PERIYAR UNIVERSITY

NAAC A++ Grade – State University – NIRF Rank 59 – NIRF Innovation Band of 11-50

PERIYAR PALKALAI NAGAR

SALEM – 636 011

CENTER FOR DISTANCE AND ONLINE EDUCATION [CDOE]

REGULATIONS AND SYLLABUS

M.Sc. Branch – I (B): Mathematics

(For candidates admitted from 2023-2024 onwards)

(SEMESTER PATTERN)

(Under Choice Based Credit System)

CONTENTS

1. INTRODUCTION

1.1 ABOUT THE PROGRAMME

This programme is a combination of mathematics emboldened with data science and computer-assisted simulations. The curriculum has been designed in order to fulfill the current demands of applicable mathematics without altering the essence of basic mathematics courses. To make it more aligned with the latest education policy and give diverge opportunities to the students, variety of elective courses, skill enhancement courses and extra disciplinary courses have been included.

1.2 SALIENT FEATURES

(i) In-depth theoretical background and practical training for pursuing higher studies and research in pure and applied mathematics.

(ii) Create a platform for higher studies and research in mathematics, computing and inter-disciplinary areas.

(iii) Prepare students to qualify for various national and international competitive examinations.

1.3 AIMS AND OBJECTIVES OF THE PROGRAMME

Sound knowledge in a discipline can only lead to excellence in the art of teaching. The Master's in Mathematics at Periyar University, Salem nurture a prospective student into research and become industry-ready. To facilitate our students to acquire positions / assignments in the institutions of national importance and abroad.

1.4 DURATION OF THE PROGRAMME

The two-year postgraduate programme in M.Sc. Mathematics consists of four semesters under **Choice Based Credit System (CBCS).**

1.5 ELIGIBILITY

A candidate who has passed B.Sc. Degree Examination in Branch I- Mathematics and Mathematics with Computer Applications (CA) of this University or an examination of some other university accepted by the syndicate as equivalent there are eligible to apply for M.Sc Mathematics programme. They shall be permitted to appear examinations conducted by this University and qualify for the M.Sc. Mathematics (CBCS) Degree of this

university after completion of two academic years in the Department of Mathematics, Periyar University Center for Distance and Online Education (CDOE).

1.6 CURRICULAM HIGHLIGHTS

The curriculum is designed to provide students with in-depth theoretical background and practical training in both pure and applied mathematics. In particular, the diverse spectrum of open electives enables a student to develop a career of his/her chosen one, either academia or industry. Moreover, a student becomes competent to take challenge in mathematics at national and international levels.

Taxonomy forms three learning domains: the cognitive (knowledge), affective (attitude), and psychomotor (skill). This classification enables to estimate the learning capabilities of students.

Briefly, it is aimed to restructure the curriculum as student-oriented, skill-based and institution-industry-interaction curriculum with the various courses under "**Outcome Based Education with Problem Based Courses, Project Based Courses, and Industry Aligned Programmes**" having revised Bloom's Taxonomy for evaluating students skills.

Three domains:

(i) Cognitive Domain

(Lower levels: K1: Remembering; K2: Understanding; K3: Applying;
Higher levels: K4: Analysing; K5: Evaluating; K6: Creating)

(ii) Affective Domain

(iii) Psychomotor Domain

REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION

Programme	**M.Sc., Mathematics**
Programme Code	**MAT**
Duration	**PG - 2 years**
Programme Outcomes (Pos)	**PO1: Problem Solving Skill** Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context. **PO2: Decision Making Skill** Foster analytical and critical thinking abilities for data-based decision-making. **PO3: Ethical Value** Ability to incorporate quality, ethical legal and value-based perspectives to all organizational activities. **PO4: Communication Skill** Ability to develop communication, managerial and interpersonal skills. **PO5: Individual and Team Leadership Skill** Capability to lead themselves and the team to achieve organizational goals. **PO6: Employability Skill** Inculcate contemporary business practices to enhance employability skills in the competitive environment. **PO7: Entrepreneurial Skill** Equip with skills and competencies to become an entrepreneur. **PO8: Contribution to Society** Succeed in career endeavors and contribute significantly to society. **PO9: Multicultural competence** Possess knowledge on values and beliefs of multiple cultures and also in global perspective. **PO10: Moral and ethical awareness/reasoning** Ability to embrace moral/ethical values in one's life.
Programme Educational Outcomes (PEOs)	**PEO1 – Placement** To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.

	PEO2 - Entrepreneur To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations. **PEO3 – Research and Development** Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development. **PEO4 – Contribution to Business World** To produce employable, ethical and innovative professionals to sustain in the dynamic business world. **PEO5 – Contribution to the Society** To contribute to the development of the society by collaborating with stakeholders for mutual benefit.

Programme Specific Outcomes:

PSO1: Acquire sound knowledge to solve specific theoretical & applied problems in different areas of mathematics & statistics.

PSO2: Understand, formulate, develop mathematical arguments, logically and use quantitative models to address issues arising in social sciences, business and other related context /fields.

PSO3: To prepare the students who will demonstrate respectful engagement with other's ideas, behaviors, beliefs and apply diverse frames of references to take decisions and actions.

To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups potential and higher level organizations.

To encourage practices grounded in research that comply with employment laws, leading the organization towards growth and development.

Mapping of Course Learning Outcomes (CLOs) with Programme Outcomes (POs) and Programme Specific Outcomes (PSOs) can be carried out accordingly, assigning the appropriate level in the grids:

	POs							PSOs		
	1	2	3	4	5	6	…	1	2	…
CLO 1										
CLO 2										
CLO 3										
CLO 4										
CLO 5										

Strong: 1 **Medium: 2** **Low: 3**

BLOOM'S TAXONOMY

Provides a taxonomy of cognitive levels for learning objectives

Recall →	**K1**
Understand →	**K2**
Apply →	**K3**
Analyze →	**K4**
Evaluate →	**K5**
Create →	**K6**

ACTION VERBS FOR LEARNING OBJECTIVES

K1	**Recall – Remember previously learned material** cite, label, name, reproduce, define, list, quote, pronounce, identify, match recite, state
K2	**Understand- Grasp meaning** alter, explain, rephrase, substitute, convert, give example, restate, translate, describe, illustrate, interpret, paraphrase
K3	**Apply- Use learned material in new and concrete situations** apply, relate, solve, classify, predict compute, prepare
K4	**Analyze- break down into component parts to understand structure** ascertain, diagnose, distinguish, infer, associate, examine, differentiate, reduce, discriminate, dissect, determine
K5	**Evaluate- judge the value of material for a given purpose** appraise, conclude, critique, judge assess, contrast, deduce, weigh compare, criticize, evaluate
K6	**Create- combine parts together to form a new whole** combine, devise, compile, expand, plan, compose, extend, synthesize, conceive, modify generalize, revise, integrate, design, invent, rearrange, develop

2. STRUCTURE OF THE COURSE

Course Code	**Course Name**		**Credits**
Lecture Hours: (L) per week	**Tutorial Hours : (T) per week**	**Lab Practice Hours: (P)per week**	**Total: (L+T+P) per week**
Course Category :	**Year & Semester:**	**Admission Year:**	
Pre-requisite			
Links to other Courses			
Learning Objectives: (for teachers: what they have to do in the class/lab/field)			
Course Learning Outcomes: (for students: To know what they are going to learn) **CLO 1:** **CLO 2:** **CLO 3:** **CLO 4:** **CLO 5:**			
Recap: (not for examination) Motivation/previous lecture/ relevant portions required for the course) [This is done during 2 Tutorial hours)			
Units	**Contents**		**Required Hours**
I			**18**
II			**18**
III			**18**
IV			**18**
V			**18**
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)		
Skills acquired from the course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill		
Learning Resources: • **Recommended Texts** • **Reference Books** • **Web resources**			
Board of Studies Date:			

3. ASSESSMENT ACTIVITIES

3.1. Assessment Principles:

Assessment for this course is based on the following principles

1. Assessment must encourage and reinforce learning.
2. Assessment must measure achievement of the stated learning objectives.
3. Assessment must enable robust and fair judgments about student performance.
4. Assessment practice must be fair and equitable to students and give them opportunity to demonstrate what they learned.
5. Assessment must maintain academic standards.

3.2 Assessment Details:

Assessment Item	Distributed Due Date	Weightage	Cumulative Weightage
Assignment 1	3rd week	2%	2%
Assignment 2	6th Week	2%	4%
Cycle Test – I	7th Week	6%	10%
Assignment 3	8th Week	2%	12%
Assignment 4	11th Week	2%	14%
Cycle Test – II	12th Week	6%	20%
Assignment 5	14th Week	2%	22%
Model Exam	15th Week	13%	35%
Attendance	All weeks as per the Academic Calendar	5%	40%
University Exam	17th Week	60%	100%

4. Teaching Methodologies

Traditional Teaching method like Chalk and Board, Virtual Class room, LCD projector, Smart Class, Video Conference, Guest Lectures.

Asking students to formulate a problem from a topic covered in a week's time
Assignment, Class Test, Slip test

Asking students to use state-of-the-art technologies/software to solve problems
Applications, Use of Mathematical software

Introducing students to applications before teaching the theory. Training students to engage in self-study without relying on faculty (for example – library and internet search, manual and handbook usage, etc.)
Library, Net Surfing, Manuals, NPTEL Course Materials published in the website / other universities websites.

5. 5.1 TEMPLATE FOR PG PROGRAMME CREDIT DISTRIBUTION

Semester–I	Credits	Hours	Semester-II	Credits	Hours	Semester-III	Credits	Hours	Semester–IV	Credits	Hours
1.1. Core-I	5	5	2.1. Core-IV	5	5	3.1. Core-VII	5	5	4.1. Core-X	5	5
1.2 Core-II	5	5	2.2 Core-V	5	5	3.2 Core-VIII	5	5	4.2 Core-XI	5	5
1.3 Core – III	5	5	2.3 Core – VI	5	5	3.3 Core – IX	5	5	4.3 Core-XII	5	5
1.4 Elective -I	3	5	2.4 Elective – III	3	5	3.4 Elective - V	3	5	4.4 Project with viva voce	6	5
1.5 Elective-II:	3	5	2.5 Elective -IV:	3	5	3.4 Elective - VI	3	5	4.5 Elective - VII	3	5
						3.5 Internship	2	-	4.5 Elective - VIII	3	5
	21	**25**		**21**	**25**		**23**	**25**		**27**	**30**
Total Credit Points -92											

5.2 Consolidated Table for Credits Distribution

	Category of Courses	Credits for each Course	Number of Courses	Number of Credits in each Category of Courses	Total Credits	Total Credits for the Programme
PART A	Core	5	12	60	90	92 (CGPA)
	Project with viva voce	6	1	06		
	Elective (Generic and Discipline Centric)	3	8	24		
PART B (i)	Summer Internship Program	2	1	2	2	
				Total	**92**	**92**

5.3 SUMMER INTERNSHIP PROGRAM:

Every student shall undergo summer internship programme during summer vocation at the end of 1st year for a minimum period of 2 weeks. The students should get the attendance certificate from the Head of the training institute / industry. After the training, the student has to submit a report to the department based on the training undergone. The departmental committee shall evaluate & conduct Viva-Voce examination during 3rd semester. The result of the Viva-Voce shall be **Commended** (or) **Highly Commended** and the same should be communicated to the COE for printing in the 3rd semester mark sheet. No Credits / No Marks shall be awarded for the internship training but is mandatory to complete the training for the award of M.Sc degree.

Paper Code	Title	Semester	Credit
23CDOEMATI01	Internship programme	III	2

6. INSTRUCTIONS FOR COURSE TRANSACTION

Courses	Lecture hrs	Tutorial hrs	Lab Practice	Total hrs
Core	72	18	--	90
Electives	72	18	--	90
Project	18	18	54	90

7. STRUCTURE OF THE PROGRAMME

Choice Based Credit System (CBCS), Learning Outcomes Based Curriculum Framework (LOCF), Guideline Based Credits and Hours Distribution system.

S. No	COURSE CODE	CATEGORY	TITLE OF THE COURSE	Hours per week	CREDITS	MARKS (CIA = 25 + Ext =75)
SEMESTER - I						
1.	23CDOEMATC01	Core I	**Algebraic Structures**	5	5	100
2.	23CDOEMATC02	Core II	**Real Analysis I**	5	5	100
3.	23CDOEMATC03	Core III	**Ordinary Differential Equations**	5	5	100
4.		Elective-I	One from Group A	5	3	100
5.		Elective-II	One from Group B	5	3	100
SEMESTER - II						
6.	23CDOEMATC04	Core IV	**Advanced Algebra**	5	5	100
7.	23CDOEMATC05	Core V	**Real Analysis – II**	5	5	100
8.	23CDOEMATC06	Core VI	**Topology**	5	5	100
9.		Elective-III	One from Group C	5	3	100
10.		Elective-IV	One from Group D	5	3	100
SEMESTER - III						
11.	23CDOEMATC07	Core VII	**Complex Analysis**	5	5	100
12.	23CDOEMATC08	Core VIII	**Functional Analysis**	5	5	100
13.	23CDOEMATC09	Core IX	**Partial Differential Equations**	5	5	100
14.		Elective-V	One from Group E	5	3	100
15.		Elective-VI	One from Group F	5	3	100
16.	23CDOEMATI01	Summer Internship	(Carried out in Summer Vacation at the end of 1st year)	-	2	-
SEMESTER - IV						
17.	23CDOEMATC10	Core X	**Measure Theory & Integration**	5	5	100
18.	23CDOEMATC11	Core XI	**Differential Geometry**	5	5	100
19.	23CDOEMATC12	Core XII	**Probability Theory**	5	5	100
20.	23CDOEMATD01	Project	**Project with viva voce**	5	6	100
21.		Elective-VII	One from Group G	5	3	100
22.		Elective-VIII	One from Group H	5	3	100
Total				**105**	**92**	**2100**

8. ELECTIVE COURSES OFFERED

Courses are grouped (Group A to Group F) so as to include topics from Pure Mathematics (PM), Applied Mathematics (AM), Industrial Components (IC) and IT Oriented courses (ITC) for flexibility of choice by the stakeholders / institutions.

SEMESTER	COURSE CODE	TITLE OF THE COURSE	CREDITS
I		**GROUP - A**	
	23CDOEMATE01	Number Theory and Cryptography	3
	23CDOEMATE02	Graph Theory and Applications	3
		GROUP - B	
	23CDOEMATE04	Discrete Mathematics	3
	23CDOEMATE03	Mathematical Programming	3
II		**GROUP – C**	
	23CDOEMATE05	Mathematical Modeling	3
	23CDOEMATE06	Mathematical Statistics	3
		GROUP – D	
	23CDOEMATE07	Difference Equations	3
	23CDOEMATE08	Mechanics	3
III		**GROUP – E**	
	23CDOEMATE09	Mathematical Biology	
	23CDOEMATE10	Methods of Applied Mathematics	
		GROUP – F	
	23CDOEMATE11	Mathematical Python	
	23CDOEMATE12	Mathematical Documentation using LATEX	
IV		**GROUP – G**	
	23CDOEMATE13	Numerical Analysis	
	23CDOEMATE14	Financial Mathematics	
		GROUP – H	
	23CDOEMATE16	Research Tools and Techniques	
	23CDOEMATE15	Industrial Mathematics	

9. EXAMINATION

Internal Assessment

Theory Course: For the purpose of uniformity, particularly for interdepartmental transfer of credits, there shall be a uniform pattern of examination to be adopted by all the teachers offering courses. There shall be three tests, one seminar and one assignment for internal evaluation and End semester examination during each semester.

The distribution of marks for internal evaluation and End Semester Examination shall be 25 marks and 75 marks, respectively. Further, distribution of internal marks shall be 10 marks for test, 5 marks for seminar, 5 marks for assignment and 5 marks for attendance, respectively. Best mark out of the first two internal tests (5 marks) and one model examination (5 marks) should be taken for Internal Assessment.

(Internal marks for corresponding attendance percentage)

65.00 % to 74.99 % = 2
75.00 % to 84.99 % = 3
85.00 % to 94.99 % = 4
95% and above = 5

Computer Laboratory Courses: For Computer Laboratory oriented Courses, there shall be two tests in Theory part and two tests in Laboratory part. Choose one best from Theory part and other best from the two Laboratory part. The average of the best two can be treated as the CIA for a maximum of 25 marks. The duration of each test shall be two hours. There is no improvement for CIA of both theory and laboratory, and, also for University End Semester Examination.

Courses	Marks			No. of Courses	Total Marks	Credits
	External	Internal	Total			
Core	75	25	100	12	1200	55
Elective	75	25	100	06	600	18
Project + Viva Voce*	25+25	25+25	100	01	100	05
Internship				-		02
	Grand Total			**25**	**2200**	**92**

*Dissertation: **100** (Internal Valuation 25 + External Valuation 25)
and Joint Viva Voce 25 + 25 Marks

10. QUESTION PAPER PATTERN

(a) Question Paper Pattern for Theory Examination

Intended Learning Skills	**Maximum: 75 Marks** **Passing Minimum: 50% (i.e. 38 marks) out of 75 marks** **Duration : 3 Hours**
	Part –A (10 x 2 = 20 Marks) Answer ALL questions **Two questions from each Unit**
	Part – B (5 x 5 = 25 Marks) **Internal choice, two questions from each Unit (either-or)**
	Part-C (3x 10 = 30 Marks) **Three out of five: one question from each Unit**

Each question should carry the course outcome and cognitive level
For instance,

1. [CO1 : K2] Question xxxx
2. [CO3 : K1] Question xxxx

(b) Question paper pattern for Practical Examination

Time: **3** Hours Maximum: **100** (Internal: 40 + External: 60) Marks

The components of 40 marks are

Periodical assessment	- 20 marks
Test (best 2 out of 3)	- 10 marks
Record	- 10 marks

The components of 60 marks are

Experiments	- 40 marks
Viva-voce	- 10 marks
Record	- 10 marks

Passing Minimum : **30 Marks** (Aggregate of Experiments, Viva-voce and Record)

(No passing minimum for records)

There will be one question with or without subsections to be asked for the practical examination. Every question should be chosen from the question bank prepared by the examiner(s). A question may be used for at most three students in a batch.

11. PASSING MINIMUM

Passing Minimum in the end semester examination shall be 50% out of 75 marks (i.e., 38 marks).

There shall be no passing minimum for internal marks. A candidate who has secured a minimum of 50% marks in all the courses (including practical) prescribed in the programme and earned a minimum of **92 credits** will be considered to qualify the Master's programme.

For the Practical paper, a minimum of 30 marks out of 60 marks in the University examination and marks for the record notebook taken together is necessary for a pass. There is no passing minimum for the record notebook. However submission of record notebook is a must.

For the Project work and viva-voce, a candidate should secure 50% of the marks for pass. The candidate should attend viva-voce examination to secure pass in the Project.

12. COMMENCEMENT OF THIS REGULATION:

These regulations shall take effect from the academic year 2023-2024, that is, for students who are admitted to the first year of the programme during the academic year 2023-2024 and thereafter.

13. PROJECT

For M.Sc Mathematics students, the project is individual and compulsory.

Dissertation project:

The topic of the project shall be assigned to the candidate at the beginning of third semester and a copy of the same should be submitted to the University for approval.

(a) No. of copies of Project:

Students should prepare **three copies** of project and submit the same for the evaluation by Examiners. After evaluation **one copy** is to be retained by the respective guide, **one** in the Department Library and **one** with the student.

(b) Format for the preparation of the project:

(a) Title page
(b) Bonafide Certificate
(c) Acknowledgement
(d) Table of contents

CONTENTS

Format of the Title Page

TITLE OF THE PROJECT

Dissertation submitted in partial fulfillment of the requirements for the award of the

Degree of

Master of Science in

MATHEMATICS

(Under Choice Based Credit System)

Submitted to

Periyar University Center for Distance and Online Education

Periyar University, Salem – 636 011.

By

Students Name :

Register Number :

Department :

Year :

Format of the Certificate

CERTIFICATE

This is to certify that the project entitled ..... submitted in partial fulfillment of the requirements for the award of the Degree of Master of Science in **MATHEMATICS (Under Choice Based Credit System)** to the Periyar University, Periyar Palkalai Nagar, Salem is a record of bonafide research work carried out by ..... under my supervision and guidance and that no part of the dissertation has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journals or magazines.

Date:

Place:

Signature of the Guide Signature of the Head of the Department

Signature of External Examiner

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CORE COURSES - SYLLABUS

23CDOEMATC01	ALGEBRAIC STRUCTURES	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to introduce the concepts and to develop working knowledge on class equation, solvability of groups, finite abelian groups, linear transformations, real quadratic forms.

UNIT I: Sylow's theorems

Counting Principle - Class equation for finite groups and its applications - Sylow's theorems (For theorem 2.12.1, First proof only).

UNIT II: Finite abelian groups and Modules

Solvable groups - Direct products - Finite abelian groups- Modules.

UNIT III: Triangular form

Linear Transformations: Canonical forms –Triangular form - Nilpotent transformations.

UNIT IV: The Rational and Jordan forms

Jordan form - Rational canonical form.

UNIT V: Hermitian, unitary, normal transformations

Trace and transpose - Hermitian, unitary, normal transformations, real quadratic form.

TEXT BOOK:

1. **I.N. Herstein**. *Topics in Algebra,* (II Edition) Wiley Eastern Limited, New Delhi, 1975.

UNIT	Chapter(s)	Sections
I	2	2.11 – 2.12 (Omit lemma 2.12.5)
II	2, 4 & 5	2.13 and 2.14 (Theorem 2.14.1 only) 4.5 5.7 (Lemma 5.7.1 & 5.7.2, Theorem 5.7.1)
III	6	6.4 – 6.5
IV	6	6.6 – 6.7
V	6	6.8, 6.10 and 6.11 (Omit 6.9)

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. M. Artin, *Algebra,* Prentice Hall of India, 1991.
2. P.B. Bhattacharya, S.K. Jain, and S.R. Nagpaul, *Basic Abstract Algebra* (II Edition) Cambridge University Press, 1997. (Indian Edition)
3. I.S. Luther and I.B.S. Passi, *Algebra,* Vol. I –Groups(1996); Vol. II Rings, Narosa Publishing House , New Delhi, 1999
4. D.S. Malik, J.N. Mordeson and M.K. Sen, *Fundamental of Abstract Algebra*, McGraw Hill (International Edition), New York. 1997.
5. N. Jacobson, Basic *Algebra,* Vol. I & II W.H. Freeman (1980); also published by Hindustan Publishing Company, New Delhi.

WEBSITE AND E-LEARNING SOURCE

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.algebra.com

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Deliver class equation and use it in various counting problems.	K1, K2, K3
CLO 2	Understand direct products and to know the use of Sylow subgroups in studying the structure of finite abelian groups.	K2, K3, K4
CLO 3	Determine the similarity of linear transformations via triangular forms and nilpotent transformations.	K2, K3, K4
CLO 4	Fid the Jordan/rational canonical forms of linear transformations and to determine the similarity classes of linear transformations.	K2, K3, K4, K5
CLO 5	Understand the Hermitian, unitary and normal operators with their properties and determine the rank and signature of the real quadratic form.	K1, K2, K3, K4

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	3	1	3	2	3	3	3	2	1
CLO 2	2	1	3	1	3	3	3	2	1
CLO 3	3	2	3	1	3	3	3	2	1
CLO 4	1	2	3	2	3	3	3	2	1
CLO 5	3	1	2	3	3	3	3	2	1

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23CDOEMATC02	REAL ANALYSIS- I	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to work comfortably with functions of bounded variation, Riemann-Stieltjes Integration, convergence of infinite series, infinite product and uniform convergence and its interplay between various limiting operations.

UNIT-I: Functions of bounded variation

Introduction - Properties of monotonic functions - Functions of bounded variation - Total variation - Additive property of total variation - Total variation on [a, x] as a function of x - Functions of bounded variation expressed as the difference of two increasing functions - Continuous functions of bounded variation.

Infinite Series

Absolute and conditional convergence - Dirichlet's test and Abel's test - Rearrangement of series - Riemann's theorem on conditionally convergent series.

UNIT-II: The Riemann - Stieltjes Integral

Introduction - Notation - The definition of the Riemann - Stieltjes integral - Linear Properties - Integration by parts- Change of variable in a Riemann - Stieltjes integral - Reduction to a Riemann Integral – Euler's summation formula - Monotonically increasing integrators, Upper and lower integrals - Additive and linearity properties of upper, lower integrals - Riemann's condition - Comparison theorems.

UNIT-III: The Riemann-Stieltjes Integral

Integrators of bounded variation-Sufficient conditions for the existence of Riemann-Stieltjes integrals-Necessary conditions for the existence of RS integrals- Mean value theorems -integrals as a function of the interval – Second fundamental theorem of integral calculus-Change of variable -Second Mean Value Theorem for Riemann integral-Riemann-Stieltjes integrals depending on a parameter- Differentiation under integral sign-Lebesgue criterion for existence of Riemann integrals.

UNIT-IV: Infinite Series and Infinite Products

Double sequences - Double series - Rearrangement theorem for double series - A sufficient condition for equality of iterated series - Multiplication of series – Cesarosummability - Infinite products.

Power series - Multiplication of power series - The Taylor's series generated by a function - Bernstein's theorem - Abel's limit theorem - Tauber's theorem

UNIT-V: Sequences of Functions

Pointwise convergence of sequences of functions - Examples of sequences of real - valued functions - Uniform convergence and continuity - Cauchy condition for uniform convergence - Uniform convergence of infinite series of functions - Riemann - Stieltjes integration – Non-uniform Convergence and Term-by-term Integration - Uniform convergence and differentiation - Sufficient condition for uniform convergence of a series - Mean convergence.

TEXT BOOK:

Tom M. Apostol, *Mathematical Analysis*, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974.

UNIT	Chapter(s)	Pages
I	6	6.1 - 6.8
	8	8.8, 8.15, 8.17 and 8.18
II	7	7.1 – 7.14
III	7	7.15 – 7.26
IV	8	8.20, 8.21 to 8.26
	9	9.14 9.15, 9.19, 9.20, 9.22, 9.23
V	9	9.1 to 9.6, 9.8,9.9,9.10,9.11, 9.13

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Bartle, R.G. *Real Analysis*, John Wiley and Sons Inc., 1976.
2. Rudin, W. *Principles of Mathematical Analysis*, 3rd Edition. McGraw Hill Company, New York,1976.
3. Malik, S.C. and Savita Arora. *Mathematical Analysis*, Wiley Eastern Limited, New Delhi, 1991.
4. Sanjay Arora and Bansi Lal, *Introduction to Real Analysis*, Satya Prakashan, New Delhi, 1991.
5. Gelbaum, B.R. and J. Olmsted, *Counter Examples in Analysis*, Holden day, San Francisco, 1964.
6. A.L. Gupta and N.R. Gupta, *Principles of Real Analysis*, Pearson Education, (Indian print) 2003.

WEBSITE AND E-LEARNING SOURCE

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Analyze and evaluate functions of bounded variation and determine the convergence of the series with complex terms.	K1, K2, K3
CLO 2	Study classes of Riemann-Stieltjes integrable functions and application of fundamental theorem of calculus..	K2, K3, K4
CLO 3	Understand the Rearrangement of terms of a double series.	K2, K3, K4
CLO 4	Compute the Taylor series and power series for given functions.	K3, K4, K5
CLO 5	Illustrate the effect of uniform convergence on the limit function with respect to continuity differentiability and integrability.	K2, K3, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	3	1	3	2	3	3	3	2	1
CLO 2	2	1	3	1	3	3	3	2	1
CLO 3	3	2	3	1	3	3	3	2	1
CLO 4	1	2	3	2	3	3	3	2	1
CLO 5	3	1	2	3	3	3	3	2	1

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23CDOEMATC03	ORDINARY DIFFERENTIAL EQUATIONS	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to develop strong background on finding solutions to linear differential equations with constant and variable coefficients and also with singular points, to study existence and uniqueness of the solutions of first order differential equations

UNIT-I: Linear equations with constant coefficients

Second order homogeneous equations-Initial value problems-Linear dependence and independence-Wronskian and a formula for Wronskian-Non-homogeneous equation of order two.

UNIT-II: Linear equations with constant coefficients

Homogeneous and non-homogeneous equation of order n –Initial value problems-Annihilator method to solve non-homogeneous equation- Algebra of constant coefficient operators.

UNIT-III: Linear equation with variable coefficients

Initial value problems -Existence and uniqueness theorems – Solutions to solve a non-homogeneous equation – Wronskian and linear dependence – reduction of the order of a homogeneous equation – homogeneous equation with analytic coefficients-The Legendre equation.

UNIT-IV: Linear equation with regular singular points

Euler equation – Second order equations with regular singular points –Exceptional cases – Bessel Function.

UNIT-V: First order ordinary differential equations

Existence and uniqueness of solutions to first order equations: Equation with variable separated – Exact equation – method of successive approximations – the Lipschitz condition – convergence of the successive approximations and the existence theorem.

TEXT BOOK:

E.A. Coddington, *A introduction to ordinary differential equations* (3rd Printing) Prentice-Hall of India Ltd., New Delhi, 1987.

UNIT	Chapter(s)	Pages
I	6	6.1 - 6.8
	8	8.8, 8.15, 8.17 and 8.18
II	7	7.1 – 7.14
III	7	7.15 – 7.26
IV	8	8.20, 8.21 to 8.26
	9	9.14 9.15, 9.19, 9.20, 9.22, 9.23
V	9	9.1 to 9.6, 9.8,9.9,9.10,9.11, 9.13

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Williams E. Boyce and Richard C. DI Prima, *Elementary differential equations and boundary value problems*, John Wiley and sons, New York, 1967.
2. George F Simmons, *Differential equations with applications and historical notes,* Tata McGraw Hill, New Delhi, 1974.
3. N.N. Lebedev, *Special functions and their applications*, Prentice Hall of India, New Delhi, 1965.
4. W.T. Reid. *Ordinary Differential Equations*, John Wiley and Sons, New York, 1971
5. M.D. Raisinghania, *Advanced Differential Equations*, S.Chand& Company Ltd. New Delhi 2001
6. lRai, D.P.Choudary and H.I. Freedman, *A Course in Ordinary Differential Equations,* Narosa Publishing House, New Delhi, 2002.

WEBSITE AND E-LEARNING SOURCE

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Establish the qualitative behavior of solutions of systems of differential equations.	K1, K2, K3
CLO 2	Recognize the physical phenomena modeled by differential equations and dynamical systems.	K2, K3
CLO 3	Analyze solutions using appropriate methods and give examples.	K2, K3, K4
CLO 4	Formulate Green's function for boundary value problems.	K3, K4, K5
CLO 5	Understand and use various theoretical ideas and results that underlie the mathematics in this course.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	3	1	3	2	3	3	3	2	1
CLO 2	2	1	3	1	3	3	3	2	1
CLO 3	3	2	3	1	3	3	3	2	1
CLO 4	1	2	3	2	3	3	3	2	1
CLO 5	3	1	2	3	3	3	3	2	1

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23CDOEMATC04	ADVANCED ALGEBRA	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to study field extension, roots of polynomials, Galois Theory, finite fields, division rings, solvability by radicals and to develop computational skill in abstract algebra.

UNIT-I: Algebraic Extension
Extension fields – Transcendence of e.

UNIT-II: Splitting Field and Simple Extension
Roots of Polynomials - More about roots.

UNIT-III: Galois Theory
Elements of Galois Theory.

UNIT-IV: Finite fields
Finite fields - Wedderburn's theorem on finite division rings.

UNIT-V: Frobenius and Four - Square theorem
Solvability by radicals - A theorem of Frobenius - Integral Quaternions and the Four - Square theorem.

TEXT BOOK:
I.N. Herstein, *Topics in Algebra* (II Edition) Wiley Eastern Limited, New Delhi, 1975.

UNIT	Chapter(s)	Sections
I	5	5.1, 5.2
II	5	5.3, 5.5
III	5	5.6
IV	7	7.1, 7.2 (Theorem 7.2.1 only)
V	5	5.7 (omit lemma 5.7.1, Lemma 5.7.2 and Theorem 5.7.1)
	7	7.3, 7.4

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. M. Artin, *Algebra,* Prentice Hall of India, 1991.
2. P.B. Bhattacharya, S.K. Jain, and S.R. Nagpaul, *Basic Abstract Algebra* (II Edition) Cambridge University Press, 1997. (Indian Edition)
3. I.S. Luther and I.B.S. Passi, *Algebra,* Vol. I –Groups(1996); Vol. II *Rings,* Narosa Publishing House , New Delhi, 1999
4. D.S. Malik, J.N. Mordeson and M.K. Sen, *Fundamental of Abstract Algebra*, McGraw Hill (International Edition), New York. 1997.
5. N. Jacobson, *Basic Algebra,* Vol. I & II Hindustan Publishing Company, New Delhi.

WEBSITE AND E-LEARNING SOURCE

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics,
http://www.opensource.org, www.algebra.com

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Understand the concept of finite extension, algebraic element, algebraic extension, algebraic number, algebraic integer and transcendental number.	K1, K2, K3
CLO 2	Count a root of multiplicity m, find the splitting field of a given polynomial and to understand the concepts of simple extension & separable extension	K2, K3, K4
CLO 3	Find the fixed field by Galois group and to understand the concept of normal extension and the fundamental theorem of Galois theory.	K3, K4, K5
CLO 4	Determine the structure of finite multiplicative group and to find the primitive roots.	K3, K4, K5
CLO 5	Understand the concept of solvability by radical and Frobenius and Four square theroms.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	3	1	3	2	3	3	3	2	1
CLO 2	2	1	3	1	3	3	3	2	1
CLO 3	3	2	3	1	3	3	3	2	1
CLO 4	1	2	3	2	3	3	3	2	1
CLO 5	3	1	2	3	3	3	3	2	1

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23CDOEMATC05	REAL ANALYSIS- II	L	T	P	C
		4	1	0	5

OBJECTIVE: This course covers vector and multivariable calculus. This topics include vectors and matrices, parametric curves, partial derivatives, double and triple integrals, and vector calculus in 2 and 3 dimensional spaces, line integrals and integration theorems generalizing the Fundamental theorem of Calculus (Green theorem, Stokes theorem and Gauss's theorem) also known as the divergence theorem.

UNIT-I: Multivariable Differential Calculus

Introduction - The Directional derivative - Directional derivative and continuity - The total derivative - The total derivative expressed in terms of partial derivatives - The matrix of linear function - The Jacobian matrix - The chain rule - Matrix form of chain rule - The mean - value theorem for differentiable functions - A sufficient condition for differentiability - A sufficient condition for equality of mixed partial derivatives - Taylor's theorem for functions of R^n to R^1.

UNIT-II: Implicit Functions and Extremum Problems: Functions with non-zero Jacobian determinants – The inverse function theorem-The Implicit function theorem-Extrema of real valued functions of severable variables-Extremum problems with side conditions.

Unit-III: Line Integrals

Introduction – Paths and line integrals – Other notations of line integrals – Basic properties of line integrals – Line integrals with respect to the arc length – Open connected sets & Independence of the path – Second fundamental theorem of calculus for line integrals – The first fundamental theorem of calculus for line integrals.

Unit-IV: Multiple integrals: Introduction – Partitions of rectangle, Step functions – The double integral of a step function – The definition of the double integral of a function defined and bounded on a rectangle – Upper and lower double rectangles – Evaluation of a double integral by repeated one-dimensional integration – Geometric interpretation of the double integral as a volume – Integrability of continuous functions – Integrability of bounded functions with discontinuities.

Unit-V: Green's theorem and Surface integrals

Green's theorem in the plane – Change of variables in a double integral – Extensions to higher dimensions – Worked examples.

Surface Integrals: Definition of surface integral – Change of parametric representation – Stoke's theorem – The divergence theorem – Applications of the divergence theorem.

TEXT BOOK:

1. **Tom M. Apostol**: *Mathematical Analysis*, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974. (for Units I to II).
2. **T.M. Apostol**, *"Calculus Vol.2, Multi-Variable Calculus and Linear Algebra with Applications to Differential Equations and Probability",* Second Edition, John Wiley & Sons, 1969. (Units III to V).

UNIT	Chapter(s)	Sections
I	12 (Book [1])	12.1 to 12.14
II	13 (Book [1])	13.1 to 13.7
III	10 (Book [2])	10.1-10.5, 10.7, 10.10 – 10.11, 10.14
IV	11 (Book [2])	11.1 to 11.11
V	11 (Book [2])	11.19, 11.22,11.26
	12 (Book [2])	12.7, 12.8, 12.11, 12.19

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. L.H. Loomis and S. Sternberg, Advanced Calculus, Revised Edition, Jones and Bartlett Publisher, Inc. Boston, MA 02116, 1990.
2. R. Ghorpade and B.V. Limaye, A Course in Multivariable Calculus and Analysis, Undergraduate Texts in Mathematics, Springer-Verlag, New York, 2010.
3. J.R.C, Webb, Functions of Several Real Variables, Ellis Horwood, Chichester, 1991.
4. H. Rogers. Jr, Multivariable Calculus with Vectors, Prentice Hall, New Jersey, 1998.
5. James Stewart, Multivariable Calculus, Cengage Learning Publisher, 2016.
6. J.H. Hubbard and Busbar Burke Hubbard, Vector Calculus, Linear Algebra and Differential Forms: A Unified Approach, 5th Edition, Matrix Editions Publisher, 2015.

WEBSITE AND E-LEARNING SOURCE

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Identify and explain fundamental concepts of multivariable calculus of real and vector functions, such as continuity of function, limit, partial derivative and differential of function, as well as multiple, linear and surface integrals.	K1, K2, K3
CLO 2	Compute partial derivatives of compound functions, implicit functions and the function defined by parametric equations.	K2, K3, K4
CLO 3	Use differential calculus for computing tangential plane and normal on surface and in optimization problems of (local) extremes of multivariable functions.	K2, K3, K4
CLO 4	Calculate areas and volumes using double and trible integrals. Compute curve and surface integrals and use them to calculate lengths, areas and volumes.	K3, K4, K5
CLO 5	Connect concepts of calculus through fundamental theorems, such as implicit function theorem, mean value theorem, change of variable theorem, Fubini, Green, Stokes and divergence theorem.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	1	1	2	2	2	1	2	2
CLO 2	1	2	2	2	2	2	1	2	2
CLO 3	1	2	2	2	2	3	1	2	3
CLO 4	1	1	2	2	2	2	1	2	2
CLO 5	1	2	2	2	2	3	1	2	3

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23CDOEMATC06	TOPOLOGY	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to study topological spaces, continuous functions, connectedness, compactness, countability and separation axioms.

UNIT-I: Topological spaces

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

UNIT-II: Continuous functions

Continuous functions – The product topology – The metric topology.

UNIT-III: Connectedness

Connected spaces- Connected subspaces of the Real line – Components and local connectedness.

UNIT-IV: Compactness

Compact spaces – Compact subspaces of the Real line – Limit Point Compactness – Local Compactness.

UNIT-V: Countability and Separation Axiom

The Countability Axioms – The separation Axioms – Normal spaces – The Urysohn Lemma – The Urysohn metrization Theorem – The Tietz extension theorem.

TEXT BOOK:

1. **James R. Munkres**, *Topology* (2nd Edition), Prentice Hall of India, New Delhi, 2011.

UNIT	Chapter(s)	Sections
I	2	12 to 17
II	2	18 to 21 (Omit Section 22)
III	3	23 to 25
IV	3	26 to 29
V	4	30 to 35

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. 1. J. Dugundji, *Topology*, Prentice Hall of India, New Delhi, 1975.
2. George F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw Hill Book Co., 1963
3. J.L. Kelly, *General Topology*, Van Nostrand, Reinhold Co., New York
4. L. Steen and J. Subhash, Counter Examples in Topology, Holt, Rinehart and Winston, New York, 1970.
5. S. Willard, *General Topology*, Addison - Wesley, Mass., 1970

WEBSITE AND E-LEARNING SOURCE

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics,
http://www.opensource.org , http://en.wikipedia.org

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Define what a topological space is, and to identify the concepts like open sets, closed sets, limit points and continuous functions.	K1, K2, K4
CLO 2	Explain various properties of continuous functions and to examine the metrizability of various topological spaces.	K1, K2, K3, K4, K6
CLO 3	Form new connected spaces from given ones and understand the concepts of path connectedness and local connectedness.	K1, K2, K3, K6
CLO 4	Construct new compact spaces from existing ones, give compact subspaces of the real line and relate different versions of compactness.	K2, K3, K6
CLO 5	Classify the countability and separation axioms, and to determine the conditions under which a topological space is metrizable.	K1, K2, K3, K4

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	3	1	3	2	3	3	3	2	1
CLO 2	2	1	3	1	3	3	3	2	1
CLO 3	3	2	3	1	3	3	3	2	1
CLO 4	1	2	3	2	3	3	3	2	1
CLO 5	3	1	2	3	3	3	3	2	1

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23CDOEMATC07	COMPLEX ANALYSIS	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to study Cauchy integral formula, local properties of analytic functions, general form of Cauchy's theorem and evaluation of definite integral and harmonic functions.

UNIT-I: Cauchy's Integral Formula

The Index of a point with respect to a closed curve – The Integral formula – Higher derivatives. Local Properties of analytical Functions:
Removable Singularities-Taylors's Theorem – Zeros and poles – The local Mapping – The Maximum Principle.

UNIT-II: The general form of Cauchy's Theorem

Chains and cycles- Simple Continuity - Homology - The General statement of Cauchy's Theorem - Proof of Cauchy's theorem - Locally exact differentials- Multiply connected regions - Residue theorem - The argument principle.

UNIT-III: Evaluation of Definite Integrals and Harmonic Functions

Evaluation of definite integrals - Definition of Harmonic function and basic properties - Mean value property - Poisson formula.

UNIT-IV: Harmonic Functions and Power Series Expansions

Schwarz theorem - The reflection principle - Weierstrass theorem – Taylor's Series – Laurent series.

UNIT-V: Partial Fractions and Entire Functions

Partial fractions - Infinite products – Canonical products – Gamma Function- Jensen's formula – Hadamard's Theorem.

TEXT BOOK:

1. **Lars V. Ahlfors**, *Complex Analysis*, (3rd edition) McGraw Hill Co., New York, 1979

UNIT	Chapter(s)	Sections
I	4	Section 2 : 2.1 to 2.3
	4	Section 3 : 3.1 to 3.4
II	4	Section 4 : 4.1 to 4.7
	4	Section 5: 5.1 and 5.2
III	4	Section 5 : 5.3
	4	Sections 6 : 6.1 to 6.3
IV	4	Sections 6.4 and 6.5
	5	Sections 1.1 to 1.3
V	5	Sections 2.1 to 2.4
	5	Sections 3.1 and 3.2

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

2. H.A. Presfly, *Introduction to complex Analysis*, Clarendon Press, oxford, 1990.
3. J.B. Conway, *Functions of one complex variables* Springer - Verlag, International student Edition, Naroser Publishing Co.1978
4. E. Hille, *Analytic function Thorey*(2 vols.), Gonm& Co, 1959.
5. M.Heins, *Complex function Theory*, Academic Press, New York,1968.

WEBSITE AND E-LEARNING SOURCE

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org , http://en.wikipedia.org

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Analyze and evaluate local properties of analytical functions and definite integrals.	K1, K2, K3
CLO 2	Describe the concept of definite integral and harmonic functions.	K1, K2, K3
CLO 3	Demonstrate the concept of the general form of Cauchy's theorem.	K2, K3, K4
CLO 4	Develop Taylor and Laurent series.	K2, K3, K4
CLO 5	Explain the infinite products, canonical products and jensen's formula.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	3	1	3	2	3	3	3	2	1
CLO 2	2	1	3	1	3	3	3	2	1
CLO 3	3	2	3	1	3	3	3	2	1
CLO 4	1	2	3	2	3	3	3	2	1
CLO 5	3	1	2	3	3	3	3	2	1

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23CDOEMATC08	FUNCTIONAL ANALYSIS	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to provide students with a strong foundation in functional analysis, focusing on spaces, operators and fundamental theorems and to develop student's skills and confidence in mathematical analysis and proof techniques.

UNIT-I: Banach Spaces

The definition and some examples – Continuous linear transformations – The Hahn-Banach theorem – The natural imbedding of N in N^{**}- The open mapping theorem – The conjugate of an Operator.

UNIT-II: Hilbert Spaces

The definition and some simple properties–Orthogonal complements–Ortho normal sets–The conjugate space H^*-The adjoint of an operator–self-adjoint operators-Normal and unitary operators – Projections.

UNIT-III :Finite-Dimensional Spectral Theory

Matrices – Determinants and the spectrum of an operator –The spectral theorem.

UNIT-IV: General Preliminaries on Banach Algebras

The definition and some examples – Regular and singular elements – Topological divisors of zero – The spectrum – The formula for the spectral radius– The radical and semi-simplicity.

UNIT-V: The Structure of Commutative Banach Algebras

The Gelfand mapping – Application of the formula $r(x) = \lim \|x^n\|^{1/n}$– Involutions in Banach algebras-The Gelfand-Neumark theorem.

TEXT BOOK:

1. **G.F. Simmons**, Introduction to Topology and Modern Analysis, McGraw Hill Education (India)Private Limited, New Delhi, 1963.

UNIT	Chapter(s)	Sections
I	9	46 to 51
II	10	52 to 59
III	11	60 to 62
IV	12	64 to 69
V	13	70 to 73

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. W. Rudin, Functional Analysis, McGraw Hill Education (India) Private Limited, New Delhi, 1973.
2. B.V. Limaye, Functional Analysis, New Age International, 1996.
3. C. Goffman and G. Pedrick, First course in Functional Analysis, Prentice Hall of India, NewDelhi, 1987.
4. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, New York, 1978.
5. M. Thamban Nair, Functional Analysis, A First course, Prentice Hall of India, New Delhi, 2002.

WEBSITE AND E-LEARNING SOURCE

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, http://en.wikiepedia.org

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Understand the Banach spaces and Transformations on Banach Spaces.	K2, K3, K4
CLO 2	Prove Hahn Banach theorem and open mapping theorem.	K3, K4, K5
CLO 3	Describe operators and fundamental theorems.	K3, K4, K5
CLO 4	Validate orthogonal and orthonormal sets.	K3, K4
CLO 5	Analyze and establish the regular and singular elements.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	3	1	3	2	3	3	3	2	1
CLO 2	2	1	3	1	3	3	3	2	1
CLO 3	3	2	3	1	3	3	3	2	1
CLO 4	1	2	3	2	3	3	3	2	1
CLO 5	3	1	3	2	3	3	3	2	1

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23CDOEMATC09	PARTIAL DIFFERENTIAL EQUATIONS	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to classify the second order partial differential equations and to study Cauchy problem, method of separation of variables, boundary value problems.

UNIT-I: Mathematical Models and Classification of second order equation

Classical equations-Vibrating string – Vibrating membrane – waves in elastic medium – Conduction of heat in solids – Gravitational potential – Second order equations in two independent variables – canonical forms – equations with constant coefficients – general solution.

UNIT-II: Cauchy Problem

The Cauchy problem – Cauchy-Kowalewsky theorem – Homogeneous wave equation – Initial Boundary value problem- Non-homogeneous boundary conditions – Finite string with fixed ends – Non-homogeneous wave equation – Riemann method – Goursat problem – spherical wave equation – cylindrical wave equation.

UNIT-III : Method of separation of variables: Separation of variable- Vibrating string problem – Existence and uniqueness of solution of vibrating string problem - Heat conduction problem – Existence and uniqueness of solution of heat conduction problem – Laplace and beam equations.

UNIT-IV: Boundary Value Problems

Boundary value problems – Maximum and minimum principles – Uniqueness and continuity theorem – Dirichlet Problem for a circle , a circular annulus, a rectangle – Dirichlet problem involving Poisson equation – Neumann problem for a circle and a rectangle.

UNIT-V: Green's Function

The Delta function – Green's function – Method of Green's function – Dirichlet Problem for the Laplace and Helmholtz operators – Method of images and eigen functions – Higher dimensional problem – Neumann Problem.

TEXT BOOK:

1. **Tyn Myint-U** and **Lokenath Debnath**, *Partial Differential Equations for Scientists and Engineers* (Third Edition), North Hollan, New York, 1987.

UNIT	Chapter(s)	Sections
I	2	2.1 to 2.6
	3	3.1 to 3.4 (Omit 3.5)
II	4	4.1 TO 4.11
III	6	6.1 to 6.6 (Omit 6.7)
IV	8	8.1 to 8.9
V	10	10.1 to 10.9

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. M.M. Smirnov, *Second Order partial Differential Equations*, Leningrad, 1964.
2. I.N. Sneddon, *Elements of Partial Differential Equations,* McGraw Hill, New Delhi, 1983.
3. R. Dennemeyer, *Introduction to Partial Differential Equations and Boundary Value Problems,* McGraw Hill, New York, 1968.
4. M.D. Raisinghania, *Advanced Differential Equations,* S. Chand& Company Ltd., New Delhi, 2001.
5. S, Sankar Rao, *Partial Differential Equations*, 2nd Edition, Prentice Hall of India, New Delhi. 2004

WEBSITE AND E-LEARNING SOURCE

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	To understand and classify second order equations and find general solutions	K2, K3, K4
CLO 2	To analyze and solve wave equations in different polar coordinates	K2, K3, K4
CLO 3	To solve Vibrating string problem, Heat conduction problem, to identify and solve Laplace and beam equations	K2, K3, K4
CLO 4	To apply maximum and minimum principle's and solve Dirichlet, Neumann problems for various boundary conditions	K3, K4, K5
CLO 5	To apply Green's function and solve Dirichlet, Laplace problems, to apply Helmholtz operation and to solve Higher dimensional problem	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	3	1	3	2	3	3	3	2	1
CLO 2	2	1	3	1	3	3	3	2	1
CLO 3	3	2	3	1	3	3	3	2	1
CLO 4	1	2	3	2	3	3	3	2	1
CLO 5	3	1	2	3	3	3	3	2	1

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23CDOEMATC10	MEASURE THEORY AND INTEGRATION	L	T	P	C
		4	1	0	5

OBJECTIVES: The objectives of this course are

- To gain understanding of the abstract measure theory and main properties of the Lebesgue integral.
- To make the students acquire basic knowledge of measure theory needed to understand probability theory, statistics and functional analysis.
- To get ability to differentiate and integrate the Lebesgue integral.

UNIT I: Lebesgue Measure

Introduction – Outer measure - Measurable sets and Lebesgue measure – Measurable functions - Littlewood's three principles.

UNIT II: Lebesgue integral

The Riemann integral - Lebesgue integral of bounded functions over a set of finite measure - The integral of a nonnegative function - The general Lebesgue integral.

UNIT III: Differentiation and Integration

Differentiation of monotone functions - Functions of bounded variation - Differentiation of an integral - Absolute continuity.

UNIT IV: General Measure and Integration

Measure spaces – Measurable functions – Integration - General convergence theorems – Signed Measure – The Radon - Nikodym theorem.

UNIT V: Measure and Outer Measure

Outer measure and measurability – The Extension theorem – Product measures.

TEXT BOOK:

H.L. Royden, "Real Analysis", 3rd Edition, Macmillan Publishing Company, New York, 1988.

UNIT	Chapter	Sections
I	3	**1 – 3, 5 & 6**
II	4	**1 – 4**
III	5	**1 – 4**
IV	11	**1 – 3, 5, 6**
V	12	**1, 2, 4**

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Robert G. Bartle, The Elements of Integration and Lebesgue Measure, 2nd Edition, Wiley-Blackwell, 1995.
2. G. De Barra, Measure Theory and Integration, 2nd Edition, Horwood, Publishing, 2003.
3. W. Rudin, Real and Complex Analysis, 3rd Edition, Tata McGraw-Hill Education, New Delhi, 2013.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Know the meaning of outer and inner measures with their basic properties and know the meaning with examples of algebras, sigma-algebras, measurable sets, measurable space and measure space..	K1, K2
CLO 2	Understand the concept of Lebesgue integration both on the general measure space and the real line and know the basic theory of integration and convergence, with the application in evaluating integrals..	K2, K3
CLO 3	Develop the concepts of Differentiation of monotone functions, Functions of bounded variation, Differentiation of an integral, Absolute continuity	K4, K6
CLO 4	Study the Radon-Nikodym theorem and its applications. Understand the concepts of Convergence in Measure and Lebesgue Integrability	K4, K3
CLO 5	Demonstrate understanding of the statements of the main results on integration on product spaces and an ability to apply these in examples.	K2, K4

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	2	1	2	2	3	1	1	2
CLO 2	1	2	2	2	2	3	1	2	2
CLO 3	1	2	2	2	2	3	1	2	2
CLO 4	1	1	2	2	2	3	1	2	2
CLO 5	1	1	2	2	3	3	1	2	3

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23CDOEMATC11	DIFFERENTIAL GEOMETRY	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to introduce space curves and their intrinsic properties of a surface and geodesics. Further the non-intrinsic properties of surface and the differential geometry of surfaces are explored.

UNIT-I: Space curves

Definition of a space curve – Arc length – tangent – normal and binormal – curvature and torsion – contact between curves and surfaces- tangent surface- involutes and evolutes- Intrinsic equations – Fundamental Existence Theorem for space curves- Helies.

UNIT-II: Intrinsic properties of a surface

Definition of a surface – curves on a surface – Surface of revolution – Helicoids – Metric- Direction coefficients – families of curves- Isometric correspondence- Intrinsic properties.

UNIT-III: Geodesics

Geodesics – Canonical geodesic equations – Normal property of geodesics- Existence Theorems – Geodesic parallels – Geodesics curvature- Gauss- Bonnet Theorem – Gaussian curvature- surface of constant curvature.

UNIT-IV: Non Intrinsic properties of a surface

The second fundamental form- Principle curvature – Lines of curvature – Developable - Developable associated with space curves and with curves on surface - Minimal surfaces – Ruled surfaces.

UNIT-V: Differential Geometry of Surfaces

Compact surfaces whose points are umblics- Hilbert's lemma – Compact surface of constant curvature – Complete surface and their characterization – Hilbert's Theorem – Conjugate points on geodesics.

TEXT BOOK:

1. **T.J. Willmore**, *An Introduction to Differential Geometry,* Oxford University Press,(17th Impression) New Delhi 2002. (Indian Print)

UNIT	Chapter(s)	Sections
I	1	1 to 9
II	2	1 to 59
III	2	10 to 18
IV	3	1 to 8
V	4	1 to 8 (omit 9-15)

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Struik, D.T. *Lectures on Classical Differential Geometry*, Addison – Wesley, Mass. 1950.
2. Kobayashi. S. and Nomizu. K. *Foundations of Differential Geometry,* Inter science Publishers, 1963.

3. Wilhelm Klingenberg: *A course in Differential Geometry*, Graduate Texts in Mathematics, Springer-Verlag, 1978.
4. J.A. Thorpe *Elementary topics in Differential Geometry*, Under- graduate Texts in Mathematics, Springer – Verlag, 1979.

WEBSITE AND E-LEARNING SOURCE

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.physicsforum.com

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Explain space curves, Curves between surfaces, metrics on a surface, fundamental form of a surface and Geodesics.	K2, K3, K4
CLO 2	Evaluate these concepts with related examples.	K2, K3, K4
CLO 3	Compose problems on geodesics.	K3, K4, K5
CLO 4	Recognize applicability of developable.	K3, K4, K5
CLO 5	Construct and analyze the problems on curvature and minimal surfaces.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	3	1	3	2	3	3	3	2	1
CLO 2	2	1	3	1	3	3	3	2	1
CLO 3	3	2	3	1	3	3	3	2	1
CLO 4	1	2	3	2	3	3	3	2	1
CLO 5	3	1	2	3	3	3	3	2	1

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23CDOEMATC12	PROBABILITY THEORY	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to introduce axiomatic approach to probability theory and to study some statistical characteristics, discrete and continuous distribution functions and their properties, characteristic function and basic limit theorems of probability.

UNIT-I: Random Events and Random Variables

Random events – Probability axioms – Combinatorial formulae – conditional probability – Bayes Theorem – Independent events – Random Variables – Distribution Function – Joint Distribution – Marginal Distribution – Conditional Distribution – Independent random variables – Functions of random variables.

UNIT-II: Parameters of the Distribution

Expectation- Moments – The Chebyshev Inequality – Absolute moments – Order parameters – Moments of random vectors – Regression of the first and second types.

UNIT-III: Characteristic functions

Properties of characteristic functions – Characteristic functions and moments – semi0invariants – characteristic function of the sum of the independent random variables – Determination of distribution function by the Characteristic function – Characteristic function of multidimensional random vectors – Probability generating functions.

UNIT-IV: Some Probability distributions

One point , two point , Binomial – Polya – Hypergeometric – Poisson (discrete) distributions – Uniform – normal gamma – Beta – Cauchy and Laplace (continuous) distributions.

UNIT-V: Limit Theorems

Stochastic convergence – Bernaulli law of large numbers – Convergence of sequence of distribution functions – Levy-Cramer Theorems – de Moivre-Laplace Theorem – Poisson, Chebyshev, Khintchine Weak law of large numbers – Lindberg Theorem – LapunovTheroem – Borel-Cantelli Lemma - Kolmogorov Inequality and Kolmogorov Strong Law of large numbers.

TEXT BOOK:

1. **M. Fisz**, *Probability Theory and Mathematical Statistics,* John Wiley and Sons, New York, 1963.

UNIT	Chapter(s)	Sections
I	1	1.1 to 1.7
	2	2.1 to 2.9
II	3	3.1 to 3.8
III	4	4.1 to 4.7
IV	5	5.1 to 5.10 (Omit Section 5.11)
V	6	6.1 to 6.4, 6.6 to 6.9 , 6.11 and 6.12. (Omit Sections 6.5, 6.10,6.13 to 6.15)

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. R.B. Ash, *Real Analysis and Probability*, Academic Press, New York, 1972
2. K.L. Chung, *A course in Probability*, Academic Press, New York, 1974.
4. R. Durrett, *Probability: Theory and Examples*, (2nd Edition) Duxbury Press, New York, 1996.
5. V.K. Rohatgi, *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern Ltd., New Delhi, 1988(3rd Print).
6. S.I. Resnick, *A Probability Path*, Birhauser, Berlin,1999.
7. B.R.Bhat, *Modern Probability Theory* (3rd Edition), New Age International (P)Ltd, New Delhi, 1999

WEBSITE AND E-LEARNING SOURCE

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, http://www.probability.net

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Calculate the expectation and moments of random variables	K1, K2, K3
CLO 2	Identify the applications of various moment inequalities	K2, K3, K4
CLO 3	Find the expressions for the characteristic function of a random variable and verify its properties	K2, K3, K4
CLO 4	Describe the assumptions for each of the discrete and continuous probability distributions	K2, K3, K4
CLO 5	Apply the various laws of large numbers to sequence of random variables	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	3	1	3	2	3	3	3	2	1
CLO 2	2	1	3	1	3	3	3	2	1
CLO 3	3	2	3	1	3	3	3	2	1
CLO 4	1	2	3	2	3	3	3	2	1
CLO 5	3	1	2	3	3	3	3	2	1

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23CDOEMATD01	PROJECT WITH VIVA VOCE	L	T	P	C
		4	0	0	5

Project work, which is compulsory, carries 100 marks. A student must select a topic for project work in the first week of the Fourth semester and submit the project report (dissertation) at the end of the Fourth semester. Project Viva will be conducted during IV Semester examinations.

LEARNING OBJECTIVE:

The primary objective of the project is to provide an opportunity to our students to make an intensive study of practical aspects of international business activities to sharpen their conceptual, analytical and problem solving skills.

Project Period

The students are required to do the project during their fourth semester and to submit on or before 15th April Every year.

Project Guide

The institution may assign the students to each staff known as project guide to act as a facilitator and mentor .The project guide may

1. Help the student identify a project that can be completed within the duration.
2. Provide assistance in data collection.
3. Review periodically the progress of the student
4. Offer necessary help in the preparation of project report

Evaluation:

The project guide and the external shall evaluate the performance of the student.

Format for project report

(a) Title page

(b) Bonafide Certificate

(c) Acknowledgement

(d) Table of contents

Bibliography

Books and articles can be arranged in chronological order.

SCHEDULE

December - Finding the topic
January - First Review
Feb - Second Review
Mar - Submission of Project – Model Viva-voce.

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ELECTIVE COURSES -SYLLABUS

23CDOEMATE01	NUMBER THEORY AND GRYPTOGRAPHY	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is to give elementary ideas from number theory which will have applications in cryptology.

UNIT I: Elementary Number theory
Time estimates for doing arithmetic – divisibility and the Euclidean algorithm

UNIT II: Elementary Number theory
Congruences – Some applications to factoring

UNIT III: Finite Fields and Quadratic Residues

Finite Fields - Quadratic residues and reciprocity

UNIT IV: Cryptography
Some simple cryptosystems – Enciphering matrices.

UNIT V: Public Key Cryptography
Public key cryptography – RSA

TEXT BOOK:

1. **Neal Koblit**, A course in Number Theory and Cryptography, Springer – Verlag, New York, 2nd edition, 2002.

UNIT	Chapter(s)	Sections
I	1	1 and 2
II	1	3 and 4
III	2	1 and 2
IV	3	1 and 2
V	4	1 and 2

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. I. Niven and H. S. Zuckermann, An Introduction to Theory of Numbers (Edition 3), Wiley Eastern Ltd, New Delhi 1976
2. D. M. Burton, Elementary Number Theory, Brown Publishers, Iowa, 1989
3. K. Ireland and M. Rosen, A classic Introduction to Modern Number Theory, Springer – Verlag, 1972
4. N. Koblit, Algebraic Aspects of Cryptography, Springer-Verlag, 1998.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge Level
CLO 1	Recall the definitions and results from elementary number theory.	K1, K2
CLO 2	Solve the congrunces and estimating the number of bit operations.	K1, K2, K3
CLO 3	Estimate the multiplicative order of non-zero elements of a finite field. Find the number of irreducible polynomials over finite field of degree d. Find how many n^{th} roots of unity are there in $F_{q.}$	K2, K3, K4
CLO 4	Invent a crypto system is to label all possible plaintext message units and all possible ciphertext message units. Solve the systems of simultaneous congruence's. Find the deciphering matrix and read the message.	K2, K3, K4
CLO 5	Understand the concepts of enciphering and deciphering transformations. Describe how RSA works.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO1	2	1	1	1	2	3	1	2	3
CLO2	1	1	1	2	2	3	1	2	3
CLO3	1	2	2	2	3	3	1	2	3
CLO4	1	1	1	2	3	3	1	2	3
CLO5	1	1	1	2	3	3	1	2	3

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23CDOEMATE02	GRAPTH THEORY AND APPLICATIONS	L	T	P	C
		4	1	0	3

OBJECTIVES:

The objective of the course is to introduce students with the fundamental concepts in graph theory, with a sense to know some of the new developments and its modern applications. They will be able to use these concepts/techniques in subsequent courses in the design and analysis of algorithms, software engineering and computer systems.

UNIT I: Graphs and Digraphs

Basic concepts – subgraphs – degrees of vertices – paths and connectedness – automorphism of a simple graphs – line graphs –operations on graphs –applications to social psychology - basic concepts in digraphs – tournaments.

UNIT II: Connectivity and trees

Vertex cuts and edge cuts – connectivity and edge connectivity – Cyclical edge connectivity of a graph - Definition, Characterization and simple properties of trees – centers and centraoids - counting spanning trees – cayley's formula – Applications: Connector Problem – Kruskal's Algorithm.

UNIT III: Independent sets, Matchings and Cycles

Independents sets and coverings (both vertex & edge) – matchings and factors – matchings in bipartite graphs – Eularian graphs and Hamiltonian graphs – Introduction – Eulerian Graphs – Hamiltonian Graphs – 2-Factorable Graphs.

UNIT IV:Graph colorings

Vertex colorings – applications of graph coloring - critical graphs – Brooks Theorem – other coloring parameters – b-colorings; Edge colorings – the time table problem – Vizings theorem – Kirkman's Schoolgirl Problem – chromatic polynomials.

UNIT V: Planar Graphs

Planar and non planar graphs – Euler formula and its consequences – K_5 and $K_{3,3}$ are non planar graphs – dual of a plane graph – The four color theorem and the Heawood five color theorem – Hamiltonian plane graphs – Tait coloring.

TEXT BOOK:

R. Balakrishnan and **K. Ranganathan**, "*A Textbook of Graph Theory*" (2nd edition),

Springer, New York, 2012.

UNIT	Chapter	Sections
I	1 & 2	**1.1 – 1.8, 1.11, 2.1 – 2.3**
II	3 & 4	**3.1 - 3.3, 3.5, 4.1 - 4.5, 4.7.1 – 4.7.2**
III	5	**5.1 – 5.5, 6.1 - 6.3, 6.6**
IV	7	**7.1 - 7.3, 7.6, 7.8, 7.9**
V	8	**8.1 – 8.6, 8.8, 8.9**

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. J. Clark and D.A. Holton, A First look at Graph Theory, Allied Publishers, New Delhi, 1995.
2. R.J. Wilson and J.J. Watkins, Graphs: An Introductory Approach, John Wiley and Sons, New York, 1989.
3. S.A. Choudum, A First Course in Graph Theory, MacMillan India Ltd. 1987.
4. J.A. Bondy and U.S.R. Murty, Graph Theory and Applications, Macmillan, London, 1976.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Understand the basic concepts on various types of graphs, trees/cycles/matchings/colorings, directed graphs and able to present a graph as a model to solve many real life problems.	K1, K2, K3
CLO 2	Understand the properties of bipartite graphs, Hamiltonian/Eularian graphs, maximum/maximal matchings, bounds for chromatic numbers, planarity and able to find a minimal spanning tree for a given weighted graph.	K1, K2, K3
CLO 3	Understand necessary/sufficient conditions for bipartite graphs, connectedness, and relation with minimum/maximum degrees, connection between independent / matchings, Eulerian and Hamiltonian graphs which makes the model for optimal communication systems.	K2, K3, K4
CLO 4	Apply Known properties to solve simple problems to enhance problem solving skill.	K3, K4
CLO 5	Solve critical problems by applying more than one concepts / properties which creates interest enhance confidence on basic research skill	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	1	2	3	3	3	1	2	2
CLO 2	1	2	2	3	2	3	1	1	2
CLO 3	1	2	3	3	2	2	1	2	2
CLO 4	1	1	2	3	2	2	2	1	2
CLO 5	2	2	2	1	3	3	2	2	2

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23CDOEMATE03	DISCRETE MATHEMATICS	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is to understand the basic ideas of logic, proof methods and strategy, the growth of functions, counting techniques, pigeonhole principle, recurrence relations, solving recurrences using generating functions, Boolean functions, apply Boolean algebra to circuits and gatting networks, use finite state-machines to model computer operations.

UNITI: The Foundation of Logic

Logic – Propositional equivalence – Predicates and quantifiers – Proof Methods and Strategy – The growth of functions.

UNITII: Counting

Basics of counting – The pigeonhole principle – permutations and combinations –Generalized permutations and combinations – Generating permutations and combinations.

UNITIII: Advanced counting techniques

Recurrence relation – Solving recurrence relations – Generating functions.

UNITIV: Boolean Algebra

Boolean functions – Representing Boolean functions – Logic Gates – Minimization of circuits.

UNITV: Modeling Computations

Finite – state machines with output, finite – State machines with no output – Turing machines

TEXTBOOK:

1. **Kenneth H. Rosen,** "Discrete Mathematics and its Applications"**,** 7th Edition, WCB/ McGraw Hill Publications, New Delhi, 2011.

UNIT	Chapter(s)	Sections
I	1&3	1.1–1.3,1.8, 3.2
II	5	5.1–5.6
III	6	6.1,6.2,6.4
IV	10	10.1–10.4
V	12	12.2,12.3,12.5

BOOKS FOR SUPPLEMENTAR YREADING AND REFERENCES:

1. Edward A. Bender and S. Gill Williamson, *"A Short Course in Discrete Mathematics",* Dover Publications, 2006.
2. M.O. Albertson and J.P. Hutchinson, *"Discrete Mathematics with Algorithms*", John Wiley & Sons, 2008.
3. Rajendra Akerkar and Rupali Akarkar, *"Discrete Mathematics*", Pearson Education Pvt. Ltd, Singapore,2004.
4. J.P. Trembley and R. Manohar, *"Discrete Mathematical Structures*", Tata McGraw Hill, New Delhi,1997.
5. Martin Aigner, *"A Course in Enumeration"*, Springer-Verlag, Heidelberg, 2007.
6. J.H. Van Lint and R.M. Wilson, *"A Course in Combinatorics"*, 2nd Edition, Cambridge University Press, Cambridge, 2001.

COURSE LEARNING OUTCOMES: After the successful completion of the course students will be able to

CLO	Statements	Knowledge level
CLO 1	Express a logic sentence interms of predicates, quantifiers and logical connectives.	K1, K2
CLO 2	Apply the rules of inference and methods of proof including direct and indirect proof forms, proof by contradiction and mathematical induction.	K2, K3
CLO 3	Solve discrete mathematics problems that involve permutations and combinatios of set, fundamental enumeration principles.	K2, K3, K4
CLO 4	Evaluate Boolean functions and simplify Boolean expressions using the properties of Boolean algebra.	K3, K4, K5
CLO 5	Simplify Boolean function using circuits with different type of gates.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	2	2	2	2	3	1	2	2
CLO 2	1	1	2	2	3	3	1	1	2
CLO 3	1	1	1	2	2	2	1	1	2
CLO 4	1	2	2	2	3	3	2	2	2
CLO 5	2	2	2	2	3	3	2	2	3

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23CDOEMATE04	MATHEMATICAL PROGRAMMING	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is

- the understanding mathematical structure and properties of the fundamental problem (e.g., linear, non-linear and integer programming, dynamic programming).
- the use of Mathematical Problem algorithms for problem solving but also the design of their variants for special problem cases.
- the formulation and solving of problems arising from the practical, real-life settings.

UNIT I: Integer Linear Programming

Types of integer linear programming problems – concepts of cutting plane – Gomary's all integer cutting plane method – Gomary's mixed integer cutting plane method – Branch and Bound method – Zero-one integer programming.

Dynamic programming: characteristic of dynamic programming problem – developing optimal decision policy – Dynamic programming under certainty – DP approach to solve LPP.

UNIT II: Classical Optimization Methods

Unconstrained optimization – constrained multi-variable optimization with equality constraints – constrained multi-variable optimization with inequality constraints.

Non-linear programming method: Examples of NLPP – General NLPP – Graphical solution – Quadratic programming – Wolfe's modified simplex methods – Beale's method.

UNIT III: Theory of simplex method

Canonical and standard form of LP-slack and surplus variables – Reduction of any feasible to a basic feasible solution – alternative optimal solution – unbounded solution – optimality conditions – some complications and their resolution – Degeneracy and its resolution.

UNIT IV: Revised Simplex Method

Standard forms for revised simplex Method-Computational procedure for Standard form I - comparison of simplex method and revised simplex Method.

BOUNDED VARIABLES LPPROBLEM: The simplex algorithm

UNIT V: Parametric Linear Programming

Variation in the coefficients c_j, Variations in the Right hand side, b_i.

Goal Programming: Difference between LP and GP approach - Concept of Goal Programming - Goal Programming Model formulation - Graphical Solution Method of Goal Programming –Modified Simplex method of Goal Programming.

TEXT BOOK:

J.K. Sharma, *Operations Research*, Theory and Applications, Third Edition (2007) Macmillan India Ltd.

UNIT	Chapter	Sections
I	7 20	7.1 – 7.7 20.1 – 20.5
II	23 24	23.1 – 23.4 24.1 – 24.4
III	25	25.1 – 25.4, 25.6 – 25.9
IV	26 28	26.1 – 26.4 28.1, 28.2
V	29 8	29.1 – 29.3 8.4, 8.6 and 8.7

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Hamdy A. Taha, *Operations Research,* (seventh edition) Prentice-Hall of India Private Limited, NewDelhi,1997.
2. F.S. Hillier & J. Lieberman *Introduction to Operation Research* (7thEdition) Tata-McGraw Hill company, New Delhi, 2001.
3. Beightler. C, D. Phillips, B. Wilde, *Foundations of Optimization* (2nd Edition) Prentice Hall Pvt Ltd., New York, 1979.
4. S.S. Rao - *Optimization Theory and Applications*, Wiley Eastern Ltd., NewDelhi.1990.

COURSE LEARNING OUTCOMES: After the successful completion of the course students will be able to

CLO	Statements	Knowledge level
CLO 1	Formulate the linear programming problems.	K1, K2, K3
CLO 2	Solve various constrained and unconstrained problems in single variable as well as multivariable	K1, K2, K3
CLO 3	Solve optimization problem using simplex method.	K1, K2, K3
CLO 4	Apply the teaching of Revised simplex method to solve LPP.	K2, K3, K4
CLO 5	Apply modified simplex method to goal programming problems. Analyze the difference between LP and G approach.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	1	3	3	2	2	1	1	2
CLO 2	1	1	2	3	2	2	1	1	2
CLO 3	1	1	2	2	2	2	1	1	1
CLO 4	1	2	3	3	2	2	1	1	2
CLO 5	1	2	2	3	2	3	1	2	2

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23CDOEMATE05	MATHEMATICAL MODELING	L	T	P	C
		4	1	0	3

OBJECTIVE: This course aims to

- Provide rigorous instruction in fundamental mathematical concepts and skills presented in the context of real-world applications.
- Gain a working knowledge of core techniques behind mathematical modelling and develop a basic ability to quantify certain phenomena associated with the physical sciences

Represent real-world systems in a mathematical framework.

Unit I: Mathematical Modelling through Ordinary Differential Equations of First order

Linear Growth and Decay Models – Non-Linear Growth and Decay Models – Compartment Models – Dynamics problems – Simple problems.

Unit II: Mathematical Modelling through Systems of Ordinary Differential Equations of First Order

Population Dynamics – Epidemics – Compartment Models – Economics – Medicine, Arms Race, Battles and International Trade – – Simple problems.

Unit III: Mathematical Modelling through Ordinary Differential Equations of Second Order

Planetary Motions – Circular Motion and Motion of Satellites – Mathematical Modelling through Linear Differential Equations of Second Order – Miscellaneous Mathematical Models– Simple problems...

Unit IV: Mathematical Modelling through Difference Equations

Simple Models – Basic Theory of Linear Difference Equations with Constant Coefficients – Economics and Finance – Population Dynamics and Genetics – Probability Theory– Simple problems...

Unit V: Mathematical Modelling through Graphs

Solutions that can be Modelled through Graphs – Mathematical Modelling in Terms of Directed Graphs, Signed Graphs, Weighted Digraphs – Simple problems.

TEXT BOOK:

J.N. Kapur, Mathematical Modelling, Wiley Eastern Limited, New Delhi, 4th Reprint, May 1994.

UNIT	Chapter(s)	Sections	Pages
I	2	2.1 – 2.6	30 – 48
II	3	3.1 – 3.6	53 – 72
III	4	4.1 – 4.4	76 – 95
IV	5	5.1 – 5.6	96 – 121
V	7	7.1 – 7.4	151 – 170

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. M. Braun, C.S. Coleman and D. A. Drew, *Differential Equation Models*, 1994.
2. A.C. Fowler, *Mathematical Models in Applied Sciences*, Cambridge University Press, 1997.
3. Walter J. Meyer, *Concepts of Mathematical Modeling*.
4. Edward A. Bender, Introduction to Mathematical Modelling, Dover Publications, 1st ed., 2000.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Create mathematical models of empirical or theoretical phenomena in domains such as the physical, natural, or social science.	K1, K2, K3
CLO 2	Draw inferences from models using mathematical techniques including problem solving, quantitative reasoning, and exploration using multiple representations such as equations, tables, and graphs.	K2, K3, K4
CLO 3	Design difference equation based mathematical model and resolve the problem of field population, pollution, Econometrics, and cooling system etc.	K2, K3, K4
CLO 4	Apply the difference equation based mathematical model to resolve the problems related to Epidemic model, compartment model, inflection model etc.	K2, K3, K4
CLO 5	Establish the connection of applicability of mathematical models to resolve the real problems arise in the fields of science and engineering.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	2	2	1	2	2	1	1	3
CLO 2	1	2	2	1	2	3	1	2	3
CLO 3	2	3	2	3	3	3	1	1	3
CLO 4	1	2	2	2	3	2	1	2	3
CLO 5	1	2	2	2	3	3	1	2	3

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23CDOEMATE06	MATHEMATICAL STATISTICS	L	T	P	C
		4	1	0	3

OBJECTIVE: This course aims to teach the students about Special distributions and Random Process. To prepare students for lifelong learning and successful careers using their mathematical statistics skills.

UNIT-I: Characteristic function

properties of characteristic functions-characteristic function and moments - semi invariants - the characteristic functions of sum of independent random variables - determination of distribution function of the characteristic function - Probability generating function.

UNIT-II: Some Probability Distributions

One-point and two-point distributions – The Bernoulli scheme: Binomial distribution - The Poisson scheme: The generalized binomial distribution - The Pólya and hyper-geometric distributions - The Poisson distribution - The uniform distribution.

UNIT –III: Some Probability Distributions

The normal distribution - The gamma distribution - The beta distribution - The Cauchy and Laplace distributions - The multinomial distribution - Compound distributions.

UNIT – IV: Limit Theorems

Stochastic Convergence – Bernoulli's law of large numbers – the convergence of a sequence of distribution functions – The Lévy-Cramér theorem - The De Moivre-Laplace theorem – The Lindeberg-Lévy theorem – The Lapunov theorem.

UNIT – V: Markov Chains

Homogeneous Markov chains – The transition matrix – The Ergodic theorem – Random variables forming a homogeneous Markov Chain.

Stochastic Processes:

The Wiener Process – The Stationary Processes.

TEXT BOOK:

1. **M. Fisz**, *Probability Theory and Mathematical Statistics,* John Wiley and sons, New Your, 3RD Edition, 1963.

UNIT	Chapter	Section
I	4	4.1 – 4.7
II	5	5.1 – 5.6
III	5	5.7 – 5.10, 5.12, 5.13
IV	6	6.2 – 6.4, 6.6 – 6.9
V	7	7.1 – 7.5

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. T. Veerarajan , Fundamentals of Mathematical Statistics, Yesdee Publishing, 2017
2. P.R. Vittal, "Mathematical Statistics", Margham Publications , 2002.
3. T. Veerarajan, Probability, Statistics and Random Processes, Mc Graw Hill Education (India) Private Limited, Third Edition, 2015.
4. R.S.N. Pillai and V. Bagavathi, Statistics, S.Chand & CO, 2010.
5. Singaravelu.A, S. Sivasubramanian, Probability & Random Processes , Meenakshi Agency 2008,
6. DN Elhance, Veena Elhance and BM Aggarwal, Fundamentals of Statistics, Kitab Mahal.
7. S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, Edition 2008.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Study characteristic function and convergence.	K1, K2
CLO 2	Analyse the various measures of discrete distribution.	K1, K2, K3
CLO 3	Determine the various measures of continuous distribution	K2, K3, K4
CLO 4	Classify the types of Random process.	K2, K3, K4
CLO 5	Apply the concept of Random process to solve daily life problems.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	1	2	3	3	3	1	1	2
CLO 2	1	2	2	2	3	3	1	1	2
CLO 3	1	1	2	2	3	3	1	1	2
CLO 4	2	1	2	2	3	3	1	1	2
CLO 5	1	2	2	2	2	3	1	2	2

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23CDOEMATE07	DIFFERENCE EQUATIONS	L	T	P	C
		4	1	0	3

OBJECTIVE: Difference equations usually describe the evolution of certain phenomena over the course of time. The aim of studying this course is

- To introduce the difference calculus.
- To study linear difference equations and to know how to solve them.
- To know the stability theory for homogeneous linear system of difference equations.
- To study the asymptotic behavior of solutions of homogeneous linear difference equations.

UNIT I: Difference Calculus

Difference operator - Summation – Generating functions and approximate summation.

UNIT II: Linear Difference Equations

First order equations - General results for linear equations - Solving linear equations.

UNIT III: Linear Difference Equations

Equations with variable coefficients – The z -transform.

UNIT IV: Stability Theory

Initial value problems for linear systems – Stability of linear systems.

UNIT V: Asymptotic Methods

Introduction – Asymptotic analysis of sums – Linear equations.

TEXT BOOK:

W.G. Kelley and **A.C. Peterson,** *"Difference Equations"*, 2nd Edition, Academic Press, New York, 2001.

UNIT	Chapter	Sections
I	2	2.1 – 2.3
II	3	3.1 – 3.3
III	3	3.5, 3.7
IV	4	4.1, 4.2
V	5	5.1 – 5.3

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. R.P. Agarwal, *"Difference Equations and Inequalities"*, 2nd Edition, Marcel Dekker, New York, 2000.
2. S.N. Elaydi, "*An Introduction to Difference Equations*", 3rd Edition, Springer, India, 2008.
3. R. E. Mickens, *"Difference Equations"*, 3rd Edition, CRC Press, 2015.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Define a difference operator and to state the properties of difference operator	K1, K2, K3
CLO 2	Explain the computation of sums, the concept of generating function and the important Euler summation formula	K1, K2, K3
CLO 3	Solve linear difference equations by applying different methods, namely, annihilator method, z-transform method, etc.	K1, K2, K3
CLO 4	Examine the stability of linear system of difference equations using eigen value criteria	K2, K3, K4
CLO 5	Analyze the asymptotic behavior of solutions to linear difference equations by the theorems of Poincare and Perron	K2, K3, K4

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	2	2	2	3	3	1	2	3
CLO 2	1	1	2	2	2	3	1	2	2
CLO 3	1	1	2	2	2	3	1	1	2
CLO 4	1	1	2	2	2	3	1	1	2
CLO 5	1	2	2	2	2	3	1	2	2

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23CDOEMATE08	MECHANICS	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is to understand the Lagrangian and Hamiltonian equations for dynamical systems.

UNIT I: Mechanical Systems

The Mechanical system – Generalized coordinates – Constraints – Virtual work – Energy and Momentum.

UNIT II : Lagrange's Equations

Derivation of Lagrange's Equations – Examples – Integrals of the motion.

UNIT III: Hamilton's Equations

Hamilton's Principle – Hamilton's Equations – other variational principles.

UNIT IV: Hamilton – Jacobi Theory

Hamilton Principle Function – Hamilton-Jacobi Equation – Separability.

UNIT V: Canonical Transformation

Differential forms and Generating Functions – Special Transformations – Lagrange and Poisson Brackets.

TEXT BOOK:

D.T. Greenwood, *"Classical Dynamics*", Prentice Hall of India, New Delhi, 1985.

UNIT	Chapter	Sections
I	1	1.1 to 1.5
II	2	2.1 to 2.3
III	4	4.1 to 4.3
IV	5	5.1 to 5.3
V	6	6.1 to 6.3

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **H. Goldstein**, *"Classical Mechanics",* 2nd Edition, Narosa Publishing House, New Delhi.
2. **R.D. Gregory**, *"Classical Mechanics"*, Cambridge University Press, 2006
3. **J.L.Synge** and **B.A.Griffth**, *"Principles of Mechanics*", 3rd Edition, McGraw Hill Book Co., New York, 1970.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge Level
CLO 1	Define the mechanical system of generalized coordinates, virtual work , energy and momentum	K1, K2
CLO 2	Explain the Derivation of Lagrange's equation and the concept of the Integrals of the motion	K1, K2, K3
CLO 3	Classify the Hamilton's equations and Modified Hamilton's principle	K2, K3
CLO 4	Determine the Hamilton form of the equation of motion and find the solutions of integral of equation by the Hamilton's Jacobi theory	K2, K3, K4
CLO 5	Analyze the Principle function of the generating function for canonical transformation, namely, Special Transformations, Lagrange and Poisson Brackets.	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	2	2	3	3	3	1	1	2
CLO 2	1	2	2	2	3	3	1	1	2
CLO 3	1	2	2	3	3	3	1	1	2
CLO 4	1	2	2	3	3	3	1	1	2
CLO 5	2	2	2	3	3	3	1	1	2

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23CDOEMATE09	MATHEMATICAL BIOLOGY	L	T	P	C
		4	1	0	3

OBJECTIVE: Biology is undergoing a quantitative revolution, generating vast quantities of data that are analysed using bioinformatics techniques and modelled using mathematics to give insight into the underlying biological processes. This module aims to give a flavour of how mathematical modelling can be used in different areas of biology.

UNIT I: Single Species Population Dynamics

Continuous time models – Growth models, Logistic model –Evolutionary Aspects –Delay models.

UNIT II: Two Species Population Dynamics

The Lotka-Volterra Prey-Predator equations – Modelling the predator functional response Competition – Ecosystems modeling.

UNIT III: Infectious Diseases

Simple epidemic and SIS diseases –SIR Epidemics –SIR Endemics.

UNIT IV: Biochemical Kinetics

Transitions between states at the molecular and populations level – Law of mass action – Enzyme kinetics.

UNIT V: Biochemical Kinetics

Simple models for polymer growth dynamics.

TEXT BOOK:

1. **N. Britton,** "*Essential Mathematical Biology",* Springer Science & Business Media, 2012.
2. **L.A. Segel** and **L. Edelstein-Keshet,** *"A Primer in Mathematical Models in Biology",* SIAM, Vol. 129, 2013.

UNIT	Chapter/ Text Book	Section(s)
I	1 of [1]	1.3 – 1.5, 1.7
II	2 of [1]	2.3 - 2.6
III	3 of [1]	3.1 - 3.4
IV	2 of [2]	2.1 - 2.4
V	2 of [2]	2.5

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **J.D. Murray, "***Mathematical Biology I: An Introduction*", Springer-Verlag, New York, 2002.
2. **A. D. Bazykin,** *"Nonlinear dynamics of interacting populations",* World Scientific, 1998.
3. **J.N. Kapur,** "*Mathematical Models in Biology and Medicine"*, Affiliated East–West, New Delhi, 1985.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Identify the concepts of Continuous time models, Growth models, Logistic model, Delay models.	K1, K2
CLO 2	Understand the concepts of Lotka-Volterra Prey-Predator equations and modelling the predator functional response Competition.	K2, K3
CLO 3	Develop the epidemic and SIS diseases, SIR Epidemics, SIR Endemics and its behavior.	K2, K3, K4
CLO 4	Analyze the Transitions between states at the molecular and populations level and Law of mass action.	K2, K3, K4
CLO 5	Apply the concepts of Simple models for polymer growth dynamics.	K2, K3, K4

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	2	2	2	2	2	1	2	2
CLO 2	1	1	2	2	2	3	1	1	3
CLO 3	1	1	2	2	3	3	1	2	3
CLO 4	1	2	2	2	3	3	1	2	3
CLO 5	1	2	2	3	3	3	1	2	3

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23CDOEMATE10	METHODS OF APPLIED MATHEMATICS	L	T	P	C
		4	1	0	3

OBJECTIVES: This course treats the foundations of calculus of variations and gives example on some applications within physics and engineering science.

UNIT I: Calculus of variations

Maxima and Minima – The simplest case – Examples - Natural and transition boundary conditions – The variational notation – The more general case – Constraints and Lagranges multipliers – Variable end points – Sturm-Liouville problems.

UNIT II: Applications of Calculus of variations

Hamilton's principle – Lagrange's equation – Generalized dynamical entities – Constraints in dynamical systems – Small vibrations about equilibrium – Variational problems for deformable bodies – Rayleih – Ritz method.

UNIT III: Integral Equations

Integral equations – Relations between differential and integral equations – The Green's function – Fredholm equations with separable kernels – Example.

UNIT IV: Integral Equations

Hilbert – Schmidt theory – Iterative method for solving equations of the second kind – The Neumann Series – Fredholm theory – Singular integral equations.

UNIT V: Special Devices

Special devices – Iterative approximation to characteristic functions – Approximation of Fredholm equations by sets of algebraic equations.

TEXT BOOK:

F.B. Hildebrand, *"Methods of Applied Mathematics"*, Prentice-Hall of India Pvt., New Delhi, 1968.

UNIT	Chapter	Sections
I	2	2.1 – 2.9
II	2	2.10 – 2.14, 2.16, 2.19
III	3	3.1 – 3 .3, 3.6, 3.7
IV	3	3.8 – 3.12
V	3	3.13 – 3.15

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **A.S. Gupta**, *"Calculus of Variations with Application",* Prentice-Hall of India, New Delhi, 2005.
2. **L. Elsgolts**, *"Differential Equations and Calculus of Variations*", University Press of the Pacific, 2003.
3. **I.M. Gelfand and S.V. Fomin, "**Calculus of Variations"**,** Prentice Hall, New Jersey, 1963.
4. **R.P. Kanwal,** "*Linear integral equation: Theory and Techniques*", 2nd Edition, Birkhäuser, 1996.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Give an account of the foundations of calculus of variations and of its applications in Mathematics and Physics.	K1, K2
CLO 2	Describe the brachistochrone problem mathematically and solve it.	K2, K3, k4
CLO 3	Solve isoperimetric problems of standard type.	K2, K3, K4
CLO 4	Solve simple initial and boundary value problems by using several variable.	K2, K3, K4
CLO 5	Use the theory, methods and techniques of the course solve problems.	K4, K5, K6

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	1	1	2	2	2	1	1	2
CLO 2	1	2	1	2	2	2	1	2	2
CLO 3	1	1	1	2	2	3	1	2	3
CLO 4	1	1	1	2	2	2	1	1	2
CLO 5	1	2	1	2	2	3	1	1	2

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23CDOEMATE11	MATHEMATICAL PYTHON	L	T	P	C
		4	1	0	3

OBJECTIVE: This course aims

- To introduce to students Python programming.
- To learn python coding to implement algorithms for Mathematical problems.

UNIT I: Introduction to Python

Basic syntax, variable types, basic operators, numbers, strings, lists, tuples, functions and input/output statements. Some simple programs to understand the relational, conditional and logical operators. Compare two numbers (less than, greater than) using *if* statement. Sum of natural numbers using *while* loop; Finding the factors of a number using *for* loop; To check the given number is prime or not (use *if... else* statement); Find the factorial of a number (use *if...if...else*).; Simple programs to illustrate *logical operators (and, or, not*).

UNIT II: Matrices, Differential Calculus & Analytical Geometry of Three Dimensions

Python commands to reduce given matrix to echelon form and normal form with examples. Python program/command to establish the consistency or otherwise and solving system of linear equations. Python command to find the nth derivatives. Python program to find nth derivative with and without Leibnitz rule. Obtaining partial derivative of some standard functions Verification of Euler's theorem, its extension and Jacobean. Python program for reduction formula with or without limits. Python program to find equation and plot sphere, cone, cylinder.

UNIT III: Roots of High-Degree Equations- Systems of Linear Equations

Introduction, Simple Iterations Method - Finite Differences Method, Gauss Elimination Method: Algorithm, Gauss Elimination Method, Jacobi's Method, Gauss-Seidel's Method.

UNIT IV: Numerical differentiation, Integration and Ordinary Differential Equations

Introduction & Euler's Method, Second Order Runge-Kutta's Method, Fourth Order Runge-Kutta's Method, Fourth Order Runge-Kutta's Method: Plot Numerical and Exact Solutions.

UNIT V: Two-Point Boundary Value Problems

Introduction to two-point boundary value Problems: second order differential equations - Higher order differential equations - solution of second order differential equation using Finite Difference Method.

TEXT BOOKS:

1. www.python.org
2. www.rosettacode.org
3. http://faculty.msmary.edu/heinold/python.html
4. J. Kiusalaas, Numerical methods in engineering with Python 3. Cambridge University Press, 2013.
5. H. P. Langtangen, *Solving PDEs in Python: the FEniCS tutorial I.* Springer Open, 2016

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Hans Fangohr, Introduction to Python for Computational Science and Engineering (A beginner's guide), University of Southampton, 2015.
2. J. Crank, H. G. Martin, and D. M. Melluish, Non-Linear Ordinary Differential Equations. Oxford University Press.
3. Brain Heinold, A practical Introduction to Python Programming, Department of Mathematics and Computer Science, Mount St. Maru's University, 2019.
4. H. P. Langtangen and Anders Logg, *Solving PDEs in Python,* Springer Open, 2017.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Understand one of the most popular and robust general purpose programming language python.	K1, K2, K3
CLO 2	Understand how scientific programming can be performed using python using various open source mathematics libraries and tools available.	K2, K3, K4
CLO 3	Visualize mathematics concepts and get the ability to demonstrate mathematical ideas through graphics.	K2, K3, K4
CLO 4	Solve any concrete mathematics or general problem programmatically using numerical methods.	K2, K3, K4
CLO 5	Develop, document and debug modular python programs to solve computational problems.	K2, K3, K4

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	2	2	2	2	3	1	2	3
CLO 2	1	2	2	2	2	2	1	2	2
CLO 3	1	2	2	2	2	3	1	2	3
CLO 4	1	1	1	2	2	2	1	1	2
CLO 5	1	1	2	2	2	3	1	2	3

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23CDOEMATE12	MATHEMATICAL DOCUMENTATION USING LaTeX	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is

- To create understanding of the LaTeX
- To typeset typical mathematical papers using the article style and figure out LaTeX errors, download and use packages, create simple diagrams.
- To prepare a short presentation using the beamer class.

Unit-I: **Introduction and the Structure of a LaTeX Document**

Installation of the software LaTeX - Environments and commands - Classes and packages – Errors - Filescreated - How to use LAEX at CUED - Document Classes - Arara- Counters and Length parameters - Document and page organization – Page breaks, footnotes. Environments , Matrix-like environments

Unit-II: Display and alignment structures

Display and alignment structures for equations Comparison with standard LaTeX - A single equation on one line - A single equation on several lines: no alignment - A Single equation on several lines: with alignment - Equation groups without alignment - Equation groups with simple alignment- Multiple alignments: align and flalign - Display environments as mini-pages- Interrupting displays, Variable symbol commands - Symbols in formulas

Unit-III: Figures Directly in LaTex

Inserting Images, Positioning Images, List of Figures, Drawing diagrams directly in LaTex, TikZ package, Graphics and PSTricks Pictures and graphics in LaTeX, simple pictures using PSTricks, Plotting of functions.

Unit IV: Presentations (The beamer Class)

Overlays -Themes **Assignments and Examinations** The exam Class - The exsheets Package – The probsoln Package - Using the data tool Package for Exams or Assignment Sheets - Random Numbers. **Charts** Flow Charts - Pie Charts - The datapie Package - The pgf-pie Package - Bar Charts - The bchart Package - The databar Package - Gantt Charts - Plots.

Unit V: Structuring Your Document

Author and Title Information, Abstract, Chapters, Sections, Subsections, Creating a Table of Contents, Cross-Referencing, Creating a Bibliography, Page Styles and Page Numbering, Multi-Lingual Support: using the babel package.

TEXT BOOK

1. Advanced LATEX by Tim Love, 2006,
2. http://www.h.eng.cam.ac.uk/help/documentation/docsource/latex_advanced.pdf
3. LaTeX for Administrative Work by Nicola L. C. Talbot, Dickimaw Books, 2015, http://www.dickimaw-books.com/latex/admin/
4. The LaTeX Companion by Frank Mittelbach and Michel Goossens, Addison-Wesley, Library ofCongress Cataloging-in-Publication Data (Second Edition)
5. Nicola L. C.Talbot, LATEX for Complete Novices Version 1.4, Dickimaw Bookshttp://www.dickimaw-books.com/2012.

UNIT	Text Book	Chapter(s)
I	1 2 3	1, 2 and 4 1 and 5 8 (8.3 only)
II	3	8 (8.2, 8.5, 8.6 and 8.9)
III		
IV	2	8, 9 and 12
V	5	5 (5.1 – 5.7)

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1) Bindner, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.
2) Lamport, Leslie (1994). LaTeX: A Document Preparation System, User's Guide and Reference Manual (2nd ed.). Pearson Education. Indian Reprint.
3) George Gratzer, More Math into LATEX, 4th Edition, 2007 Springer Science
4) Frank Mittelbach, Michel Goossens, The LaTex Companion, Second Edition, Addision-Wesley, 2004
5) A Primer, Latex, Tutorials, Indian TEX users group, Trivandrum, India.www.tug.org.in

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Create and typeset a LaTeX document	K1, K2, K3
CLO 2	Typeset a mathematical document	K1, K2, K3
CLO 3	Draw pictures in LaTeX	K1, K2, K3
CLO 4	Create beamer presentations	K2, K3, K4
CLO 5	Prepare the projects or dissertations in LaTeX	K2, K3, K4

MAPPING WITH PROGRAMME OUTCOME(S):

	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	1	1	2	2	2	1	2	2
CLO 2	1	1	1	1	2	2	1	1	2
CLO 3	1	1	1	1	2	2	1	1	2
CLO 4	1	1	1	1	2	2	1	1	2
CLO 5	1	1	1	1	2	2	1	1	2

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23CDOEMATE13	NUMERICAL ANALYSIS	L	T	P	C
		4	1	0	3

OBJECTIVES: The objectives of this course are

- to make the students familiarize with the ways of solving complicated mathematical problems numerically.
- To provide numerical methods for solving the non-linear equations, interpolation, differentiation, integration, ordinary and partial differential equations.
- Describing and understanding error analysis in numerical methods.

Unit I: Solutions of Equations in One Variable

Newton's Method and its Extensions – Error Analysis for Iterative Methods – interpolation and Polynomial Approximation - Interpolation and the Lagrange Polynomial – Cubic Spline Interpolation.

Unit II: Numerical Differentiation and Integration

Numerical Differentiation – Elements of Numerical Integration – Romberg Integration.

Unit III: Initial Value Problems for Ordinary Differential Equations

Elementary Theory of Initial Value Problems – Euler's Method – Taylor Method – Runge-Kutta Methods.

Unit IV: Initial Value Problems for Ordinary Differential Equations (Continued)

Multistep Methods – Higher-Order Equations and Systems of Differential Equations – Stability.

Unit V: Numerical Solutions to Partial Differential Equations

Elliptic Partial Differential Equations – Parabolic Partial Differential Equations - Hyperbolic Partial Differential Equations.

TEXT BOOK:

R. L. Burden and **J.D. Faires**, *"Numerical Analysis"*, 9th Edition, Thomson Learning. Inc., Stanford, Connecticut, 2011.

UNIT	Chapter(s)	Sections
I	2 & 3	2.3, 2.4, 3.1, 3.4, 3.5
II	4	4.1, 4.3, 4.5
III	5	5.1, 5.2, 5.4
IV	5	5.6, 5.9, 5.10
V	12	12.1 – 12.3
Algorithms are not included in the syllabus		

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **C.F. Gerald and P.O. Wheatley**, "*Applied Numerical Analysis"* Sixth Edition, Addison- Wesley, Reading, 1998.
2. **M.K. Jain,** "*Numerical Methods for Scientific and Engineering Computation*" New Age International, 2003.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Apply numerical methods to obtain approximate solutions to mathematical problems.	K1, K2, K3
CLO 2	Understand how to approximate the functions using interpolating polynomials	K1, K2, K3
CLO 3	Perform error analysis for various methods	K2, K3, K4
CLO 4	Learn numerical solution of ordinary and partial differential equations with an understanding of convergence, stability and consistency.	K2, K3, K4
CLO 5	Analyze and evaluate the accuracy of common numerical methods	K3, K4, K5

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	2	2	3	3	3	1	2	3
CLO 2	1	2	2	3	2	3	1	2	2
CLO 3	1	2	2	3	3	3	1	2	3
CLO 4	1	2	3	3	3	3	1	3	3
CLO 5	1	2	2	2	3	3	1	2	3

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23CDOEMATE14	FINANCIAL MATHEMATICS	L	T	P	C
		4	1	0	3

OBJECTIVE: In this course, the students will understand the concept of issue of risk management in a portfolio of asserts, derivative pricing models, arbitrage, finite probability spaces, discrete time pricing models, The Cox-Ross-Rubinstein model, The Blook-Schdes option pricing formula, the problem of pricing nonattainable alternatives in an incomplete discrete model.

UNIT – I: Portfolio Management and the Capital Asset Pricing Model

Portfolios, returns and risk – two-asset portfolios – Multi asset portfolios – stock options – the purpose of options – profit and Payoff curves – selling short.

UNIT – II: An Aperitif on Arbitage and more Discrete Probability

Background on forward contacts – the pricing of forward contracts – the put-call option parity formula – option prices – conditional probability – partitions and measurability – algebras – conditional expectation stochastic – processes – filtrations and martingales.

UNIT – III: Discrete – Time Pricing Models

Assumptions – positive random variables – the basic model by example – the basic model – portfolios and trading strategies – the pricing problem – arbitrage trading strategies – admissible – characterizing arbitrage – computing Martingale measures – the model – Martingale measures in the CRR model – pricing in the CRR model.

UNIT – IV: Continuous Probability

General probability spaces – probability measures on $\mathbb{R}$ - distribution functions –density functions – types of probability measures on $\mathbb{R}$ - random variables – the normal distribution – convergence in distribution – the central limit theorem – stock prices and Brownian motion – the CRR model in the limit – taking the limit as $\Delta t \to 0$.

UNIT – V: The Black – Scholes Option Pricing Formula and Optional Stopping

The natural CRR Model – the Martingale measure CRR model – more on the model from a different perspective – the Black – Scholes option pricing formula – how dividends affect the use of black – schools – the model – the payoffs – stopping times – stopping the payoff process – optimal stopping times and the Snell envelope – existence of optimal stopping times – optimal stopping times and the Doob decomposition – the smallest and the largest optimal stopping time.

TEXT BOOK

Steven Roman, *"Introduction to the Mathematics of Finance from Risk Management to Options Pricing"*, Springer International edition, India, 2010.

UNIT	Chapter	Section
I	2 & 3	2.1 – 2.3 & 3.1 - 3.4
II	4 & 5	4.1 – 4.4 & 5.1 - 5.6
III	6 & 7	6.1 - 6.10 & 7.1 - 7.4
IV	8 & 9	8.1 – 8.9 & 9.1 – 9.3
V	9 & 10	9.4 – 9.10 & 10.1 10.16

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **A. Etheridge**, A Course in Financial Calculus, Cambridge university press, Cambridge, 2002.
2. **H. Föllmer**, Stochastic Finance: An Introduction to Discrete Time, Walter de Gruyter, 2002.
3. **G. Kallianpur** and **R. Karamdikar**, Introduction to Option pricing Theory, Birkhouser, 1997.
4. **S. Ross**, An Introduction to Mathematical Finance: Options and Other Topics, Cambridge University Press, 1999.
5. **S. Ross**, An Elementary Introduction to Mathematical Finance, Cambridge University press, 2002.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Describe the main investment and risk characteristics of the standard asset classes available for investment purpose.	K1, K2, K3
CLO 2	Calculate the discounted mean term or volatility of an asset or liability and analyse whether an asset-liability position is matched or immunized.	K1, K2, K3
CLO 3	Demonstrate an understanding of the nature and use of simple stochastic interest rate models.	K2, K3, K4
CLO 4	Calculate the forward price and value of a forwarded contract using no-arbitrage pricing.	K2, K3, K4
CLO 5	Know about basic probability, random walks, central limit theorem, Brownian motion, Block schools theory of options.	K2, K3, K4

MAPPING WITH PROGRAMME OUTCOME(S):

CLO	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	2	2	1	2	2	3	1	3	3
CLO 2	1	2	2	2	2	3	2	2	3
CLO 3	1	2	1	2	2	3	1	2	3
CLO 4	1	1	1	2	2	3	1	1	3
CLO 5	1	1	1	2	2	3	1	2	3

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23CDOEMATE15	RESEARCH TOOLS AND TECHNIQUES	L	T	P	C
		4	1	0	3

OBJECTIVE: The primary objective of this course is to develop a research orientation among the students and to acquaint them with fundamentals of research methods. Specifically, the course aims at introducing them to the basic concepts used in research and the various approaches. It includes discussions on sampling techniques, research designs and
techniques of analysis.

Unit-I: **Foundations of Research**

Meaning, Objectives and Motivation of Research - Types of Research and Research Approaches -Research Methods versus Methodology - Research Process and Criteria of Good Research - Ethics in Research – Copy right, Intellectual Property Rights, Plagiarism, Citation & Acknowledgement

Unit-II: Stages of a Research Process

Selection of a Research Topic - Writing a Research Proposal – Title, Abstract – Literature Survey - Formulation of Hypotheses - Research Design – Sampling techniques - Data Analysis - Interpretation of Result - Report Writing- Types, Layout, Guidelines for Presenting Tabular Data & Visual Representations - Writing a Bibliography – Different Styles

Unit-III: Defining the Research Problem and Research Design

Understanding & Selection of Research Problem - Necessity of Defining the Problem - Technique Involved in Defining a Problem - Meaning of Research Design and Need for Research Design - Important Concepts Relating to Research Design - Different Research Designs

Unit IV: Methods of Data Collection

Collection of Primary Data - Observation, Interview Method, Questionnaires & Schedules - Difference between Questionnaires and Schedules - Techniques of Developing Data Collection Tools – Questionnaires, Rating Scales - Collection of Secondary Data Selection of Appropriate Method for Data Collection - Case Study Method

Unit V: Processing and Analysis of Data

Processing Operations - Use of Microsoft Excel for Classification & Tabulation - Univariate and Bivariate Data Analysis – Frequency tables, bar graphs, pie charts, Cross tabulation - Statistics in Research - Measures of Central Tendency - Measures of Dispersion, Asymmetry - Correlation (Karl Pearson's Correlation Coefficient & Rank Correlation) - Simple Regression Analysis

RECOMMENDED TEXT BOOK

1. Kothari C. R, 'Research Methodology: Methods and Techniques' (Fourth Revised Edition), NewAge International Publishers, 2019
2. Ranjit Kumar, 'Research Methodology: A Step-by-Step Guide for Beginners', SAGE

Publications Ltd; Fourth Edition, 2014.
3. J. David Creswell and John W. Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, SAGE Publications Inc; Fourth Edition, 2013.
4. Chawla, Deepak & Sondhi, Neena, Research methodology: Concepts and cases, Vikas Publishing House Pvt. Ltd. Delhi, 2011.
5. V Sinha, S.C. and Dhiman, A.K., Research Methodology, Ess Ess Publications. 2 Volumes, 2002.

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. M. Graziano, A.M. and Raulin, M.L., Research Methods: A Process of Inquiry, Allyn andBacon, 2009.
2. Fink, A., Conducting Research Literature Reviews: From the Internet to Paper. SagePublications, 2009.
3. Leedy, P.D. and Ormrod, J.E., Practical Research: Planning and Design, 2004.
4. Carlos, C.M., Intellectual property rights, the WTO and developing countries: the TRIPSagreement and policy options. Zed Books, New York, 2000.
5. Satarkar, S.V., Intellectual property rights and Copy right. Ess Ess Publications, 2000.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Develop understanding of the basic framework of research process.	K1, K2, K3
CLO 2	Develop an understanding of various research designs and techniques.	K2, K3, K4
CLO 3	Identify various sources of information for literature review and data collection.	K3, K4, K5
CLO 4	Develop an understanding of the ethical dimensions of conducting applied research.	K4, K5, K6
CLO 5	Demonstrate the ability to choose methods appropriate to research objectives.	K4, K5, K6

MAPPING WITH PROGRAMME OUTCOME(S):

	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	1	1	2	2	3	1	2	3
CLO 2	1	1	1	2	2	3	1	2	3
CLO 3	1	2	2	2	2	3	1	2	3
CLO 4	1	1	1	2	2	3	1	2	3
CLO 5	1	1	1	2	2	2	1	2	2

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23CDOEMATE16	INDUSTRIAL MATHEMATICS	L	T	P	C
		4	1	0	3

OBJECTIVE: The objectives of this course are

- to provide good mathematical modeling skills based on fundamental skills.
- to understand that the key factors can be expressible in terms of dimension less parameters.
- to understand methods for constant coefficient ordinary differential equations, systems of linear algebraic equations, graphical solutions of nonlinear transcendental equations.
- to introduce the method of regular perturbations.
- to introduce a case study about fires in a chipboard factory.

Unit-I: **Dimensional Analysis**

Mathematical Industry – Overview of the case studies – Unit and dimensions – Diffusion equations – Heat conduction equations – Boundary conditions – Solving the heat/diffusion equation – Scaling equations – Dimensional analysis

Unit-II: Continuous Casting

Introduction to the case study problem – The Boltzmann similarity solution – A moving boundary problem – The pseudo-steady-state approximate solution – Solving the continuous casting case study.

Unit-III: Water Filtration

Introduction to the case study problem – Stretching transformations – Diffusion from a point source – Solving the water filtration case study.

Unit IV: Laser Drilling

Introduction to the case study problem – Method of perturbations – Boundary perturbations – Solving the laser drilling case study.

Unit V: Factory Fires

Bifurcations and spontaneous ignition – ignition with conduction – Solving the factor fire case study.

TEXT BOOK

Glenn R. Fulford and **Philip Broadbridge**, Industrial Mathematics: Case studies in the Diffusion of Head and Matter, Cambridge University Press, Cambridge, UK, 2002.

UNIT	Chapter(s)	Sections
I	1	1.1 – 1.10
II	2	2.1 – 2.5
III	3	3.1 – 3.4
IV	4	4.1 – 4.4
V	5	5.1 – 5.4

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Aziz and T.Y. Na, Pertubation Methods in Heat Transfer, Springer-Verlag, Berlin, 1984, G.L. Barenblatt, Dimentional Analysis, Gordon and Breach, 1984.
2. G.L. Barenblatt, Dimensional Analysis, Gordon and Breach, 1987.
3. N.D. Fowkeys and J.J. Mahony, An Introduction to Mathematical Modelling, Wiley Publishers, UK, 1994.
4. Edward L. Cussler, Diffusion-Mass Transfer in Fluid Systems, Cambridge University Press, 3rd Edition, 2009.

COURSE LEARNING OUTCOMES: After the successful completion of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Understand the physical concepts for diffusion and heat conduction, and show how to formulate the main partial differential equations that describe these physical processes.	K1, K2, K3
CLO 2	Find the puddle length in a continuous casting operation and calculate how fast molten steel solidifies and determine.	K2, K3, K4
CLO 3	Understand the stretching symmetries of the PDE's and boundary conditions which allow the construction of variable combination which reduce the PDE to ODE.	K3, K4, K5
CLO 4	Develop a mathematical model to calculate the drilling speed of a laser through a thick sheet of metal.	K3, K4, k5
CLO 5	Obtain a criterion for safe storage of mildly combustible materials.	K4, k5, k6

MAPPING WITH PROGRAMME OUTCOME(S):

	POs						PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3
CLO 1	1	1	1	2	2	2	1	1	2
CLO 2	2	2	2	2	2	3	2	2	3
CLO 3	1	1	1	2	2	2	1	1	2
CLO 4	1	1	1	2	2	2	1	1	2
CLO 5	1	1	1	2	2	3	1	2	3

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