PERIYAR UNIVERSITY

NAAC A++ Grade – State University – NIRF Rank 56 – NIRF Innovation Band of 11-50

PERIYAR PALKALAI NAGAR

SALEM – 636 011

REGULATIONS AND SYLLABUS

M.Sc. Branch – I (B): Mathematics

(For candidates admitted from 2023-2024 onwards)

(SEMESTER PATTERN)

(Under Choice Based Credit System)

(For Department of Mathematics, Periyar University & Periyar University Centre for Post Graduate and Research Studies, Dharmapuri)

CONTENTS

1. INTRODUCTION

1.1 ABOUT THE DEPARTMENT

The Department of Mathematics is one of the departments functioning from the inception of Periyar University in the year 1997. The Department offers programmes of study and research leading to M.Sc., M.Phil., and Ph.D. degrees and is on a relentless march towards academic excellence. Based on the contributions towards research, University Grants Commission (UGC) has granted fund under Special Assistance Programme (SAP), Department of Science and Technology (DST) has granted fund for Improvement of S&T infrastructure (FIST) and DAE-NBHM has been supporting Library Grant to this department.

1.2 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.

1.3 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.

1.4 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.

1.5 DURATION OF THE PROGRAMME

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

1.6 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 / Department of Mathematics, Periyar University Centre for Post Graduate and Research Studies, Dharmapuri.

1.7 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)	**At the time of graduation, students will be able to** **PO1** gain knowledge in the fundamental subjects of pure and applied mathematics **PO2** explain the mathematical concepts with good understanding and clarity **PO3** conduct research independently with strong mathematics background **PO4** crack lectureship/fellowship exams like CSIR – NET/JRF, GATE, NBHM, SET, TRB etc. **PO5** apply the acquired mathematical techniques to solve the socio-economic and industrial problems **PO6** obtain career in the field of education/research/industry/administration
Programme Educational Outcomes (PEOs)	**1. Core Competence in Mathematical Theories and Applications** Graduates will acquire an in-depth understanding of advanced mathematical concepts, theories, and methods. They will be able to apply these concepts effectively in various fields such as pure mathematics and applied mathematics. **2. Technical Proficiency and Computational Skills** Graduates will gain proficiency in using advanced mathematical software, tools, and programming languages that are essential for modelling, simulation, and solving complex mathematical problems in various industries and academic research. **3. Preparation for Advanced Careers** Graduates will be well-prepared to pursue careers in academia, research, industry, or government organizations that require high-level mathematical expertise. **4. Research and Analytical Skills** Graduates will develop strong analytical and problem-solving skills that enable them to conduct independent research in mathematics. They will be proficient in identifying, formulating, and solving complex mathematical problems.

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: 28.04.2023		

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	4	5	4.2 Core-XI	5	5
1.3 Core – III	4	5	2.3 Core – VI	4	5	3.3 Core – IX	4	5	4.2 Core-XII	4	5
1.4 Discipline Centric Elective -I	3	5	2.4 Discipline Centric Elective – III	3	5	3.4 Discipline Centric Elective - V	3	5	4.3 Project with viva voce	5	5
1.5 Generic Elective-II:	3	5	2.5 Generic Elective -IV:	3	5	3.5 SEC-II	3	5	4.4 Elective - VI	3	4
			2.6 SEC-I	2	4	3.4 NME - II	2	2	4.5 SEC-III	2	4
			2.7 NME – I (SWAYAM/ MOOC/ NPTEL – online course)	2	-	3.7 Internship/ Industrial Activity	2	-	4.6 Extension Activity	1	
			2.8 Human Rights	1	1						
	20	**25**		**25**	**30**		**22**	**27**		**25**	**28**
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 4	7 5	35 20	82	88 (CGPA)
	Project with viva voce	5	1	5		
	NME	2	2	4		
	Elective (Generic and Discipline Centric)	3	6	18		
PART B (i)	Skill Enhancement (Term paper and Seminar &Generic / Discipline - Centric Skill Courses) (Internal Assessment Only)	2	3	6	6	
PART B (ii)	Summer Internship Program	2	1	2	2	4 (Non CGPA)
PART B (iii)	Human Rights	1	1	1	1	
PART C	Extension Activity	1	1	1	1	
				Total	**92**	**92**

5.3 NON MAJOR ELECTIVE COURSES (NME)

Non Major Elective Courses split into two courses:

- Non Major Elective – I (**NME-I**): Swayam/ MOOC/ NPTEL – online course with 2 credits.
- Non Major Elective – II (**NME-II**): Choose one course from the **Group-H** with 2 credits.

5.4 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
23UPMAT1I01	Summer Internship programme	III	2

5.5 EXTRA CREDIT COURSE

Compulsory

- Value Added Course with 2 extra credits will be offered in any one of the semester. Choose one value added course from the **Group-I**.

6. INSTRUCTIONS FOR COURSE TRANSACTION

Courses	Lecture hrs	Tutorial hrs	Lab Practice	Total hrs
Core	72	18	--	90
Electives	72	18	--	90
NME	72	18	--	90
SEC	72	18	---	90
Lab Practice Courses	36	18	36	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.	23UPMAT1C01	Core I	**Algebraic Structures**	5	5	100
2.	23UPMAT1C02	Core II	**Real Analysis I**	5	5	100
3.	23UPMAT1C03	Core III	**Ordinary Differential Equations**	5	4	100
4.		Elective-I	One from Group A	5	3	100
5.		Elective-II	One from Group B	5	3	100
SEMESTER - II						
6.	23UPMAT1C04	Core IV	**Advanced Algebra**	5	5	100
7.	23UPMAT1C05	Core V	**Real Analysis – II**	5	5	100
8.	23UPMAT1C06	Core VI	**Topology**	5	4	100
9.		Elective-III	One from Group C	5	3	100
10.		Elective-IV	One from Group D	5	3	100
11.		SEC - I	One from Group G	4	2	-
12.	-	**NME – I** (Online Course)	Swayam /MOOC/NPTEL	-	*2*	100
13.	23UPPGC1H01	HR	Fundamentals of Human Rights	1	1	100
SEMESTER - III						
14.	23UPMAT1C07	Core VII	**Complex Analysis**	5	5	100
15.	23UPMAT1C08	Core VIII	**Functional Analysis**	5	4	100
16.	23UPMAT1C09	Core IX	**Partial Differential Equations**	5	4	100
17.		Elective-V	One from Group E	5	3	100
18.		SEC - II	One from Group G	4	2	-
19.		**NME - II**	Non Major Elective (one from **Group - H**)	2	2	100
20.	23UPMAT1I01	Summer Internship	(Carried out in Summer Vacation at the end of 1st year)	-	2	-
SEMESTER - IV						
21.	23UPMAT1C10	Core X	**Measure Theory & Integration**	5	5	100
22.	23UPMAT1C11	Core XI	**Differential Geometry**	5	5	100
23.	23UPMAT1C12	Core XII	**Probability Theory**	5	4	100
24.	23UPMAT1P01	Project	**Project with viva voce**	5	5	100
25.		Elective-VI	One from Group F	5	3	100
26.		SEC - III	One from Group G	4	2	-
27.	23UPMAT1X01	-	Extension Activity	-	1	-
Total				**110**	**92**	**2200**

❖ **EXTRA CREDIT COURSES - COMPULSORY**

One value added course with **2 extra credits** will be offered in any one of the semester. Choose one value added course from the **Group-I.**

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**	
	23UPMAT1E01	Number Theory and Cryptography	3
	23UPMAT1E02	Graph Theory and Applications	3
	23UPMAT1E03	Formal Languages and Automata Theory	3
	23UPMAT1E04	Programming in C++ and Numerical Methods	3
	23UPMAT1E05	Mechanics	3
	23UPMAT1E06	Analytical Number Theory	3
		GROUP - B	
	23UPMAT1E07	Mathematical Programming	3
	23UPMAT1E08	Fuzzy Sets and Their Applications	3
	23UPMAT1E09	Discrete Mathematics	3
	23UPMAT1E10	Mathematical Foundation of Data Science	3
	23UPMAT1E11	Coding Theory	3
II		**GROUP - C**	
	23UPMAT1E12	Algebraic Number Theory	3
	23UPMAT1E13	Lie Algebra	3
	23UPMAT1E14	Statistical Data Analysis using R Programming	3
	23UPMAT1E15	Tensor Analysis and Relativity	3
	23UPMAT1E16	Combinatorial Mathematics	3
	23UPMAT1E17	Commutative Algebra	3
	23UPMAT1E18	Mathematical Modeling	3
		GROUP - D	
	23UPMAT1E19	Mathematical Statistics	3
	23UPMAT1E20	Wavelets	3
	23UPMAT1E21	Modeling and Simulation with Excel	3
	23UPMAT1E22	Machine Learning and Artificial Intelligence	3
	23UPMAT1E23	Mathematical Biology	3
	23UPMAT1E24	Neural Networks	3
	23UPMAT1E25	Representation Theory of Finite Groups	3
III		**GROUP - E**	
	23UPMAT1E26	Algebraic Topology	3
	23UPMAT1E27	Fluid Dynamics	3
	23UPMAT1E28	Stochastic Processes	3
	23UPMAT1E29	Mathematical Python	3
	23UPMAT1E30	Advanced Partial Differential Equations	3
	23UPMAT1E31	Numerical Analysis	3
	23UPMAT1E32	Mathematical Physics	3
	23UPMAT1E33	Non Commutative Algebra	3
	23UPMAT1E34	Difference Equations	3
IV		**GROUP – F**	
	23UPMAT1E35	Algebraic Geometry	3
	23UPMAT1E36	Financial Mathematics	3
	23UPMAT1E37	Resource Management Techniques	3
	23UPMAT1E38	Nonlinear Differential Equations	3
	23UPMAT1E39	Stochastic Differential Equations	3
	23UPMAT1E40	Control Theory	3
	23UPMAT1E41	Methods of Applied Mathematics	3
	23UPMAT1E42	Operator Theory	3
	23UPMAT1E43	Fixed Point Theory and Applications	3

9. SKILL ENHANCEMENT COURSES OFFERED [SEC]

Skill Enhancement Courses (SEC) are chosen so as to keep in pace with the latest developments in the academic / industrial front and provides flexibility of choice by the stakeholders / institutions.

S. No.	COURSE CODE	TITLE OF THE COURSE	CREDITS
		GROUP – G	
1.	23UPMAT1S01	Computational Mathematics using SageMath	2
2.	23UPMAT1S02	Mathematical Documentation using LATEX	2
3.	23UPMAT1S03	Office Automation and ICT Tools	2
4.	23UPMAT1S04	Numerical Analysis using MATLAB	2
5.	23UPMAT1S05	Differential Equations using MATLAB	2
6.	23UPMAT1S06	Industrial Mathematics	2
7.	23UPMAT1S07	Research Tools and Techniques	2

10. NON MAJOR ELECTIVE COURSES (NME) FOR OTHER DEPARTMENTS (not for mathematics students)

Students from other Departments may choose any one of the following as Non Major Elective Course.

S. No.	COURSE CODE	TITLE OF THE COURSE	CREDITS
		GROUP – H	
1.	23UPMAT1N01	Mathematics for Life Sciences	2
2.	23UPMAT1N02	Mathematics for Social Sciences	2
3.	23UPMAT1N03	Mathematical Economics	2
4.	23UPMAT1N04	Statistics for Life and Social Sciences	2
5.	23UPMAT1N05	Game Theory and Strategy	2
6.	23UPMAT1N06	Financial Mathematics	2
7.	23UPMAT1N07	Numerical and Statistical Methods	2

11. VALUE ADDED COURSES OFFERED [VAC]

S. No.	COURSE CODE	TITLE OF THE COURSE	CREDITS
		GROUP – I	
1.	23UPMAT1V01	LaTeX (Lab)	2
2.	23UPMAT1V02	Mathematica (Lab)	2
3.	23UPMAT1V03	Matlab (Lab)	2

12. 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
NME	75	25	200	02	200	04
Project + Viva Voce*	25+25	25+25	100	01	100	05
SEC				03		06
Human Rights	75	25	100	01	100	01
Internship / Industrial Activity				-		02
Extension Activity				-		01
	Grand Total			**25**	**2200**	**92**

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*Dissertation: **100** (Internal Valuation 25 + External Valuation 25)

and Joint Viva Voce 25 + 25 Marks

13. 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 (20 x 1 = 20 Marks) Answer ALL questions **Each Question carries 1 mark**
Memory Recall / Example/ Counter Example / Knowledge about the Concepts/ Understanding	Question **1** to Question **20** (Four Objective type questions from each unit)
	Part – B (3 x 5 = 15 Marks) **Answer any three questions out of five questions**
Descriptions/ Application (problems)	Question **21** to Question **25** (One question should be taken from each Unit)
	Part-C (5x 8 = 40 Marks) **Answer all the questions** **Each question carries 8 Marks**
Analysis /Synthesis / Evaluation	Question **25(a)** or **25(b)** to Question **30(a)** or **30(b)** (Either or type one pair 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.

14. 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.

15. 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.

16. PROJECT AND EDUCATIONAL TOUR:

For M.Sc Mathematics students, the project is individual and compulsory. In order to choose their topics/titles for the project, the students may like to visit the Libraries at the Universities/Indian Institute of Technology/Institute of Mathematical Sciences etc. So, the Department of Mathematics may arrange an Educational Tour either at the end of III semester or in the beginning of IV semester, for the students to visit the Libraries.

(a) 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.

(b) 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.

(c) Format for the preparation of the project:

(a) Title page

(b) Bonafide Certificate

(c) Acknowledgement

(d) Table of contents

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Chapter No.	Title	Page No.
1.	Introduction	
2.	Review of Literature	
3.	Summary	
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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

Department of Mathematics

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

23UPMAT1C01	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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23UPMAT1C02	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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23UPMAT1C03	ORDINARY DIFFERENTIAL EQUATIONS	L	T	P	C
		4	1	0	4

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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23UPMAT1C04	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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23UPMAT1C05	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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23UPMAT1C06	TOPOLOGY	L	T	P	C
		4	1	0	4

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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23UPMAT1C07	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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23UPMAT1C08	FUNCTIONAL ANALYSIS	L	T	P	C
		4	1	0	4

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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23UPMAT1C09	PARTIAL DIFFERENTIAL EQUATIONS	L	T	P	C
		4	1	0	4

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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23UPMAT1C10	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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23UPMAT1C11	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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23UPMAT1C12	PROBABILITY THEORY	L	T	P	C
		4	1	0	4

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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23UPMAT1D01	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

23UPMAT1E01	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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23UPMAT1E02	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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23UPMAT1E03	FORMAL LANGUAGE AND AUTOMATA THEORY	L	T	P	C
		4	1	0	3

OBJECTIVES:

The objective of the course is to introduce the fundamental concepts of formal languages, grammars and automata theory. Identify different formal language classes and their relationship. Knowledge in basic concepts of calculus and matrices.

UNIT I: Lattices and Boolean Algebra

Lattices as partially ordered sets – Boolean algebra –Boolean Functions –Representations and Minimization of Boolean Functions.

UNIT II: Grammars and Languages

Discussion of Grammars – Formal Definition of a Language – Notation of Syntax Analysis.

UNIT III: Finite Automata, Regular Expressions and Languages

An Informal picture of Finite Automata – Deterministic Finite Automata – Nondeterministic Finite Automata – An Application: Text Search – Finite Automata with Transitions – Regular Expressions – Finite Automata and Regular Expressions – Applications of Regular Expressions – Algebraic Laws for Regular Expressions.

UNIT IV: Properties of Regular Languages

Proving languages not to be regular – Closure properties of Regular Languages – Decision properties of Regular Languages – Equivalence and Minimization of Automata.

Context-Free Grammars and Languages

Context-Free Grammars – Parse Trees – Applications of Context-Free Grammars – Ambiguity in Grammars and Languages.

UNIT V: Pushdown Automata

Definition of the Pushdown Automaton – The languages of a PDA – Equivalence of PDA's and CFG's – Deterministic Pushdown Automata.

Properties of Context-Free Languages

Normal Forms for Context – Free Grammars – The Pumping Lemma for CFL's – Closure properties of CFL's – Decision properties of CFL's.

TEXT BOOK:

1. **J.P Tremblay** and **R.P. Manohar,** "*Discrete mathematical Structures with Applications to Computer Science*" McGraw Hill Publishing company, reprint 2016.
2. **John E. Hopcroft, Rajeev Motwani**and**Jeffrey D. Ullman,** "*Introduction to Automata Theory, languages and Computation*" Pearson Education, 2nd Edition, reprint 2005.

UNIT	Chapter	Sections
I	Book 1: 4	4.1.1 – 4.4.2
II	Book 1: 3	3.3.1 – 3.3.3
III	Book 2: 2 and 3	-
IV	Book 2: 4 and 5	-
V	Book 2: 6 and 7	-

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. T. Veerarajan, Discrete Mathematics with Graph Theory and Combinatorics, Tata Mcgraw-Hill Publishing company Ltd, 2008.
2. Dr. M.K. Venkatraman, Dr. N. Sridharan and N. Chandrasekaran, Discrete Mathematics, First Edtion Reprint, The National Publishing Company, Chennai, 2003.
3. Peter Linz, Introduction to formal Language & Automata, Jones &Bartilett Learning, 5th edition,2012.
4. T. Santha and P. Radha, Discrete Mathematics for Computer Science and Applications, Kalaikathir Publications, 2003.
5. John Truss, Discrete Mathematics for Computer Scientists, Pearson Education Ltd, 2nd Edition, 2001.

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 in Lattices, formal Language and automata Theory.	K1, K2
CLO 2	Demonstrate abstract models of computing, including deterministic (DFA), Non-Deterministic (NFA), Push Down Automata (PDA).	K2, K3
CLO 3	Relate practical problem to languages and automata.	K2, K3, K4
CLO 4	Design Grammara and recognizers for different formal languages.	K3, K4, K5
CLO 5	Formalize the structure of a given formal language using regular expressions and context-free grammars.	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	2	3	3	1	2	3
CLO 2	2	1	2	2	3	3	2	2	3
CLO 3	1	2	3	3	3	3	2	1	3
CLO 4	2	1	2	3	3	3	2	2	2
CLO 5	2	1	2	3	3	3	2	2	3

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23UPMAT1E04	PROGRAMMING IN C++ AND NUMERICAL METHODS	L	T	P	C
		4	1	0	3

OBJECTIVES: The objective of the course is to introduce a higher level language C++ and numerical methods for hand-on experience on computers. Stress is also given on the error analysis.

UNIT I:

Principles of OOP-Tokens-Expressions, Control Structures-Functions-Classes and Objects-construction and destructors.

UNIT II:

Operator Overloading and type Conversions – Inheritance – Pointers, Virtual Functions and Polymorphism – Managing Console I/O Operations – Working with Files.

UNIT III: Finite Digit Arithmetic and Errors

Floating point arithmetic – Propagated Error – Genarated Error – Error in Evaluation of a function f(x).

Non-linear Equations: Bisection method – Secant Method – RegulaFalsi Method – Newton's method – Muller's method – Fixed Point Method.

UNIT IV: System of Linear Equations

Gauss – Elimination Method – Crout's method – Inverse of a matrix – Condition numbers and errors – Jacobi's method – gauss-Seidel Method – Relaxation method.

Numerical Differential and Integration: Numerical Differentiation – Numerical Integration – Newton-Cotes Formulas – Qaudrature – Double Integral.

UNIT V: Ordinary differential Equations

Difference Equation – Differential Equations: Single Step method – Rung-Kutta Method – Multi-step methods.

TEXT BOOK:

1. **E. Balagurusamy,** "*Object Oriented Programming with C++*" Tata McGraw Hill, New Delhi, 1999.
2. **Devi Prasad,** "*An Introduction to Numerical Analysis*", 3rd edition, Narosa Publishing House, New Delhi, 2006.

UNIT	Book	Chapter /Sections
I	Book 1	1 - 6
II	Book 1	7 - 11
III	Book 2	Chapter 1 Chapter 2 (2.1 to 2.6)
IV	Book 2	Chapter 3 Chapter 5 (5.1 to 5.5 and 5.7)
V	Book 2	Chapter 6 (6.1 to 6.5)

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. D. Ravichandran, Programming with C++, Tata Mcgraw-Hill, New Delhi, 1996.
2. Conte and de Boor, Numerical Analysis, McGraw Hill, New York, 1990.
3. John H. Mathews, Numerical Methods for Mathematics, Science and Engineering (2nd Edition), Prentice Hall, New Delhi, 2000.

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

CLO	Statements	Knowledge level
CLO 1	Understanding basics of C++, structures and objectives	K1, K2, K3
CLO 2	Learning I/O operators, functions and console	K1, K2, K3
CLO 3	Analyze the solutions f(x)=0 by using C++	K1, K2, K3
CLO 4	Analyze the solutions of linear system of equations with C++ and numerical differentiation and integration.	K2, K3, K4
CLO 5	Discuss the numerical solutions of ordinary differential equation.	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	1	1	2	2	3	1	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	2	1	2	2

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23UPMAT1E05	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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23UPMAT1E06	ANALYTIC NUMBER THEORY	L	T	P	C
		4	1	0	3

OBJECTIVE: The aim of this course is to teach the students about the basics of elementary number theory starting with the fundamental theorem of arithmetic, arithmetic functions, multiplicative functions, some equivalent forms of prime number theorem.

UNIT I: The Fundamental Theorem of Arithmetic

Divisibility – greatest common divisor – prime numbers – the fundamental theorem of arithmetic – the series of reciprocals of the primes – the euclidean algorithm – the gcd of more than two numbers.

UNIT II: Arithmetic functions and Dirichlet Multiplication

The Möbius function μ(n) – the Eulertotient functionφ(n) – a relation connecting φandμ - a product formula for φ(n) – the Dirichlet product of arithmetical functions – Dirichlet inverse and the Möbius inversion formula – the Mangoldt function Λ(n).

UNIT III: Multiplicative functions

Multiplicative functions – multiplicative functions and Dirichlet multiplication – the inverse of a completely multiplicative function – Liouville's function – the divisor functions – generalized convolutions.

UNIT IV: Averages of Arithmetical Functions

Asymptotic equality of functions – Euler's summation formula – some elementary asymptotic formula – the average order of d(n) – average order of the divisor functions the average order of φ(n) – the average order of μ(n) and of Λ(n).

UNIT V: Distribution of Prime Numbers

The partial sums of a Dirichlet product – applications to μ(n) and Λ(n) - Chebyshev's functions ψ(x) and I(x) – relations connecting I(x)and π(x).Some equivalent forms of the prime number theorem, inequalities for Λ(n) and pn.

TEXT BOOK:

Tom M. Apostol, *"Introduction to Analytic Number Theory",* Springer, International Student Edition, 2013.

UNIT	Chapter	Sections
I	1	full
II	2	2.1 – 2.8
III	2	2.9 – 2.14
IV	3	3.1 – 3.9
V	3	3.10, 3.11
	4	4.1 – 4.5

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. R.G. Ayoub, "An Introduction to the Analytic Theory of Numbers", Mathematical Survays, No.10, Providence, R.I, AMS Publications, 1963.
2. K. Chandrasekharan, "Introduction to Analytic Number Theory" ,Springer Verlag, 1968.
3. D.T. Newman, "Analytic Number Theory" GTM Vol 177, Correeted Edition, Springer, 2000.
4. HengHuat Chan, "Analytic Number Theory for undergraduate" World Scientific, 2009.
5. William Duke and Yuri Tschinkel, "Analysis Number Theory: A Tribute to Gauss and Dirichlet,Clay Mathematics"Proceeding Vol. 7, AMS Publication, Providence, RI, 2007.
6. H. Iwaniec, and E. Kowalski, "Analytic Number Theory" AMS Colloquium Publications, Vol. 53, AMS, 2004.

COURSE LEARNING OUTCOMES: Students will be able to

CLO	Statements	Knowledge Level
CLO 1	Know the definition and properties of Dirichlet product the Möbius inversion formula, the greatest integer function, Euler's phi-function.	K1, K2, K3
CLO 2	Analyze how analytical methods can be used to tackle problems in number theory. Famous examples include Prime Number Theorem about the asymptotic density of prime and Dtichlet theorem about prime numbers in arithmetic progressions.	K2, K3
CLO 3	Analyze the interrelationships between various arithmetical	K2, K3, K4
CLO 4	Understand some elementary identities involving μ(n) and Λ(n). This will be used in studying the distribution of primes.	K2, K3, K4
CLO 5	Apply multiplicative functions to deal with Dirichet series as functions of a complex variable.	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	3	2	2	3	3	1	1	2
CLO 2	2	2	1	3	3	3	2	2	3
CLO 3	1	1	2	3	2	3	1	1	3
CLO 4	1	3	3	3	3	3	1	1	2
CLO 5	1	1	2	3	3	3	1	1	2

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23UPMAT1E07	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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23UPMAT1E08	FUZZY SETS AND THEIR APPLICATIONS	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is to introduce the basic ideas of Fuzzy Sets; Fuzzy sets versus crisp sets, operation on Fuzzy sets, Fuzzy arithmetic and methods of contracting fuzzy sets.

UNIT I: Fuzzy sets

Fuzzy sets – Basic types – basic concepts – Characteristics- Significance of the paradigm shift - Additional properties of $\alpha-$cuts.

UNIT II: Fuzzy sets versus crisp sets

Representation of Fuzzy sets- Extension principle of Fuzzy sets – Operation on Fuzzy Sets – Types of operation – Fuzzy complements.

UNIT III: Operations on Fuzzy sets

Fuzzy intersection – t-norms, Fuzzy unions – t conorms-Combinations of operations – Aggregation operations.

UNIT IV: Fuzzy Arithmetic

Fuzzy numbers – Linguistic variables – Arithmetic operation on intervals – Lattice of Fuzzy numbers.

UNIT V: Constructing Fuzzy Sets

Methods of construction: an overview – direct methods with one expert – direct method with multiple experts – indirect method with multiple experts and one expert- Construction from sample data.

TEXT BOOK:

G. J. Klir and **Bo Yuan,** *"Fuzzy Sets and Fuzzy Logic: Theory and Applications"*, Prentice Hall of India Ltd, New Delhi, 2005.

UNIT	Chapter(s)	Sections
I	1 & 2	1.3 – 1.5, 2.1
II	2 & 3	2.2, 2.3, 3.1, 3.2
III	3	3.3 – 3.6
IV	4	4.1 – 4.4
V	10	10.1 – 10.7

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. H.J. Zimmermann, "*Fuzzy Set Theory and its Applications"*, Allied Publishers, Chennai, 1996.
2. A. Kaufman, "*Introduction to the Theory of Fuzzy Subsets"*, Academic Press, New York, 1975.
3. V. Novak, *"Fuzzy Sets and Their Applications"*, Adam Hilger, Bristol, 1969.

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

CLO	Statements	Knowledge level
CLO 1	Distinguish between the crisp set and fuzzy set concepts.	K1, K2
CLO 2	Draw a parallelism between crisp set operations and fuzzy set operations through the use of characteristic and membership functions, respectively.	K1, K2, K3
CLO 3	Define fuzzy sets using linguistic words and represent these sets by membership functions.	K1, k2, K3
CLO 4	Know how to perform mapping of fuzzy sets by a function and also use α– level sets in such instances.	K2, K3, K4
CLO 5	Become aware of the use of fuzzy inference systems in the design of intelligent or humanistic systems.	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	3	1	1	2
CLO 2	2	2	2	2	3	3	2	2	2
CLO 3	1	2	1	2	3	3	1	1	3
CLO 4	2	2	2	2	3	3	2	2	3
CLO 5	2	1	1	2	3	3	2	2	3

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23UPMAT1E09	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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23UPMAT1E10	MATHEMATICAL FOUNDATIONS OF DATA SCIENCE	L	T	P	C
		4	1	0	3

OBJECTIVE: This course introduces fundamental mathematical concepts required for getting into the field of data science.

UNIT – I: Data Science Fundamentals

Identifying and framing a data science problem in different fields - Data - Types, Pre-processing; Different types of Analytics - Introduction to Machine Learning, Artificial Intelligence.

UNIT – II: Probability

Probability axioms, Conditional Probability, Bayes' Theorem, Independence, Counting Problems, Discrete and Continuous Random Variables, Expectation, Iterated Expectation, Total Law of Probability, Covariance, Correlation, Entropy, Mutual Information.

UNIT – III: Computational Methods

Calculus for Data Science: Functions, Derivative, Partial derivative, Gradient of vector-valued functions and matrices and automatic differentiation, Second derivative Hessian matrix.

UNIT – IV: Linear Algebra

Vectors, Basis, Linear Dependence and Independence, Tensors, Scalars, Inner Products, Outer product, Norms, Basis, Orthogonal and Orthonormal Vectors, Orthogonalization and Normalization.

UNIT – V: Matrix

Linear transformation - Frobenius Norm, Matrix Multiplication, Solutions of system of algebraic equations; Matrix Decomposition - QR Factorization - Cholesky Decomposition**,** Eigen value Decomposition, Singular Value Decomposition, Principal Component Analysis.

TEXT BOOK

1. Shah, Chirag. *A Hands – On Introduction to Data Science*. Cambridge University Press, 2020.
2. Bertsekas, Dimitri P. and John N. Tsitsiklis. *Introduction to Probability*. Vol.1. Belmont, MA: Athena Scientific, 2002.
3. Shaw, Zed A. *Learn python 3 the hard way: A very simple introduction to the terrifyingly beautiful world of computers and code*. Addison-Wesley Professional, 2017.
4. Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong. Mathematics for Machine Learning. Cambridge University Press, 2020.(https://mml-book.github.io)
5. Gibert Strang . *Linear Algebra and Learning from Data*. Wellesley-Cambridge Press, 2019
6. Gibert Strang . *Linear Algebra for Everyone*, Wellesley-Cambridge Press, 2020.

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

CLO	Statements	Knowledge level
CLO 1	Understand the basic mathematical concepts in data science, related to linear algebra, probability, and calculus	K1, K2, K3
CLO 2	Employ techniques and methods related to these concepts in a variety of data science applications.	K1, K2, K3
CLO 3	Apply logical thinking to understand and solve problems	K1, K3, K3
CLO 4	Demonstrate skills in writing mathematics	K1, K2, K3
CLO 5	Adopt a rigorous and mathematical approach to solving problems in machine learning and data science.	K1, K2, K3

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	3	2	2	1
CLO 2	2	2	2	1	2	3	2	2	2
CLO 3	3	3	2	1	2	3	2	2	2
CLO 4	2	2	2	2	2	3	2	2	1
CLO 5	3	3	2	1	2	3	2	2	2

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23UPMAT1E11	CODING THEORY	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is to equip the students with knowledge of Coding theory which deals exclusively with binary codes and codes over Fields of character degree 2, stressing the construction, encoding and decoding of several important families of codes.

UNIT – I: Error - Correcting Codes

Detecting and correcting error patterns, Information rate, The effects of error detection and correction, Finding the most likely code word transmitted, Weight and distance, MLD, Errordetecting and correcting codes.

UNIT – II: Linear codes

Linear codes, bases for C = <S> and $C^{\perp}$, generating and parity check matrices, Equivalent codes, Distance of a linear code, MLD for a linear code, Reliability of IMLD for linear codes.

UNIT – III: Perfect codes, the Hamming and Golay codes

Perfect codes, Hamming code, Extended codes, Golay code and extended Golay code, RedHulles Codes.

UNIT – IV: Cyclic linear codes

Cyclic linear codes, Polynomial encoding and decoding, dual cyclic codes.

UNIT – V: BCH Codes over finite fields

BCH Codes, Cyclic Hamming Code, Decoding 2 error correcting BCH codes

TEXT BOOK

D.R. Hankerson, D.G. Hoffman, D.J. Leonard, C.C. Lidner, K.T. Phelps, C.A. Rodger and **J.R. Wall "***Coding Theory and Cryptography The Essentials",* Published by Marcel Dekker Inc, 2000.

UNIT	Chapter	Section
I	1	1.1 – 1.12
II	2	2.1 – 2.12
III	3	3.1 – 3.8
IV	4	4.1 – 4.5
V	5	5.1 – 5.5

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. E.R Berlekamp, *Algebriac Coding Theory,* Mc Graw-Hill, 1968
2. P.J Cameron and J.H Van Lint, *Graphs,* Coded and Designs CUP
3. H. Hill, *A First Course in Coding Theory,* OUP 1986.

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

CLO	Statements	Knowledge level
CLO 1	Understand the basic of error detection and correction in communication systems.	K1, K2, K3
CLO 2	Use various mathematical structures and methods for errors correction.	K1, K2, K3
CLO 3	Construct and implement algorithms for coding.	K2, K3, K4
CLO 4	Understand how the use of mathematical structures and methods reduce the complexity of error correction.	K2, K3, K4
CLO 5	Construct efficient codes for error correction.	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	2	2	3	1	1	3
CLO 2	1	2	2	2	2	3	2	2	3
CLO 3	2	2	2	3	3	3	1	2	3
CLO 4	1	2	2	3	3	3	1	1	3
CLO 5	1	1	2	3	3	3	1	2	2

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23UPMAT1E12	ALGEBRAIC NUMBER THEORY	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is to equip the students with knowledge of fundamental ideas of algebraic numbers which deals with the ring of integers of a number field and exploring factorization within it, cyclotomic fields, quadratic fields, the classification of Euclidean imaginary fields, the factorization theory of ideals in a ring of algebraic integers.

UNIT-I: Algebraic background

Rings and fields – factorization of polynomials field extensions – symmetric polynomials modules – free abelian groups

UNIT-II: Algebraic Numbers

Algebraic numbers – conjugate and discriminants – algebraic integers – integral bases – norms and traces – rings of integers

UNIT –III: Quadratic fields and factorization into irreducibles

Quadratic fields cyclotomic fields – trivial factorization into irreducibles – examples of non – unique factorization into irreducible.

UNIT – IV: Unique factorization Domain

Prime factorization – Euclidean domain – Euclidean quadratic fields – consequences of unique factorization – the Ramanujan – Nagell theorem

UNIT – V: Ideals

Historical background – prime factorization of ideals - the norm of an ideal – non unique factorization in cyclotomic fields.

TEXT BOOK:

1. **Ian stewart** and **David Tall**, Algebraic Number Theory and Fermat's Last Theorem, Third Edition, A.K. Peters Ltd., Natick, MA 0176,2002.

UNIT	Chapter	Section
I	1	1.1 to 1.6
II	2	2.1 to 2.6
III	3 & 4	3.1 to 3.2 & 4.1 to 4.4
IV	4	4.5 to 4.9
V	5	5.1 to 5.4

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Pierre Samuel, Algebraic Theory of Numbers, Dover Books on mathematics, 2013,
2. David S Dummit and Richard Foote, Abstract Algebra, 3rd Edition, Wiley student Edition, 2011.
3. TIFR Mathematical Pamphlet : Algebraic Number Theory (online),
4. M. Rosen and K. Ireland, A Classical Introduction to Number Theory, GTM, Springer, 1982
5. S.P. Serre, Local fields, GTM, Springer, 1995.

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

CLO	Statements	Knowledge level
CLO 1	Understand the fundamental facts about rings, fields, abelian groups and modules. Study the factorization of polynomials and the theory of elementary symmetric polynomials.	K1, K2, K3
CLO 2	Understand the concept of number field, conjugates and discriminates. Calculate the integral basis and discriminates.	K2, K3, K4
CLO 3	Study the quadratic fields are those of degree 2, the cyclotomic field and the elementary properties of units, associates and irreducible.	K2, K3, K4
CLO 4	Understand the characterization of uniqueness of factorization. Exhibit some number fields for which the ring of integers is Euclidean.	K3, K4, K5
CLO 5	Study the factorization of ideals. Calculate the norm of a principal ideal. Emphasize the correspondence between factorization of elements and principal ideals.	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	2	1	1	2	2	3	1	1	2
CLO 2	1	2	2	2	3	3	1	1	2
CLO 3	1	1	2	2	2	2	1	1	3
CLO 4	2	2	2	2	2	2	1	1	2
CLO 5	2	1	2	3	3	3	1	2	3

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23UPMAT1E13	LIE ALGEBRA	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is to enable the concepts of ideals and homomorphism of Lie algebras, Lie algebras of small dimension, solvable and nilpotent Lie algebras, Engel's Theorem, Lie's Theorem, Cartan's criteria, the root space decomposition of a semisimple Lie algebra and Dynkin diagram.

Unit I: Ideals and homomorphisms

Definition of Lie algebras - some example – Classical Algebras – Subalgebras and Ideals, Homomorphisms, Derivations – Structure Constants – Ideals and Homomorphisms – Constructions with Ideals – Quotient Algebras – Correspondence between Ideals.

Unit II: Engel's Theorem and Lie's Theorem

Low-Dimensional Lie Algebras – Dimensions 1,2, and 3 – Solvable Lie Algebras – Nilpotent Lie Algebras – Subalgebras of gl (V) – Weights – The invariance Lemma – Engel's Theorem – Lie's Theorem – Some representation Theory – Definitions – Examples of Representations – Modules for Lie Algebras – irreducible and Indecomposable Modules – Schur's Lemma

Unit III: Cartan's criteria

Representations of sl(2, **C**) – Classifying the Irreducible sl(2, **C**)-Modules – Weyl's Theorem – Cartan's criteria – Jordon Decomposition – Testing for Solvability – The Killing Form - Testing for Semisimplicity – Derivations of Semisimple Lie Algebras.

Unit IV: Root Systems

The root Space Decomposition – Cartan Subalgebras – Subalgebras Isomorphic to sl(2, C **) –** Root String and Eiganvalues **–** Cartan Subalgebras as Inner-Product Spaces – Root Systems – Bases for Root Systems – Cartan Matrices and Dynkin Diagrams.

Unit V: The Classification of root system

sl(ℓ + 1 , C**) –** so(2ℓ + 1 , C**) -** so(2ℓ + C**) -** sp(2ℓ , C**) –** Killing Forms of the Classical Lie Algebras – Root Systems and Isomorphisms – Classification of Dynkin Diagrams - Constructions

TEXT BOOK:

Karin Erdmann and **Mark J. Wildon**, Introduction to Lie Algebras, , Springer International Edition, 2009.

UNIT	Chapter(s)	Sections
I	1 and 2	1.1-1.7, 2.1 – 2.3
II	3, 4, 5, 6 and 7	3.1,3.2,4.1 -,4.3, 5.1 – 5.4, 6.1 – 6.4, 7.1 – 7.4
III	8 and 9	8.1 – 8.3, 9.1 – 9.6
IV	10 and 11	10.1 – 10.6, 11.1 – 11.4
V	12 and 13	12.1 – 12.7, 13.1, 13.2

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. N. Jacobson, LieAlgebras, Wiley-Interscience, New York, 1962.
2. J.P. Serre, LieAlgebras and LieGroups, Benjamin, New York, 1965.
3. Willi-Hans Steeb, I. Tamski and Y. Hardy, Problems and Solutions for Groups, Lie Algebras with Applications, World Scientific Publishing Co. Pvt Ltd, Singapore, 2012

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

CLO	Statements	Knowledge level
CLO 1	Understand the basics of Lie Algebras, solvable and nilpotent Lie algebras and apply it solve problems.	K1, K2, K3
CLO 2	Study the classification of finite dimensional complex simple Lie algebras, irreducible and indecomposable modules for Lie algebras.	K2, K3, k4
CLO 3	Study the finite dimensional and irreducible representations of sl(2, C), Jordan decomposition and testing for solvability.	K2, K3, K4
CLO 4	Describe the root space decomposition of semisimple Lie algebras.	K3, K4, K5
CLO 5	Study Dynkin diagrams and apply it to 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	2	2	2	2	3	2	3	3
CLO 2	1	1	1	2	2	3	1	2	3
CLO 3	2	2	2	2	2	3	2	2	3
CLO 4	1	2	2	2	3	3	1	2	3
CLO 5	2	2	2	2	3	3	2	2	3

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23UPMAT1E14	STATISTICAL DATA ANALYSIS USING R PROGRAMMING	L	T	P	C
		4	1	0	3

OBJECTIVE: This course provides knowledge

- Use R for statistical programming, computation, graphics and modeling.
- Write functions and use R in an efficient way.
- Fit some basic types of statistical models.

UNIT-I: Introduction to R programming

What is R? - Installing R and R Studio – R Studio Overview - Working in the Console - Arithmetic Operators - Logical Operations - Using Functions - Getting Help in R and Quitting R Studio- Installing and loading packages. **Data structures, variables, and data types in R**: Creating Variables - Numeric, Character and Logical Data - Vectors - Data Frames - Factors -Sorting Numeric, Character, and Factor Vectors - Special Values.

UNIT-II: Data Visualization using R

Scatter Plots - Box Plots - Scatter Plots and Box-and-Whisker Plots Together -Customize plot axes, labels, add legends, and
add colours.

UNIT –III: Descriptive statistics in R

Measures of central tendency - Measures of variability - Skewness and kurtosis - Summary functions, describe functions,and descriptive statistics by group.

UNIT – IV: Testing of Hypothesis using R

T-test, Paired Test, correlation, Chi Square test, Analysis of Variance and Correlation

UNIT – V: Predictive Analytics

linear Regression model, **Non-Linear Least Square,** multiple regression analysis, Logistic Regression, Panel Regression Analysis,ARCH Model, GARCH models, VIF model.

TEXT BOOK:

1. Crawley, M. J. (2006), “Statistics - An introduction using R”, John Wiley, London 32.
2. Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015), “Statistics using R”, second edition.Narosa Publishing House, New Delhi.
3. Shahababa B. (2011) , “Biostatistics with R”, Springer, New York.
4. Braun & Murdoch (2007), “A first course in statistical programming with R”, CambridgeUniversity Press, New Delhi.

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Timothy C. Heeren, Basic Statistical Analysis using the R Statistical Package, Boston University School of Public Health, 2016.
2. C. Heumann, M. Schomaker and Shalabh, Introduction to Statistics and Data Analysis with Exercises, Solutions and Applications in R, Springer, 2016.

WEBSITE AND E-LEARNING SOURCE

1. https://cran.r-project.org/doc/contrib/Owen-TheRGuide.pdf
2. https://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/R/R-Manual/R-Manual2.html
3. https://smac-group.github.io/ds/
4. https://www.geeksforgeeks.org/predictive-analysis-in-r programming/#:~:text=Predictive%20analysis%20in%20R%20Language,are%20used%20in%20predictive%20analysis

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

CLO	Statements	Knowledge level
CLO 1	Apply R programming and understand different data sets	K1, K2, K3
CLO 2	Apply R Programme and construct graphs and charts	K2, K3, K4
CLO 3	Analyze the data and know descriptive statistics by using R Programming	K2, K3, K4
CLO 4	Apply R Programming to test the hypothesis of the study	K3, K4, K5
CLO 5	Predict the data and take decisions through R programming.	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	1	2
CLO 2	1	2	2	2	2	2	1	2	3
CLO 3	1	1	1	2	2	3	1	1	2
CLO 4	1	2	2	2	2	2	1	2	2
CLO 5	1	2	2	2	2	2	1	3	2

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23UPMAT1E15	TENSOR ANALYSIS AND RELATIVITY THEORY	L	T	P	C
		4	1	0	3

OBJECTIVE: The objectives of this course are

- To understand the concept of tensor variables and difference from scalar or vector variables.
- Express the transformation of tensors and explain the first and 2^{nd} kind of christoffel's symbols .
- To study Galilean transformations.
- To study the principle of relativity and relativistic kinematics

UNIT-I: TENSOR ALGEBRA

Systems of Different orders – Summation Convention – Kronecker Symbols –Transformation of coordinates in S_n - Invariants – Covariant and Contravariant vector- Tensors of Second Order - Mixed Tensors - Zero Tensor - Tensor Field - Algebra of Tensors – Equality of Tensors – Symmetric and Skew–symmetric tensors –Outer multiplication, Contraction and Inner Multiplication – Quotient Law of Tensors –Reciprocal Tensor of Tensor – Relative Tensor – Cross Product of Vectors.

UNIT-II: TENSOR CALCULUS

Riemannian Space – Christoffel Symbols and their properties

UNIT-III: TENSOR CALCULUS (Contd...)

Covariant Differentiation of Tensors – Riemann - Christoffel Curvature Tensor - Intrinsic Differentiation.

UNIT-IV: SPECIAL THEORY OF RELATIVITY

Galilean Transformation - Maxwell's equations - The ether Theory - The Principle of Relativity.

Relativistic Kinematics : Lorentz Transformation equations - Events and simultaneity –Example – Einstein Train – Time dilation – Longitudinal Contraction – Invariant Interval -Proper time and Proper distance - World line - Example - twin paradox - addition of velocities – Relativistic Doppler effect.

UNIT-V: RELATIVISTIC DYNAMICS

Momentum – Energy - Momentum - energy four vector- Force - Conservation of Energy - Mass and energy - Example - inelastic collision - Principle of equivalence –Lagrangian and Hamiltonian formulations.

Accelerated Systems: Rocket with constant acceleration - example - Rocket with constant thrust

TEXT BOOKS:

1. **U.C. De, Absos Ali Shaikh** and **Joydeep Sengupta**, *Tensor Calculus*, Narosa Publishing House, New Delhi, 2004.
2. **D. Greenwood**, *Classical Dynamics*, Prentice Hall of India, New Delhi, 1985.

UNIT	Book	Chapter	Section
I	1	1 & 2	1.1 – 1.3, 1.7, 1.8 2.1 – 2.19
II	1	3	3.1 & 3.2
III	1	3	3.3 – 3.5
IV	2	7	7.1 & 7.2
V	2	7	7.3 & 7.4

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. J. L. Synge and A. Schild, *Tensor Calculus*, Toronto, 1949.
2. A.S. Eddington, *The Mathematical Theory of Relativity*, Cambridge University Press, 1930.
3. P.G. Bergman, *An Introduction to Theory of Relativity*, New York,1942
4. C.E. Weatherburn, *Riemannian Geometry and the Tensor Calculus*, Cambridge, 1938.

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

CLO	Statements	Knowledge level
CLO 1	Understand basic concepts of Tensors.	K1, K2, K3
CLO 2	Understand Christoffel Symbols and problems.	K2, K3, K4
CLO 3	Understand tensor differentiation and Christoffel curvature tensor.	K2, K3, K4
CLO 4	Understand Galilean transformation, principle of relativity and realistic kinematics.	K2, K3, K4
CLO 5	Understand the principle of equivalence and accelerated systems.	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	1	1	2	2	2	2	2	2
CLO 2	1	1	1	2	2	3	1	2	3
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	2	2	2	3	1	2	3

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23UPMAT1E16	COMBINATORIAL MATHEMATICS	L	T	P	C
		4	1	0	3

OBJECTIVE: Combinatorial mathematics is the study of the arrangements of objects, according to prescribed rules, to count the number of possible arrangements or patterns, to determine whether a pattern of a specified kind exists and to find methods of constructing arrangements of a given type. The objective of this course is to acquaint the students with the concepts of permutations and combinatorics, generating functions, recurrence relations, the principle of inclusion and exclusion and Polya's theory of counting.

UNIT I: Permutations and Combinatorics

The Rules of sum and product – Permutations – Combinations – Distributions of distinct objects – Distribution of nondistinct objects.

UNIT II: Generating Functions

Generating functions for combinations – Enumerators for permutations- Distributions of distinct objects into nondistinct cells – Partitions of integers – The Ferrers graph – Elementary relations.

UNIT III: Recurrence relations

Linear recurrence relations with constant coefficients – Solution by the technique of generating functions – A special class of nonlinear difference equations – Recurrence relations with two indices.

UNIT IV: The Principle of inclusion and exclusion

The Principle of inclusion and exclusion – The general formula – Derangements – Permutations with restrictions on relative positions – The rook polynomials – Permutations with forbidden positions.

UNIT V: Polya's theory of counting

Sets, relations and groups – Equivalence classes under a permutation group – Equivalence classes of functions – Polya's fundamental theorem.

TEXT BOOK

C.L. Liu, *"Introduction to Combinatorial Mathematics",* McGraw Hill Book Company, New York, 1968.

UNIT	Chapter(s)	Sections
I	1	1.1 – 1.7
II	2	2.1 – 2.7
III	3	3.1 – 3.5
IV	4	4.1 – 4.7
V	5	5.1 – 5.7

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Murray Edelbergand C.L. Liu, *"Solutions to Problems in Introduction to Combinatorial Mathematics"*, MC Grow-Hill Book & Co., New York, 1968.
2. R.P. Stanley, *"Enumerative Combinatorics*", Volume I, 2nd Edition, Cambridge Studies in Advanced Mathematics (Book 49)s, Cambridge University Press, 1997.
3. P.J. Cameron, *"Combinatorics: Topics, Techniques, Algorithms*", Cambridge University Press, Cambridge, 1998.
4. Miklos Bona, *"A Walk through Combinatorics*", World Scientific Publishing Company, 2002.
5. M. 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	Use formulas for counting basic combinatorial outcomes to construct solutions to complete combinatorial enumeration problems: • permutation with and without repetitions; • combination with and without repetitions.	K1, K2
CLO 2	Apply counting strategies to solve discrete probability problems.	K1, K2, K3
CLO 3	Use specialized techniques to solve combinatorial enumeration problems: • generating functions; • recurrence relations; • Inclusion-exclusion principle.	K2, K3, K4
CLO 4	Understand the concepts of permutations with restrictions on relative positions and the rook polynomials.	K3, K4, K5
CLO 5	Enumerate configuration using Polya's theory.	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	1	1	1	3	2	1	1	1	2
CLO 2	1	1	2	3	2	2	1	2	2
CLO 3	2	2	2	3	2	2	2	2	2
CLO 4	1	2	2	3	3	2	1	2	2
CLO 5	2	1	1	1	2	2	1	1	2

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23UPMAT1E17	COMMUTATIVE ALGEBRA	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is to study modules, exact sequences, tensor product of modules, local properties, primary decomposition, Noetherian rings and Artinian rings. Also, another important class of Dedekind domain is studied.

Unit I: Rings and Ideals

Rings and ring homomorphism's – ideals – Extension and Contraction, modules and module homomorphism – exact sequences.

Unit II: Rings and Modules of Fractions

Tensor product of modules – Tensor product of algebra – Local properties – extended and contracted ideals in rings of fractions.

Unit III: Primary Decomposition

Primary Decomposition – Integral dependence – The going-up theorem – The going-down theorem – Valuation rings.

Unit IV: Noethorian rings

Chain conditions – Primary decomposition in Noetherian rings.

Unit V: Artin local rings

Artin rings – Discrete valuation rings – Dedekind domains – Fractional ideals.

TEXT BOOK:

S.M. Atiyah and **I.G. Macdonald**, *"Introduction to Commutative Algebra"*, Addison – Wesley Publication Company, Inc, 1969.

UNIT	Chapter(s)	Pages
I	1, 2	1 - 24
II	2, 3	24 - 49
III	4, 5	50 - 73
IV	6, 7	74 – 88
V	8, 9	89 – 99

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. N.S. Gopalakrishnan, *"Commutative Algebra"*, Oxonian Press Pvt. Ltd, New Delhi, 2015.
2. I. Kaplansky, *"Commutative Rings*", University of Chicago Press, Chicago, 1974.
3. H. Matsumura, *"Commutative Ring Theory*", Cambridge University Press, 1986.

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

CLO	Statements	Knowledge level
CLO 1	Know the definition of commutative rings, local rings, prime and maximal ideals and modules over commutative rings.	K1, K2, K3
CLO 2	Understand the important properties and applications of exact sequences.	K1, K2, K3
CLO 3	Understand how to define tensor products of modules and the concept of flatness.	K1, K2, K3
CLO 4	Analyze about localize rings and modules, and the important applications of localization.	K2, K3, K4
CLO 5	Apply the notions of Noetherian and Artinian rings and modules, Hilbert basis theorem and the structure theorem for Artinian rings.	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	2	2	1	1	2
CLO 2	1	2	2	3	2	1	1	1	3
CLO 3	1	2	2	3	2	1	1	2	3
CLO 4	2	2	2	3	2	3	2	2	3
CLO 5	2	2	2	3	2	2	2	2	2

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23UPMAT1E18	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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23UPMAT1E19	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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23UPMAT1E20	WAVELETS	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is to introduce the basic notions and techniques of Wavelets theory.

UNIT-I: The Discrete Fourier Transforms

Basic Properties of Discrete Fourier Transforms, Translation Invariant Linear Transforms, The Fast Fourier Transforms.

UNIT-II: Wavelets on Z

Construction of Wavelets on Z_n – The First Stage, Construction of Wavelets on Z_n –the Iteration Step.

UNIT –III: Wavelets on Z_n

$l^2(Z)$, Complete Orthonormal Sets in Hilbert Spaces, $L^2([\pi,\pi])$ and Fourier Series, The Fourier Transform and convolution on $l^2(Z)$, First-Stage Wavelets on Z, Implementation and Examples.

UNIT – IV: Wavelets on R

$L^2(R)$ and Approximate identities, The Fourier Transform on R, Multiresolution Analysis and Wavelets, Construction of Multiresolution Analysis.

UNIT – V:Wavelets and Differential Equations

The Condition Number of a matrix, Finite Difference methods for Differential Equation, Wavelet – Galerkin Methods for Differential Equations.

TEXT BOOK:

1. **Michael W. Frazier** "An Introduction to Wavelets Through Linear Algebra" Springer New York, 1999.

UNIT	Chapter(s)	Sections
I	2	2.1 – 2.3
II	3	3.1 – 3.2
III	4	4.1 – 5.5, 4.7
IV	5	5.1 – 5.4
V	6	6.1 – 6.3

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Benedetto .J and Frazier .M, Wavelets: Mathematics and Applications, CRC Press, Boca Raton, Fla., 1993.
2. Beylkin .G, Coifman .R and Rokhlin .V, Wavelets in numerical analysis, in M. Ruskai at al., eds., Wavelets and Their Applications, Jones and Bartlett, Boston, 1992, 181-210.
3. Chui .C, An Introduction to wavelets, Academic Press, Boston, 1992.
4. Hernández .E and Weiss .G, A First course in Wavelets, CRC Press, Boca Ratan, FL, 1996.

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 Discrete Fourier Transform	K1, K2, K3
CLO 2	Understand the applied structure through wavelets. Construct wavelets iteration.	K1, K2, K3
CLO 3	Familiarize the knowledge on applications of Fourier transforms. Analyse the properties of complete orthonormal sets in inner product spaces.	K2, K3, K4
CLO 4	Construct wavelet systems, which are complete orthonormal sets for L2 (R) of a particular form.	K3, K4, K5
CLO 5	Solving numerically a linear ODE by various methods and using the Galerkin method with wavelet systems.	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	3	3	1	2	3
CLO 2	2	2	2	2	3	3	2	2	3
CLO 3	1	2	2	2	3	3	1	2	3
CLO 4	1	2	2	2	3	3	1	2	3
CLO 5	1	1	1	2	2	3	1	2	2

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23UPMAT1E21	MODELING AND SIMULATION WITH EXCEL	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is

- To learn basics of modeling, how models can be used and how to construct them, methods for constructing Monte Carlo simulations, Monte Carlo simulation uses random numbers to model the probability distributions of outcomes for certain variable in our problems.
- To develop a sampling mechanism to determine the random Poisson arrivals of autos.
- To introduce the optimization tools solver and scenario.

UNIT-I: Modeling Concepts

What is a model? – how do we classify models? – an example of deterministic modeling – Understanding the important elements of a model: pre modeling or design phase, modeling phase, resolution of weather and related attendance, summary of OLPs modeling effort.

UNIT-II: Model Building with Excel

Basic model – sensitivity analysis – Controls from the forms control tools – option buttons – scroll bars – types of simulation and uncertainty: incorporating uncertain processes in models.

UNIT –III: Intro to Simulation

The Monte carlo sampling methodology: implementing Mote Carlo simulation methods, a word about probability distribution, modeling arrivals with the Poisson distributions, VLOOKUP and HLOOKUP functions – a financial example – income statement.

UNIT – IV: Autohaus an example of Operations

Status of Autohaus model – building the brain worksheet – building the calculation worksheet – consideration of modeling accuracy – sufficient sample size – building the data collection worksheet – summary.

UNIT – V: Solver and Scenarios

Solver – constrained optimization – Example-York river archaeology budgeting: formulation, formulation of YRA problem, preparing a solver worksheet, using solver, solver report, some questions for YRA – scenarios.

TEXT BOOK:

Hector Guerrero, Excel Data Analysis: Modeling and Simulation, 2nd Edition, Springer Nature Switzerland AG, 2019.

UNIT	Chapter(s)	Pages
I	7	225 - 244
II	7 & 8	245 - 267
III	8	268 - 285
IV	8 & 9	286 - 308
V	9	311 - 337

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Averil M Law and W. David Kelton, Simulation modeling and Analysis, 5/e, McGraw, Hill, 2015.
2. TayFur Altiok and Benjamin Melamed, Simulation modeling and Analysis with Arena, 2007.
3. Ben Hiron, Grimes, How Excel Simulation and Modeling Speeds up Data Analysis, 2021.

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

CLO	Statements	Knowledge level
CLO 1	Understand the concepts of excel database functions in excel, creating charts using forms and control.	K1, K2, K3
CLO 2	Identify different types of models and simulations including discrete-event and continuous simulation.	K2, K3, K4
CLO 3	Understand the basic methods for generating random variables and variates,	K3, K4, K5
CLO 4	Analyze modeling and simulation input and output data.	K3, K4, K5
CLO 5	Analyze optimization models and modeling uncertainty.	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	2	2
CLO 2	1	2	2	2	2	3	1	2	3
CLO 3	1	1	1	2	2	3	1	2	3
CLO 4	1	2	2	2	2	2	1	2	2
CLO 5	1	2	2	2	2	3	1	2	3

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23UPMAT1E22	MECHINE LEARNING AND ARTIFICIAL INTELLIGENCE	L	T	P	C
		4	1	0	3

OBJECTIVE: This course is aimed at building the foundation of computational thinking with applications to Artificial Intelligence and Machine learning (AI & ML). Besides, how to build a neural network and how to train, evaluate and optimize it with TensorFlow will also be covered in this course.

UNIT – I: Programming Foundation

Digital storage of data in computers, memory and data representation, Overflow and Underflow, Round-off errors, the performance of a computer, Caches, Debugging and Profiling, Basic optimization techniques for serial code.

UNIT – II: Introduction to Python

Object and Data Structure Basics, Python Statements, Methods andFunctions,Object-orientedprogramming(OOP):Inheritance,Encapsulation,Abstraction,Polymorphism. OOP concepts in Python.

UNIT – III: Python tools for Data Science

Pandas, NumPy, Matplotlib, Scikit-Learn, Just-in-Time (JIT) compilers, Numba.

UNIT – IV: Computational Thinking

Arrays, Matrix-Vector, Matrix multiplication, Solving dense and sparse systems.

UNIT – V: Deep Learning with Tensor Flow

Tensors, Install TensorFlow, TensorFlow basics, Simple statistics and plotting, Loading and exploring data, learning with TensorFlow and Keras, Mini-project.

TEXT BOOK

1. John Hennessy David Patterson. Computer Architecture. A Quantitative Approach. 6thedition, Morgan Kauffman, 2017. https://www.elsevier.com/books/computer-architecture/hennessy/978-0-12-811905-1
2. Shaw, Zed A. *Learn python 3 the hard way: A very simple introduction to the terrifyingly beautiful world of computers and code*.Addison-Wesley Professional, 2017.
3. Aurélien Géron, Hands-O Machine Learning with Scikit-Learn, Keras, and Tensor Flow, 2nd Edition, O'Reilly Media, Inc. 2019.

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

CLO	Statements	Knowledge level
CLO 1	Develop the soft skills required for data science career**.**	K1, K2
CLO 2	To learn basics of data structure and object-oriented programming (OOP)	K1, K2, k3
CLO 3	To learn basics of python tools	K1, k2, k3
CLO 4	Understanding computational thinking	K2, K3, k4
CLO 5	Application of tensors flow to deep learning	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	1	2	2	2	3	1	1	2
CLO 2	1	1	1	2	2	3	1	1	2
CLO 3	1	1	1	2	2	2	1	1	2
CLO 4	1	1	1	2	2	3	1	1	3
CLO 5	2	2	2	2	2	3	2	2	3

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23UPMAT1E23	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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23UPMAT1E24	NURAL NETWORKS	L	T	P	C
		4	1	0	3

OBJECTIVE:

This course enables the students to learn

- The neural networks for classification and regression
- The design methodologies for neural networks
- About the multi-layer perception.
- The introduction and different architectures of Back propagation Algorithm.
- The fundamental concepts of optimization in neural networks.
- To develop and train radial-basis function networks.

UNIT – I: Evolution Of Neural Networks

Mathematical Neuron Model – Network Architectures – Perceptron –Hamming Network-Hopfield Network-Learning Rules.

UNIT – II: Perceptron Learning Rule

Perceptron Architectures and Learning Rule with Proof of Convergence. Supervised Hebbian Learning-Linear Associator.

UNIT – III: Multi-Layer Perceptrons

The Hebb Rule-Pseudo inverse Rule - Variations of Hebbian Learning - Back Propagation –Multilayer Perceptrons.

UNIT – IV: Back Propagation

Back propagation Algorithm - Convergence and Generalization –Performances Surfaces and Optimum Points - Taylor series.

UNIT – V: Optimitation in Neural Network

Directional Derivatives - Minima-Necessary Conditions for Optimality – Quadratic Functions-Performance Optimizations – Steepest Descent - Newton's Method – Conjugate Gradient.

TEXT BOOK

1. Martin T Hagan., Howard B Demuth., and Mark Beale., (2014). Neural Network Design, Vikas, Publishing House, New Delhi,
2. James A Freeman., and David M Skapura., (2011). Neural Networks Algorithms, Applications and Programming Techniques, Pearson Education.
3. Robert J Schalkoff., Artificial Neural Network, McGraw-Hill International Edition, 2000.

WEBSITELINK

1. https://ocw.mit.edu/courses/brain-and-cognitive-sciences/9-641j-introduction-to-neural-networks-spring-2005/
2. https://www.youtube.com/watch?v=xbYgKoG4x2g&list=PL53BE265CE4A6C05

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

CLO	Statements	Knowledge level
CLO 1	Comprehend the concepts of feed forward neural networks	K1, K2, K3
CLO 2	Analyze the various Linear Associator.	K2, K3
CLO 3	Design single and multi-layer feed-forward neural networks	K2, K3, K4
CLO 4	Analyze the various Back Propagation Algorithm	K2, K3, K4
CLO 5	Supervised learning and unsupervised learning.	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	3	3
CLO 2	1	2	2	2	3	3	1	2	3
CLO 3	1	2	2	2	3	3	1	2	3
CLO 4	1	1	2	2	2	3	1	2	2
CLO 5	1	2	2	3	3	3	1	3	3

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23UPMAT1E25	REPRESENTATION THEORY OF FINITE GROUPS	L	T	P	C
		4	1	0	4

OBJECTIVE: Representation theory, the art of realizing a group in a concrete way, usually as a collection of matrices, is a fundamental tool for studying groups by means of linear algebra. The results of the theory of representations of finite groups play a fundamental role in many recent developments of mathematics and theoretical physics. The study of the representation theory of groups becomes a special case of the study of modules over rings. This course provides the concepts of the characters of groups and the basic properties of irreducible characters and their connection with the ring structure of group algebras.

UNIT I: Group representations

Group representations – FG Modules – FG - submodules and Reducibility- Group algebras.

UNIT II: Group algebra

FG-homomorphisms – Maschke's theorem – Consequences of Maschke's theorem – Schur's lemma – Irreducible modules and the group algebra.

UNIT III: More on the group algebra

More on the group algebra – The spaces of FG-homeomorphisms – Conjugacy classes - Conjugacy class sizes – Characters – The values of a character – The regular character.

UNIT IV: Irreducible characters

Inner product of characters – Applications – Decomposing CG-modules – Class functions – The number of irreducible characters.

UNIT V: Character tables

Character Tables and Orthogonality relations- Normal subgroups and Lifted characters- Some Elementary Character Tables.

TEXT BOOK:

G. James and **M. Liebeck**, "*Representations and Characters of Groups"*, 2nd Edition, Cambridge University Press, London, 2001.

UNIT	Chapter(s)
I	3 – 6
II	7 – 10
III	11 – 13
IV	14 – 15
V	16 – 18

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **C.W. Curtis** and **I.Reiner**, *"Methods of Representation Theory with Applications to Finite Groups and Orders*", Volume 1, Wiley – Interscience, New York, 1981.
2. **J.P. Serre**, *"Linear Representation of Finite Groups"*, Springer-Verlag, New York, 1977.
3. **W. Fulton** and **J. Harris**, *"Representation Theory – A First Course"*, Graduate Texts in Mathematics 129, Springer – Verlag, New York, 1991.

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

CLO	Statements	Knowledge level
CLO 1	Find the number of irreducible representations of a finite group	K1, K2, K3
CLO 2	Understand the special role played by the famous Maschke's Theorem	K1, K2, K3
CLO 3	Find a finite set of irreducible CG-modules such that every irreducible CG-module is isomorphic to one of them.	K2, K3, K4
CLO 4	Calculate the dimension of Hom(V,W) over CG.	K3, K4, K5
CLO 5	Find a method for decomposing a given CG-module as a direct sum of CG-sub modules, using characters.	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	1	2
CLO 2	1	1	1	2	2	3	1	2	3
CLO 3	1	1	1	2	2	3	1	2	3
CLO 4	1	2	2	2	3	3	1	2	3
CLO 5	1	2	2	2	3	3	1	2	3

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23UPMAT1E26	ALGEBRAIC TOPOLOGY	L	T	P	C
		4	1	0	3

OBJECTIVE: This is a basic course in algebraic topology where we introduce the notion of fundamental groups, covering spaces, methods for computing fundamental groups using Seifert Van Kampen theorem and some applications such as the Brouwer's fixed point theorem, Borsuk Ulam theorem, fundamental theorem of algebra. We discuss some classical groups and their fundamental groups. The second part of the course concerns singular homology theory and would cover all the standard machinery such as homotopy invariance of homology, relationship with the fundamental group, excision and the Mayer Vietoris sequence.
After discussing the relative versions, the course closes with the proof of the famous Jordan Brouwer separation theorem.

UNIT – I: Basic Topological Notions
Homotopy – convexity, contractibility and cones – paths and path connectedness – affine spaces - affine maps.

UNIT – II: The fundamental group
The fundamental groupoid – the functorπ_1 - π_1 (S^1) – Holes and Green's theorem – free abelian groups – the singular complex and homology functors.

UNIT – III: Singular Homology
Dimension axiom and compact supports – the homotopy axiom – the Hurewicz theorem – the category Comp.

UNIT – IV: Long Exact Sequence
Exact homology sequences – reduced homology – simplicial complexes: definitions-simplicial approximation – abstract simplicial complexes – simplicial homology.

UNIT – V: Simplicial Complexes
Comparison with singular homology – calculations – fundamental groups of polyhedra – the Seifert – van Kampen theorem.

TEXT BOOK
J.J. Rotman, *"An Introduction to Algebraic Topology"*, GTM Vol.119, Springer International Edition, 1998.

UNIT	Chapter	Pages
I	1 and 2	14 - 38
II	3 and 4	39 - 68
III	4 and 5	68 - 93
IV	5 and 7	93 – 105, 131 - 147
V	7	147 - 179

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **J.F. Adams**, Algebraic Topology: A Students Guide, Cambridge University Press, Cambridge, 1972.
2. **E. Artin** and **H. Brawn**, Introduction to Algebraic Topology, Merril, Westerville, OH, 1969.
3. **J.R. Munkress**, Elements of Algebraic Topology, Addison-Wesley, Reading, MA, 1984.
4. **A. Hatcher**, Algebraic Topology, Cambridge University Press, Cambridge, 2002.

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

CLO	Statements	Knowledge level
CLO 1	Compute algebraic invariants associated to topological spaces and maps between them.	K1, K2, K3
CLO 2	Know about the fundamental group and covering spaces.	K3, K4, K5
CLO 3	Understand the basic algebraic and geometric ideas that underpin homology and cohomology theory. These include the cup product and Poincare Duality for manifolds.	K3, K4, K5
CLO 4	Give the definition of simplicial complexes and their homology groups and a geometric understanding of what these groups measure.	K3, K4, K5
CLO 5	Give the extension to singular homology and develop a geometric understanding of how to use these groups in practice.	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	2	2	2	2	3	3	2	2	3
CLO 2	1	2	2	2	3	3	1	2	3
CLO 3	1	2	2	2	3	3	1	2	3
CLO 4	1	2	3	2	3	3	1	3	3
CLO 5	2	2	2	2	3	3	2	3	3

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23UPMAT1E27	FLUID DYNAMICS	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is

- To give fundamental knowledge of fluid, its properties and behavior under various conditions of internal and external flows.
- To understand basic laws and equations used for analysis of static and dynamic fluids.
- To develop an appreciation for the properties of Newtonian fluids.
- To understand the dynamics of fluid flows and the governing non-dimensional parameters

Unit I: Inviscid Theory

Introductory Notions, velocity: Streamlines and paths of the particles-stream tubes and filaments-fluid body- Density – Pressure – Bernoulli's theorem. Differentiation with respect to time- Equation of continuity- Boundary conditions: kinematical and physical – Rate of change of linear momentum – The equation of motion of an inviscid fluid.

Unit II: Inviscid Theory (contd...)

Euler's momentum theorem- conservative forces – Lagrangian form of the equation of motion – Steady motion – The energy equation – Rate of change of circulation – Vortex motion – Permanence of vorticity.

Unit III: Two Dimensional Motions

Two dimensional functions: Stream function – Velocity potential – Complex potential – Indirect approach – Inverse function. Basic singularities: Source – Doublet – Vortex – Mixed flow – Method of images: Circle theorem – Flow past circular cylinder with circulation. The aerofoil: Blasius's theorem – Lift force.

Unit IV: Viscous Theory

The equations of motion for viscous flow: The stress tensor – The Navier-Stokes equations – Vorticity and circulation in a viscous fluid. Flow between parallel flat plates: Couette flow, Plane Poiseuille flow. Steady flow in pipes: Hagen-Poiseuille flow.

Unit V: Boundary Layer Theory

Boundary layer concept- Boundary layer equations in two dimensional flow- Boundary layer along a flat plate: Blasius solution – Shearing stress and boundary layer thickness – Momentum integral theorem for the boundary layer: The von Karman integral relation – von Karman integral relation by momentum law.

TEXT BOOKS:

1. **L.M. Milne Thomson**, "*Theoretical Hydrodynamics"*, Dover, 1996.
2. **N. Curle**and **H.J. Davies**, "*Modern Fluid Dynamics Vol-I"* by, D Van Nostrand Company Ltd., London, 1968.
3. **S.W. Yuan,** *"Foundations of Fluid Mechanics"* by Prentice- Hall of India, New Delhi, 1988.

UNIT	Chapter(s)	Sections
I	I & III of [1]	1.0 – 1.4, 3.10 – 3.31, 3.40, 3.41
II	III of [1]	3.42 – 3.45, 3.50 – 3.53
III	3 of [2]	3.2, 3.3, 3.5 - 3.5.1, 3.5.2, 3.7.4, 3.7.5
IV	5 of [2]	5.2.1- 5.2.3
	8 of [3]	8.3 – a,b, 8.4 – a
V	9 of [3]	9.1, 9.2, 9.3 – a,b, 9.5 – a,b

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **R.K. Bansal**, *"An Introduction to Fluid Dynamics",* Firewall Media, 2005.
2. **G.K. Batchelor,** *"An Introduction to Fluid Dynamics",* Cambridge University Press, 2000.
3. **F. Chorlton,** *"Text Book of Fluid Dynamics*", CBS Publications, Delhi, 1985.
4. **D.E. Rutherford**, *"Fluid Dynamics",* Oliver and Boyd, 1959.

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

CLO	Statements	Knowledge level
CLO 1	Recognize and find the values of fluid properties	K1, K2, K3
CLO 2	The relationship between them and understand the principles of continuity, momentum, and energy as applied to fluid motions.	K1, K2, K3
CLO 3	Identify these principles written in form of mathematical equations.	K1, K2, K3
CLO 4	Application of The Navier-Stokes equations	K2, K3, K4
CLO 5	Apply dimensional analysis to predict physical parameters that influence the flow in fluid mechanics.	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	1	2
CLO 2	1	2	2	2	2	3	1	1	2
CLO 3	2	2	2	2	3	3	2	2	3
CLO 4	1	2	2	2	3	3	1	2	3
CLO 5	1	2	2	3	3	3	1	3	3

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23UPMAT1E28	STOCHASTIC PROCESS	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is to enable the students to under the concepts of probability theory and random variable sums of independent and identically distributed random variables, decomposition of arrival process, Markov chains, computation of R and F, Markov and strong Markov properties, limiting properties of transition functions.

UNIT I: Probability Spaces and Random Variables

Probability spaces, Random Variables and Stochastic Processes, Conditional Probability, Expected Value, Conditional Expectations

UNIT II: Bernoulli Process and Poisson Process

Bernoulli Process, Number of Successes, Times of Successes, Sum of Independent Random Variables, Arrival Counting Process, Times of Arrival

UNIT III: Markav Chains

Forward Recurrence Times, Superposition of Poisson Processes, Decomposion of Poisson Processes, Compound Poisson Processes, Introduction to Markov Chain, Visits to a Fixed State

UNIT IV: Limiting Behaviour and Applications of Markov Chains

Classification of States, Computation of R and F, Recurrent States and the Limiting probabilities, Periodic States, Transient States

UNIT V: Markov Processes

Markov Processes, Sample path behavior, Structure of a Markov Process Potentials and Generators, Limit Theorem.

TEXT BOOKS:

1. **K: Erhan Cinlar**, Introduction to Stochastic Processes, First Edition, Dover Publication, Inc. Mineola, New York, 2013.

UNIT	Chapter(s)	Sections
I	1 & 2	1.1 – 1.3, 2.1, 2.2
II	3 & 4	3.1 – 3.4, 4.1, 4.2
III	4 & 5	4.3 – 4.6, 5.1, 5.2
IV	5 & 6	5.3, 6.1 – 6.1
V	8	8.1 – 8.5

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. D. Zwillinger, Handbook of Differential Equations, Academic Press, Boston, 1997 (3rd edition).
2. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and Their Applications, Chapman and Hall/CRC Chapman and Hall/CRC, Second Edition

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

CLO	Statements	Knowledge level
CLO 1	Understand stochastic processes their classification add real life applications.	K1, K2, k3
CLO 2	Understand the concept of Markov Chains and to obtain higher transitions probabilities.	K1, K2, K3
CLO 3	Explain various properties of Poisson process.	K2, K3, K4
CLO 4	Demonstrate the ideas of birth and death process, immigration-emigration process, renewal process, Regenerative stochastic process, Markov renewal process.	K2, K3, K4
CLO 5	Apply the stochastic theory for modeling real system/phenomena.	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	1	2	2	1	1	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	2	2	2	3	1	1	2
CLO 5	1	1	2	2	2	3	1	1	2

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23UPMAT1E29	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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23UPMAT1E30	ADVANCED PARTIAL DIFFERENTIAL EQUATIONS	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective is to

- develop an understanding of the theory and methods of solution for partial differential equations.
- provide an introduction to the study and solution methods for partial differential equations of first and second order.
- make the students to understand the characteristics of heat, wave, and Laplace's equations.
- provide the students a better understanding to the diffusion and wave equations and their applications.

Unit-I: Laplace Equation

Partial Differential Equations – Classifications – Examples - Fundamental solution – Mean-value formulas – Properties of harmonic functions – Green's functions – Energy methods.

UNIT II: Heat Equation

Fundamental solution – Mean-value formula – Properties of solutions – Energy methods.

UNIT III: Wave Equation

Solution by spherical means – Nonhomogeneous problem – Energy methods.

UNIT IV: Other ways to represent solutions

Separation of variables - Similarity solutions.

UNIT V: Other ways to represent solutions

Transform methods - Converting nonlinear into linear PDE.

TEXTBOOK:

L. C. EVANS, *"Partial Differential Equations",* American Mathematical Society, Indian Edition, 2009.

UNIT	Chapter(s)	Sections
I	1 & 2	1.1, 1.2, 2.2
II	2	2.3
III	2	2.4
IV	4	4.1, 4.2
V	4	4.3, 4.4

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. D. Colton, *"Partial Differential Equations: An Introduction"*, Dover Publishers, New York, 1988.
2. F. John, "*Partial Differential Equations*", Applied Mathematical Science (Vol. 1), Springer, 1982.
3. M. Renardy and R.C.Rogers, *"An Introduction to Partial Differential Equations*", Springer, 2004.
4. R. McOwen, *"Partial Differential Equations: Methods and Applications*", 2nd Edition, Pearson Education, 2005.

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

CLO	Statements	Knowledge level
CLO 1	Obtain the fundamental solutions of Laplace's, Heat and Wave equations	K1, K2, k3
CLO 2	Derive the mean-value formula of Laplace's, Heat and Wave equations	K2, K3, K4
CLO 3	Enhance their mathematical understanding in representing solutions of partial differential equations.	K2, K3, K4
CLO 4	Understand the fundamental theory to take a research career in the area of partial differential equations	K2, K3, K4
CLO 5	Apply different methods to obtain solutions	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	1	2	2	2	2	1	2	2
CLO 2	1	2	2	2	3	3	1	2	3
CLO 3	1	2	2	2	2	3	1	1	3
CLO 4	1	1	2	2	3	3	1	2	3
CLO 5	1	2	2	2	2	3	1	2	2

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23UPMAT1E31	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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23UPMAT1E32	MATHEMATICAL PHYSICS	L	T	P	C
		4	1	0	3

OBJECTIVES: The purpose of the course is to introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of theoretical physics.

UNIT I: Integral Equations
Integral equations, Sturm–Liouville theorem and Green's functions

UNIT II: Phase Portraits
Methods of non linear dynamics – I : Phase Portraits .

UNIT III: Stability and Bifurcation
Methods of non linear dynamics - II : Stability and Bifurcation.

UNIT IV: Non linear Differential Equation
Non linear differential equations and their solutions.

UNIT V: Non linear Integral Equation
Non linear Integral equations and their solutions.

TEXT BOOK:
R.S. Kaushal and **D. Parashar**, Advanced Methods of Mathematical Physics, Narosa Publishing House Pvt Ltd, 2008.

UNIT	Chapter	Sections
I	4	4.1 – 4.4
II	6	6.1 – 6.4
III	7	7.1 – 7.4
IV	8	8.1 – 8.3
V	9	9.1 – 9.7

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. G. Arfken, Mathematical Methods for Physicists, A.P.NY, 1996.
2. E. Butkor, Mathematical Physics, Addison –Wesley, 1968.
3. S.H. Strogatz, Non linear Dynamics and Chaos : With Applications to Physics, Biology, Chemistry and Engineering, Addison – Wesley, 1994.
4. M. Tabor, Chaos and integrability in Non linear systems: An Introduction, John Wiley &Sons,NY, 1989.
5. M. Lakshmanan, Solitons : Introduction and Applications, Springer Verlag, Berlin, 1988.
6. Debnath, Lokenath, Introduction to Non linear PDE for Scientists and Engineers , Birkhauser , Boston, 1997.

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

CLO	Statements	Knowledge level
CLO 1	Understand the general prescriptions for solving integral equations and in the process introduce some relevant terminology and Sturn-Liouville theory and the Green functions.	K2, K3, K4
CLO 2	Investigate the qualitative nature of trajectories on the phase plane for both linear and non-linear systems.	K3, K4, K5
CLO 3	Examine the stability in terms of the parameter dependence of the system.	K3, K4, K5
CLO 4	Determine solutions of the Van Der Pol nonlinear ODE, the non linear PDE the Korteweg-de Vries equation and the non linear Schrödinge equation.	K4, K5, K6
CLO 5	Understand the tools for solving of non linear differential and integral equations.	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	2	2
CLO 2	1	1	1	2	2	3	1	2	3
CLO 3	1	2	2	2	2	2	1	2	2
CLO 4	1	1	1	2	2	3	1	2	3
CLO 5	1	1	1	2	2	3	1	2	2

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23UPMAT1E33	NON COMMUTATIVE ALGEBRA	L	T	P	C
		4	1	0	3

OBJECTIVE: The objective of this course is to equip the students with knowledge of some advanced concepts namely decomposition of rings, Artinian rings, Noetherian rings, categories, functors, projective, injective and flat modules and homological dimensions. This course also provides the foundation required for more advanced study in Algebra.

UNIT I: Decompositions of Rings:
Modules and homomorphisms – Classical isomorphism theorems – direct sums and products – free modules – two sided Peirce decomposition of a ring – the Wedderburn – Artin theorem – finitely decomposable rings.

UNIT II: Artinian and Noetherian Rings:
The Jordan-Holder theorem – the Hilbert basis theorem – the radical of a module and a ring – the radical of an Artinian rings – Semiprimary rings.

UNIT III: Categories and Functors:
Exact sequences – direct sums and direct products – the Hom functors – tensor product functor – direct and inverse limits.

UNIT IV: Projectives, Injectives and Flats:
Projective modules – injective modules – essential extensions and injective hulls – flat modules – right hereditary and right semihereditary rings – Herstein-Small rings.

UNIT V: Homological Dimensions:
Complexes and homology, free solutions – Projective and Injective resolutions, Derived functors – the functors Tor, EXT__ , projective and injective dimensions – global dimensions.

TEXT BOOK:
M. Hazewinkel, N. Gubareni and **V.V. Kirichenko, "***Algebras, Rings and Modules", Volume I,* Springer International Edition, New Delhi, 2011.

UNIT	Chapter(s)	Sections
I	1 & 2	1.1 – 1.5, 2.1 – 2.4
II	3	3.1 – 3.7
III	4	4.1 – 4.7
IV	5	5.1 – 5.6
V	6	6.1 – 6.6

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **T.Y. Lam**, *"Lectures on Modules and Rings*", Graduate Texts in Mathematics, Vol. 189, Springer-Verlag, Berlin-Heidelberg, New York, 1999.
2. **J. Lambek,** *"Lectures on Rings and Modules*", 3rd Edition, AMS Chelsea Publishing, AMS, Providence, Rhode Island, 2009.
3. **D.S. Passman,** *"A Course in Ring Theory"*, AMS Chelsea Publishing, AMS, Providence, Rhode Island, 2004.
4. **L.R. Vermani,** *"An Elementary Approach to Homological Algebra"*, Chapman & Hall / CRC Monographs and Surveys in Pure and Applied Mathematics. Vol. 130, CRS Press, LLC, Florida, 2003.

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

CLO	Statements	Knowledge level
CLO 1	Find whether the given ring is decomposable or not? by using centrally primitive orthogonal idempotents,	K1, K2, K3
CLO 2	Know the properties of the radical of a module and a ring.	K1, K2, K3
CLO 3	Understand the role of the Hom and tensor product functors.	K2, K3, K4
CLO 4	Find whether the given module is injective or not? by using many structure theorems for injective modules.	K3, K4, K5
CLO 5	Calculate the homological dimensions of modules.	K3, K4, 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	2	2	3	3	3	1	2	3
CLO 2	1	2	2	2	3	3	1	2	2
CLO 3	1	1	1	2	2	3	1	1	2
CLO 4	1	2	2	2	3	3	1	2	3
CLO 5	1	2	2	2	3	3	1	2	3

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23UPMAT1E34	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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23UPMAT1E35	ALGEBRAIC GEOMETRY	L	T	P	C
		4	1	0	3

OBJECTIVE: Algebraic geometry is the study of systems of polynomial equations. The solution set of a system of polynomial equations forms a geometric object called an algebraic variety. The aim of this course is to develop basic algebraic tools to explore the geometry of these varieties. We will build up a dictionary between geometric properties of varieties and numerical invariants of equations.

UNIT – I: Commutative Algebra

Nakayama lemma – Hilbert basis theorem – localization – Noetherian graded rings – Euler and Taylor identities – homogeneous localization – Krull and Chevally dimensions – Hilbert-Samuel polynomial – dimension theorem – Krull's principal ideal theorem – dimention of polynomial rings.

UNIT – II: Commutative Algebra (Contd....)

Generalities – going up theorem – Noether's normalization lemma – Hilbert's Nullstellensatz – regular ring and UFDs – criteria for normality – relative normalizations – towards Zariski's main theorem – Schmidt and Lüroth's theorems – elimination theory.

UNIT – III: Affine Varieties

Affine algebraic sets – regular functions – irreducible algebraic sets – affine varieties – complete intersections – finite sets and curves – surfaces and solids.

UNIT – IV: Affine Varieties (Contd...)

Linear varieties – determinantal varieties – group varieties – morphisms – rational morphisms –birational equivalence – products.

UNIT – V: Projective Varieties

Terminology – projective Algebraic sets – homogenisation / dehomogenisation – projective closures – morphisms – products – complete varieties.

TEXT BOOK

C. Musli, *"Algebraic Geometry for Beginners"*, Text and Readings in Mathematics Vol.20, Hindustan Book Agency (India), New Delhi, 2001.

UNIT	Chapter	Section
I	1	10 - 14
II	1	15 - 18
III	2	21 - 26.2
IV	2	26.3 – 28
V	3	31 - 37

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. N. Bourbaki, Commutative Algebra, Chapters 1-7, Springer, 1985.
2. D. Bump, Algebraic Geometry, World Scientific, Singapore, 1998.
3. D. Eisenbud, Commutative Algebra with a view towards Algebraic Geometry, GTM Vol. 150, Springer, 1995.
4. J. Harris, Algebraic Geometry – A First Coursc, GTM Vol. 52, Springer, 1992.

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

CLO	Statements	Knowledge level
CLO 1	Know results in algebraic geometry connected to the Zariski topology, affine and projective varieties, their regular functions, rational functions and singularities, as well as morphisms and rational maps between varieties.	K1, K2, K3
CLO 2	Perform an elementary analysis of simple varieties, in particular answer questions on irreducible components and singularities.	K1, K2, K3
CLO 3	Know fundamental intersection theory and Veronese embedding theorem.	K2, K3, K4
CLO 4	Give an account of important connections between geometry and commutative algebra.	K3, K4, K5
CLO 5	Produce the main ideas in the proofs of the most important results connected to the notions above.	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	2	2	2	3	3	1	2	3
CLO 2	1	2	2	2	3	3	1	2	3
CLO 3	1	1	1	2	3	3	1	1	3
CLO 4	1	1	1	2	2	3	1	2	3
CLO 5	2	2	2	2	3	3	2	3	3

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23UPMAT1E36	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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23UPMAT1E37	RESOURSE MANAGEMENT TECHNIQUES	L	T	P	C
		4	1	0	3

OBJECTIVE: The objectives of this course are

- To get familiarize with the mathematical formulation of a real world problem.
- To acquaint with the problem solving techniques theoretically as well as graphically.
- To tackle several parameters into account while dealing with the problem.
- To make aware the students about the applications of various forms of Linear programming.

UNIT I: Linear Programming

Formulation of Linear Programming Models, Graphical solution of Linear Programs in two variables, Linear programs in standard form, basic variable, basic solution, basic feasible solution, Solution of Linear Programming problem using simplex method, Big-M simplex method, The two phase simplex method.

UNIT II: Transportation Problems

Linear programming formulation, Initial basic feasible solution, degeneracy in basic feasible solution, Modified distribution method, Optimality test.

Assignment Problems

Standard assignment problems, Hungarian method for solving an assignment problem.

UNIT III: Project management

Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM).

UNIT IV: Kuhn Tucker Theory and Nonlinear Programming

Lagrangian function, saddle point, Kuhn Tucker conditions, Primal and dual problems, Quadratic Programming.

UNIT V: Dynamic Programming

Minimum path, Dynamic Programming problems, Computational economy in DP, serial multistage model, Examples of failure, Decomposition, Backward recursion.

TEXT BOOK:

1. **Ravindran, Philips, Solberg**, *Operations Research, Principles and Practice*, Second Edition, John Wiley & Sons.

2. **K. V. Mital**, **C. Mohan**. *Optimization Methods in Operations Research and Systems Analysis*, Third Edition, New Age International Publishers, New Delhi

UNIT	Text Book	Chapter	Section(s)
I	1	2	2.1 to 2.9
II	1	3	3.1 to 3.3
III	1	3	3.7
IV	2	8	1 to 6
V	2	10	1 to 10

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Anderson, "Quantitative Methods for Business", 8th Edition, Thomson Learning, 2002.
2. Winston, "Operation research", Thomson Learning 2003.
3. H.A. Taha, "Operation Research", Prentice Hall of India, 2002.
4. Anand Sharna, "Operation Research", Himalaya Publishing House, 2003.

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

CLO	Statements	Knowledge level
CLO 1	Find the solutions of LPP using various techniques.	K1, K2, K3
CLO 2	Analyse transportation and assignment problems.	K1, K2, K3
CLO 3	Analyse CPM and PERT methods.	K2, K3, K4
CLO 4	Use Kuhn-Tucker solution methods for nonlinear optimization problems.	K2, K3, K4
CLO 5	Apply the techniques of Dynamic Programming to solve 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	1	2	2	1	1	1	1
CLO 2	1	1	1	2	2	2	1	1	2
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	2	1	1	2

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23UPMAT1E38	NONLINEAR DIFFERENTIAL EQUATIONS	L	T	P	C
		4	1	0	3

OBJECTIVE: The main objective of this course is

- to discuss nonlinear ordinary differential equations for their different behavior of the solutions.
- to study periodic solutions and averaging methods, perturbation methods and stability.
- to analyze some applications of nonlinear ordinary differential equations studied in the present work to some concrete problem of the other areas of mathematics.

UNIT I: Plane autonomous systems and linearization

The general phase plane - Some population models – Linear approximation at equilibrium points – Linear systems in matrix form.

UNIT II: Periodic Solutions and Averaging Methods

An energy balance method for limit cycles – Amplitude and frequency estimates – Slowly varying amplitudes; Nearly periodic solutions - Periodic solutions: Harmonic balance – Equivalent linear equation by harmonic balance – Accuracy of a period estimate.

UNIT III: Perturbation Methods

Outline of the direct method – Forced oscillations far from resonance- Forced oscillations near resonance with weak excitation – Amplitude equation for undamped pendulum – Amplitude perturbation for the pendulum equation – Lindstedt's method – Forced oscillation of a self – excited equation – The Perturbation method and Fourier series.

UNIT IV: Stability

Poincare stability – Paths and solution curves for general systems - Stability of time solutions: Liapunov stability - Liapunov stability of plane autonomous linear systems

UNIT V: Stability

Structure of the solutions of n-dimensional linear systems - Structure of n-dimensional inhomogeneous linear systems - Stability and boundedness for linear systems - Stability of linear systems with constant coefficients.

TEXT BOOK:

D.W. Jordan and **P. Smith,** *"Nonlinear Ordinary Differential Equations"*, 4th Edition, Oxford University Press, New York, 2007.

UNIT	Chapter	Sections
I	2	2.1 – 2.5
II	4	4.1 – 4.5
III	5	5.1 – 5.5, 5.8 – 5.11
IV	8	8.1 – 8.4
V	8	8.5 – 8.8

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **G.F. Simmons,** "*Differential Equations"*, Tata McGraw-Hill, New Delhi, 1995.
2. **D.A. Sanchez,** "*Ordinary Differential Equations and Stability Theory"*, Dover, New York, 1979.
3. **J.K. Aggarwal**, "*Notes on Nonlinear Systems"*, Van Nostrand, 1972.

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 population model with phase plane.	K1, K2, K3
CLO 2	Derive the limit cycle via energy balance method	K3, K4, K5
CLO 3	Use perturbation method and Fourier series to solve Forced oscillations and Amplitude equation for undamped pendulum	K2, K3, K4
CLO 4	Understand the stability through Liapunov function and Poincare stability	K2, K3, K4
CLO 5	Apply stability theory to n-dimensional linear systems.	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	1	2	2	3	1	2	3
CLO 2	2	2	2	2	2	3	2	2	3
CLO 3	1	1	1	2	2	3	1	1	2
CLO 4	1	2	2	2	2	3	1	2	3
CLO 5	1	2	2	2	2	2	1	2	3

*****

23UPMAT1E39	STOCHASTIC DIFFERENTIAL EQUATIONS	L	T	P	C
		4	1	0	3

OBJECTIVE:

Stochastic differential equations have been used extensively in many areas of application, including finance and social science as well as in physics, chemistry. This course develops the theory of Itô's calculus and stochastic differential equations.

Unit I: A Crash Course in Probability Theory

Basic definitions - Expected value, variance - Independence - Some probabilistic methods -- Law of Large Numbers - Central Limit Theorem - Conditional expectation - Martingales

Unit II: Brownian Motion and "White Noise"

Motivation - Definition, elementary properties - Construction of Brownian motion - Sample path properties - Markov property

Unit III: Stochastic Integrals

Preliminaries - Ito's integral - Ito's chain and product rules - Ito's integral in higher dimensions

Unit IV: Stochastic Differential Equations

Definitions, examples - Existence and uniqueness of solutions - Properties of solutions - Linear stochastic differential equations

Unit V: Applications

Stopping times - Applications to PDE, Feynman–Kac formula - Optimal stopping - Options pricing - The Stratonovich integral

TEXT BOOK:

Lawrence C. Evans, "An Introduction to *Stochastic Differential Equations",* AMS, 2013.

UNIT	Chapter (s)	Pages
I	2	7-34
II	3	35-57
III	4	58-80
IV	5	81-101
V	6	102-124

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **L. Arnold**, *"Stochastic Differential Equations: Theory and Applications"*, Dover Publications, 2011.
2. **A. Friedman**, "*Stochastic Differential Equations and Applications",* Dover Publications, 2006.
3. **D. Henderson** and **P. Plaschko**, *"Stochastic Differential Equations in Science and Engineering"*, World Scientific, 2006.
4. **B. Oksendal**, "*Stochastic Differential Equations: An Introduction with Applications",* 6th Edition, Springer - Verlag, Heidelberg, 2003.

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

CLO	Statements	Knowledge level
CLO 1	Understand the basics of Ito calculus	K1, K2
CLO 2	obtain solution to stochastic differential equations	K1, K2, K3
CLO 3	learn about general existence and uniqueness results for stochastic differential equations	K2,K3, K4
CLO 4	Apply Ito's Lemma to find SDEs arising in real-world applications	K2, K3, K4
CLO 5	take a research career in the area of stochastic differential equations	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	1	2	2	2	1	2	2
CLO 3	2	2	2	2	2	3	2	2	3
CLO 4	1	2	1	2	2	3	1	2	3
CLO 5	2	2	2	2	2	3	2	2	3

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23UPMAT1E40	CONTROL THEORY	L	T	P	C
		4	1	0	3

OBJECTIVE: This is an introductory course in mathematical systems theory. The subject provides the mathematical foundation of modern control theory. The aim of the course is to acquire a systematic understanding of linear dynamical systems. The acquirement of such knowledge is useful in preparation for work on system analysis and design problems that appear in many engineering fields.

Unit-I: Observability

Linear Systems – Nonlinear Systems.

Unit-II: Controllability

Linear systems – Nonlinear systems.

Unit-III: Stability

Stability – Perturbed linear systems – Nonlinear systems.

Unit IV: Stabilizability

Stabilization via linear feedback control – The controllable subspace – Stabilization with restricted feedback.

Unit V: Optimal Control

Linear time varying systems – Linear time invariant systems – Nonlinear Systems.

TEXT BOOK

K. Balachandran and **J.P. Dauer**, "*Elements of Control Theory*", 2nd Edition (revised), Alpha Science International Ltd, 2011.

UNIT	Chapter(s)	Sections
I	2	2.1 – 2.3
II	3	3.1, 3.2
III	4	4.1 – 4.3, 4.5
IV	5	5.1 – 5.4
V	6	6.1 – 6.3

Books for Supplementary Reading and References:

1. **R. Conti**, "*Linear Differential Equations and Control",* Academic Press, London, 1976.
2. **R.F. Curtain** and **A.J. Pritchard**, "*Functional Analysis and Modern Applied Mathematics",* Academic Press, New York, 1977.
3. **J. Klamka,** "*Controllability of Dynamical Systems",* Kluwer Academic Publisher, Dordrecht, 1991.

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

CLO	Statements	Knowledge level
CLO 1	understand the building blocks of basic and modern control systems	K1, K2, K3
CLO 2	get an understanding of the basic ingredients of linear systems theory	K1, K2, K3
CLO 3	select appropriate methodologies for the analysis or design of feedback and open-loop control systems	K2, K3, K4
CLO 4	learn some basic notions and results in control theory, which are very useful for applied mathematicians	K1, K2, K3
CLO 5	take a research career in the area of differential equations and control theory	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	1	2
CLO 4	1	1	1	1	2	2	1	1	2
CLO 5	2	2	2	2	2	2	2	2	2

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23UPMAT1E41	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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23UPMAT1E42	OPERATOR THEORY	L	T	P	C
		4	1	0	3

OBJECTIVES: The aim of this course is to understand the concept of various operators on Banach space.

UNIT I: Bounded Linear Maps on Banach Space

Spectrum of a Bounded Operator - Gelfand–Mazur theorem – spectral radius formula.

UNIT II: Compact operators on normed Spaces

Compact linear maps-spectrum of a compact operator –eighen spectrum.

UNIT III: Bounded Operators on a Hilbert Space

Bounded operators and adjoints – Schur test – Fredholm integral operator.

UNIT IV: Bounded Operators on a Hilbert Space

Normal, Unitary and self adjoint operators- positive operators – Generalized schur's inequality - Spectrum and Numerical Range – Ritz method.

UNIT V: Bounded Operators on a Hilbert Space

Finite Dimensional Operators, Compact self-adjoint operators – Hilbert Schmitt operator – spectral theory.

TEXT BOOK:

Balmohan V. Limaye, Functional Analysis, 2nd Edition, 2010.

UNIT	Chapter	Pages
I	III	192-203, 208-211
II	V	303-307, 312, 317-326
III	VII	442-455
IV	VII	460-473, 483-492, 495
V	VII	496-500, 504-507, 510-518

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. M. Thamban Nair, Functional Analysis A First Course, Prentice-Hall of India, 2008.
2. G.F Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, International Book Company, International student Edition 1963.
3. Walter Rudin, Functional Analysis, Tata McGraw-Hill. Edition, 2009.
4. D. Somasundaram, A first Course in Functional Analysis, Narosa publishing house, Pvt Ltd, 2008.
5. S. Ponnuswamy, Foundations of functional Analysis, Narosa publishing house, Pvt Ltd, 2011.

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 spectrum Bounded operators	K1, K2, K3
CLO 2	Interpret compact Linear maps and spectrum of compact operators	K1, K2, K3
CLO 3	Analyze the adjoint operators	K2, K3, K4
CLO 4	Examine unitary and self adjoint operators	K2, K3,K4
CLO 5	Investigate the spectrum of a self adjoint operatos	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	1	2
CLO 2	1	1	1	2	2	2	1	1	2
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	2	1	2	2	2	1	1	2

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23UPMAT1E43	FIXED POINT THEORY AND APPLICATIONS	L	T	P	C
		4	1	0	3

OBJECTIVES: The objective of this course is

- to introduce the Banach contraction principle and its various generalization for non- expensive mappings, quasi-non-expensive mappings and densifying mappings.
- to acquaint the multivalued mappings and its fixed points and use this technique in integral equations.
- to understand the methods of successive approximations to obtain the fixed points. Also, the study of the mano interative process and iterative methods for variational inequalities.

UNIT I: Introductory Concepts and Fixed Point Theorems

Topological preliminaries – normal structure – Fixed points – The Banach contraction principle – Fixed point theorem for non-expensive mappings.

UNIT II: Fixed Point Theorems (Contd..)

Quasi-non-expensive mappings and fixed points – Densifying maps and fixed points – multivalued mappings and fixed points – integral equations.

UNIT III: Successive Approximations

The methods of successive approximations – the iteration process for continuous functions – Ky Fan Type theorems in Hilbert space.

UNIT IV: Approximation Theorem

Applications to fixed point theorems – Prolla's theorem and extensions – K_y Fan's Best approximation theorem for multifunctions.

UNIT V: Principle and Applications of KKM-Maps

Kakutani factorizable maps and applications – the KKM-Map principle –extensions of the KKM-Map principle and applications–two functions theorems and applications – Applications to variational inequalities – further extensions of the KKM-Map principle.

TEXT BOOK:

1. **Sankatha Singh, Bruce Watson and Pramila Srivastava,** Fixed Point Theory and Best Approximation: The KKM-Map Principle, Springer Science Business media Dordrechi, 1997. (OriginallyAcademic Publishers, 1997).

UNIT	Chapter(s)	Section(s)
I	1	1.1 – 1.5
II	1	1.6 – 1.9
III	1 & 2	1.10 – 1.11, 2.1, 2.2
IV	2	2.3 - 2.5
V	2 & 3	2.6, 3.1 – 3.6

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. V.I. Istratescu, Fixed Point Theory –An Introduction, D. Reidel Publishing Company, Dordrecht, Holland, 1981.
2. M.A. Khamsi and W.A. Kirk, An Introduction to metric spaces and Fixed Point Theory, A Wiley-Intersicience Publication, 2001.
3. A. Granas and J. Dugundji, Fixed Point Theory, Springer Monographs in Mathematics, 2008.

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

CLO	Statements	Knowledge level
CLO 1	Study Banach contraction mapping theorem and its consequences.	K2, K3, K4
CLO 2	Understand and apply the concepts of fixed point theorems to prove the existence and uniqueness of solution to certain ordinary differential equations.	K2, K3, K4
CLO 3	Study non-expensive mappings and discuss approximations of fixed points of non-expensive mappings.	K3, K4, K5
CLO 4	Evaluate the fixed point of multivalued mappings and apply this technique for solution of differential and integral equations	K3, K4, K5
CLO 5	Appriciate the generalization of Brouwer's fixed point theorem, viz, Schauder and its use in analysis and differential equations.	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	3	1	2	3
CLO 2	1	2	2	2	2	3	1	2	3
CLO 3	1	1	1	2	3	3	1	2	3
CLO 4	1	2	2	3	3	3	1	2	3
CLO 5	1	2	2	2	3	3	1	2	3

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SKIL ENHANCEMENT COURSES - SYLLABUS

23UPMAT1S01	COMPUTATIONAL MATHEMATICS FOR SAGEMATH	L	T	P	C
		4	1	0	2

OBJECTIVE: The objective of this course is to provide an introduction to SageMath software and the main focus will be on using SageMath to explore topics in Calculus, Applied Linear Algebra and Numerical Method along with several applications.

Unit-I: **Sage as a Calculator**

Introduction to Sage Math program, Symbolic Expressions, Python Variables, Symbolic variables, Transforming Expressions Elementary functions and usual constants.

Unit-II: Graphics

Usual mathematical functions, solving equations, plotting of curves and surfaces.

Unit-III: Analysis

Limit sequence, series, evaluation of sum, power series, derivative, partial derivative, integral, solutions of ordinary differential equations displaying solutions of ordinary differential equations.

Unit IV: Linear Algebra

Solving linear systems, vector computations, reduction of square matrix, space of vectors and matrices, basis range and nullspace, Eigen values and Eigen vectors, diagonalization and similarity transformation.

Unit V: Algebra of Polynomials

Creating polynomials on different rings, basic operation on polynomials, Euclidean division and computation of the greatest common divisor of polynomials, factorization and roots of polynomials.

TEXT BOOK

P. Zimmermann et. al., Computational Mathematics with SageMath, Society for Industrial and Applied Mathematics (SIAM), 2018.

UNIT	Chapter(s)	Sections
I	1 & 2	1.2.1, 1.2.2, 1.2.4, 1.2.5, 2.1.1, 2.1.2
II	2 & 4	2.1.3, 2.2.1, 2.2.2, 4.1.1 – 4.1.4, 4.2
III	2, 4 & 10	2.3, 4.1.6, 10.1.1, 10.1.2, 10.1.3
IV	2 & 8	2.4, 8.1.1, 8.1.2, 8.2.2, 8.2.3
V	7	7.1, 7.2.1, 7.3.1, 7.3.2

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Razvan A. Mezei, An introduction to Sage Programming, John wiley & amp: Sons, InC, Hoboken, New Jesecy.
2. Craig Finch, Sage-Biginner's Guide, Packt Publishing, 2011.

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

CLO	Statements	Knowledge level
CLO 1	Solve mathematical problem and plot curves and surfaces using Sage Math.	K1, K2, K3
CLO 2	Solve mathematical problem of mathematical analysis using Sage Math.	K2, K3, K4
CLO 3	Solve mathematical problem of linear algebra using Sage Math.	K1, K2, K3
CLO 4	Solve mathematical problem of algebra of polynomials using Sage Math.	K1, K2, K3
CLO 5	Use mathematical computing software in studying and analyzing mathematical concepts.	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	1	1	2	1	1	2
CLO 2	1	1	1	1	1	2	1	1	2
CLO 3	1	1	1	1	1	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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23UPMAT1S02	MATHEMATICAL DOCUMENTATION USING LaTeX	L	T	P	C
		4	1	0	2

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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23UPMAT1S03	OFFICE AUTOMATION AND ICT TOOLS	L	T	P	C
		4	1	0	2

OBJECTIVE: The objective this course is

- To develop a strong foundation in office automation base on ICT tools.
- A holistic development of academic excellence to contribute effectively to the understanding of digital automation.
- To equip the students with the basic skills in identifying and labeling different office tools.
- Describe the usage of computers and why computers are essential components in business and society.

Unit-I: **Elements of Information Technology**

Information Types: Text, Audio, Video, and Image, storage formats

Components: Operating System, Hardware and Software, firmware

Devices: Computer, Mobile Phones, Tablet,Touch Screen, Scanner, Printer, Projector, smart boards

Processor & Memory: Processor functions, speed, Memory types: RAM/ ROM/ HDD/ DVD-ROM/ Flash drives, memory measurement metrics

Unit-II: Office Automation-Text Processing

Views: Normal View, Web Layout View, Print Layout View, Outline View, Reading Layout View

Working with Files: Create New Documents, Open Existing Documents, Save Documentsto different formats, Rename Documents, Close Documents

Working with Text: Type and Insert Text, Highlight Text, Formatting Text, Delete Text, Spelling and Grammar, paragraphs, indentation, margins

Lists: Bulleted and Numbered Lists,

Tables: Insert Tables, Draw Tables, Nested Tables, Insert Rows and Columns, Move and Resize Tables, Moving the order of the column and/or rows inside a table, Table Properties Page Margins, Gutter Margins, Indentations, Columns, Graphics, Print Documents, Paragraph Formatting, Paragraph Attributes, Non-printing characters, Types of document files: RTF, PDF, DOCX etc

Unit-III: Office Automation-Worksheet Data Processing

Spreadsheet Basics: Adding and Renaming Worksheets, Modifying Worksheets, Moving Through Cells, Adding Rows, Columns, and Cells, Resizing Rows and Columns, Selecting Cells, Moving and Copying Cells

Formulas and Functions: Formulas, Linking Worksheets, Basic Functions, AutoSum, Sorting and Filtering: Basic Sorts, Complex Sorts, Auto-fill, Deleting Rows, Columns and Cells

Charting: Chart Types, drawing charts, Ranges, formatting charts

Unit IV: Office Automation- Presentation Techniques and slide shows

Create a new presentation: AutoContent Wizard, Design Template, Blank Presentation, Open an Existing Presentation, PowerPoint screen, Screen Layout

Working with slides: Insert a new slide, Notes, Slide layout, Apply a design template, Reorder Slides, Hide Slides, Hide Slide text, Add content, resize a placeholder or textbox, Move a placeholder or text box, Delete a placeholder or text box, Placeholder or Text box

properties, Bulleted and numbered lists, Adding notes

Work with text: Add text and edit options, Format text, Copy text formatting, Replace fonts, Line spacing, Change case, Spelling check, Spelling options

Working with tables: Adding a table, Entering text, Deleting a table, Changing row width, Adding a row/column, Deleting a row/column, Combining cells ,Splitting a cell, Adding color to cells, To align text vertically in cells, To change table borders, Graphics, Add clip art, Add an image from a file, Save & Print, slide shows, slide animation/transitions.

Unit V: Internet& Applications

Computer Network Types: LAN, PAN, MAN, CAN, WAN, Defining and describing theInternet, Brief history, Browsing the Web, Hypertext and hyperlinks, browsers,Uniform resource locator

Internet Resources: Email, Parts of email,

Protecting the computer: Passwordprotection, Viruses, Virus protection software, Updating the software, Scanning files, Net banking precautions.

Social Networking: Features, Social impact, emerging trends, issues, Social Networkingsites: Facebook, Twitter, linkedin, orkut, online booking services

Online Resources: Wikipedia, Blog, Job portals, C.V. writing, e-learning:e-Books, e-Magazines, e-News papers, OCW(open course wares) : Sakshat (NPTEL) portal, MIT courseware

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. TCI, "Introduction to Computers and Application Software", Publisher: Jones &Bartlett Learning, 2010, ISBN: 1449609821, 9781449609825
2. Laura Story, Dawna Walls, "Microsoft Office 2010 Fundamentals", Publisher: Cengage Learning, 2010, ISBN: 0538472464, 9780538472463
3. June Jamrich Parsons, Dan Oja, "Computer Concepts Illustrated series" Edition Publisher Course Technology, 2005, ISBN 0619273550, 9780619273552
4. Cloud computing online resources

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

CLO	Statements	Knowledge level
CLO 1	Understand the expectations of industry.	K2, K3, K4
CLO 2	Improve employability skills.	K2, K3, K4
CLO 3	Bridge the skill gaps and make students industry ready.	K2, K3, K4
CLO 4	Provide an opportunity to students develop inter-disciplinary skills.	K2, K3, K4
CLO 5	Perform documentation, accounting operations, presenting skills.	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	2	2	2	2	3	1	2	3
CLO 2	1	2	2	2	2	2	1	2	2
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	2	1	2	3

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23UPMAT1S04	NUMERICAL ANALYSIS USING MATLAB	L	T	P	C
		4	1	0	2

OBJECTIVE: The objective of this course is to introduce students to numerical methods and techniques for solving mathematical problems that arise in various scientific and engineering disciplines. Emphasis is placed on both theoretical understanding and practical implementation using MATLAB.

Unit-I: **Introduction to MATLAB**

Starting with MATLAB – Creating arrays – Mathematical operations and arrays – User defined functions files.

Unit-II: Plots and Curve fitting

Polynomial, curve fitting and interpolations - Two-dimensional plots and Three-dimensional plots

Unit-III: Introduction to Numerical Analysis

Overview of numerical methods and their importance. Sources of errors in numerical computations.

Unit IV: Root Finding and Nonlinear Equations

Bisection method. Newton-Raphson method. Secant method. Convergence and convergence rates.

Unit V: Numerical Solutions of Linear Systems

Gaussian elimination.LU decomposition. Iterative methods: Jacobi, Gauss-Seidel. Matrix factorizations and their implementation in MATLAB.

TEXT BOOK

1. **Amos Gilat**, MATLAB An introduction with applications, 4th Edition Wiley, 2016.
2. **John H. Mathews** and **Kurtis D. Fink**, Numerical Methods using MATLAB, 3rd Edition, Prentice Hall, 1999.

UNIT	Chapter(s)	Sections
I	1,2,3 and 7 of **[1]**	-
II	5,8,10 of **[1]**	-
III	2 of **[2]**	-
IV	2 of **[2]**	-
V	3 of [**2]**	-

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. R. Pratap, *Getting started with MATLAB: a quick introduction for scientists and engineers*. Oxford University Press, Inc., 2009.
2. R.S. Esfandiari, Numerical methods for engineers and scientists using MATLAB®. Crc Press, 2017.
3. A. Gupta, Numerical methods using MATLAB. Apress, 2015.

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

CLO	Statements	Knowledge level
CLO 1	Understand the basic starting of MATLAB and Windows, Mathematical operation.	K1, K2, K3
CLO 2	Define plots in 2D and 3D and course fitting an interpolation.	K1, K2, K3
CLO 3	Understand the numerical methods and their important.	K1, K2, K3
CLO 4	Apply numerical methods to non linear equations with MATLAB.	K2, K3, K4
CLO 5	Analyze the solutions of linear system of equations with MATLAB	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	1	1	2	1	1	2
CLO 2	1	2	2	2	2	3	1	2	3
CLO 3	1	1	1	1	1	2	1	1	2
CLO 4	1	2	2	2	2	3	1	2	3
CLO 5	1	1	1	1	1	2	1	1	2

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23UPMAT1S05	DIFFERENTIAL EQUATIONS USING MATLAB	L	T	P	C
		4	1	0	2

OBJECTIVE: This course introduces students to numerical methods and techniques for solving differential equations that arise in various scientific and engineering disciplines. Emphasis is placed on both theoretical understanding and practical implementation using MATLAB.

Unit-I: **Introduction to MATLAB**

Starting with MATLAB – Creating arrays – Mathematical operations and arrays – User defined functions files.

Unit-II: Plots

User defined functions files - Two-dimensional plots and Three-dimensional plots

Unit-III: Numerical Differentiation and Integration

Finite difference approximations. Trapezoidal rule. Simpson's rule. Romberg integration.

Unit IV: Numerical Solutions of Ordinary Differential Equations (ODEs):

Euler's method. Runge-Kutta methods. Multi step method (Predictor – Corrector methods)

Unit V: Partial Differential Equations (PDEs) and Finite Difference Methods

Classification of PDEs. Explicit and implicit finite difference methods. MATLAB implementation of finite difference methods for 1D and 2D problems.

TEXT BOOK

1. **Amos Gilat**, MATLAB An introduction with applications, 4th Edition Wiley, 2016.
2. **John H. Mathews** and **Kurtis D. Fink**, Numerical Methods using MATLAB, 3rd Edition, Prentice Hall, 1999.

UNIT	Books	Chapter(s)	Sections
I	1	1,2,3	full
II	1	5,7,10	full
III	2	6 & 7	full
IV	2	9	9.1-9.6
V	2	10	full

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. R. Pratap, *Getting started with MATLAB: a quick introduction for scientists and engineers*. Oxford University Press, Inc., 2009.
2. R.S. Esfandiari, Numerical methods for engineers and scientists using MATLAB®. Crc Press, 2017.
3. A. Gupta, Numerical methods using MATLAB. Apress, 2015.

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

CLO	Statements	Knowledge level
CLO 1	Understanding the basic starting of MATLAB an windows and mathematical Operations.	K1, K2. k3
CLO 2	Define function files are plot (2D & 3D)	K1, K2, K3
CLO 3	Apply numerical differentiation and integration.	K1, K2, K3
CLO 4	Apply MATLAB ODE such in function to ODE's	K2, K3, K4
CLO 5	Apply PDPE tool to PDE's.	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	1	2
CLO 2	1	2	2	2	2	2	1	2	2
CLO 3	1	1	1	1	1	2	1	2	2
CLO 4	1	1	1	1	1	2	1	1	2
CLO 5	1	1	1	1	1	2	1	1	3

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23UPMAT1S06	INDUSTRIAL MATHEMATICS	L	T	P	C
		4	1	0	2

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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23UPMAT1S07	RESEARCH TOOLS AND TECHNIQUES	L	T	P	C
		4	1	0	2

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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NON MAJOR ELECTIVE COURSES - SYLLABUS

23UPMAT1N01	MATHEMATICS FOR LIFE SCIENCES	L	T	P	C
		2	-	-	2

OBJECTIVE: Mathematics plays a crucial role in various aspects of life sciences, including biology, medicine, ecology, and more. The objectives of incorporating mathematics into life sciences are to enhance understanding, analysis, and interpretation of biological phenomena, as well as to develop tools and techniques for solving complex problems.

Unit-I: **A brief Summary of Calculus**

Working with Parameters – Scaling Parameters – Nonlinear Parameters- Bifurcations – Rates of Change and the Derivative – Rate of Change for a Function of Discrete Time – Rate of Change for a Function of Continuous Time – The Derivative – Slope of a Tangent to a Graph – Computing Derivatives – Two Notations – Elementary Derivative Formulas – Genera; Derivative Rules – Partial Derivatives

Unit-II: Local Behavior and Linear Approximation

Tangent Lines – Local Extrema – Linear Approximation – Optimization – The Marginal value Theorem – Related Rates – Differential Equations – The chain Rule

Unit-III: Mathematical Modeling

Empirical Modeling I : Fitting Linear Models to Data – The Basic Linear Least Squares Method (y=mx) – Adapting the method to the General Linear Model – Implied Assumptions of Least Squares – Empirical Modeling II : Fitting semi linear Models to Data – Fitting the Exponential Model by Linear least Squares – Linear least squares Fit for the Power function Model – Semi linear Least Squares

Unit IV: Creating Models from Biological Principles

Mechanistic Modeling I: Construction Mechanistic Models – Dimensional Analysis – A Mechanistic model for Resource Consumption – A More Sophisticated Model for Food Consumption – A compartment Model for Pollution in a Lake – Mechanistic Modeling II: Equivalent Forms – Algebraic Equivalence – Different Parameters – Visualizing Models with Graphs – Dimensionless Variables – Dimensionless Forms

Unit V: Choosing Among Models

Empirical Modeling III: Quantitative Accuracy – Complexity – The Akaike Information Criterion – Choosing Among Models

TEXT BOOK:

Gleen Ledder, Mathematics for the Life Sciences: Calculus, Modeling, Probability, and Dynamical Systems, Springer Undergraduate Texts in Mathematics and Technology, University of Nebraska – Lincoln, USA, 2013.

UNIT	Chapter(s)	Sections
I	1	1.1 – 1.3
II	1	1.3 – 1.6
III	2	2.3 – 2.4
IV	2	2.5 (2.5.1 – 2.5.5) - 2.6 (2.6.2 – 2.6.6)
V	2	2.7

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. N. Britton, "*Essential Mathematical Biology",* Springer Science & Business Media, 2012.
2. J.D. Murray, *"Mathematical Biology I: An Introduction*", Springer-Verlag, New York, 2002.

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

CLO	Statements	Knowledge level
CLO 1	Understand the basic mathematical concepts in rate of change, continuous and discrete time, derivative and partial derivative	K1, K2
CLO 2	Understanding Linear Approximation – Optimization, Differential equations and chain rule	K1, K2, K3
CLO 3	To develop mathematical modeling through linear least square method	K1, K2, K3
CLO 4	Construction Mechanistic Models and Dimensional Analysis	K2, K3, K4
CLO 5	Studying the Quantitative Accuracy of empirical model	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	3
CLO 2	1	1	1	2	2	2	1	1	2
CLO 3	1	1	1	2	2	1	1	1	1
CLO 4	1	2	2	2	2	2	1	2	2
CLO 5	1	1	1	2	2	2	1	1	2

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23UPMAT1N02	MATHEMATICS FOR SOCIAL SCIENCES	L	T	P	C
		2	-	-	2

OBJECTIVE: The objective of this course is to provide basic mathematical concepts that are necessary to treat mathematical models in social sciences.

Unit-I: Linear Equations and Matrices

System of Linear Equations – Matrices – Matrix Multiplication – Algebraic Properties of Matrix Operations – Special Types of Matrices and Partitioned Matrices

Unit-II: Solving Linear Systems
Echelon Form of a Matrix – Solving Linear Systems

Unit-III: Determinants

Definition – Properties of Determinants – Cofactor Expansion – Inverse of a Matrix – Other Applications of Determinants

UNIT IV: Correlation and Regression

Curve fitting – Principle of Least Squares – Correlation - Rank correlation – Regression - Correlation Coefficient for a Bivariate Frequency Distribution (Theorems without proof)

UNIT IV: Basic Distributions
Binominal distribution – Poisson distribution – Normal distribution

TEXT BOOKS:

1. **Bernard Kolman** and **David R. Hill**, "Elementary Linear Algebra with Applications", 9th Edition, Pearson Education, Inc, 2019.
2. **S. Arumugam** and **A. Thangapandi Isaac**, Statistics, New Gamma Publishing House, Palayamkottai, 2015.

UNIT	Chapter(s)	Sections
I	1 of [1]	1.1 – 1.5
II	2 of [1]	2.1 – 2.2
III	3 of [1]	3.1 – 3.5
IV	5, 6 of [2]	5.1, 6.1 – 6.4
V	13 of [2]	13.1 – 13.3

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Ward Cheney and David Kincaid, Linear Algebra: Theory and Applications, 2nd Edition, Jones and Bartlett Pvt. Ltd., 2014
2. Frank Ayres, JR, Theory and Problems of Matrices, Schaum's Outline Series, McGraw-Hill Book Company, Singapore, 1986.
3. S.C. Gupta and V.K. Kapoor, *"Fundamentals of Mathematical Statistics*", Sultan chand & Sons, 1994.
4. S.P.Gupta, "Statistical Methods", Fortieth Revised Edition, Sultan Chand and Sons, New Delhi, 2011.

COURSE LEARNING OUTCOMES: At the end of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	know the notion of matrices, study the algebraic properties of matrix operations and to identify the types of matrices	K1, K2, K3
CLO 2	find the Echelon form of a matrix and to solve system of linear equations by Gaussian elimination and Gauss-Jordan reduction methods	K1, K2, K3
CLO 3	find the inverse of a matrix using determinant and to apply determinants to solve a system of linear equations	K1, K2, K3, K4
CLO 4	know the Principle of Least Squares to learn the concepts of correlation and regression	K1, K2, K4
CLO 5	know the properties and applications of Binominal, Poisson and Normal distributions	K1, K2, 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	1	2	2	1	1	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	2	2	2	2	2	1	2	2
CLO 5	1	1	1	2	2	2	1	1	2

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23UPMAT1N03	MATHEMATICAL ECONOMICS	L	T	P	C
		2	-	-	2

OBJECTIVE: To initiate the study on consumer behavior, Theory of Firms, Markets Equilibrium, Welfare Economics

Unit-I: The theory of consumer behavior

Utility function – Indifference Curves – Rate of Commodity Substitution – Existence of Utility Function – maximization of Utility – Choice of a Utility Index

Unit-II:

Demand curves – Income and Leisure – Substitution and Income effects – Generalisation to n variables – Theory of Revealed Preference – Problem of Choice in Risk.

Unit-III: The Theory of Firm

Production Function – Productivity Curves – isoquents – Optimization behavior – Input Demand Functions – Cost Functions (short – run and long –run) – Homogeneous Production functions and their properties – CES Production Function and their properties – Joint products – Generalisation to m variables

UNIT IV: Market Equilibrium

Assumption of Perfect Competition – Demand Functions – Supply Functions – Commodity Equilibrium – Applications of the Analysis – factor Market Equilibrium – Existence of Existence Equilibrium – Stability of Equilibrium – Dynamic Equilibrium with lagged adjustment.

UNIT V: Monopolistic Competition

Monopoly and its applications – Duopoly and Oligopoly – Monopolistic Composition – Monopsony, Duopsony and Oligopsony – Bilateral Monopoly

TEXT BOOKS:

J.M. Henderson and **R.E. Quandt**, Micro Economic Theory – A Mathematical Approach 2nd Edition, McGraw Hill, New York , 1971.

UNIT	Chapter(s)	Sections
I	2	2.1 - 2.3
II	2	2.4 - 2.10
III	3	3.1 – 3.6
IV	4	4.1 – 4.9
V	6	6.1 - 6.5

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. W.J. Baumol, Economic Theory and Operation Analysis, Prentice Hall of India, New Delhi, 1978
2. A.C. Chiang, Fundamental Methods of Mathematical Economics, McGraw Hill, New York, 1984
3. M.D. Intriligator, Mathematical Optimization and Economic Theory, Prentice hall, New York, 191
4. A. Kautsoyiannis, Modern Microeconomics (2nd Edn) McMillan, New York, 1979.

COURSE LEARNING OUTCOMES: At the end of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Knowledge and understanding of the mathematical concepts and methods used by professional economists.	K2, K3, K4
CLO 2	The facility to express economic ideas in the language of mathematics.	K2, K3, K4
CLO 3	The expertise to analyze economic models by formal mathematical methods.	K2, K3, K4
CLO 4	Determine stability/instability of a dynamic system by solving differential/difference equations.	K3, K4, K5
CLO 5	Solve economic problems using the mathematical methods described in the course.	K3, K4, K5

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	1	2	2	1	1	2
CLO 2	1	1	1	1	2	2	1	1	2
CLO 3	1	2	2	2	2	2	1	2	2
CLO 4	1	1	1	2	2	2	1	1	2
CLO 5	1	1	1	2	2	2	1	1	2

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23UPMAT1N04	STATISTICS FOR LIFE AND SOCIAL SCIENCES	L	T	P	C
		2	-	-	2

OBJECTIVE: This course provides an introduction to the application of statistics to a range of real world situations relevant to the life and social sciences.

Unit-I: Descriptive Statistics

Measures of central tendency – Computation of central tendency – Properties of mean – Measure of variability – Range, Interquartile range, Standard deviation

Unit-II: Descriptive Statistics

The regression coefficient – The regression equation - Computation of regression coefficient – Interpretation of regression coefficient

Correlation coefficient – Computation – Interpretation of r – Factors affecting the size of r

Unit-III: Interfacial Statistics

Statistical principles – Sample and population – Random and independent sampling – Sampling distribution – Properties of statistics

UNIT IV: Interfacial Statistics

Binomial distribution – Normal distribution – Properties – Standard normal distribution – t distribution – Chi square distribution – F distribution

UNIT IV: Analysis of variance

One way ANOVA: The ANOVA model – Estimation and testing – Assumptions and interpretation

Two way ANOVA: Factorial design – Definitions – Estimation and definition formulas – Computation of two way ANOVA

TEXT BOOKS:

David A Kenney, Statistics for the Social and Behavioral Sciences, Prentice-Hall of India Pvt. Ltd, New Delhi, 2013.

UNIT	Chapter(s)	Sections
I	II	3, 4
II	II	6, 7
III	III	9 upto Page 153
IV	III	9 from Page 154, 10 upto page 168, 11
V	III	14, 15 upto page 261

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. Myra L. Samuels, Jeffrey A. Witmer and Andrew A. Schaffner, Statistics for the Life Sciences, 5th Edition, Pearson Education Ltd, 2016.
2. Russell T. Warne, Statistics for the Social Sciences: A General Linear Model Approach, 2nd Edition, Cambridge University press,, Cambridge, UK, 2021.
3. C.A. Hasse and J.B. Ofosu, Statistical Methods for the Social Sciences, Atrong Publications Ltd, Accra, Ghana, 2017.
4. Denis Anthony, Statistics for Health, Life and Social Sciences, Denis Anthony & Ventus Publishing ApS, 2011.
5. Pieter-Paul Verhaeghe, Statistics for the Social Sciences: Exercises and Solutions, 2nd Edition, Academic Scientific Publishers, 2022.

COURSE LEARNING OUTCOMES: At the end of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Calculate and interpret the mode, the median, and the mean.	K1, K2
CLO 2	articulate the basic concepts and methodological procedures of data analysis	K1, K2, K3
CLO 3	process, analyze, and interpret data	K1, K2, K3
CLO 4	Identify and apply different sampling designs.	K1, K2, K3
CLO 5	Understand the statistical techniques that underpin data analysis and hypothesis testing.	K1, K2, K3

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	1	1	3	1	1	3
CLO 3	1	1	1	2	2	2	1	1	2
CLO 4	1	1	1	1	1	2	1	1	2
CLO 5	1	1	1	1	1	2	1	1	2

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23UPMAT1N05	GAME THEORY AND STRATEGY	L	T	P	C
		2	-	-	2

OBJECTIVE: The objective of this course is to introduce the basics of game theory. It focuses on fundamentals of game theory including basic concepts and techniques, various ways of describing and solving games and various applications. It will help the students sharpen their understanding of strategic behavior in different situations involving many individuals.

Unit-I: Introduction & Nash Equilibrium

Strategic games – Nash equilibrium – exist of Nash equilibrium - Strictly competitive games, strategic games with imperfect information – mixed strategy Nash equilibrium – interpretation of mixed strategy Nash equilibrium.

Unit-II: Evolutionary Equilibrium knowledge and Equilibrium

Correlate and evolutionary equilibriums – ratinalizability – iterated elimination of strictly and weakly dominated actions – a model of knowledge – common knowledge – the electronic mail game.

Unit-III: Extensive Games with Perfect Information

Extensive games with perfect information – subgame perfect equilibrium – two notable finite horizon games – bargaining and game theory – variations and extensions.

Unit IV: Repeated Games

Infinitely repeated games – Nash Folk theorems – perfect Folk theorems for the limit of means criterion, overtaking criterion and discounting criterion – finitely repeated games – complexity and the machine game – the case of Laxicographic preferences.

Unit V: Coalitional Games

Coalitional games with and without transferable payoff – the stable sets of von Neumann and Morgenstern – the bargaining set, kernel and nucleolus – the Shapley value – bargaining problems – the Nash solutions and the bargaining game of alternating offers – an exact implementation of the Nash solution.

TEXT BOOK

1. **Martin J Osborne** and **Ariel Rubinstein,** A Course in Game Theory, the MIT press, Cambridge, Massachusetts London, England, 1992.

UNIT	Part	Chapter(s)	Page(s)
I	I	1, 2, 3	1 - 43
II	I	3, 4, 5	44 - 86
III	II	6, 7	89 – 132
IV	II	8, 9	133 – 176
V	IV	13, 14, 15	257 - 312

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. M.J. Osborne, An Introduction in Game Theory, Oxford University Press, 2000.
2. D. Fudenberg and J. Tirole, Game theory, The MIT press, Cambridge, London, England, 1991
3. J. Watson, Strategy: An Introduction to Game theory, 3rd Edition, W.W. Norton & company, London, 2013.
4. N.N. Vorobev, Game Theory, Springer Verlag, 1977.

COURSE LEARNING OUTCOMES: At the end of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Distinguish a game situation from a pure individual's decision problem.	K2, K3, K4
CLO 2	Explain concepts of players, strategies, payoffs, rationality and equilibrium.	K2, K3, K4
CLO 3	Describe simple simultaneous - move games using game tables, and to explain concepts of dominant, dominated, and rationalizable strategies, pure and mixed strategies, and best responses	K2, K3, K4
CLO 4	Find dominant strategy equilibrium, pure and mixed strategy Nash-equilibrium.	K3, K4, K5
CLO 5	Describe simple games involving both sequential – and simultaneous – moves, and to explain and to find sub-game perfect Nash- equilibrium.	K3, K4, K5

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	2	2	2	2	2	1	2	2
CLO 2	1	1	1	2	2	2	1	1	2
CLO 3	1	1	1	2	2	2	1	1	2
CLO 4	1	2	2	2	2	2	1	2	3
CLO 5	1	1	1	2	2	2	1	2	3

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23UPMAT1N06	FINANCIAL MATHEMATYICS	L	T	P	C
		2	-	-	2

OBJECTIVE: The objective of this course is to

- Introduce some basic definitions from finance and investigate the problem of pricing financial instruments in the context of a very crude model.
- Build some more sophisticated market models that track the evolution stock prices over a succession of time periods.
- Basic properties of discrete parameter martingales are presented.
- Know about the Levy's construction of Brownian motion.

Unit-I: Single Period Models

Definitions from Finance – Pricing of a Forward – One – step Binary Model

Unit-II: Single Period Models (Contn..)

A characterization of no arbitrage – Risk – Neutral Probability Measure

Unit-III: Binomial trees and discrete parameter Martingales

Multi period Binary Model – American options

Unit IV: Binomial trees and Discrete parameter Martingales (Contn..)

parameter martingales and Markov processes – Martingale theorems

Unit V: Brownian Motion

Definition of the process – Levy's construction of Brownian Motion

TEXT BOOK

A. Etheridge, A course in Financial Calculus, Cambridge University Press, 2002.

UNIT	Chapter(s)	Sections
I	1	1.1 – 1.3
II	1	1.5, 1.6
III	2	2.1, 2.2
IV	2	2.3, 2.4
V	3	3.1, 3.2

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. M. Boxter and A. Rennie, Financial calculus: An Introduction to Derivatives Pricing, Cambridge University Press, 1996
2. D. Lamberton and B. Lapeyre, Introduction to Stocahstic calculus Applied to Finance, Chapman and hall, 1966
3. M. Musiela and M. Rutkowski, Martingale Methods in Financial Modeling, Springer, New York, 1988
4. R.J. Elliott and P.Ekkehard Kopp, Mathematics of Financial Markets, Springer, New York, 2001 (3rd Printing)

COURSE LEARNING OUTCOMES: At the end of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Understand the basic concepts of financial mathematics and financial derivative instruments.	K2, K3, K4
CLO 2	fundamental understanding of ho-Arbitrage pricing concept.	K2, K3, K4
CLO 3	Apply basic probability theory to option pricing in discrete time in the context of simple financial models.	K3, K4, K5
CLO 4	calculate basic quantities in financial mathematics and apply these concepts in financial markets and real- life situations.	K3, K4, K5
CLO 5	Study and random walks and use continuous martingale theory to simplify a number of calculations for Brownian motion.	K3, K4, K5

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	2	2	2	2	2	1	2	2
CLO 2	1	1	1	2	2	2	1	1	2
CLO 3	1	1	1	2	2	2	1	1	2
CLO 4	1	1	1	2	2	2	1	1	3
CLO 5	1	2	2	2	2	2	1	2	3

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23UPMAT1N07	NUMERICAL & STATISTICAL METHODS	L	T	P	C
		2	-	-	2

OBJECTIVE: The objective of this course is to provide the foundation for numerical methods and statistics.

UNIT I: Algebraic and Transcendental Equations

Bisection Method – Iteration Method – The Method of False Position – Newton- Raphson – Method

UNIT II: System of Linear Equation

Gauss Elimination, Gauss Jordon elimination – Triangularization method –Iterative Methods, Jacobi, Gauss-Seidal iteration, Iterative method for A^{-1}

UNIT III: Interpolation

Interpolation with equal intervals – Newton forward and backward formula – Central Difference Interpolation formula – Gauss forward and backward formula – Stirling's formula – Bessel's Formula - Numerical differentiation: Maximum and minimum values of a tabulated function. Numerical Integration: Trapezoidal Rule – Simpson's Rule – Numerical double Integration.

UNIT IV: Basic Distribution

Binominal distribution – Poisson distribution – Normal distribution – Properties and Applications.

UNIT V: Correlation and Regression

Correlation Coefficient – Rank correlation coefficient of determination – Linear regression –Method of least squares – Fitting of the curve of the form $ax+b$, ax^2+bx+c, ab^x and ax^b – Multiple and partial correlation (3-variable only).

TEXT BOOK:

1. **P. Kandasamy, K. Thilagavathy** and **K. Gunavathi**, *"Numerical Methods"*, 3rd Edition, S. Chand, 2006.
2. **S.C. Gupta** and **V.K. Kapoor,** *"Fundamentals of Mathematical Statistics"*, Sultan Chand & Sons, 1994.

UNIT	Chapter(s)	Sections
I	3 *of* [1]	3.1 to 3.4
II	4 of [1]	4.1 to 4.4, 4.8
III	8, 9 of [1]	8.1 to 8.8, 9.1 to 9.16
IV	7 of [2]	7.1 to 7.4
V	10 of [2]	10.1 to 10.7

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. S. Kalavathy, *"Numerical Methods"*, Vijay Nicole, Chennai, 2004.
2. S.S. Sastry, *"Introductory Methods of Numerical Analysis"*, Prentice Hall of India, Pvt Ltd., 1995

COURSE LEARNING OUTCOMES: At the end of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Apply numerical methods to obtain approximate solutions to algebraic equations.	K1, K2
CLO 2	Understand how to solve system of linear equation	K1, K2, K3
CLO 3	Application of numerical integration and differentation.	K1, K2, K3
CLO 4	Basic concepts of distribution	K1, K2, K3
CLO 5	Computation of correlation and regression	K1, K2, K3

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	1	1	1	2	2	3	1	1	3
CLO 3	1	1	1	2	2	2	1	1	2
CLO 4	1	1	1	2	2	3	1	1	2
CLO 5	1	1	1	2	2	2	1	1	2

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VALUE ADDED COURSES - SYLLABUS

23UPMAT1V01	LaTeX (LAB)	L	T	P	C
				2	2

OBJECTIVE:

Typeset mathematical formulae using LaTeX. Use the preamble of LaTeX file to define document class and layout options. Use tabular and array environments within LaTeX document. Use various methods to either create or import graphics into a LaTeX document. Use Theorem, Corollary, and other environments. Use BibTeX to maintain bibliographic information and to generate a bibliography for a particular document.

Unit I:

Text formatting, TEX and its offspring, What's different in LATEX 2ϵ, Distinguishing LATEX 2ϵ , Basics of a LATEX file.

Unit II:

Commands and environments–Command names and arguments, Environments, Declarations, Lengths, Special Characters, Fragile Commands, Exercises.

Unit III:

Document layout and organization – Document class, Page style, Parts of the document, Table of contents, Fine – tuning text, Word division. Displayed text - Changing font, Centering and indenting, Lists, Generalized lists, Theorem–like declarations, Tabulator stops, Boxes.

Unit IV:

Tables, Printing literal text, Footnotes and marginal notes. Drawing pictures with LATEX.

Unit V:

Mathematical formulas – Mathematical environments, Main elements of math mode, Mathematical symbols, Additional elements, Fine–tuning mathematics.

Text Book:

"A Guide to LATEX" by H. Kopka and P.W. Daly, Third Edition, Addison – Wesley, London,
1999.

UNIT	Chapter(s)	Sections
I	1	1.1 - 1.3, 1.4.1, 1.5.
II	2	2.1 - 2.7.
III	3 & 4	3.1 - 3.6, 4.1 - 4.7
IV	4& 6	4.8 - 4.10, 6.1.
V	5	5.1 -5.5.

List of practical programs will be issued by course teacher.

COURSE LEARNING OUTCOMES: At the end of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Basic of LATEX and LATEX 2ϵ, LATEX file creation Tex formatting	K1, K2, K3
CLO 2	Discus the command, environments and creating special characters	K1, K2, K3
CLO 3	Formatting the document layout, page style part of document and Table of contents	K1, K2, K3
CLO 4	Creating the table and drawing pictures in LATEX	K1, K2, K3
CLO 5	Drive the mathematical environments mathematical symbol for typing thesis project and report	K1, K2, K3

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	2	2	2	3	3	1	2	3
CLO 2	1	2	2	2	2	3	1	2	3
CLO 3	1	1	2	2	2	3	1	2	3
CLO 4	1	1	1	2	2	2	1	2	2
CLO 5	1	1	1	2	2	2	1	2	2

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23UPMAT1V02	MATHEMATICA (LAB)	L	T	P	C
				2	2

OBJECTIVE:

Numerical calculation, Compile notes, equations, sample calculations, graphics, references, and hyperlinks in a single document. Visualize data or functions with 2D/3D graphics and charts. Analyze real-world data with ready-to-use data sets. Mathematical functions – Algebraic manipulation – Numerical calculations of differential and integral Calculus.

Unit – I:

Running Mathematica - Numerical calculations – Building up calculations – Using the Mathematica system – Algebraic calculations - Symbolic mathematics – Numerical mathematics.

Unit – II:

Graphics and Sound - Files and External Operations

Unit – III:

Textual Input and Output - The Structure of Graphics and Sound

Unit – IV:

Numbers - Mathematical functions – Algebraic manipulation – Manipulating equations - Calculus.

Unit – V:

Series, limits and residues - Linear algebra.

Text Book:

"The Mathematica Book" by S. Wolfram, Fourth Edition, Cambridge University Press, Cambridge, 1999.

UNIT	Chapter(s)	Sections
I	1	1.0- 1.6
II	1	1.9- 1.11
III	2	2.9- 2.10
IV	3	3.1- 3.5
V	3	3.6- 3.7

List of practical programs will be issued by course teacher.

COURSE LEARNING OUTCOMES: At the end of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Start with Running mathematical- Basic Mathematical calculation with symbolic	K1, K2, K3
CLO 2	Understanding the graphics & sound in 2D and 3D	K2, K3, K4
CLO 3	Learning the output and input formation in mathematica	K2, K3, K4
CLO 4	Evaluate the mathematical functions and calculus in mathematica	K2, K3, K4
CLO 5	Applications to mathematical calculation like a series, limits, residue at Linear Algebra	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	2	2	2	2	3	1	2	2
CLO 2	1	1	2	2	2	2	1	2	2
CLO 3	1	1	1	1	2	2	1	1	2
CLO 4	1	1	2	2	2	3	1	2	3
CLO 5	1	1	2	2	2	3	1	2	3

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23UPMAT1V03	MATLAB (LAB)	L	T	P	C
				2	2

OBJECTIVE:

This course provides basic fundamentals on MATLAB, primarily for numerical computing. To learn the characteristics of script files, functions and function files, two-dimensional plots and three-dimensional plots. To enhance the programming skills with the help of MATLAB and its features which allow learning and applying specialized technologies.

Unit – I:

Starting with Matlab - Creating arrays - Mathematical operations with arrays.

Unit – II:

Script files - Functions and function files.

Unit – III:

Two-dimensional plots - Three-dimensional plots.

Unit – IV:

Programming in MATLAB. (Keywords to be included)

Unit – V:

Polynomials, Curve fitting and interpolation - Applications in numerical analysis.

Text Book:

"MATLAB - An Introduction with Application" by A. Gilat, John Wiley & Sons, Singapore, 2004.

UNIT	Chapter(s)	Sections
I	1, 2 & 3	-
II	4 & 6	-
III	5 & 9	-
IV	7	-
V	8 & 9	-

List of practical programs will be issued by course teacher.

COURSE LEARNING OUTCOMES: At the end of the course, students will be able to

CLO	Statements	Knowledge level
CLO 1	Learning the basic windows in MATLAB and mathematical operations with arrays	K1, K2, K3
CLO 2	Creating scripts e functions file in MATLAB	K2, K3, K4
CLO 3	Understanding the various type of 2D&3D plots and animations	K2, K3, K4
CLO 4	Study the various type of loops in MATLAB	K2, K3, K4, K5
CLO 5	Applications to numerical analysis like solving algebraic equation, curve fitting and interpolation	K3, K4, K5

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	2	2	2	3	3	1	2	3
CLO 2	1	2	2	2	2	3	1	2	3
CLO 3	1	2	2	2	2	2	1	2	2
CLO 4	1	2	2	3	3	3	1	2	3
CLO 5	1	1	1	2	2	2	1	1	2

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