3	3	3	3
Avg.	**2.2**	**2.2**	**3**	**2.4**	**2.4**	**2.4**

MT3029 ANALYSIS OF HEAT AND MASS TRANSFER **L T P C**
3 0 0 3

OBJECTIVES
To understand the basic concept of
- heat and mass transfer,
- derivation of boundary layer equations
- to compute heating / cooling times and
- to find the temperature and velocity fields and heat fluxes in a material domain.

UNIT I FLOW ALONG SURFACES AND IN CHANNELS 9
Boundary layer and turbulence - Momentum equation - Laminar flow boundary layer equation - Plane plate in longitudinal flow - Pressure gradients along a surface – Exact solutions for a flat plate.

UNIT II FORCED CONVECTION IN LAMINAR FLOW 9
Heat flow equation - Energy equation - Plane plate in laminar longitudinal flow - Arbitrarily varying wall temperature - Exact solutions of energy equation.

UNIT III FORCED CONVECTION IN TURBULENT FLOW 9
Analogy between momentum and heat transfer - Flow in a tube - Plane plate in turbulent longitudinal flow - Recent developments in the theory of turbulent heat transfer.

UNIT IV FREE CONVECTION 9

Laminar heat transfer on a vertical plate and horizontal tube - Turbulent heat transfer on a vertical plate - Derivation of the boundary layer equations - Free convection in a fluid enclosed between two plane walls - Mixed free and forced convection.

UNIT V MASS TRANSFER 9

Diffusion - Flat plate with heat and mass transfer - Integrated boundary layer equations of mass transfer - Similarity relations for mass transfer - Evaporation of water into air.

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course students will be able to

CO1: derive boundary layer equations and understand the flow along surfaces and in channels
CO2: understand heat flow and energy equations
CO3: understand flow in a tube
CO4: understand the laminar heat transfer on a vertical plate and horizontal tube
CO5: understand diffusion, heat and mass transfer on a flat plate

REFERENCES

1. E.R. G. Eckert and R.M. Drake, "Heat and Mass Transfer", Tata McGraw Hill Publishing Co., New Delhi, Second Edition, 1979.
2. Frank. P. Incropera & P. Dewitt., "Fundamentals of Heat and Mass Transfer", John Wiley & Sons,1998.
3. Gebhart B., "Heat Transfer", Mc Graw Hill Publishing Co., New York, 1971.
4. Schlichting. H.and Gersten.K, "Boundary Layer Theory", Springer – Verlag, Eighth Edition, New Delhi, 2004.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3030 THEORY OF ELASTICITY L T P C 3 0 0 3

(Prerequisite: Continuum Mechanics)

OBJECTIVES

- To introduce the elasticity concepts of strain and stress.
- To enable the students to derive the governing equations of equilibrium and those of motion.
- To introduce the theory of linear elastic homogeneous isotropic materials.
- To make the students understand the torsion experiment in various geometries.
- To demonstrate the two and three dimensional problems in elasticity.

UNIT I ANALYSIS OF STRAIN 9

Deformation - Strain tensor in rectangular Cartesian coordinates - Geometric interpretation of infinitesimal strain - Rotation - compatibility of strain components - Properties of strain tensor - Strain in spherical and cylindrical polar coordinates.

UNIT II ANALYSIS OF STRESS 9

Stresses - Laws of motion - Cauchy's formula - Equations of equilibrium - Transformation of coordinates - Plane state of stresses - Cauchy's stress quadric - Shearing stress - Mohr's circle - Stress deviation - Stress tensor in general coordinates – Physical components of a stress tensor in general coordinates - Equation of equilibrium in curvilinear coordinates.

UNIT III LINEAR THEORY OF ELASTICITY 8

Generalized Hooke's law - Stress-Strain relationship for an isotropic elastic material, Basic equation of elasticity for homogeneous isotropic bodies - Boundary value problems - The problem of equilibrium and the uniqueness of solution of elasticity - Saint-Venant's principle.

UNIT IV TORSION 7

Torsion of prismatic bars - Torsion of circular - Elliptic and rectangular bars - Membrane analogy - Torsion of rectangular section and hollow thin walled sections.

UNIT V SOLUTION OF TWO AND THREE DIMENSIONAL PROBLEMS IN ELASTICITY 12

Bending of a cantilever beam - Simply supported beam with simple loadings - Semi-infinite medium subjected to simple loadings - Plane elastic waves - Rayleigh surface waves - Love waves - Vibration of an infinite isotropic solid cylinder.

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course, the students will be able to

CO1: understand the elasticity concepts of strain and stress

CO2: derive the equations of equilibrium and those of motion

CO3: derive the constitutive equation of linear elastic homogeneous isotropic materials

CO4: perform the torsion experiment in various geometries

CO5: solve two and three dimensional problems in elasticity.

REFERENCES

1. Achenbach J.D "Wave Propagation in Elastic Solids", Elsevier, Amsterdam, 2012.
2. Fung Y.C., "Foundations of Solid Mechanics", Prentice Hall Inc., New Jersey, 1965.
3. Hetnarski R.B. and Ignaczak J. "Mathematical Theory of Elasticity", Taylor & Francis, London,2004.
4. Sokolnikoff I.S. "Mathematical Theory of Elasticity", Tata-McGraw Hill, New Delhi, 1974.
5. Srinath L.S., "Advanced Mechanics of Solids", Tata McGraw Hill, Third Edition, New Delhi, 2008.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

Attested

MT3031 **NONLINEAR SCIENCE** **L T P C**
3 0 0 3

- The students will be introduced to the basics of nonlinear dynamics and its applications.
- The students will learn about the mathematical models needed to study the concepts of fixed points, oscillations, bifurcations and integrability.
- The students will know about the nonlinear dynamical phenomena in chemical systems.
- The students will understand the importance of nonlinear dynamics in biological systems.
- The students will be introduced to the concepts of nonlinear dynamical analysis in geological systems.

UNIT I NONLINEAR DYNAMICS 9

Dynamical systems - linear systems - importance of nonlinearity - nonlinear dynamical systems - Autonomous and non-autonomous systems - phase-space, flows and limit sets. Classification of equilibrium points in planar systems – periodic and chaotic motions - fractals - pattern formation - cellular automata - self-self-organised criticality - networks - stochastic resonance.

UNIT II MATHEMATICAL MODELS 9

First-order differential equations - separation of variables - slope fields - Euler's method - equilibria and phase plane - bifurcations - higher-order equations - trace-determinant plane - harmonic oscillators - equilibrium point analysis - non-autonomous systems and chaos - finite dimensional integrable systems - dispersive systems - solitary waves - solitons - analysis of soliton solutions.

UNIT III CHEMICAL SYSTEMS 9

Chemical oscillations - waves and patterns - transport and external field effects - polymer systems - coupled oscillators - Turing patterns - stirring and mixing effects - Briggs-Rauscher reaction - Belousov-Zhabotinsky reaction - BZ waves - propagating pH front - chemical clocks.

UNIT IV BIOLOGICAL SYSTEMS 9

Biological oscillators - excitable systems - neuronal systems: HH equations - FN equations - physiological control systems - dynamics of bone remodelling - dynamics of nucleic acids:Protein complexes - patterns in biological membranes - cell replication and control - pupil light reflex - dynamical analysis of human tremor - fractals in living organisms.

UNIT V GEOLOGICAL SYSTEMS 9

Computational models of earthquakes - earthquake processes - multi fractals in geosciences - entropy analysis of seismicity - tectonics - spatial distribution of earthquakes - volcanic eruptions - short and long range interactions - RJB model - precursory dynamics - landscape dynamics - dynamics of earth's magnetosphere. Snow avalanches and system model - geomorphology: drainage networks, fractal trees, growth models, diffusion-limited aggregation.

TOTAL: 45 PERIODS

OUTCOMES

After completing this course, the students should able to

CO1: Understand the basics of nonlinear dynamics and its applications.

CO2: Gain knowledge on the concepts of fixed points, oscillations, bifurcations and integrability.

CO3: Appreciate the importance of nonlinear dynamical phenomena in chemical systems.

CO4: Understand the role of nonlinear dynamics in biological systems.

CO5: Apply nonlinear dynamical analysis for geological systems.

REFERENCES

1. M. Lakshmanan and S. Rajasekar. Nonlinear Dynamics: Integrability Chaos and Patterns. Springer-Verlag, 2003
2. M. Lakshmanan and K. Murali. Chaos in Nonlinear Oscillators. World Scientific,Singapore, 1996.
3. S.H.Strogatz. Nonlinear Dynamics and Chaos. CRC Press, 2014.

4. Paul Blanchard, R.L.Devaney and G.R.Hall. Differential Equations. Brooks/Cole, 2012.
5. Irving R.Epstein and J.A. Pojman. An Introduction to Nonlinear Chemical Dynamics. Oxford University Press, 1998.
6. Anne Beuter, Leon Glass, M.C.Mackey and M.S.Titcombe. Nonlinear Dynamics in Physiology and Medicine. Springer, 2003.
7. Donald L. Turcotte. Fractals and Chaos in Geology and Geophysics. Cambridge University Press, 1997.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3032 DYNAMICAL SYSTEMS L T P C
3 0 0 3

OBJECTIVES

- To make the students familiarizing with the mathematical techniques of dynamical systems.
- To give qualitative insights in stability and bifurcation analysis of differential equations.
- To improve problem solving skills in discrete dynamical systems.
- To equip the students in understanding the concept of fractals.
- To create awareness of the importance of nonlinear evolution equations.

UNIT I FLOWS AND STABILITY 9

Linear and nonlinear differential equations - Autonomous and nonautonomous systems - Phase trajectories, phase-space, flows and limit sets – Classification of equilibrium points in planar systems – Invariant manifolds - stable, unstable and center manifolds - Periodic orbits, limit cycles, Poincaré maps and Floquet theory - Poincaré-Bendixson theorem – Exercises and problems.

UNIT II BIFURCATIONS AND CHAOS 9

Bifurcation theory – Local and global bifurcations - Three dimensional autonomous systems and chaos, Lyapunov exponents -– Torus – quasi-periodic attractor – Poincaré map – Period doubling cascades – Feigenbaum number – characterization – Homoclinic orbits, heteroclinic orbits – Strange attractor and strange non-chaotic attractor – Exercises and problems.

UNIT III DISCRETE SYSTEMS 9

Linear and nonlinear discrete dynamics systems – complex iterated maps – Logistic map – Linear stability – fixed points and periodic points – cobweb diagram – bifurcations – analysis of logistic map - Period doubling phenomena and chaos – Lyapunov exponents - renormalization– Newton's method as a difference equation – delayed logistic and two-dimensional iteration

UNIT IV FRACTALS AND CELLULAR AUTOMATA 9

Dimension of regular and chaotic attractors – Fractals – countable and uncountable sets - Koch curve – Cantor set – Sierpinski set – Julia and Mandelbrot sets – dimension of self-similar fractals – box dimension – pointwise and correlation dimension – strange attractors – Henon map – cellular automata: simple programs - Self organized criticality.

UNIT V INTEGRABLE SYSTEMS AND SOLITONS 9

Finite dimensional integrable systems - Linear and nonlinear dispersive systems – Cnoidal and solitary waves - The Scott Russel phenomenon and derivation of Korteweg-de Vries (KdV) equation – Fermi – Pasta – Ulam (FPU) numerical problem – FPU recurrence phenomenon – Numerical experiments of Zabusky and Kruskal – Explicit soliton solutions: one-, two- and N- soliton solutions of KdV equation – Hirota’s bilinear method

TOTAL:45 PERIODS

OUTCOMES

After completing this course, the students should able to

CO1: express sound knowledge in terms of differential equations.

CO2: Determine the stability of fixed points..

CO3: Recognize bifurcation points and type.

CO4: Master the ideas of fractals and cellular automata.

CO5: Work with different types of dynamical equations for the study of regular and chaotic dynamics.

REFERENCES

1. Steven H. Strogatz, Nonlinear Dynamics and Chaos, CRC Press, 2015.
2. Paul Blanchard, Robert L. Devaney and G.R. Hall, Differential Equations, Brooks/Cole Cengage Learning, 2012.
3. Stephen Wiggins, Introduction to Applied Nonlinear Dynamical Systems and Chaos, Springer, 2003.
4. Stephen Wolfram, A New Kind of Science, Wolfram Media Inc., 2002.
5. M.Lakshmanan and S. Rajasekar, Nonlinear Dynamics: Integrability, Chaos and Patterns, Springer, 2003.
6. Stephen Lynch, Dynamical Systems with Applications using Python, Birkhauser,2018.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3033 **FRACTIONAL CALCULUS** **L T P C**
3 0 0 3

OBJECTIVE

- To make the students to familiarize with the concept and historical development of fractional calculus.
- To introduce the usage of special functions of .fractional calculus.
- To educate the students on the concepts of fractional derivatives.
- To equip the students for solving fractional differential equations.
- To familiarize the students about the numerical methods for solving fractional equations.

UNIT I SPECIAL FUNCTIONS 9

Overview of fractional calculus and importance of special functions - Gamma function, hypergeometric functions, Mittag-Leffler function, Wright function, Agarwal function, Erdelyi's function, R-H function, Miller-Ross function – generatlized R and G functions, Laplace and Inverse Laplace trasforms related to fractional calculus.

UNIT II DERIVATIVES 9

Sequential fractional derivatives- Left and right fractional derivatives - properties of fractional derivatives - Laplace transforms of fractional derivatives - Fourier transforms of derivatives - Mellin transforms of fractional derivatives – approximation of fractional derivatives – Riemann-Lioville integrals and derivatives – Caputo's approach.

UNIT III DIFFERENTIAL EQUATIONS-I 9

Linear fractional differential equations - fractional differential equation of a general form.- Existence and uniqueness theorem as a method of solution - dependence of a solution on initial conditions. Laplace transform method: Standard fractional differential equations - Sequential fractional differential equations – Fractional harmonic oscillator equation: according to Fourier, Riemann, Caputo.

UNIT IV DIFFERENTIAL EQUATIONS-II 9

Fractional Green's Function, Definition and Some Properties, One-Term Equation, Two Term Equation, Three-Term Equation, Four-Term Equation, General Case: n-term Equation. The Laplace transform method, The Mellin transform method, Power series method, Babenko's symbolic calculus method, Method of orthogonal polynomials.

UNIT V NUMERICAL METHODS 9

Variational iteration method of fractional differential equations – least squares method – Galerkin method – Runge-Kutta method: second-order, fourth-order, more general system, Fractional linear multistep methods, vectorial algorithm.

TOTAL: 45 PERIODS

OUTCOMES

After completing this course, the students should able to

CO1: express sound knowledge of special functions for fractional calculus.
CO2: exhibit adequate understanding of fractional derivatives.
CO3: test sufficient conditions of fractional integrals and derivatives.
CO4: solve linear fractional differential equations using the Laplace transform and define the applicability of fractional calculus to the real-world problems.
CO5: apply different numerical methods to solve the fractional differential equations.

REFERENCES

1. I.Podlubny, Fractional Differential Equations, Academic Press, 1999.
2. Keith B.Oldham and Jerome Spanier, The Fractional Caclulus, Academic Press, 2006.
3. Constantin Milici, G.Draganeuscu, J.T.Machado, Introduction to Fractional Differential Equations, Springer, 2019.

4. A. Kilbas, H. M. Srivastava and J.J. Trujillo, Theory and Applications of Fractional Differential Equations, Elsevier, Amsterdam, (2006).
5. K. S. Miller, B. Ross, An Introduction to the Fractional Calculus, John Wiley, New York, (1993).
6. Shantanu Das, Functional Fractional Calculus for System Identification and Controls, Spinger, 2008.
7. Kai Diethelm, The Analysis of Fractional Differential Equations, Springer, 2004.
8. Changpin Li, Numerical Methods for Fractional Calculus, CRC Press, 2015.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

MT3034 STATISTICAL LEARNING **L T P C**
3 0 0 3

OBJECTIVES

- To make the students in learning modern statistical techniques for modeling and drawing inferences from large data sets.
- To give familiarity in analyzing real data sets and communicating their outcome.
- To improve problem solving skills in visual and numerical diagnostics to assess the validity of the models.
- To equip the students in understanding the concept of applied statistics.
- To create awareness of the importance of regression analysis.

UNIT I LEARNING 9

Overview of statistical learning – types of data, terminology – regression versus nearest neighbor challenges. Supervised learning: variable types – approached to prediction – statistical decision theory – local methods in high dimensions – function approximation – structures regression models – restricted estimators.

UNIT II REGRESSION 9

Linear regression models and least squares – subset selection - shrinkage methods – derived input directions - linear discriminant analysis – logistic regression – separating hyper-planes.

UNIT III BASIS EXPANSION 9

Introduction – piecewise polynomials and splines – filtering and feature extraction – smoothing splines – automatic selection – nonparametric logistic regression – multidimensional splines – regularization and reproducing Kernel Hilbert spaces - wavelet smoothing.

UNIT IV KERNEL SMOOTHING 9

One- dimensional Kernel smoothers – selecting the width of the Kernel – local regression in R^p - local likelihood and other models – Kernel density estimation and classification – radial basis functions and Kernels – mixture models.

UNIT V MODEL ASSESSMENT AND INFERENCE 9

Bias, variance and model complexity – Bayesian approach and BIC, Vapnik-Chernovenkis dimension – cross-validation – bootstrap and maximum likelihood estimation – additive models and trees – support vector machines – nearest neighbor methods – unsupervised learning.

TOTAL:45 PERIODS

OUTCOMES

After completing this course, the students should able to

CO1: express sound knowledge in terms of learning from data

CO2: Determine the appropriate model for data analysis.

CO3: Recognize computational requirements for analyzing large data sets.

CO4: Master the ideas of the statistics based learning.

CO5: Work with different types of real data sets and apply statistical tools.

REFERENCES

1. Trevor Hastie, R.Tibshirani and J.Friedman, The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer,2008.
2. Gareth James, D.Witten, T.Hastie and R.Tibshirani, An Introduction to Statistical Learning with Applications in R, Springer, 2021.
3. Robert Nisbet, G.Miner and K.Yale, Handbook of Statistical Analysis and Data Mining Applications, Academic Press, 2018.
4. R.Lyman Ott and M.Longnecker, An Introduction to Statistical Methods and Data Analysis, Brooks/Cole – Cengage Learning, 2010.
5. Joe Suzuki, Statistical Learning with Math and Python, Springer, 2021

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**