DEPARTMENT OF MATHEMATICS
ANNA UNIVERSITY, CHENNAI

VISION

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

- Achieve excellence in Mathematics education by providing high quality teaching, research and training in Mathematics to all our students to significantly contribute in the fields of Mathematics, Computer Science and all related Engineering fields.
- Contribute to the quality Human Resource Development in Mathematics and Computer Science through our effective Masters and Research Programmes.

MISSION

- To provide strong Mathematical background to Engineering Students to cope up with the needs of emerging technologies both at National and International levels.
- To popularize and to project the proper perspective of Mathematics and Computer Science towards attracting young talents to take up teaching and research careers in Mathematical Sciences.

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M.Sc. MATHEMATICS (2 years)

REGULATIONS – 2019

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 ability to:

PO#	Graduate Attribute	Programme Outcome
1	Engineering knowledge	Apply knowledge of mathematics, basic science and engineering science.
2	Problem analysis	Identify, formulate and solve engineering problems.
3	Design/development of solutions	Design a system or process to improve its performance, satisfying its constraints.
4	Conduct investigations of complex problems	Conduct experiments &collect, analyze and interpret the data.
5	Modern tool usage	Apply various tools and techniques to improve the efficiency of the system.
6	The Engineer and society	Conduct themselves to uphold the professional and social obligations.
7	Environment and sustainability	Design the system with environment consciousness and sustainable development.
8	Ethics	Interaction with industry, business and society in a professional and ethical manner.
9	Individual and team work	Function in a multi-disciplinary team.
10	Communication	Proficiency in oral and written Communication.
11	Project management and finance	Implement cost effective and improved system.
12	Life-long learning	Continue professional development and learning as a life-long activity.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs):

By the completion of the Post Graduate programme in Mathematics the student will have the following Programme specific outcomes.

1. To be able to demonstrate standard mathematical principles and methods.
2. To be able to identify the logical background of real world problems or research problems.
3. To be able to utilize appropriate mathematical tools to solve research level or real world problems.
4. To be able to critically analyse the possible solutions of the emerging mathematical problems.

4. PEO / PO Mapping:

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
I	√	√	√	√	√				√	√		√
II	√	√	√	√						√		
III	√		√	√	√	√						
IV	√							√	√	√	√	√
V	√			√		√	√	√	√	√	√	√

Mapping of Course Outcome and Programme Outcome

		Course Name	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
YEAR 1	Semester 1	Abstract Algebra	√	√	√	√						√		√
		Advanced Calculus	√	√	√	√						√		√
		Object Oriented Programming	√	√	√	√						√		
		Ordinary Differential Equations	√	√	√	√						√		√
		Real Analysis	√	√	√	√						√		√
		Elective I	√	√	√	√						√		√
		Audit Course – I (One from list of Audit courses)						√		√		√		√
		Object Oriented Programming Laboratory	√	√	√	√	√					√		
	Semester 2	Classical Mechanics	√	√	√	√						√		√
		Complex Analysis	√	√	√	√						√		√
		Linear Algebra	√	√	√	√						√		√
		Partial Differential Equations	√	√	√	√						√		√
		Probability and Random Processes	√	√	√	√						√		√
		Elective II	√	√	√	√						√		
		Audit Course – II (One from list of Audit courses)						√		√		√		√
		Continuum Mechanics	√	√	√	√						√		√

YEAR 2	Semester 3	Functional Analysis	√	√	√	√						√		√
		Integral Transforms and Calculus of Variations	√	√	√	√						√		√
		Numerical Analysis	√	√	√	√						√		√
		Topology	√	√	√	√						√		√
		Elective III	√	√	√	√						√		
		Computational Laboratory	√	√	√	√	√					√		
	Semester 4	Open Elective	√	√	√	√						√		
		Elective IV	√	√	√	√						√		
		Elective V	√	√	√	√						√		
		Project Work	√	√	√	√						√		

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS

M.Sc. MATHEMATICS (2 years)

REGULATIONS - 2019
CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI

SEMESTER I

S. NO.	CODE NO.	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MT5101	Abstract Algebra	PCC	4	0	0	4	4
2.	MT5102	Advanced Calculus	PCC	4	0	0	4	4
3.	MT5103	Object Oriented Programming	PCC	3	0	0	3	3
4.	MT5104	Ordinary Differential Equations	PCC	3	0	0	3	3
5.	MT5105	Real Analysis	PCC	4	0	0	4	4
6.		Program Elective I	PEC	3	0	0	3	3
7.		Audit Course – I*	AC	2	0	0	2	0
PRACTICAL								
8.	MT 5111	Object Oriented Programming Laboratory	PCC	0	0	4	4	2
			TOTAL	**23**	**0**	**4**	**27**	**23**

***Audit course is optional**

SEMESTER II

S. NO.	CODE NO.	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MT5201	Classical Mechanics	PCC	3	0	0	3	3
2.	MT5202	Complex Analysis	PCC	4	0	0	4	4
3.	MT5203	Linear Algebra	PCC	3	0	0	3	3
4.	MT5204	Partial Differential Equations	PCC	4	0	0	4	4
5.	MT5205	Probability and Random Processes	PCC	4	0	0	4	4
6.		Program Elective II	PEC	3	0	0	3	3
7.		Audit Course – II*	AC	2	0	0	2	0
			TOTAL	**23**	**0**	**0**	**23**	**21**

***Audit course is optional**

SEMESTER III

S. NO.	CODE NO.	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MT5301	Continuum Mechanics	PCC	3	0	0	3	3
2.	MT5302	Functional Analysis	PCC	3	0	0	3	3
3.	MT5303	Integral Transforms and Calculus of Variations	PCC	4	0	0	4	4
4.	MT5304	Numerical Analysis	PCC	3	0	0	3	3
5.	MT5305	Topology	PCC	3	0	0	3	3
6.		Program Elective III	PEC	3	0	0	3	3
PRACTICAL								
7.	MT5311	Computational Laboratory	PCC	0	0	4	4	2
			TOTAL	**19**	**0**	**4**	**23**	**21**

SEMESTER IV

S. NO.	CODE NO.	COURSETITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Open Elective	OEC	3	0	0	3	3
2.		Program Elective IV	PEC	3	0	0	3	3
3.		Program Elective V	PEC	3	0	0	3	3
PRACTICAL								
4.	MT5411	Project Work	EEC	0	0	20	20	10
			TOTAL	**9**	**0**	**20**	**29**	**19**

Total No. of Credits : 84

PROGRAM CORE COURSES (PCC)

Sl.No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	MT5101	Abstract Algebra	4	0	0	4	1
2.	MT5102	Advanced Calculus	4	0	0	4	1
3.	MT5103	Object Oriented Programming	3	0	0	3	1
4.	MT5104	Ordinary Differential Equations	3	0	0	3	1
5.	MT5105	Real Analysis	4	0	0	4	1
6.	MT 5111	Object Oriented Programming Laboratory	0	0	4	2	1
7.	MT5201	Classical Mechanics	3	0	0	3	2
8.	MT5202	Complex Analysis	4	0	0	4	2
9.	MT5203	Linear Algebra	3	0	0	3	2
10.	MT5204	Partial Differential Equations	4	0	0	4	2
11.	MT5205	Probability and Random Processes	4	0	0	4	2
12.	MT5301	Continuum Mechanics	3	0	0	3	3
13.	MT5302	Functional Analysis	3	0	0	3	3
14.	MT5303	Integral Transforms and Calculus of Variations	4	0	0	4	3
15.	MT5304	Numerical Analysis	3	0	0	3	3
16.	MT5305	Topology	3	0	0	3	3
17.	MT5311	Computational Laboratory	0	0	4	2	3
					Total Credits	56	

PROGRAM ELECTIVE COURSES (PEC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MT5001	Advanced Analysis	PEC	3	3	0	0	3
2.	MT5002	Advanced Graph Theory	PEC	3	3	0	0	3
3.	MT5003	Algorithmic Graph Theory	PEC	3	3	0	0	3
4.	MT5004	Analysis of Heat and Mass Transfer	PEC	3	3	0	0	3
5.	MT5005	Boundary Layer Theory	PEC	3	3	0	0	3
6.	MT5006	Data Structures	PEC	3	3	0	0	3
7.	MT5007	Design and Analysis of Algorithms	PEC	3	3	0	0	3
8.	MT5008	Discrete Mathematics	PEC	3	3	0	0	3
9.	MT5009	Differential Topology	PEC	3	3	0	0	3

10..	MT5010	Finite Element Method	PEC	3	3	0	0	3
11.	MT5011	Finite Volume Method	PEC	3	3	0	0	3
12.	MT5012	Fixed Point Theory	PEC	3	3	0	0	3
13.	MT5013	Fluid Mechanics	PEC	3	3	0	0	3
14.	MT5014	Formal Languages and Automata Theory	PEC	3	3	0	0	3
15.	MT5015	Functional Analysis and its Applications to PDE	PEC	3	3	0	0	3
16.	MT5016	Fuzzy Set Theory	PEC	3	3	0	0	3
17.	MT5017	Geometric Function Theory	PEC	3	3	0	0	3
18.	MT5018	Graph Theory	PEC	3	3	0	0	3
19.	MT5019	Introduction to Algebraic Topology	PEC	3	3	0	0	3
20.	MT5020	Introduction to Lie Algebras	PEC	3	3	0	0	3
21.	MT5021	Mathematical Aspects of Finite Element Method	PEC	3	3	0	0	3
22.	MT5022	Mathematical Finance	PEC	3	3	0	0	3
23.	MT5023	Mathematical Programming	PEC	3	3	0	0	3
24.	MT5024	Mathematical Statistics	PEC	3	3	0	0	3
25.	MT5025	Networks, Games and Decisions	PEC	3	3	0	0	3
26.	MT5026	Number Theory	PEC	3	3	0	0	3
27.	MT5027	Number Theory and Cryptography	PEC	3	3	0	0	3
28.	MT5028	Numerical Solutions of Partial Differential Equations	PEC	3	3	0	0	3
29.	MT5029	Queueing and Reliability Modeling	PEC	3	3	0	0	3
30.	MT5030	Stochastic Processes	PEC	3	3	0	0	3
31.	MT5031	Theory of Elasticity	PEC	3	3	0	0	3
32.	MT5032	Theory of Wavelets	PEC	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

Sl.No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1	MT5411	Project Work	0	0	20	10	4
				Total Credits:		**10**	

OPEN ELECTIVE COURSES (OEC)

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MP5491	Nuclear Energy in Health Care and Industry	OEC	3	0	0	3	3
2.	MP5492	Smart Materials for Energy and Environment Applications	OEC	3	0	0	3	3
3.	EA5491	Climate Journalism	OEC	3	0	0	3	3
4.	EA5492	Digital Photography	OEC	3	0	0	3	3
5.	AC5491	Green Chemistry	OEC	3	0	0	3	3
6.	AC5492	Food Chemistry	OEC	3	0	0	3	3
7.	AG5491	Natural Hazards and Management	OEC	3	0	0	3	3
8.	AG5492	Ocean Resources and Exploration Techniques	OEC	3	0	0	3	3
9.	MC5491	Basic Crystallography and Crystal Growth	OEC	3	0	0	3	3
10.	MC5492	Nonlinear Science	OEC	3	0	0	3	3
11.	MT5491	Statistical Methods	OEC	3	0	0	3	3
12.	HS5491	Professional Email Communication	OEC	3	0	0	3	3
13.	HS5492	Project Report Writing	OEC	3	0	0	3	3
14.	HS5493	Basic Presentation Skills	OEC	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

SL.NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development through Life Enlightenment Skills.	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	
Total Credits:						0	

SUMMARY

	M. Sc Mathematics					
	Subject Area	**Credits per Semester**				**Credits Total**
		I	II	III	IV	
1.	PCC	20	18	18	00	56
2.	PEC	03	03	03	06	15
3.	EEC	00	00	00	10	10
4.	OEC	00	00	00	03	03
5.	Non Credit/Audit course	✓	✓	00	00	-
	Total Credit	**23**	**21**	**21**	**19**	**84**

MT5101 **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 S_n, 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:

- Students would have learnt the basics of group theory and some important results like Lagrange's theorem
- 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
- The basics of ring theory, including the knowledge of Euclidean domains, PIDs and UFDs would have been imparted to the students
- Students will be knowledgeable about division algorithm for polynomial rings over a field and about different irreducibility criteria for polynomials
- 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.

MT5102 ADVANCED CALCULUS L T P C
4 0 0 4

OBJECTIVES:

- To introduce the basic notion of applied aspects of analysis and familiarize with the theoretical sides of the subject.
- To distinguish between implicit and explicit functions.
- To find Maxima and Minima using Taylor's theorem.
- To introduce line integrals and surface integrals.
- To find line integrals in space.

UNIT I PARTIAL DIFFERENTIATION 12

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 12

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 12

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 12

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 12

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

TOTAL: 60 PERIODS

OUTCOMES:

- This course prepares the student to take up other courses in Mathematics. It provides theoretical foundation for calculus of one and several variables at advanced level.
- Should be able to identify dependent and independent variables and Jacobians.
- Should be able to use Taylor's theorem and Lagrange's theorem for optimization problems.
- Should be able to verify Green's and Gauss theorems and apply them to convert line and surface integrals.
- Should be able to verify Stoke's theorem and apply it for multiple integrals.

REFERENCES

1. Apostol T.M., "Mathematical Analysis", Narosa Publishing House, Second Edition, New Delhi, 2013.
2. Burkill J.C. and Burkill H., "A Second course in Mathematical Analysis", Cambridge University Press, New York, 2002.
3. Kaplan W., "Advanced Calculus", Addison Wesley, Fifth Edition, Boston, 2003.
4. Malik S.C., "Mathematical Analysis", New Age International Publishers, New Delhi, 1992.
5. Widder D.V., "Advanced Calculus", Prentice Hall of India, Second Edition, New Delhi, 2002.

MT5103 OBJECT ORIENTED PROGRAMMING L T P C
3 0 0 3

OBJECTIVE

- The language accommodates several programming paradigms, including object-oriented programming, generic programming, and the traditional procedural programming. It exposes students to modern object-oriented programming techniques that have proved successful in the development of large complex software systems by multiple programmers. It teaches object-oriented design and explores techniques for building modular, efficient and robust systems. The goal of the course is to develop skills such as program design and testing as well as the implementation of programs using object-oriented features.

UNIT I FUNDAMENTALS OF OOP 9

Object Oriented Paradigm – Procedural oriented programming Vs. Object Oriented Programming - Characteristics of Object Oriented Programming – Introduction to C++ - Data Types - Control Structures – Expressions.

UNIT II OOP PROGRAMMING IN C++ 9

Classes and objects – creating and accessing class members – Constructor and Destructor – Objects-Member Functions - Inline Function - Friend Functions - Operator Overloading – prefix and postfix, overloading binary operators, instream and outstream operator overloading - Function Templates and Class Templates.

UNIT III INHERITANCE 9

Introduction - protected data, private data, public data - inheriting constructors and destructors, constructors for virtual base classes, constructors and destructors of derived classes and virtual functions, size of derived class - order of invocation - types of inheritance - single inheritance, hierarchical inheritance, multiple inheritance, hybrid inheritance.

UNIT IV POLYMORPHISM AND VIRTUAL FUNCTIONS 9

Importance of virtual function, function call binding, virtual functions, implementing late binding, need for virtual functions, abstract base classes and pure virtual functions, virtual destructors.

UNIT V FILES AND STREAMS 9

Components of a file, file operations, communication in files, creation of file streams, stream classes, header classes, header files, updating of files, opening and closing a file, file pointers and their manipulations, function manipulation of file pointers, detecting end-of-file.

TOTAL: 45 PERIODS

OUTCOMES

- Students will be able to design and write computer programs that are correct, simple, clear, efficient, well organized, and well documented.
- Students will be able to apply programming skills in the areas of pure, applied mathematics and related areas.
- The student will understand the hardware and software aspects of computer systems that support application software development.

REFERENCES

1. H. M. Deitel and P. J. Deitel, "C++ How to Program", Prentice Hall of India Pvt. Ltd., Seventh Edition, New Delhi, 2010.
2. Bjarne Stroustrup, "The C++ Programming Language",Addison-Wesley, Fourth Edition, Upper Saddle River, 2018.
3. Robert Lafore, "Object Oriented Programming in Microsoft C++", Pearson Education, Fourth Edition, Corte Madera, 2010.
4. Balaguruswamy E., "Object Oriented Programming with C++", Tata McGraw Hill, Fourth Edition, New Delhi, 2007.

MT5104 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 value problems.
- 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

- formulate and solve linear higher order ordinary differential equations.
- analyze the existence of solutions for boundary value problems.
- investigate the stability aspects of autonomous linear and nonlinear systems.
- apply power series solutions to second order linear equations with ordinary points.
- obtain the series solutions to second order linear equations 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. Krantz S. G., “Differential Equations, Theory, Technique and Practice”, CRC Press, Second Edition, Dubuque, 2014.
5. Ravi P. Agarwal and Ramesh C. Gupta, “Essentials of Ordinary Differential Equations”, Tata McGraw-Hill, New York, 1993.

MT5105 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 - 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.

TOTAL : 60 PERIODS

OUTCOMES

- The students will be able to get a deeper understanding of limits, continuity and differentiability.
- The students should be able to gain another perspective of integral through the Riemann-Stieltjes integral.
- The students should be able to identify the convergence of sequences and series of functions.
- The students will be able to understand the methods of Decomposing signed measures which have applications in probability theory and Functional Analysis..
- 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. G. de Barra, “Measure Theory and Integration”, New Age International Pvt. Ltd, Second Edition, New Delhi, 2013.
3. Kumaresan, S., “Topology of metric spaces”, Narosa Publishing House Pvt. Ltd., Second Edition, New Delhi, 2011.
4. Rana I. K., “An Introduction to Measure and Integration”, Narosa Publishing House Pvt. Ltd., Second Edition, New Delhi, 2007.
5. Royden H. L., Patrick Fitzpatrick, “Real Analysis”, Pearson Publication, Fourth Edition, New York, 2018.
6. Rudin, W., “Principles of Mathematical Analysis”, Tata McGraw-Hill Education, Third Edition, Singapore, 2013.

MT5111 OBJECT ORIENTED PROGRAMMING LABORATORY

L	T	P	C
0	0	4	2

OBJECTIVE

- The purpose of this lab course is to develop skills in program designing and testing using C++.

1. Console I/O operations
2. Function Overloading
3. Function Templates and Class Templates in C++
4. Classes in C++ with all possible operations/operators for encapsulating Complex Number,
5. String, Time, Date and Matrix (Operators are to be overloaded)
6. Scope Resolution and Memory Management Operators
7. Inheritance
8. Virtual Functions
9. Friend Functions
10. Constructors and Destructors
11. 10.‘this’ Pointer
12. File I/O Operations

TOTAL: 60 PERIODS

OUTCOMES

- Students will be able to understand the difference between procedural and object-oriented programming approach.
- Students will be able to implement the mathematical knowledge of analysis.
- Students will be able to program Discrete mathematical structures and related algorithms using object-oriented programming concepts.

REFERENCES

1. Balaguruswamy E., “Object Oriented Programming Using C++ and JAVA”, Tata McGraw Hill, New Delhi, 2012.
2. Robert Lafore, “Object Oriented Programming in Microsoft C++”, Pearson Education, Fourth Edition, Corte Madera, 2010.
3. H. M. Deitel and P. J. Deitel, “C++ How to Program”, Prentice Hall of India Pvt. Ltd., Seventh Edition, New Delhi, 2010.

MT5201 **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

- deal with kinematics of objects in motion.
- derive the equations of motion of a particle, a system and that of a rigid body.
- apply the dynamics in space to motion of rigid bodies.
- derive the Lagrangean and Hamiltonian equations of motion.
- 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. Greenwood D. T., "Principles of Dynamics", Prentice Hall of India Pvt. Ltd., New Delhi, 1988.
5. Rana N.C. and Joag P.S., "Classical Mechanics", Tata McGraw Hill, New Delhi, 2001.
6. Sankara Rao K. "Classical Mechanics", Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
7. Synge L. and Griffith B.A., "Principles of Mechanics", Nabu Press, New York, 2015.

MT5202 **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

- The student will get good foundation on complex analysis as well as motivation at advanced level.
- The student will gain an insight into integrating complex functions through Cauchy's theorem.
- The student will be able to integrate complex functions through residues.
- The student will be able to get in-depth understanding of harmonic functions.
- 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. Mathews J.H. and Howell R.W., "Complex Analysis for Mathematics and Engineering", Narosa Publishing House, Third Edition, New Delhi, 1998.
4. Ponnusamy S., Foundations of Complex Analysis, Narosa Publishing House, Second Edition, New Delhi, 2018.

MT5203 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

- The students would have developed their knowledge and understanding of the concepts of linear algebra .
- Students will be able to find out matrices corresponding to linear transformations.
- Students will analyse the linear transformations on various subspaces.
- Students will understand various methods of canonical forms and utilize in solving system of equations.
- Students will learn about the inner product spaces and its algebraic properties.

REFERENCES

1. Halmos P.R.,Finite-dimentional Vector spaces,Courier Dover Publications, New York, 2017.
2. Herstein I.N.," Topics in Algebra" Wiley Eastern Limited, Second Edition, New York, 2008.
3. Hoffmann K. and Kunze R., "Linear Algebra", Pearson Education, Second Edition, Noida, 2015.
4. Kumaresan S., "Linear Algebra: A Geometric Approach", Prentice Hall of India, New Delhi, 2014.
5. Strang G., "Linear Algebra and its applications: Thomson Brooks", Cengage learning, 4th Edition, New Delhi, 2017.
6. Williams G., "Linear Algebra and its applications", Jones and Bartlett India pvt Ltd. 9th Indian Edition, New Delhi, 2019.

MT5204 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 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 ORDER EQUATIONS 12

Classification of second order Partial Differential Equations - Reduction to canonical form - Adjoint operators.

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 - Properties of harmonic functions - Green's Function for Laplace Equation - The Methods of Images - The Eigen function Method.

TOTAL: 60 PERIODS

OUTCOMES

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

- solve various types of first order partial differential equations
- classify the second order partial differential equations
- solve initial value problems in vibrating strings
- solve one-dimensional and two-dimensional diffusion equations
- solve boundary value problems involving Laplace equation.

REFERENCES

1. Dennemeyer R.,"Introduction to Partial Differential Equationsand 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.

MT5205 PROBABILITY AND RANDOM PROCESSES L T P C
4 0 0 4

OBJECTIVES

- To understand 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 and the significance of the Central Limit theorem.
- To learn the classifications of random processes with emphasis on stationarity of various orders along with strict sense stationarity, wide-sense stationarity and ergodicity.
- To understand the concepts of correlation functions and power spectral density and their properties.
- To be able to apply the knowledge gained so far with respect to linear systems with random inputs.

UNIT I RANDOM VARIABLES 12

Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Functions of a random variable.

UNIT II TWO-DIMENSIONAL RANDOM VARIABLES 12

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and Linear regression – Transformation of random variables – Central limit theorem (for independent and identically distributed random variables).

UNIT III RANDOM PROCESSES 12

Classification – Stationary process – Markov process – Poisson process – Random telegraph process.

UNIT IV CORRELATION AND SPECTRAL DENSITIES 12

Auto-correlation functions – Cross-correlation functions – Properties – Power spectral density – Cross-spectral density – Properties.

UNIT V LINEAR SYSTEMS WITH RANDOM INPUTS 12

Linear time invariant system – System transfer function – Linear systems with random inputs – Auto-correlation and Cross-correlation functions of input and output – White noise.

TOTAL: 60 PERIODS

OUTCOMES

- To analyze the performance in terms of probabilities and distributions achieved by the determined solutions
- To be familiar with some of the commonly encountered two dimensional random variables and be equipped for a possible extension to multivariate analysis
- To appreciate wide sense stationarity with respect to Poisson and Random Telegraph processes
- To gain proficiency in determining the correlation functions and spectral density characteristics of random processes
- To demonstrate the specific applications to linear systems with random inputs and white noise models.

REFERENCES

1. Ghahramani, S. “Fundamentals of probability with respect to stochastic processes”, Chapman and Hall/ CRC, 4th Edition, Boca Raton, 2018.
2. George R. Cooper, Clare D. McGillem, “Probabilistic Methods of Signal and System Analysis”, Oxford University Press, 3rd Edition, New York, 2010.
3. Hwei Hsu, “Schaum’s Outline of Theory and Problems of Probability, Random Variables and Random Processes”, McGraw Hill Education, 3rd Edition, New Delhi, 2017.
4. Ibe, O.C. “Fundamentals of Applied Probability and Random Processes”, Elsevier, U.P., Academic Press, 2nd Edition, Boston, 2014.
5. Miller, S.L. and Childers, D.G., “Probability and Random Processes with Applications to Signal Processing and Communications”, Academic Press, 2nd Edition, Amsterdam, 2012.
6. Peebles, P.Z. “Probability, Random Variables and Random Signal Principles”, Tata McGraw Hill, 4th Edition, New Delhi, 2017.
7. Yates, R.D. and Goodman, D.J., Famolari, D. “Probability and Stochastic Processes”, John Wiley and Sons, 3rd Edition, New Jersey, 2014.

MT5301 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 – Manipulation in Indicial notations - Components of a tensor – Transformation laws - Symmetric & anti-symmetric tensors - Principal values and directions - Scalar invariants.

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 - Principal Stresses – Equations of motion - Boundary conditions – Integral formulation of general principals of mechanics.

UNIT IV LINEAR ELASTIC SOLIDS 9

Isotropic 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

- mathematically manipulate with indicial notations and understand the concept of tensors.
- understand the strain and rate of deformation tensors of a continuum
- obtain the equations of the basic principles of continuum mechanics.
- derive the equations of the infinitesimal theory of elasticity and solve in specific applications.
- 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.

MT5302 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 get to 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

- The student will be in a position to take up advance courses in analysis.
- The student will be able to apply the concepts and theorems for studying numerical analysis, design maturity, the evolution of the design and the complexity of the mission etc.
- The student will be able to use orthogonalization process to various problems.
- The student will be able to use operators on Hilbert space.
- The student will be able to apply the fixed point theorem to solve differential equations and integral equations.

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. Limaye B. V., "Functional Analysis", New Age International Ltd Publishers, Third Edition, New Delhi, 2014.
6. Nair M.T., "Functional Analysis, A First course", Prentice Hall of India, New Delhi, 2010.
7. Simmons G.F., "Introduction to Topology and Modern Analysis", Tata McGraw Hill Pvt. Ltd., New Delhi, 2017.

MT5303 INTEGRAL TRANSFORMS AND CALCULUS OF VARIATIONS L T P C
4 0 0 4

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 - Transforms involving 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.

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: 60 PERIODS

OUTCOMES

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

- develop the mathematical models of applied mathematics and mathematical physics.
- understand integral transform techniques.
- apply integral transforms for solving linear ODEs and standard PDEs.
- give variational formulation of any differential equation.
- 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.

MT5304 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

- The students will be able to understand, analyze and solve various problems arising in Science and Engineering numerically.
- The students will be able to solve differentiation and integration problems numerically.
- The students will be able to approximate functions using least square method, cubic spline technique etc.
- The students will be able to solve ordinary differential equations through a variety of numerical techniques.
- 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. Froberg C.E, "Introduction to Numerical Analysis", Addison-Wesley Publishing Company, Second Edition, New York, 1969.
5. Isaacson E. and Keller, H.B., "Analysis of Numerical Methods", Dover Publication, New York, 1994.
6. Iserles, A., "A first course in the Numerical Analysis of Differential Equations", Cambridge University press, New Delhi, 2010.
7. 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.
8. Kincaid D. and Chenney W., "Numerical Analysis: Mathematics of Scientific Computing", AMS, University Press, Third Edition, Hyderabad, 2009.
9. Philips G.M and Taylor P.J., "Theory and Applications of Numerical Analysis", Elsevier, Second Edition, New Delhi, 2006.

MT5305 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 teach them 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.

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 - T_1-spaces - Hausdorff 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

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

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.

MT5311 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

11. Splines
12. 2D Graphs
13. 3D Graphs
14. Program on Statistical Data Analysis
15. Program to Animation

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

OUTCOME

- Students will be capable of handling any mathematical techniques using MATLAB, SPSS and TORA.

REFERENCES:

1. Duane C. Hanselman, Bruce L. Littlefield, "Mastering MATLAB 7", Pearson Education, New Jersey, 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.

MT5001 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 L^P SPACES 9

Convex functions and inequalities – The L^P 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 on L^P- 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

Formal properties - The inversion theorem - The Plancheral theorem - The Banach algebra L^1.

UNIT V HOLOMORPHIC FOURIER TRANSFORMS 9

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

TOTAL : 45 PERIODS

OUTCOMES

- The students get introduced to the classical Banach spaces.
- The students will get good understanding of methods of decomposing signed measures which has applications in probability theory and Functional Analysis.
- The students will be able to use measure theory for differentiation.
- The students will get good understanding of Fourier Transform and its Holomorphic extensions.
- 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.

MT5002 ADVANCED GRAPH THEORY L T P C
3 0 0 3

(Prerequisite: An introductory course in Graph Theory)

OBJECTIVES:

- 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 explain the significance of connectedness in digraphs.
- To provide exposure to the special 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 - Eigenvalues and Expanders - 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

- Able to apply edge coloring idea in solving real world problems relevant to partitioning.
- Able to apply graph ramsey theory principles in solving combinatorial problems.
- Able to compute eigenvalues of graphs and use them for structural studies.
- Able to understand connectedness in digraphs in various applications of digraphs.
- 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 International Group, 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.

MT5003 ALGORITHMIC GRAPH THEORY L T P C
3 0 0 3

(Prerequisite: Graph Theory)

OBJECTIVES
- To introduce fundamentals of Graph Algorithms
- To provide exposure to planarity algorithm and Network flow algorithm.
- To provide algorithmic aspect f Graph Traversal problems.
- To give exposure to graph coloring and its significance.
- To introduce graph problems and their computational challenges.

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 - Classes P and NP - NP - Completeness and Cook’s theorem. - Problems of Vertex cover - Problem 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
- Apply fundamental graph algorithms to solve certain optimization problems.
- Apply network flow algorithm and planarity testing algorithms in real world application problems.
- Use Eulerian circuit algorithm to solve certain traversal problems.
- Use graph coloring ideas in Graph partitioning and scheduling related problems.
- Understand the challenges in efficient algorithmic design of various graph problems.

REFERENCES
1. Balakrishnan R., Ranganathan K., “A text book of Graph Theory”, Springer Science & Business Media, New Delhi, 2012.
2. Douglas B. West, “Introduction to Graph Theory”, Pearson Education , New Delhi, 2015.
3. Gibbons. A., “Algorithmic Graph Theory”, Cambridge University Press, Cambridge, 1999.

MT5004 ANALYSIS OF HEAT AND MASS TRANSFER L T P C
3 0 0 3

(Prerequisite: Continuum Mechanics)

OBJECTIVES

- To enable the students understand the concepts of heat and mass transfer and its applications.
- To demonstrate the properties of heat conduction in solving heat equations.
- To introduce the methods of solving flow along surfaces and in channels.
- To familiarize the students with the properties of free and forced convection in laminar flows
- To present the basic ideas of mass transfer in real life problems.

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, the students will be able to

- solve heat conduction problems and obtain numerical solutions.
- solve the problems of flow along surfaces and in channels.
- apply finite element method to solve complex problems in free and forced convection flows.
- apply the fluid flow equations to various flow situations with different boundary conditions.
- analyze the mass transfer properties in various fluid flow problems.

REFERENCES

1. E.R. G. Eckert and R.M. Drake, “Heat and Mass Transfer”, Tata McGraw Hill Publishing Co., Second Edition, New Delhi, 1979.
2. Frank. P. Incropera & P. Dewitt.,”Fundamentals of Heat and Mass Transfer”, John Wiley & Sons, Canada, 2007.
3. Gebhart B., “Heat Transfer”, Mc Graw Hill Publishing Co., New York, 1971.
4. Schlichting. H.and Gersten.K, ”Boundary Layer Theory”, Springer – Verlag, New Delhi, 2016.

MT5005 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 past bodies
- 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

- derive the governing equations of any flow problem
- determine the exact solutions for flows in specific geometries
- formulate the boundary layer flows and analyze their properties
- demonstrate the exact and approximate methods of solutions of boundary layer flows and
- 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.

MT5006 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

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

MT5007 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 of algorithms.
- 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 **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 – Pratt algorithm.

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

- Describe the complexity of algorithm with appropriate asymptotic notations.
- Use efficient sorting algorithms with comparison as the basic operation for solving sorting problems.
- Use the fundamental graph algorithms in solving optimization problems.
- Use efficient string matching algorithms in string matching problems.
- 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.

MT5008 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

- Validate the logical arguments and the formal proof of theorems
- Apply integer algorithms in solving number theoretic problems.
- Apply the basic counting techniques in solving combinatorial related problems.
- Solve reccurence relations which appear in various applications.
- 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 Publishing Company Ltd., Seventh Edition, New York, 2011.
3. Scheincreman E.R., "Mathematics – A Discrete Introduction", Brooks/Cole., Boston, 2013.

MT5009 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

- 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.
- The students will gain an understanding of manifolds with boundary.
- The students will get more knowledge on orientation intersection theory.
- The students will gain a thorough understanding of Hopf Degree theorem.
- 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.

MT5010 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

- construct integral formulations of boundary value problems
- implement Finite Element Method for one-dimensional problems
- formulate eigenvalue problems and time-dependent problems in one-dimension
- implement finite element method to time dependent problems in two-dimensions
- 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.

MT5011 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

- understand the conservation laws and governing equations of fluid flows.
- apply finite volume method for diffusion and convection-diffusion problems.
- solve momentum equations after discretizing.
- learn the finite volume methods of solving unsteady flows.
- 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: The Finite Volume Method", Pearson Education, Second Edition, Harlow, 2008.

MT5012 FIXED POINT THEORY L T P C
3 0 0 3

(Prerequisite: Real Analysis and Functional Analysis)

OBJECTIVES

- To identify all self-maps in 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 METRIC CONTRACTION PRINCIPLES 9

Banach's Contraction principle - Further Extension of Banach's principle - The Caristis-Ekeland Principle - Equivalents of the Caristis-Ekeland Principle - Set valued contractions - Generalized contractions.

UNIT II HYPERCONVEX SPACES AND NORMAL STRUCTURES IN METRIC SPACES 10

Hyperconvexity - Properties of hyperconvex spaces - A fixed point theorem - Approximate fixed points. Normal structures in metric spaces: A fixed point theorem - Structure of the fixed point set - Fixed point set structure - Separable case.

UNIT III CONTINUOUS MAPPING IN BANACH SPACES 10

Brouwer's theorem - Further comments on Brouwer's theorem - Schauder's Theorem - Stability of Schauder's Theorem - Leray-Schauder degree - Condensing mappings - Continuous mappings in hyperconvex spaces.

UNIT IV METRIC FIXED POINT THOERY 8

Contraction mappings - Basic theorems for non-expansive mappings - Structure of the fixed point set - Asymptotically regular mappings - Set valued mappings.

UNIT V ASYMPTOTIC NONEXPENSIVENESS AND DEMICLOSEDNESS 8

Some fixed point theorem - Asymptotically non expansive mappings - The demiclosedness principle.

TOTAL : 45 PERIODS

OUTCOMES

- The student will be able to apply fixed point theory in various branches of applied mathematics.
- The student will gain more in-depth understanding of metric spaces and hyperconvex spaces.
- The student will be able to apply continuous mappings in hyperconvex spaces.
- The student will be able to further apply contraction mappings and fixed point theorems.
- 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.

MT5013 FLUID MECHANICS L T P C
3 0 0 3

(Prerequisite: Continuum Mechanics)

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's equations 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.

TOTAL: 45 PERIODS

OUTCOMES

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

- understand the concepts of kinematics and kinetics of fluid mechanics.
- derive the governing equations of fluid flows.
- solve the fluid flows in two-dimensional and axisymmetric geometries.
- apply conformation transformation to fluid flows.
- 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.

MT5014 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 explain 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 explain 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

- Design finite state automata to accept regular sets.
- Form context free grammar to generate context free language and able to obtain its normal form.
- Design pushdown automata to accept a context free language.
- Design Turing machine to accept recursive enumerable language, to compute number theoretic functions and able to understand the limitation of Turing computing model.
- Understand overall set theoretical relationship of formal languages.

REFERENCES

1. Hopcroft J.E. and Ullman J.D. “Introduction to Automata Theory, Languages and Computation”, Narosa Publishing House, New Delhi, 2002.
2. Hopcroft, J.E., Rajeev Motwani and Ullman, J.D. “Introduction to Automata Theory, Languages, and Computation”, Pearson Education, Third Edition, Harlow, 2014.
3. Mishra K.L.P and Chandrasekaran. N, “Theory of Computer Science: Automata, Languages and Computation”, Prentice Hall of India, Third Edition, New Delhi, 2008.
4. Peter Linz, “An Introduction to Formal Languages and Automata”, Narosa Publishing House, Fourth Edition, New Delhi, 2012.

MT5015 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 - C_0-semigroups -Hille-Yosida theorem - contraction semigroups in Hilbert spaces - applications to the heat wave.

TOTAL: 45 PERIODS

OUTCOMES

- 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.
- The student will gain more understanding of Sobolev spaces, trace spaces etc.
- The student will be able to solve various elliptic boundary value problems.
- The student will be able to find solutions to partial differential equations through Galerkin's finite element method.
- 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.

MT5016 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-w_i compositions of Fuzzy relations.

UNIT V FUZZY RELATION EQUATIONS 9

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

TOTAL: 45 PERIODS

OUTCOMES

- It helps to understand the basics of fuzzy sets and its properties.
- It gives a clear idea of various types of operations on fuzzy sets.
- It extends the essence of operations on fuzzy sets to fuzzy numbers.
- It paves way to define the concepts and properties of relations on fuzzy sets.
- 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.

MT5017 GEOMETRIC FUNCTION THEORY L T P C
3 0 0 3

(Prerequisite: Complex Analysis)

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 $\sum$.

UNIT V COEFFICIENT CONJECTURE 9

Preliminaries – Proof of the Coefficient Conjecture.

TOTAL: 45 PERIODS

OUTCOMES

- The course equips the students with theory of Univalent functions and related mathematical concepts based on the same.
- The students will have a thorough understanding of univalent functions.
- The students will gain knowledge in subordination and univalent subordinate functions.
- The students will get an understanding in solving extremal problems.
- 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.

MT5018 GRAPH THEORY L T P C
3 0 0 3

OBJECTIVES

- To introduce graph models and their basic concepts.
- To explain 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 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

- Understand the graph models and their utilities and relevant basic concepts.
- Use graph traversability in solving application problems.
- Apply graph matching ideas in various matching related problems.
- Apply graph coloring ideas in solving graph partitioning related problems.
- Apply graph planarity ideas in solving application problems

REFERENCES

1. Balakrishnan R. and Ranganathan K., "A Text Book of Graph Theory", Springer- Verlag, New York, 2012.
2. Bondy J. A. and Murty U.S. R.,"Graph theory with Applications", Elsevier North-Holland New York,1976.
3. Chartrand G. and Lesneik Foster L., "Graphs and Digraphs", CRC Press, 4th Edition, Boca Raton, 2005.
4. Douglas B. West, "Introduction to Graph Theory", Pearson, Second Edition, New York, 2015.
5. Harary F., "Graph Theory", Narosa Publishing House, New Delhi, 2001.

MT5019 INTRODUCTION TO ALGEBRAIC TOPOLOGY L T P C
3 0 0 3

(Pre-requisites: Algebra and Topology)

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

- The students would have learnt about homotopy between maps and homotopically equivalent spaces
- Students would have learnt about fundamental groups and simple applications like the Brouwer fixed point theorem in dimension 2
- Students will be able to compute fundamental groups of spaces using Van Kampen's theorem
- Students would have understood in detail about covering spaces
- 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.

MT5020 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 Lie algebras
- 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

OUTCOMES

- Students would have learnt the basic axioms defining a Lie algebra
- Students will be knowledgeable about ideals, homomorphisms and the representations of a Lie algebra
- Students would have learnt about solvable and nilpotent Lie algebras in detail
- Students will have a good understanding of semi-simple Lie algebras
- 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.

MT5021 MATHEMATICAL ASPECTS OF FINITE ELEMENT METHOD L T P C

3 0 0 3

(Prerequisite: Functional Analysis)

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.

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

- 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.
- The student will gain more understanding of Sobolev spaces.
- The student will have more knowledge about variational formulations of elliptic and parabolic boundary value problems.
- The student will get to know about different element methods and be able to find error estimates for different methods.
- 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.

MT5022 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

- To demonstrate a comprehensive understanding of the probability concepts
- To locate and use information to solve problems in interest theory and financial engineering
- To know the main features of models commonly drawn from industry and financial firms in order to explore arbitrage strategy
- To understand and appraise utility and effectiveness in option pricing
- 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.

MT5023 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.

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations 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.

UNIT IV NON-LINEAR PROGRAMMING 9

Unconstrained one variable and multi variable optimization, KKT Conditions, Constrained optimization, Quadratic programming, Convex programming, Separable programming, Geometric programming, Non-Convex programming.

UNIT V DYNAMIC PROGRAMMING 9

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

TOTAL: 45 PERIODS

OUTCOMES

- Prepares the student to model various real life situations as Optimization problems and effect their solution through Mathematical Programming techniques
- Students will gain familiarity with some of the well-known optimization techniques and their applicability in a real setting
- Students will gain awareness on the usefulness and limitations of optimization
- An ability to use visualization and optimization tools to expose ideas and solutions

REFERENCES

1. Taha, H.A. “Operations Research: An Introduction”, Pearson Education, India, Tenth Edition, New Delhi, 2017.
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, 2016
4. Frederick S. Hillier, Gerald J. Lieberman, Bodhibrata Nag and Preetam Kantiswarup, "Introduction to Operations Research", McGraw Hill Education, Boston, 2017.

MT5024 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 Tests 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 - Interval estimates for mean, variance and proportions.

UNIT II TESTING OF HYPOTHESIS 9

Type I and Type II errors - Tests based on Normal, t, ^{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.

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:

- Demonstrate knowledge of, and properties of, statistical models in common use
- Apply the basic principles underlying statistical inference (estimation and hypothesis testing)
- Be able to construct tests and estimators, and derive their properties
- Demonstrate knowledge of applicable large sample theory of estimators and tests.
- Recognize the importance of Multivariate analysis in various practical application

REFERENCES

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

MT5025 NETWORKS, GAMES AND DECISIONS L T P C
3 0 0 3

OBJECTIVES

- To introduce the certain algorithms for solving the network models
- To expose them to different project management techniques like PERT and CPM
- To familiarize with the various aspects of game theory which involves decision situation in which two intelligent opponents with conflicting objectives are vying to outdo one another
- To introduce the students to the idea of making decision for problems involving various alternatives
- To get an idea of certain topics on random processes such as Weiner porcess and OU process.

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 (2 x n) and (m x 2) games - Solution of m x n 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

- It helps in formulating many practical problems in the frame work of Networks.
- It helps the students understand that CPM is a deterministic method whereas PERT uses a probabilistic model which deals with unpredictable activities.

- It enables the students to identifies competitive situations which can be modeled and solved by game theoretic formulations.
- It molds the students to make decisions for various real time problem subject to uncertainty and risk.
- 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 India, Tenth Edition, New Delhi, 2017.
2. Hillier F.S., Lieberman G.J., Nag, Basu, “Introduction to Operations Research”, Tata Mc -Graw Hill, Ninth Edition, New Delhi, 2011.
3. Winston W.L., “Operations Research”, Brooks/Cole Cengage Learning, Fourth Edition, Belmont, 2003.

MT5026 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

- The student would have learnt to solve divisibility problems using binomial theorem
- Students would have learnt some techniques of numerical calculations using congruences
- Students will be able to apply the Gaussian reciprocity law in public-key cryptography
- Students will have a good foundation in combinatorial number theory
- 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.

MT5027 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

- The students would have learnt to assess and improve computer algorithms required for public key cryptography.
- Students would be able to apply quadratic reciprocity law in number theory and cryptography
- The students will know about different types of crypo systems and will be able to compute discrete log
- Students will be able to apply Solovay-Strassen Primality test , Miller - Rabin test and Rho method.
- Students will be able to able to deal with elliptic curve cryptosystems and would have learnt some advanced factoring methods

REFERENCES

1. Koblitz N., “A course in Number Theory and Cryptography”, Springer-Verlag, New York, 2012.
2. Menezes A., Van Oorschot and Vanstone S.A, “Hand book of Applied Cryptography”, CRC Press, Boca Raton, 1997.

MT5028 NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS **L T P C**
3 0 0 3

(Prerequisite: Numerical Analysis and Partial Differential Equations)

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.

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 - 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

- learn various numerical methods of solving partial differential equations.
- solve one-dimensional parabolic equations using explicit and implicit schemes.
- solve two-dimensional parabolic equations and analyze the stability of the schemes.
- understand the methods of solving hyperbolic equations.
- 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.

MT5029 QUEUEING AND RELIABILITY MODELLING 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/1 queue.

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 m systems.

TOTAL : 45 PERIODS

OUTCOMES

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

REFERENCES

1. Balagurusamy E., "Reliability Engineering", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2010.
2. Charles E. Ebeling, "An Introductiion to Reliability and Maintainability Engineering", Waveland, Illinois, 2010.
3. Shortle J.F, Gross D , Thompson J.M, Harris C.M., "Fundamentals of Queueing Theory", John Wiley and Sons, New York, 2018.
4. Govil A.K., "Reliability Engineering", Tata-McGraw Hill Publishing Company Ltd., New Delhi, 1983.
5. Kleinrock. L., "Queueing Systems: Volume 1", John Wiley and Sons, New York, 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.

MT5030 **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 analyse 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 study about 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 life times - Renewal reward process - Alternating renewal process.

UNIT III MARKOV RENEWAL AND SEMI – MARKOV PROCESSES 9

Definition and preliminary results - Markov renewal equation - Limiting behaviour - 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 - Age dependent 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 - Ornstein - Uhlenbeck process.

TOTAL: 45 PERIODS

OUTCOMES

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

- Understand and characterize the random phenomena and model a stochastic system.
- Connect the real life situation and renewal processes.
- Obtain the knowledge about the advanced studies of renewal processes.
- Understand stochastic population models through branching processes.
- Obtain the knowledge about Wiener processes

REFERENCES

1. Medhi J., "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.

MT5031 **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

- understand the elasticity concepts of strain and stress
- derive the equations of equilibrium and those of motion
- derive the constitutive equation of linear elastic homogeneous isotropic materials
- perform the torsion experiment in various geometries
- 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.

MT5032 **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

- The students will be able to thoroughly handle Fourier analysis.
- Students would be trained to handle "Wavelets", which is a versatile tool with rich mathematical content and has great potential for applications in engineering.
- The student will be equipped for constructing wavelets.
- The student will be able to construct compactly supported wavelets.
- 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.

OPEN ELECTIVE COURSES (OEC)

MP5491 **NUCLEAR ENERGY IN HEALTH CARE AND INDUSTRY** **L T P C**
3 0 0 3

OBJECTIVES

- To provide the student about the action of radiation on living cells and the response.
- To make the student to understand the basic nuclear medicine physics and newer technology systems.
- To enable the students to understand the diagnostic and therapeutic nuclear medicine techniques.
- To provide a broad knowledge in radiation hazard evaluation and control

UNIT I BASICS OF NUCLEAR SCIENCE AND RADIATION EFFECTS 9

Radioactivity, nuclear reactions and interaction of ionizing radiation with matter, with emphasis on radiation detection, radiation shielding - photoelectric - Compton effect and pair production - biological effects on human health - Action of radiation on living cells -direct and indirect physical damage- cell response to radiation - somatic and genetic radiation effects -Radiation side effects - Acute and chronic effects of low dose effects.

UNIT II DIAGNOSTIC APPLICATIONS OF NUCLEAR ENERGY 9

Production of X rays and its applications X-ray radiography - CT scan -contrast studies in x ray imaging - fluoroscopic applications -Mammography - physics of nuclear medicine and nuclear imaging - radio isotopes in diagnosis of nuclear imaging - Tc-99m extraction - radiopharmaceuticals - scanning instruments and techniques.

UNIT III THERAPEUTIC APPLICATION OF NUCLEAR ENERGY 9

Production of nuclear radiations- alpha, beta and gamma rays and X-rays - External radiation therapy -telecobalt unit and linear accelerators - and internal radiation therapy - Iridium -192 HDR brachtherapy unit- therapeutic nuclear medicine.

UNIT IV INDUSTRIAL APPLICATIONS OF NUCLEAR ENERGY 9

Industrial applications — Non destructive testing - industrial radiography - tracing, gauging, Radiation sterilization of medical equipments - food preservation and other applications.

UNIT V NUCLEAR RADIATION SAFETY MEASURES 9

Basic concepts of radiation protection standards - ICRP recommendations - systems of radiological protection - Optimization of protection and individual dos limits - Radiation dose to individuals from natural radioactivity in the environment and man- made sources - Evaluation of external and internal radiation hazards - effect of time, distance and shielding - radioactive waste disposal and transport of radioactive nuclides.

TOTAL: 45 PERIODS

OUTCOMES

After successful completion of the course

- students will be able to handle radioactive source carefully for treatment purpose.
- will develop competence in radioactive waste disposal management
- Will be develop competency to face radiation emergency
- students will develop critical thinking skills in radiation safety and protection.
- will be able to safe guard the radioactive sources used in hospitals.

REFERENCE BOOKS:

1. W. R. Handee, Medical Radiation Physics, Year Book Medical Publishers Inc., London, 2003.
2. E. J. Hall, Radiobiology for Radiologists, J. B. Lippincott Co., Philadelphia, 2000.
3. W. N. Wagner, Principles of Nuclear Medicine, W. B. Saunders Co., London, 1990.
4. R. F. Mold, Radiation Protection in Hospitals, Adam Hilger Ltd., Bristol, 1985.
5. Fred A Mettler and Milton J Guiberteau, The essentials of nuclear Medicine imaging, 2011.

MP5492 SMART MATERIALS FOR ENERGY AND ENVIRONMENT APPLICATIONS

L	T	P	C
3	0	0	3

OBJECTIVES

- To provide fundamental understanding on smart and intelligent materials.
- To enhance students' understanding on the structure-property relationship.
- To enable students appreciate novel materials and their usage in current cutting edge technologies.

UNIT I BASICS OF SMART MATERIALS AND STRUCTURES 9

Introduction - components and classification of smart structures, Requirements of Intelligent Materials – Functions: Sensor, Memory, Processor, Actuator - Common smart materials - Applications of smart systems – Energy Harvesting systems: Regenerative braking - Smart polymers: Applications in drug delivery, tissue engineering. Biomimetics and bio-inspiration.

UNIT II INTELLIGENT MATERIALS FOR ENERGY GENERATION 9

Artificial Intelligence in Materials, Ferrolectricity: Introduction - Piezoelectric effect, Piezoelectric materials as sensors, Actuators and bimorphs - Transparent Conducting Materials – Band-gap and electrical conductivity, Conditions for transparency – role of defects on conductivity - Applications: Solar cells, Touch screen, etc.

UNIT III SHAPE MEMORY MATERIALS FOR ENERGY STORAGE 9

Introduction to structure types, Structure-property relationships, Shape memory effect (SME), One way and two-way SME, Shape memory alloys (SMAs), Intelligence in the form of SMA, Functional properties of SMAs. Thermal-storage, and aerospace materials. Shape-memory polymers, and their applications.

UNIT IV MULTIFERROIC MATERIALS FOR NOVEL REFRIGERATION 9

Ferromagnetism and ferroelasticity, Magneto-electric materials: Types of magnetic ordering phenomena, Conditions for multiferroicity– Applications of multiferroic materials. Magnetostrictive smart materials – Magneto-caloric materials for emission-less refrigeration - Magneto-Optic (MO) Materials: Examples (Heusler alloys, double perovskites) and Applications.

UNIT V INTELLIGENT OPTICAL MATERIALS FOR ENVIRONMENT 9

Smart optical materials for modifying spectral shift and refractive index shift. Electro-optic and Acousto-optic materials: Definitions, examples and applications –Chromogenic Materials – Types: Photochromic, Thermochromic, Electrochromic - Devices and Applications:Radiation absorption.

TOTAL: 45 PERIODS

OUTCOMES

- The student will understand the working principle of smart materials
- The student will get an overview on various types of smart materials and their application areas.
- The student will get ideas to use smart materials in green energy and environment applications
- The student will get motivated to find novel applications of these multifunctional materials in new technologies.
- The student will get an idea on different synthesis and characterization techniques

REFERENCES

1. D.J. Leo, Engineering Analysis of Smart Material Systems, Wiley 2007.
2. M. Addington, D.L. Schodek, Smart Materials and New Technologies, Elsevier 2005.
3. K. Otsuka, C.M. Wayman (Eds.), Shape Memory Materials, Cambridge University Press, 1998.
4. M.V. Gandhi, B. S. Thompson, Smart Materials and Structures, Springer, 1992.
5. P. Ball,Made to Measure: Materials for the 21st Century, Princeton University Press, 1997.
6. Ed. M. R. Aguilar and J.S. Roman, Smart Polymers and their Applications, Elsevier 2014.
7. Ed.: Peter L. Reece, Smart Materials and Structures: New Research, Nova Science 2007.
8. Ian Baker, Fifty Materials that Make the World, Springer, 2018.
9. Ed.: Mel Schwartz, Smart Materials, CRC Press, 2008.

EA5491 CLIMATE JOURNALISM L T P C

3 0 0 3

OBJECTIVES

- To offer a comprehensive approach to reporting of climate change.
- To impart knowledge about political, economic, and ethical questions raised by the need for transformative change of societies in the wake of climate change.
- To reflect over the development of climate change as a nature and a society issue.
- To synthesize knowledge from different areas related to climate change.
- To reflect on the norms and values of journalism in the context of climate change.

UNIT I HUMAN INFLUENCES 9

Anthropocene Era (anthropo: man, and cene: new) - Freshwater scarcity - The decline of our oceans, fish, and wildlife - Environmental health - Sustainable energy, agriculture, and food systems – Role and responsibility of journalists – Making climate change relevant as a society issue – Politics and economics of climate change – Environmental ethics – Human health – Species migration.

UNIT II PUBLIC NARRATIVES 9

Complex science and uncertainty - Public apathy and politics - Well-funded counter-narratives - Zealous stakeholders - What can (incorrectly) appear due to a lack of news hook for stories - Two centuries of CO_2emissions.

UNIT III JOURNALISTIC CHALLENGES 9

Environmental Journalism as a craft - Roles and differences between journalism and communications – Finding the most accurate, credible and timeliest information on science and issues – Essentials of environmental reporting – Discerning uncompromised expert sources – Using human narratives and descriptive storytelling to relate real-world impact – Tapping the databases, records and other tools commonly used by environmental reporters.

UNIT IV CLIMATE ISSUES 9

The lack of diversity in environmental journalism – "Junk science" – Battling climate denial - Covering GMOs – The problem of doomsday climate reporting – Digital security for journalists and researchers etc.

UNIT V JOURNALISTIC SKILLS 9

Hands-on journalistic series – Reporting, developing, funding, crafting and publishing environmental stories – Writing diverse stories on environmental history, a wildlife or ocean story, a clam-aquaculture story, a work of nature writing, etc. – A polished, fact-checked, final story with questions answered and edits made from the first draft and at least two added elements such as photos, audio or video clips, graphics, timelines or others to draw people in.

TOTAL: 45 PERIODS

OUTCOMES

- Students will understand the importance of climate issues.
- Students will understand the various aspects of climate change and its effect in society.
- Students will learn to cover the climate change issues.
- Students will understand the need of journalistic skills for covering climate issues.
- Students will learn the various strategies, approaches on covering climate issues in various media.

REFERENCES

1. Lakoff, G., Why it matters how we frame the environment. In Environmental Communication, 2010.
2. Vetlesen, A. J., Nature, technology and environmental crisis. In Bhaskar, R., Næss, P., Høyer, K.G. (eds.), Eco philosophy in a World of Crisis. Critical Realism and the Nordic Contributions. London: Routledge, 2012.
3. Ytterstad, A., The climate crisis challenges the objectivity ideal in Norwegian journalism. In Ytterstad. A., Norwegian Climate Change Policy – Between Hegemony and Good Sense, Oslo: Unipub, 2012.
4. Anker, Peder, A pioneer country? A history of Norwegian climate politics. In Climatic Change. ISSN 0165-0009. 2016.
5. Klein, N., This Changes Everything - Capitalism vs the Climate. Part 1 and 3. London: Allan Lane, 2014.
6. Stoknes, P.E., What We Think About When We Try Not to Think About Global Warming: Toward a New Psychology of Climate Action. Vermont: Chelsea Green, 2015.

EA5492 **DIGITAL PHOTOGRAPHY** **L T P C**
3 0 0 3

OBJECTIVES

- To create opportunities for professional and creative expression through the practice and art of photography.
- To inculcate aesthetic sense involved in creativity.
- To get to know the genres of photography

UNIT I CAMERA **9**

Different camera formats, working of an SLR and DSLR and Mirrorless Cameras. Features and functions of SLR and DSLR Cameras. Various camera controls. Anseladams Zone system. Exposure. Image sensors. Different storage formats.

UNIT II LENS AND ELEMENTS OF PHOTOGRAPHY **9**

Different type of Lenses - Basic Shots and Camera Angles, Photographic Composition - View point and Camera angle-Eye Level, Low and High, Balance- Aspects of Balancing, Shapes and Lines, Pattern, Volume, Lighting, Texture, Tone, Contrast- and Colour, Framing, various Perspectives.

UNIT III COLOUR AND LIGHTING **9**

Colour Theory, Colour Temperature, Electromagnetic spectrum, Lighting Philosophies – Basic styles of Lighting – Properties of Light – Additive and Subtractive Light – Contrast and Lighting Ratios – Direct and Indirect Light – Three point and Five Point Lighting – Light Sources. Light meters and filters

UNIT IV PEOPLE AND PORTRAIT PHOTOGRAPHY **9**

Indoor and outdoor lighting techniques for portraits, the Casual Portrait, Environmental Portraits, Group Portraits, Familiar Subjects, Hands and Other Details.

UNIT V GENRES OF PHOTOGRAPHY **9**

Basic shooting and Lighting Techniques and Equipments required for different genres of Photography like Black and White, Landscape, Cityscape, Architecture, Advertising, Table top photography Fashion, Food, Automobile, Sports, Travel, Children, Portrait, wild life, Still Life, Event, Silhouette, Festival and Themes.

TOTAL: 45 PERIODS

OUTCOMES

- Students will be able to utilize the principles of good composition in photography.
- Students will be able to develop an individual style in representing the society through photographs.
- Students will have a thorough understanding of how to create visual variety
- Students will understand the foundation principles of design
- Students will gain understanding in Depth of field
- Students will understand the different genres of photography

REFERENCES

1. Ansel Adams, The Negative, Bulfinch press, Fourteenth Edition, 2008.
2. BalakrishnaAiyer, Digital Photojournalism, Authors press, 2005
3. Ben long, Complete Digital Photography, Charles River Media, Third Edition, 2005
4. Fil Hunter, Steven Biver, Paul Fuqua, Light - Science & Magic: an Introduction to Photographic Lighting, Focal Press,2007
5. Langford Bilissi,Langford's Advanced Photography, focal press, Seventh Edition, 2008.
6. Scott Kelby, The Digital Photography Book, Peachpit Press, 2009

AC5491 **GREEN CHEMISTRY** **L T P C**
3 0 0 3

OBJECTIVES

- To introduce the basic concept and principles of green chemistry for environmental management.
- To make the students know about green reagents and its importance to the environment
- To acquaint the student with green solvents and its impacts in green chemistry
- To familiarize the synthesis of materials using green methods
- To impart the knowledge on applications of green synthesis technology

UNIT I PRINCIPLES OF GREEN CHEMISTRY 9

History of green chemistry and sustainability- Prevention of waste/by-products – maximum incorporation of reactants in final product-Atom economy – Prevention/minimization of hazardous products – Designing safer chemicals – optimizing reaction conditions.

UNIT II GREEN REAGENTS AND CATALYSTS 9

Choice of starting materials – reagents (Dimethyl carbonate, polymer supported reagents) – catalysts (microencapsulated Lewis acids, zeolites, basic catalysts polymer supported catalysts, introduction to biocatalysts).

UNIT III GREEN SOLVENTS 9

Aqueous phase reactions (Claisen rearrangement, Aldol condensation, wurtz reaction, reduction of carbon carbon double bond, oxidation of amines into nitro compounds – Electrochemical synthesis (synthesis of adiponitrile) - Ionic liquids – reactions in acidic ionic liquids- reactions in neutral ionic liquids (hydrogenations, diels-Alder reactions, Heck reactions, O-alkylation and N-alkylation, methylene insertion reactions.

UNIT IV GREEN SYNTHESES 9

Microwave induced green synthesis (Hoffmann Elimination and Oxidation of alcohols) – Ultra sound assisted green synthesis (Esterification, Saponification and Cannizaro reaction) – Solid state green synthesis (Dehydration of alcohols to alkenes, Grignard reaction)- Solid supported organic synthesis (Synthesis of furans and pyrrole)

UNIT V APPLICATIONS OF GREEN SYNTHESIS 9

Introduction – synthesis of styrene, adipica acid, catechol, 3-Dehydroshikimic acid, methyl methacrylate, urethane. Environmentally benign synthesis of aromatic amines – free radical bromination – synthesis of ibuprofen and paracetamol.

TOTAL: 45 PERIODS

OUTCOMES

- To be familiar with basic concepts of green chemistry and apply to them in various field
- To recognize the catalytic reaction with green reagents and its importance. To identify available green solvents and apply them to various synthesis process
- To recognize the preparations of materials with green process and its application to the environment.
- To gain the knowledge of preparation of various drugs using green synthesis methods
- To be have the skills and technology towards green chemistry and apply in industry.

REFERENCES

1. V.K. Ahluwalia and M. Kidwai, New trends in Green Chemistry, Anamaya Publishers, 2004.
2. V. K. Ahluwalia, Green Chemistry, Narsoa publishers, 2012
3. Bela Torok and Timothy Dransfield ,Green Chemistry, An Inclusive Approach, 1st Edition, Elsevier, 2017.

AC5492 **FOOD CHEMISTRY** **L T P C**
3 0 0 3

OBJECTIVES

- To enable the students to acquire knowledge on the macro and micro constituents of the food
- To know the structure and chemical characteristics of constituents of food.
- To demonstrate the knowledge of food chemistry and applying, the principles and concepts of chemistry as they apply to food systems.
- To familiarize the student with the relationship between water and food.
- To explain the rationale for certain food processes and preservation

UNIT I INTRODUCTION TO FOOD AND ITS PROPERTIES 12

Proteins-Enzymes- Chemistry and structure, kinetics, Maillard reaction. Food carbohydrates: Structural, nutritional and functional aspects. Emulsifiers-role of emulsifiers selection of emulsifier based on hydrophilic and Lipophilic balance (HLB) and its application. Thickeners-definition, chemical structure, gel formation, list of permitted thickeners and food application. Chemical and biochemical changes: changes occur in foods during different processing.

UNIT II PROCESSING AND PRESERVATION 12

Scope and benefits of industrial food preservation. Preservation of foods by chemicals, antibodies, antioxidants, salt and sugar. Principles of food freezing: freezing point of foods Psychrometric chart, Freeze concentration, freeze drying, IQF. Nanotechnology: Principles and application in foods, Hurdle technology: Types of preservation techniques and their principles, concept of hurdle technology and its application.

UNIT III FLAVOURS AND COLOURING AGENTS 9

Chemistry of food flavor, definitions, Flavourmatics /flavouring compounds, flavor retention-off flavours and food taints. Colour -Natural and synthetic food colours, their chemical structure, stability, permitted list of colours, usage levels and food application.

UNIT IV WATER RELATIONS IN FOOD 6

Moisture in food: Structure, properties, Types of water in food and their specific function water activity and stability.

UNIT V FOOD ADDITIVES 6

Definitions, uses and functions of: Acids, Bases, Buffer system, chelating/sequestering agents, Antioxidants, Anti-caking agents, Firming agents. Flour bleating agents and Bread improvers. Anti-microbial agents/ class I & II.

TOTAL: 45 PERIODS

OUTCOMES

- Will know about the factors governing the food quality and chemical constituents.
- Will be able to name and describe the general chemical structures of the major components of foods and selected minor components
- Will come to know about the techniques involved in food processing and preservation
- Will be acquitted with food additives and their function in preservation
- Will be familiarize with the nature of packed food from industrial processes

REFERENCES

1. Damodaran, S., Parkin, K. L., and Fennema, O.R. (2008) Fennema's Food Chemistry 4th Edition, CRC Press
2. Belitz, H-D., Grosch, W. & Schieberle, P. (2004) Food Chemistry 3rd Ed. (translation of fifth German edition), Springer
3. DeMan, J.M. Principles of Food Chemistry 4rd Ed. Aspen Publishers (2018)
4. Peter C. K. Cheng, Handbook of Food Chemistry, Vol 1, Springer Reference, 2015
5. Jaswinder Kaur and Barry H. Grump Fundamentals of Food Chemistry, Abhizeet Publications, 2010.
6. Harish Kumar Chopra and Parmjit Singh Panesar, Food Chemistry, Narosa Publication, 2010.

AG5491 NATURAL HAZARDS AND MANAGEMENT L T P C
3 0 0 3

OBJECTIVES

- To teach characteristics of natural hazards.
- To teach mitigation methods for natural hazards.
- To provide knowledge on assessment and management of natural hazards.

UNIT I DISASTER PHENOMENON 9

Disaster threat - characteristics-parameters – mapping aspects for earthquake, landslides, tsunami, cyclones, flood, drought and epidemics.

UNIT II MITIGATION 9

Geological and hydrological hazards - Reduction of hazard proneness – reducing structural vulnerability – changing the functional characteristics of settlement – building code provisions.

UNIT III ASSESSMENT 9

Elements of risk – vulnerability analysis on dam and other infrastructures – risk assessment – plan area – organizational aspects, planning and mapping levels – socio-economic aspects – cost of risk reducing measures.

UNIT IV MANAGEMENT 9

Prevention – preparedness – response – recovery – resource utilization – international assistance – policy and legislation – training – public awareness.

UNIT V CASE STUDIES AND ADVANCED TOOLS 9

Post disaster review – role of remote sensing and GIS –National and state level case studies on various disasters.

TOTAL: 45 PERIODS

OUTCOMES

On completion of this course, the students expected to be able to:

- Gain knowledge on natural hazards and their characteristics
- Have better understanding on geological and hydrological hazards
- Appreciate various mitigation techniques.
- Carryout risk assessment and vulnerability mapping
- Understand the role of remote sensing and GIS in natural hazard risk reduction.

REFERENCES

1. Nick Carter, W. Disaster management, A Disaster manager's Handbook, Publisher: Asian development bank, Manila, 1992.
2. Mitigating natural disasters: Phenomena, effects and options, a Manual for policy makers and planners. Publisher: United Nations, Hew York, 1991.
3. Edward A. Keller, DeVecchio. Natural Disasters: Earth's Processes as Hazards, Disasters and Catastophes, Routledge, 3rd Edition, 2011.
4. Harsh K. Gupta, Disaster Management, Indian National Science Academy, ISBN 8173714568,788173714566, 2006 second Edition, 152 Pages.
5. Ghanshyam Singh and Sandip Bhandari, Disaster Management, Gullybaba Publishing House (P) Ltd; 1st edition (2012), ISBN-13: 978-9381066492.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	√	√	√	√	√	√	√	√	√	√	√	√
CO2	√		√	√	√	√	√	√	√	√	√	√
CO3	√	√	√	√	√	√	√	√	√	√	√	√
CO4	√	√	√	√		√	√	√		√	√	√
CO5	√		√	√	√	√	√			√		√

AG5492 OCEAN RESOURCES AND EXPLORATION TECHNIQUES L T P C
3 0 0 3

OBJECTIVES

- To understand the Sources of Marine Minerals.
- To understand the various energy resources pertain to marine system
- To understand the importance and economic aspects of marine minerals

UNIT I INTRODUCTION 9

Marine Mineral Resources - sources of Marine Minerals -sources in ocean basins. Formation Processes of Polymetallic Sulfides (PMS) on the Ocean Floor- Plate boundaries and associated mineral and energy occurrences.

UNIT II OCEAN RESOURCES 9

Mineral deposits derived from land sources - Placer Deposits - Lime, Phosphorite and Salt Deposits - Beach Deposits of Continental Margins - rock salt (sodium chloride) - magnesium metal - magnesium compounds and bromine. metalliferous sediments-Seafloor Polymetallic Massive Sulphides - polymetallic manganese nodules. Methane hydrate.

UNIT III ENERGY RESOURCES 9

Wind Energy - Wave Energy - Tidal Energy - Ocean Current Energy - Ocean thermal energy conversion (OTEC) - osmotic power plant-Petroleum resources and radioactive nuclear mineral deposits

UNIT IV OCEAN RESOUCE EXPLORATION AND EXPLOITATION 9

Marine sampling - Water Samplers - Bottom Samplers - Instrumentation

UNIT V OCEAN MINERAL MINING 9

Mining aspects of deep-sea polymetallic sulphides - Manganese Nodules - Methane Hydrates. Sand, Sand Mining & Beach replenishment-Marine maps of Exclusive Economic Zone (EEZ)

TOTAL: 45 PERIODS

OUTCOMES

- Students will understand the various sources of marine minerals.
- Students will able to understand the Mineral deposits derived from land sources.
- Students will learn about the energy resources of marine system.
- Students will learn about various sampling methods and instrumentation.
- Students will able to understand the economic aspects of marine minerals.

REFERENCES

1. H. Kunzendorf, Marine Mineral Exploration, Volume 41, 1st Edition, Elsevier Science, 1986
2. David Spencer Cronan, Handbook of Marine Mineral Deposits, CRC Press, 24-Nov-1999
3. Yves Fouquet , Denis Lacroix , Deep Marine Mineral Resources, 2014th Edition, Springer Dordrecht Heidelberg London New York
4. H. Kunzendorf , Marine Mineral Exploration, ISBN-10: 0444426272, Elsevier Oceanography Series

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	√	√	√	√	√	√	√	√	√	√	√	√
CO2	√		√	√	√	√	√	√	√	√	√	√
CO3	√	√	√	√	√	√	√	√	√	√	√	√
CO4	√	√	√	√		√	√	√	√	√		√
CO5	√		√	√	√	√	√		√	√	√	

MC5491 BASIC CRYSTALLOGRAPHY AND CRYSTAL GROWTH L T P C
3 0 0 3

OBJECTIVES

- To introduce the basics of crystal symmetry and crystal structures.
- To provide students with a background to X-ray generation and detection
- To provide instruction on the steps involved in single crystal structure determination
- To teach the concept of powder X-ray diffraction and its applications
- To teach various crystal growth techniques

UNIT I CRYSTAL SYMMETRY AND STRUCTURES 9

Crystalline and non-crystalline materials –– symmetry: symmetry operations, symmetry elements - translational symmetries - point groups - space groups – equivalent positions - space lattice - crystal systems – Bravais lattices – crystal directions - crystal planes – Miller indices- interplanar spacing – coordination number– atomic radius – atomic packing factor of SC, BCC, FCC and HCP structures – linear density – planar density – close packed structures.

UNIT II X-RAYS 9

X-rays - generation of X-rays - sealed tube and rotating anode generators – synchrotron radiation – continuous and characteristic X-rays - X-ray absorption – X-ray monochromators – collimation – Soller slits - X-ray detectors (principles only)

UNIT III SINGLE CRYSTAL STRUCTURE DETERMINATION 9

Diffraction by X-rays - Bragg's law – reciprocal lattice and Ewald sphere – atomic scattering factor - intensities of diffracted X-rays -– Single crystal X-ray diffractometers – measurement of intensities – systematic absences – space group determination - factors affecting X-ray intensities – data reduction – solving the structure - phase problem in crystallography – direct methods – refining the structure – results - geometrical parameters.

UNIT IV POWDER X-RAY DIFFRACTION 9

X-ray diffraction by polycrystalline materials - formation of powder diffraction patterns - Debye-Scherrer camera – powder X-ray diffractometer – diffractograms – sample holders – sample preparation – orientation of crystallites – sample rotation – diffraction geometries – indexing of powder pattern – applications of powder diffraction.

UNIT V CRYSTAL GROWTH TECHNIQUES 9

Bridgman technique - Czochralski method - Verneuil technique - zone melting – gel growth – solution growth methods – low and high temperature solution growth methods – vapour growth - epitaxial growth techniques- LPE – MOCVD – MPE.

TOTAL: 45 PERIODS

OUTCOMES

Upon completion of the course the students will

- understand crystal symmetry, crystal planes and simple crystal structures
- gain a knowledge of X-ray generation, absorption, monochromatization and detection
- get a working knowledge of single crystal structure determination
- get some insight into the powder diffraction and its applications
- be able to understand the basics of various crystal growth techniques

REFERENCES

1. Tareen, J.A.K. and Kutty, T.R.N. A Basic course in Crystallography. University Press, 2001.
2. Cullity, B.D. and Stock,S.R. Elements of X-ray Diffraction. Pearson, 2014
3. Stout, G.H. and Jensen, L. X-ray Structure Determination, A Practical Guide. Macmillan : New York, 1989.
4. Woolfson, M.M. An Introduction to X-ray Crystallography. Cambridge University Press, New York, 1997.
5. Bhat, H.L Introduction to Crystal Growth: Principles and Practice. CRC Press, 2014.

MC5492 **NONLINEAR SCIENCE** **L T P C**
3 0 0 3

OBJECTIVES

- 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

- Understand the basics of nonlinear dynamics and its applications.
- Gain knowledge on the concepts of fixed points, oscillations, bifurcations and integrability.
- Appreciate the importance of nonlinear dynamical phenomena in chemical systems.
- Understand the role of nonlinear dynamics in biological systems.
- 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.

MT5491 STATISTICAL METHODS L T P C
3 0 0 3

OBJECTIVES

- To organize and describe the data and hence compute the various descriptive measures
- To give an idea of testing the statistical hypothesis claimed based on a set of data points using standard sampling distributions
- To expose to the basic principles of experimental design and hence carry out the analysis of variance
- To use non parametric methods on data sets which are not from normally distributed population
- To prepare the students to implement the various concepts in statistics using R statistical tool

UNIT I DESCRIPTIVE STATISTICS 9

Frequency distribution - Graphs of frequency distribution - Descriptive Measures - Quartiles and Percentiles - Calculation of sample mean and population mean

UNIT II HYPOTHESIS TESTING 9

Sampling Distributions- Central Limit Theorem - Testing a Statistical Hypothesis - Tests Concerning Means and variances - Independence of Attributes - Goodness of Fit

UNIT IV ANALYSIS OF VARIANCES 9

One way and two way classification - Completely Randomized Design - Randomized Block Design - Latin Square Design

UNIT V NONPARAMETRIC METHODS 9

Sign Test - Wilcoxon's Signed Rank Test - Rank Sum Tests - Tests of Randomness - Kolmogrov Smirnov and Anderson Darling Tests

UNIT V CALCULATIONS USING R 9

Classification and tabulation of data - Graphical representation - Calculation of central tendency and dispersion of data - Implementation of skewness, moments and kurtosis - Hypothesis Testing - Implementation of ANOVA, sign test and rank sum test.

TOTAL: 45 PERIODS

OUTCOMES

- It equips the student to compute mean, variances, quartiles and percentiles for a large set of data points obtained from a series of measurements
- It imparts the knowledge of various test statistics used in hypothesis testing for mean and variances of large and small samples
- It enables the students to compare several means
- It makes the students use sign test and rank test which can be applied to any raw data without the underlying assumptions that the observations are from normal population.
- It equips the students to implement the various concepts learnt using R tool for statistics

REFERENCES

1. Gupta S. C. and Kapoor V. K, "Fundamentals of Mathematical Statistics", Sultan Chand and Sons, 11th Edition, New Delhi, 2002.
2. John E. Freund ," Mathematical Statistics with Applications", 8th Edition, Pearson Education, New Delhi, 2017.
3. Richard A. Johnson, Irwin Miller and John Freund, "Miller and Freund's Probability and Statistics for Engineers", 8th edition, Pearson Education, New Delhi, 2015.

HS5491	PROFESSIONAL EMAIL COMMUNICATION	L T P C 3 0 0 3

UNIT I Email as a medium of professional communication (1 hour)

a. Clear, grammatically correct sentences
b. Clear and coherent paragraphs
c. Polite and professional expression
d. Accurate punctuation

The nature of the e-mail in its present technological state

a. The pros and cons of using email for professional communication

UNIT II Standard email conventions and etiquette

a. Conventions for effective emailing intra and inter workplaces(inclusive of formatting)
b. Interpersonal etiquette to be used in professional emailing
c. Cross- cultural dos and don'ts when using email across borders

UNIT III Understanding email messages accurately (2 hours)

a. Understanding the core message
b. Understanding the writer's intention and expectation accurately
c. Interpreting the style ad tone of the message
d. Reading and understanding messages quickly

UNIT IV Writing clear and contextually appropriate responses (12 hours)

a. Writing appropriate opening and closing sentences
b. Structuring the email logically and coherently
c. Positioning the core message for reader attention and action
d. Writing messages for a range of professional functions such as giving an update, reporting, requesting , clarifying and confirming, giving instructions etc.

UNIT V Using a range of professional styles (10 hours)

a. Maintaining courtesy and professional poise in all messages
b. Being direct or indirect as necessary
c. Being elaborate or brief as necessary
d. Being assertive and decisive when needed

TOTAL: 45 PERIODS

Learning outcome: At the end of the course, the students should

- Understand email as a professional communication medium and as it is used in workplaces today.
- Use standard e-mailing conventions and etiquette used in workplaces internationally.
- Use appropriate style and tone for communicating a variety of professional messages that are generally communicated via e-mail in work and business communication.
- Read and interpret e-mail messages accurately and write contextually appropriate responses.
- Use English accurately while writing emails in generic professional contexts.
- Use punctuation accurately while writing e-mail messages.

Assessment (with individualised feedback for mid-course tests) :

Mid-course Assessment - 1 hour + 1 hour for feedback after evaluation)

Mid-course Assessment - 2 (1 hour + 1 hour for feedback after evaluation)

Final Assessment – 2 hours (inclusive of Email English test)

Classroom teaching methodology: Concept familiarisation will be accompanied with practice in generic professional emailing contexts. Practice tests and individualised feedback will be used feedback.

Material for the course will be teacher generated

HS5492	PROJECT REPORT WRITING	L	T	P	C
		3	0	0	3

OBJECTIVES

The Course aims to,

- Develop the project writing skills of engineering graduates
- Give engineering and technology students practice in writing a project report
- Enhance their awareness on the importance of report writing in the professional context

UNIT I

Writing Skills – Essential Grammar and Vocabulary – Passive Voice, Reported Speech, Concord, Signpost words, Cohesive Devices – Paragraph writing - Technical Writing vs. General Writing

UNIT II

Project Report – Definition, Structure, Types of Reports, Purpose – Intended Audience – Plagiarism – Report Writing in STEM fields – Experiment – Statistical Analysis

UNIT III

Structure of the Project Report: (Part 1)Framing a Title – Content – Acknowledgement – Funding Details -Abstract – Introduction – Aim of the Study – Background - Writing the research question - Need of the Study/Project Significance, Relevance – Determining the feasibility – Theoretical Framework

UNIT IV

Structure of the Project Report: (Part 2) – Literature Review, Research Design, Methods of Data Collection - Tools and Procedures - Data Analysis - Interpretation - Findings –Limitations - Recommendations – Conclusion – Bibliography

UNIT V

Proof reading a report – Avoiding Typographical Errors – Bibliography in required Format – Font – Spacing – Checking Tables and Illustrations – Presenting a Report orally – Techniques

TOTAL: 45 PERIODS

OUTCOMES

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

- Write reports successfully
- Analyze issues threadbare and arrive at findings based on the analysis
- Write reports for different purposes

REFERENCE BOOKS:

1. Gerson and Gerson - Technical Communication: Process and Product, 7th Edition, Prentice Hall(2012)
2. Virendra K. Pamecha - Guide to Project Reports, Project Appraisals and Project Finance (2012)
3. Daniel Riordan - Technical Report Writing Today (1998)
4. Darla-Jean Weatherford - Technical Writing for Engineering Professionals (2016) Penwell Publishers.

HS5493	BASIC PRESENTATION SKILLS	L	T	P	C
		3	0	0	3

OBJECTIVES

The course aims to,

- Develop public speaking skills among students of engineering and technology
- Enhance the presentation skills of students
- Heighten the awareness related to the fundamentals of presentations

UNIT I

Presentation skills – Characteristics of an effective Oral Presentation – Audience - Context, Content, Speaker Status - Purpose – Modus Operandi – Extempore

UNIT II

Emphasis on syllable stress, pronunciation, intonation, pauses, pace - Preparation for a presentation – Avoiding plagiarism –Ample use of Referencing skills – Efficient ways of Collecting and Collating data (due emphasis on important information)

UNIT III

Impressive introduction – Body language – Use of icebreakers – “Start Proper” for the presentation – Relevant Anecdotes & Jokes - Responding constructively to questions – Time Management – Information sharing

UNIT IV

Impressive introduction – Body language – Use of icebreakers – “Start Proper” for the presentation – Relevant Anecdotes & Jokes - Responding constructively to questions – Time Management – Information sharing

UNIT V

Presentation skills – Guidelines – Group Presentation - Creative approaches to presenting – Technical presentation - Speaking under time constraint – variations in pitch, tone & intonation - Credibility in presentation (Use of authentic data/information) Podium panache – Effective Delivery

Learning Outcomes: At the end of the course, students will be able to,

TOTAL: 45 PERIODS

REFERENCE BOOKS:

1. Michael Osborn, Susan Osborn, Randall Osborn & Kathleen J Turner, “Public Speaking: Finding Your Voice”, 10th Edition, Pearson, 2012.
2. John Hughes & Andrew Mallett, “Successful Presentations DVD & Student’s Pack”, OUP, Oxford, 2012.
3. Nancy Duarte, “Resonate: Present Visual Stories That Transform Audiences”, John Wiley & Sons, New Jersey, 2010.
4. Scott Berkun, “Confessions of a Public Speaker”, O’Reilly Media, Inc, Canada, 2010.
5. Barbara Pease & Allan Pease, “The Definitive Book of Body Language”, Bantum Books, New York, 2006.
6. Naomi Karten, “Presentation Skills for Technical Professionals: Achieving Excellence (Soft Skills for IT Professionals), IT Governance Publishing, UK, 2010.

AUDIT COURSES (AC)

AX5091 ENGLISH FOR RESEARCH PAPER WRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first-time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

AX5092 **DISASTER MANAGEMENT** **L T P C**
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION **6**

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS **6**

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA **6**

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT **6**

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT **6**

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explaina critical understanding of key concepts in disaster riskreduction and humanitarian response.
CO3: Ability to illustratedisaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describean understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS 6

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES 6

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS 6

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE 6

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. "Abhyaspustakam" – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094	VALUE EDUCATION	L T P C
		2 0 0 0

OBJECTIVES

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I

Values and self-development–Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements

UNIT II

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

UNIT III

Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.

Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV

Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the overall personality.

Suggested reading

1. Chakroborty, S.K.“Values and Ethics for organizations Theory and practice”, Oxford University
   Press, New Delhi

AX5095 **CONSTITUTION OF INDIA** **L T P C**
2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:

History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION:

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE:

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION:

District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION:

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

Suggested reading

1. The Constitution of India,1950(Bare Act),Government Publication.
2. Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution,1st Edition, 2015.
3. M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

AX5096 **PEDAGOGY STUDIES** **L T P C**
2 0 0 0

OBJECTIVES

Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY:

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions **-** Overview of methodology and Searching.

UNIT II INTRODUCTION AND METHODOLOGY:

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions **-** Overview of methodology and Searching.

UNIT III THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT IV EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT V PROFESSIONAL DEVELOPMENT

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT VI RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to understand:

- What pedagogical practices are being used by teachers informal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Suggested reading

1. Ackers J, HardmanF (2001) Classroom interaction in Kenyan primary schools, Compare, 31(2): 245-261.
2. Agrawal M (2004)Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36(3):361-379.
3. Akyeampong K (2003) Teacher training in Ghana-does it count? Multi-site teacher education research project (MUSTER) country report 1.London:DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.

5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M(2003) Read India: Amass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

AX5097	STRESS MANAGEMENT BY YOGA	L T P C 2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do's and Don't's in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTED READING

1. 'Yogic Asanas for Group Tarining-Part-I":Janardan Swami Yoga bhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

UNIT I

Neetisatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses-29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses-71,73,75,78 (do's)

UNIT II

Approach to day to day work and duties - Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 - Personality of role model - shrimad bhagwad geeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and man kind to peace and prosperity
- Study of Neet is hatakam will help in developing versatile personality of students.

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.