M.Sc.,

MATHEMATICS

Syllabus

From the Academic Year
2023-2024

University of Madras

Chennai – 600 005.

NEW INITIATIVE IN MODERNISING

POST-GRADUATE PROGRAMME IN MATHEMATICS

CONTENTS

1. Preamble

In pursuit of the Higher Education Department Policy Note 2022-23 Demand 20, Section 1.4, Tamil Nādu State Council for Higher Education took initiative to revamp the curriculum. On 27 July 2022, a meeting was convened by the Member-Secretary Dr. S. Krishnasamy enlightening the need of the hour to restructure the curriculum of both Under-graduate and Post-graduate programmes based on the speeches at the Tamil Nādu Legislative Assembly Budget meeting by the Honourable Higher Education Minister Dr K. Ponmudy and Honourable Finance Minister Dr. P. Thiagarajan.At present there are three different modes of imparting education in most of the educational institutions throughout the globe. Outcome Based Education, Problem Based Education, and Project Based Education.

Now our Honourable Higher Education Minister announced Industry Aligned Education. During discussion, Member Secretary announced the importance of question papers and evaluation as envisaged by the Honourable Chief Secretary to Government Dr, V. IraiAnbu. This is very well imbedded in Revised Bloom's Taxonomy.

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

2 a) Post Graduate Programme

Programme Outcomes:

PO1: Disciplinary Knowledge: Capable of demonstrating comprehensive knowledge and understanding of one or more disciplines that form a part of anPost graduate programme of study.

PO2: Critical Thinking: Capability to apply analytic thought to a body of knowledge; analyse and evaluate evidence, arguments, claims, beliefs on the basis of empirical evidence; identify relevant assumptions or implications; formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development.

PO3: Problem Solving: Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum content knowledge; and apply one's earning to real life situations.

PO4: Analytical & Scientific Reasoning: Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; analyze and synthesize data from a variety of sources; draw valid conclusions and support them with evidence and examples and addressing opposing viewpoints.

PO5: Research related skills: Ability to analyse, interpret and draw conclusions from quantitative / qualitative data; and critically evaluate ideas, evidence, and experiences from an open minded and reasoned researchperspective; Sense of inquiry and capability for asking relevant questions / problem arising / synthesizing / articulating / ability to recognize cause and effect relationships / define problems. Formulate hypothesis, Test / analyse / Interpret the results and derive conclusion, formulation and designing mathematical models

PO6: Self-directed & Lifelong Learning: Ability to work independently, identify and manage a project. Ability to acquire knowledge and skills, including "learning how to learn", through self-placed and self-directed learning aimed at personal development, meeting economic, social and cultural objectives.

M.Sc Mathematics

Programme Specific Outcomes:

PSO1: Acquire good knowledge and understanding, to solve specific theoretical & applied problems in different area of mathematics & statistics.

PSO2: Understand, formulate, develop mathematical arguments, logically and use quantitative models to address issues arising in social sciences, business and other 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 decisions and actions.

To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential 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	…
CLO1										
CLO2										
CLO3										
CLO4										
CLO5										

2 b. Structure of 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 Outcomes: (for students: To know what they are going to learn) **CO1:** **CO2:** **CO3:** **CO4:** **CO5:**			
Recap: (not for examination) Motivation/previous lecture/ relevant portions required for the course) [This is done during 2 Tutorial hours)			

Units	**Contents**	**Required Hours**
I		**18**
II		**18**
III		**18**
IV		**18**
V		**18**
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)	
Skills acquired from the course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill	

Learning Resources:

- **Recommended Texts**
- **Reference Books**
- **Web resources**

Board of Studies Date:

3. Learning and Teaching Activities

3.1 Topic wise Delivery method

Hour Count	Topic	Unit	Mode of Delivery

3.2 Work Load

The information below is provided as a guide to assist students in engaging appropriately with the course requirements.

Activity	Quantity	Workload periods
Lectures	60	60
Tutorials	15	15
Assignments	5	5
Cycle Test or similar	2	4
Model Test or similar	1	3
University Exam Preparation	1	3
	Total	90 periods

1. **Tutorial Activities**

Tutorial Count	Topic

2. **Laboratory Activities**
3. **Field Study Activities**
4. **Assessment Activities**

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 the opportunity to demonstrate what they learned.
5. Assessment must maintain academic standards.

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%

TEACHING METHODOLOGIES

Traditional Teaching method like Chalk and Board, Virtual Classroom, 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 university websites.

Faculty Course File Structure

CONTENTS

a. Academic Schedule
b. Students Name List
c. Time Table
d. Syllabus
e. Lesson Plan
f. Staff Workload
g. Course Design(content, Course Outcomes(COs), Delivery method, mapping of COs with Programme Outcomes(POs), Assessment Pattern in terms of Revised Bloom's Taxonomy)
h. Sample CO Assessment Tools.
i. Faculty Course Assessment Report(FCAR)
j. Course Evaluation Sheet
k. Teaching Materials(PPT, OHP etc)
l. Lecture Notes
m. Home Assignment Questions
n. Tutorial Sheets
o. Remedial Class Record, if any.
p. Projects related to the Course
q. Laboratory Experiments related to the Courses
r. Internal Question Paper
s. External Question Paper
t. Sample Home Assignment Answer Sheets
u. Three best, three middle level and three average Answer sheets
v. Result Analysis (CO wise and whole class)
w. Question Bank for Higher studies Preparation (GATE/Placement)
x. List of mentees and their academic achievements

M.Sc Mathematics Curriculum Design

Semester–I	**Hours**	**Credit**	**Semester-II**	**Hours**	**Credit**	**Semester-III**	**Hours**	**Credit**	**Semester–IV**	**Hours**	**Credit**
1.1. Core-I	6	5	2.1. Core-IV	6	5	3.1. Core-VII	6	5	4.1. Core-XI	6	5
1.2 Core-II	6	5	2.2 Core-V	6	5	3.2 Core-VIII	6	5	4.2 Core-XII	6	5
1.3 Core – III	6	5	2.3 Core – VI	6	5	3.3 Core – IX	6	5	4.3 Project with Viva-Voce	7	5
1.4 Elective (Generic / Discipline Centric)- I	5	3	2.4 Elective (Generic / Discipline Centric) – III	5	3	3.4 Elective (Generic / Discipline Centric) – V	5	3	4.4 Elective (Generic / Discipline Centric) – VI	5	3
1.5 Elective (Generic / Discipline Centric)-II	5	3	2.5 Elective (Generic / Discipline Centric)-IV	5	3	3.5 Core (Industry Module) -X	6	4			
			2.6 Skill Enhancement	4	2	3.6 Skill Enhancement Course – Term Paper and Seminar Presentation	3	2	4.5 Skill Enhancement Course - Professional Competency Skill	4	2
						3.7 Internship/ Industrial Activity	-	2	4.6 Extension Activity		1
	28	**21**		**32**	**23**		**32**	**26**		**28**	**21**
									Total Credit Points		**91**

Credit Distribution for PG Programme in Mathematics

M.Sc Mathematics

First Year

Semester-I

	Courses	**Credit**	**Hours per Week(L/T/P)**
PartA	Core Courses3 (CC1, CC2, CC3)	15	18
	Elective Courses 2(Generic / Discipline Specific)EC1, EC2	6	10
		21	**28**

Semester-II

	Courses	**Credit**	**Hours per Week(L/T/P)**
PartA	Core Courses3 (CC4, CC5, CC6)	15	18
	Elective Course 2(Generic / Discipline Specific) EC3, EC4	6	10
PartB	Skill Enhancement Course -SEC 2 (One from Group G)	2	4
		23	**32**

Second Year -Semester-III

	Courses	**Credit**	**Hours per Week(L/T/P)**
PartA	Core Courses3 (CC7, CC8, CC9)	15	18
	Elective Course 1 (Generic / Discipline Specific)EC5	3	5
	Core Industry Module CC10	4	6
PartB	Skill Enhancement Course	2	3
	Internship / Industrial Activity (Carried out in Summer Vacation at the end of I year – 30 hours)	2	
		26	**32**

Semester-IV

Part	Courses	Credit	Hours per Week(L/T/P)
PartA	Core Courses3 (CC11, CC12)	10	12
	Elective Course 1 (Generic / Discipline Specific) EC6	3	5
	Project with Viva voce (CC13)	5	7
Part B	Professional Competency Skill Enhancement Course: Training for Competitive Examinations OR Mathematics for Advanced Research Studies (4 hours)	2	4
Part C	Extension Activity (Can be carried out from Sem II to Sem IV)	1	
		21	**28**

Component wise Credit Distribution

Credits	Sem I	Sem II	Sem III	Sem IV	Total
Part A	**21**	**21**	**22**	**18**	**82**
Part B					
(i) Soft Skill		**2**	**2**	**2**	**8**
(ii) Summer Internship / Industrial training			**2**		
Part C				**1**	**1**
Total	**21**	**23**	**26**	**21**	**91**

Part A component and Part B (i) will be taken into account for CGPA calculation for the postgraduate programme and the other components Part B and Part C have to be completed during the duration of the programme as per the norms, to be eligible for obtaining the PG degree

Credit Distribution for PG Programme in Mathematics

M.Sc Mathematics

Illustration – I

	First Year Semester-I	**Credit**	**Hours per week(L/T/P)**
Part A	428C1A: CC1 – Algebra I	5	6(5L + 1T)
	428C1B: CC2 - Real Analysis I	5	6(5L + 1T)
	428C1C: CC3 - Ordinary Differential Equations	5	6(5L + 1T)
	Elective I(Generic / Discipline Specific)(One from GroupA)	3	5(4L + 1T)
	Elective II(Generic / Discipline Specific)(One from Group B)	3	5(4L + 1T)
	Total	**21**	**28**

	Semester-II	**Credit**	**Hours per week(L/T/P)**
Part A	428C2A: CC4 – Algebra II	5	6(5L + 1T)
	428C2B: CC5 – Real Analysis II	5	6(5L + 1T)
	428C2C: CC6 - Partial Differential Equations	5	6(5L + 1T)
	ElectiveIII (Generic / Discipline Specific)(One from Group C)	3	5(4L + 1T)
	Elective-IV(Computer / IT related) (One from Group D)	3	5(3L+ 2P)
Part B	Skill Enhancement Course -SEC 2 (One from Group G)	2	4
	Total	**23**	**32**

	Second Year - Semester-III	**Credit**	**Hours per week(L/T/P)**
Part A	528C3A: CC7 - Complex Analysis	5	6(5L + 1T)
	528C3B: CC8 – Mechanics	5	6(5L + 1T)
	528C3C: CC9 – Topology	5	6(5L + 1T)
	Elective V(Generic / Discipline Specific)(One from Group E)	3	5(4L + 1T)
	528C3D: CC10-Industry Module-Statistical Methods	4	6(5L + 1T)
Part B	528S3A: Internship / Industrial Activity (Carried out in Summer Vacation at the end of I year – 30 hours)	2	
	528S3B: Skill Enhancement Course Skill -Term paper & Seminar presentation	2	3
	Total	**26**	**32**

	Semester-IV	**Credit**	**Hours per week(L/T/P)**
	528C4A: CC11 - Differential Geometry	5	6(5L + 1T)
	528C4B: CC12–Functional Analysis	5	6(5L + 1T)
	Elective VI(Generic / Discipline Specific)(One from Group F)	3	5(4L + 1T)
	528C4C: CC13 - Core Project with viva voce	5	7
Part B	528S4A: Professional Competency Skill Enhancement Course Training for Competitive Examinations • Mathematics for NET / UGC - CSIR/ SET / TRB Competitive Examinations (2 hours) • General Studies for UPSC / TNPSC / Other Competitive Examinations (2 hours) OR 528S4B: Mathematics for Advanced Research Studies (4 hours)	2	4
Part C	528V4A: Extension Activity	1	
	Total	**21**	**28**

TOTAL CREDITS: 91

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	11	55	82	88 (CGPA)
	Project with viva voce	5	1	5		
	Industry aligned Programmes-	4	1	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	
	Summer Internship	2	1	2	2	
PART C	Extension Activity	1	1	1	1	
						91

Template for Semester

Code	Category	Title of the Paper	Marks (Max 100)		Duration for UE	Credits
			CIA	UE		
Semester –I						
Part A	Core I		25	75	3 Hrs	5
	Core II		25	75	3 Hrs	5
	Core III		25	75	3 Hrs	5
	Elective I	Elective-I (Choose one from Group-A)	25	75	3 Hrs	3
	Elective II	Elective-I I (Choose one from Group-B)	25	75	3 Hrs	3
Semester-II						
Part A	Core IV		25	75	3 Hrs	5
	Core V		25	75	3 Hrs	5
	Core VI		25	75	3 Hrs	5
	Elective III	Elective-III (Choose one from Group-C)	25	75	3 Hrs	3
	Elective IV	Elective-IV (Choose one from Group-D)	25	75	3 Hrs	3
Part B	Skill Enhancement Course -SEC 2	(Choose one from Group-G)	Internal Assessment			2
Semester-III						
Part A	Core VII		25	75	3 Hrs	5
	Core VIII		25	75	3 Hrs	5
	Core IX		25	75	3 Hrs	5
	Elective / ED V	Elective-VI /ED-V (Choose one from Group-E)	25	75	3 Hrs	3

	Core -X Industry Module	ED-IV (Choose from outside the Department)	25	75	3 Hrs	4
Part B						
	Skill based (Term paper and Seminar)	Assignment of problem by the faculty Lecture -I (by the student) 25% Lecture-II (by the student) 25% Lecture-III (by the student) 25% Submission of a write-up (10-15 pages using LaTeX) 25% Marks / Grade Point/ Letter Grade as per the Regulation)				2
	Internship / Industrial - Vacation Activity					2
Semester-IV						
	Core XI		25	75	3 Hrs	5
	Core XII		25	75	3 Hrs	5
	Project with viva voce XIII		25	75	3 Hrs	5
	Elective VI	Elective-VI (Choose one from Group – F)	25	75	3 Hrs	3
Part B	Skill Enhancement Course -SEC 4	Professional Competency Skill Enhancement Course	Internal Assessment			2
Part C	Extension Activity	Performance based assessment				1
					Total Credits	**91**

Elective Courses

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(ITC) courses for flexibility of choice by the stakeholders / institutions.

Semester I : Elective I and Elective II

Elective I to be chosen from Group A and **Elective II** to be chosen from Group B

Group A: (PM/AP/IC/ITC)

1. 428E1A: Number Theory and Cryptography

2. 428E1B: Data Programing with R
3. 428E1C: Formal Languages and Automata Theory
4. 428E1D: Graph Theory

Group B:(PM/AP/IC/ITC)

1. 428E1E: Lie Groups and Lie Algebras
2. 428E1F: Fuzzy sets and their applications
3. 428E1G: Discrete Mathematics
4. 428E1H: Financial Mathematics

Semester II : Elective III & Elective IV

Elective III to be chosen from **Group C** and **Elective IV** to be chosen from **Group D**

Group C:**(PM/AP/IC/ITC)**

1. 428E2A: Algebraic Topology
2. 428E2B: Probability Theory
3. 428E2C: Modelling and Simulation with Excel
4. 428E2D: Neural Networks

Group D :(PM/AP/IC/ITC)

1. 428E2E: Algebraic Number Theory
2. 428E2F: Numerical Methods with C++ Practicals
3. 428E2G: Stochastic Process
4. 428E2H: Data Analysis

Semester III : Elective V

Elective V to be chosen from Group E.

Group E: (PM/AP/IC/ITC)

1. 528E3A: Fluid Dynamics
2. 528E3B: Machine Learning and Artificial Intelligence
3. 528E3C: Operation Research
4. 528E3D: Mathematical Python I

Semester IV : Elective VI

Elective VI to be chosen from Group F.

Group F:(PM/AP/IC/ITC)

1. 528E4A: Algebraic Geometry
2. 528E4B: Tensor Analysis and Relativity
3. 528E4C: Mathematical Programming
4. 528E4D: Mathematical Python II

Skill Enhancement Courses

Skill Enhancement Courses 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.

Group G (Skill Enhancement Courses) SEC:

- Computational Mathematics using SageMath
- Mathematical documentation using LATEX / other packages
- Office Automation and ICT Tools
- Numerical analysis using SCILAB
- Differential equations using SCILAB
- Industrial Mathematics /Statistics using latest programming packages
- Research Tools and Techniques

Ability Enhancement Courses

- Soft Skill courses

Extra Disciplinary Courses for other Departments (not for Mathematics students)

Students from other Departments may also choose any one of the following as Extra Disciplinary Course.

ED-I: Mathematics for Life Sciences

ED-II: Mathematics for Social Sciences

ED-III: Statistics for Life and Social Sciences

ED-IV: Game Theory and Strategy

ED-V: History of Mathematics

Instructions for Course Transaction

Courses	Lecture hrs	Tutorial hrs	Lab Practice	Total hrs
Core	75	15	--	90
Electives	75	15	--	90
ED	75	15	--	90
Lab Practice Courses	45	15	30	90
Project	20	--	70	90

Testing Pattern (25+75)

Internal Assessment

Theory Course: For theory courses there shall be three tests conducted by the faculty concerned and the average of the best two can be taken as the Continuous Internal Assessment (CIA) for a maximum of 25 marks. The duration of each test shall be one / one and a half hour.

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 one / one and a half hour.
There is no improvement for CIA of both theory and laboratory, and, also for University End Semester Examination.

Written Examination : Theory Paper (Bloom's Taxonomy based)

Question paper Model

Intended Learning Skills	**Maximum 75 Marks** **Passing Minimum: 50%** **Duration : Three Hours**
	Part –A(10x 2 = 20 Marks) Answer ALL questions **Each Question carries 2mark**

Memory Recall / Example/ Counter Example / Knowledge about the Concepts/ Understanding	Two questions from each UNIT
	Question 1 to Question 10
	Part – B (5 x 5 = 25 Marks) **Answer ALL questions** **Each questions carries 5 Marks**
Descriptions/ Application (problems)	**Either-or Type** Both parts of each question from the same UNIT
	Question 11(a) or 11(b) To **Question 15(a) or 15(b)**
	Part-C (3x 10 = 30 Marks) **Answer any THREE questions** **Each question carries 10 Marks**
Analysis /Synthesis / Evaluation	There shall be FIVE questions covering all the five units
	Question 16 to Question 20

Each question should carry the course outcome and cognitive level

For instance,

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

Different Types of Courses

(i) CoreCourses (Illustrative)

1. Algebra
2. Real Analysis
3. Ordinary Differential Equations
4. Partial Differential Equations
5. Topology
6. Complex Analysis
7. Mechanics
8. Functional Analysis
9. Differential Geometry and more

(ii) ElectiveCourses (ED within the Department Experts)(Illustrative)

1. Discrete Mathematics
2. Number Theory and Cryptography
3. Formal Languages and Automata Theory
4. Numerical Methods with C++ Practicals
5. Fuzzy Sets and Their Applications
6. Mathematical Programming
7. Algebraic Number Theory
8. Java Programming
9. Analytical Number Theory
10. Tensor Analysis and Relativity
11. Stochastic Processes
12. Algebraic Geometry
13. Fluid Dynamics
14. Financial Mathematics
15. Wavelets
16. Mathematical Statistics and more

(iii)ElectiveCourses (ED from other Department Experts)

(iv) Skill Development Courses

(v) Institution-Industry-Interaction(Industry aligned Courses)

Programmes /course work/ field study/ Modelling the Industry Problem/ Statistical Analysis / Commerce-Industry related problems / MoU with Industry and the like activities.

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">ALGEBRA I</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">CORE I</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2">428C1A</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td>5</td><td colspan="2">1</td><td colspan="2">--</td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level Modern Algebra</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To introduce the concepts and to develop working knowledge on class equation, solvability of groups, finite abelian groups, linear transformations, real quadratic forms</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT I–Another Counting Principle, Sylow’s theorems Chapter 2: Sections 2.11and 2.12</td></tr>
<tr><td colspan="6">UNIT II - Direct products - Finite abelian groups- Modules
Chapter 2: Sections 2.13 and 2.14
Chapter 4: Section 4.5</td></tr>
<tr><td colspan="6">UNIT III - Linear Transformations - Canonical forms -Triangular form –Nilpotent transformations.
Chapter 6: Sections 6.4 , 6.5</td></tr>
<tr><td colspan="6">UNIT IV - Jordan form - rational canonical form.
Chapter 6 : Sections 6.6 and 6.7</td></tr>
<tr><td colspan="6">UNIT V - Trace and transpose - Hermitian, unitary, normal transformations, real quadratic form.
Chapter 6 : Sections 6.8, 6.10 and 6.11 (Omit 6.9)</td></tr>
<tr><td colspan="2">Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)</td><td colspan="6">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)</td></tr>
<tr><td colspan="2">Skills acquired from this course</td><td colspan="6">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">I.N. Herstein. Topics in Algebra (II Edition) Wiley, 2002.</td></tr>
</table>

Reference Books	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 Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO 1: Recall basic counting principle, define class equations to solve problems, explain Sylow's theorems and apply the theorem to find number of Sylow subgroups

CLO 2: Define Solvable groups, define direct products, examine the properties of finite abelian groups, define modules

CLO 3: Define similar Transformations, define invariant subspace, explore the properties of triangular matrix,to find the index of nilpotence to decompose a space into invariant subspaces, to find invariants of linear transformation, to explore the properties of nilpotent transformation relating nilpotence with invariants.

CLO 4: Define Jordan,canonical form, Jordan blocks, define rational canonical form, define companion matrix of polynomial, find the elementary devices of transformation, apply the concepts to find characteristic polynomial of linear transformation.

CLO 5: Define trace, define transpose of a matrix,explain the properties of trace and transpose, to find trace, to find transpose of matrix,to prove Jacobson lemma using the triangular form, define symmetric matrix, skew symmetric matrix, adjoint,to define Hermitian, unitary, normal transformations andto verify whether the transformation in Hermitian, unitary and normal

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

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

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">REAL ANALYSIS I</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">CORE II</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2">428C1B</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td>Tutorial</td><td>Lab Practice</td><td colspan="3">Total</td></tr>
<tr><td>5</td><td>1</td><td>--</td><td colspan="3">6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level real analysis concepts</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">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.</td></tr>
<tr><td colspan="2" rowspan="2">Course Outline</td><td colspan="6">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.
Chapter – 6 : Sections 6.1 to 6.8
Infinite Series : Absolute and conditional convergence - Dirichlet's test and Abel's test - Rearrangement of series - Riemann's theorem on conditionally convergent series.
Chapter 8 : Sections 8.8, 8.15, 8.17, 8.18</td></tr>
<tr><td colspan="6">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.
Chapter - 7 : Sections 7.1 to 7.14</td></tr>
</table>

	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 integralsign-Lebesgue criteriaon for existence of Riemann integrals. Chapter - 7 : 7.15 to 7.26
	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. **Chapter - 8 Sec, 8.20, 8.21 to 8.26** **Power series** - Multiplication of power series - The Taylor's series generated by a function - Bernstein's theorem - Abel's limit theorem - Tauber's theorem **Chapter 9 : Sections 9.14 9.15, 9.19, 9.20, 9.22, 9.23**
	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. **Chapter -9 Sec 9.1 to 9.6, 9.8,9.9,9.10,9.11, 9.13**
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 this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Text	Tom M.Apostol :*Mathematical Analysis*, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974.
Reference Books	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 Anslysis*, 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 Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: Analyze and evaluate functions of bounded variation and Rectifiable Curves.
CLO2: Describe the concept of Riemann-Stieltjes integral and its properties.
CLO3:Demonstrate the concept of step function, upper function, Lebesgue function and their integrals.
CLO4: Construct various mathematical proofs using the properties of Lebesgue integrals and establish the Levi monotone convergence theorem.
CLO5: Formulate the concept and properties of inner products, norms and measurable functions.

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

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">ORDINARY DIFFERENTIAL EQUATIONS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">CORE III</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2">428C1C</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td>Tutorial</td><td>Lab Practice</td><td colspan="3">Total</td></tr>
<tr><td>5</td><td>1</td><td>--</td><td colspan="3">6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level Calculus and Differential Equations</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">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</td></tr>
<tr><td colspan="2" rowspan="4">Course Outline</td><td colspan="6">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.
Chapter 2: Sections 1 to 6</td></tr>
<tr><td colspan="6">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.
Chapter 2 : Sections 7 to 12.</td></tr>
<tr><td colspan="6">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.
Chapter : 3 Sections 1 to 8 (Omit section 9)</td></tr>
<tr><td colspan="6">UNIT-IV :Linear equation with regular singular points
Euler equation – Second order equations with regular singular points – Exceptional cases – Bessel Function.
Chapter 4 : Sections 1 to 4 and 6 to 8 (Omit sections 5 and 9)</td></tr>
</table>

	UNIT-V : 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. **Chapter 5 : Sections 1 to 6 (Omit Sections 7 to 9)**
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 this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill
Recommended Text	E.A.Coddington, *A introduction to ordinary differential equations* (3rd Printing) Prentice-Hall of India Ltd.,New Delhi, 1987.
Reference Books	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. B.Rai, 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 Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: Establish the qualitative behavior of solutions of systems of differential equations .

CLO2: Recognize the physical phenomena modeled by differential equations and dynamical systems.

CLO3: Analyze solutions using appropriate methods and give examples.

CLO4: Formulate Green's function for boundary value problems.

CLO5: Understand and use various theoretical ideas and results that underlie the mathematics in this course.

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

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Titleofthecourse</td><td colspan="6">GRAPHTHEORY</td></tr>
<tr><td colspan="2">PaperNumber</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E1D</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basics ingraph theory</td></tr>
<tr><td colspan="2">CourseOutline</td><td colspan="6">UNIT – I Graphs, Subgraphs and Trees: Graphs and simple graphs – Graph isomorphism – The incidence and adjacency matrices – Subgraphs – Vertex degrees – Path and connection – Cycles – Trees – Cut Edges and Bonds – Cut vertices.
Chapter 1 : Sections 1.1 to 1.7
Chapter 2 : Sections 2.1 to 2.3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – II Connectivity, Euler tours and Hamilton Cylcles:
Connectivity – Blocks – Euler tours – Hamilton Cycles.
Chapter 3: Sections 3.1 to 3.2
Chapter 4 : Sections 4.1 to 4.2</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III Matchings, Edge Colouring:Matchings – Matchings and coverings in bipartite graphs – Edge Chromatic number – Vizing’s theorem.
Chapter 5 : Sections 5.1 to 5.2
Chapter 6 : Sections 6.1 to 6.2</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV Indpendent sets and Cliques, Vertex colourings:
Independent sets – Ramsey’s theorem – Chromatic number – Brook’s theorem – Chromatic polynomials.
Chapter 7 : Sections 7.1 to 7.2Chapter 8 : Sections 8.1 to 8.2, 8.4</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – V Planar Graphs :Plane and planar graphs – Dual graphs – Euler’s formula – The five – colour theorem and the Four – colour conjecture.
Chapter 9 : Sections 9.1 to 9.3, 9.6</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">J.A.BondyandU.S.RMurty,GraphTheorywithApplications,Macmillan,London1976</td></tr>
<tr><td colspan="2">ReferenceBooks</td><td colspan="6">1. K.R.Parthasarathy,BasicGraph Theory,TataMcGraw-Hill, NewDelhi,1994
2. NarsinghDeo,GraphTheorywithApplicationstoEngineeringand ComputerScience,Prentice-HallofIndia, 2007
3. DouglasB.West,IntroductiontoGraphTheory,PearsonPrenticeHall,2006</td></tr>
</table>

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">NUMBER THEORY AND CRYPTOGRAPHY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E1A</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Elementary number theory and calculus</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT – I : Elementary Number Theory : Time estimates for doing arithmetic – divisibility and the Euclidean algorithm
Chapter 1 : Sections 1 and 2</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - II : Elementary Number Theory : Congruences – Some applications to factoring
Chapter 1 : Sections 3 and 4</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III : Finite Fields and Quadratic Residues: Finite Fields, Quadratic residues and reciprocity
Chapter 2 : Sections 1 and 2</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV : Cryptography : Some simple cryptosystems – Enciphering matrices
Chapter 3 : Sections 1 and 2.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - V : Public Key : Public Key Cryptography - RSA
Chapter 4 : Sections 1 and 2</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">Neal Koblit, A course in Number Theory and Cryptography, Springer – Verlag, New York, 1987</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. I. Niven and H.S.uckermann, 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</td></tr>
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UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">DATA PROGRAMING WITH R</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E1B</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT-I : General introduction to computing Using R as a calculator, Numbers, words and logicals; missing values (NA), Vectors and their attributes (names, length, type), System- and user-defined objects, Accessing data (data),Data in the system and date outside the system (read.table, scan).</td></tr>
<tr><td colspan="2" rowspan="4"></td><td colspan="6">UNIT-II : First steps in graphics, The basics of R syntax, The R workspace, Matrices and lists, Subsetting System-defined functions; the help system Errors and warnings; coherence of the workspace.</td></tr>
<tr><td colspan="6">UNIT-III : Data input and output; interface with other software packages Writing your own code; R script, Good programming practice, R syntax -- further steps, The parentheses and brackets; =, == and <–; Exploratory data analysis, Range, summary, mean, variance, median, sd, histogram, box plot, scatterplot.</td></tr>
<tr><td colspan="6">UNIT-IV : Probability distributions, Simulations, Random number generation Distributions, the practice of simulation.</td></tr>
<tr><td colspan="6">UNIT-V : Apply-type functions Compiling and applying functions, Documentation, Conditional statements, Loops and iterations, Statistical functions in R, Statistical inference, contingency tables, chi-square goodness of fit, regression, generalized linear models, advanced modeling methods, the bootstrap method to compute s.e.f.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Randall pruim, Foundations and Applications of Statistics-An introduction using R, American mathematical society,2010.
2. Robert I. Kabacoff, R in Action, Manning publication, 2015.
3. Thomas J. Pfaff, R for College Mathematics and Statistics, CRS Press,2019.</td></tr>
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UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">FORMAL LANGUAGES AND AUTOMATA THEORY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E1C</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Elementary algebra</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT-I :Finite automata, regular expressions and regular grammars
Finite state systems – Basic definitions – Nondeterministic finite automata– Finite automata with □ moves– Regular expressions – Regular grammars.

Chapter 2. Sections 2.1 to2.5
Chapter 9 Section 9.1</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-II :
Properties of regular sets.
The Pumping lemma for regular sets – Closure properties of regular sets –Decision algorithms for regular sets – The Myhill-Nerode Theorem and minimization of finite automata.

Chapter 3 : Sections 3.1 to 3.4</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-III : Context-free grammars
Motivation and introduction – Context-free grammars – Derivation trees-Simplification of context-free grammars – Chomsky normal form – Greibach normal form.

Chapter 4 : Section 4.1 to 4.6</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-IV : Pushdown automata
Informal description- Definitions-Pushdown automata and context-freelanguages – Normal forms for deterministic pushdown automat.

Chapter 5 : Sections 5.1 to 5.3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-V : Properties of context-free languages
The pumping lemma for CFL’s – Closure properties for CFL’s – Decisionalgorithms for CFL’s.

Chapter 6 : Sections 6.1 to 6.3</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">John E.Hopcraft and Jeffrey D.Ullman, Introduction to Automata Theory,Languages and Computation, Narosa Publishing House, New Delhi, 1987.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. A. Salomaa, Formal Languages, Academic Press, New York, 1973.
2. John C. Martin, Introduction to Languages and theory of Computations (2nd Edition) Tata-McGraw Hill Company Ltd., New Delhi, 1997.</td></tr>
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UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">TitleoftheCourse</td><td colspan="6">FUZZYSETSAND THEIR APPLICATIONS</td></tr>
<tr><td colspan="2">PaperNumber</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E1F</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Knowledgeofgraphs,relations,composition</td></tr>
<tr><td colspan="2">CourseOutline</td><td colspan="6">UNIT-I:FundamentalNotions

ChapterI:Sec. 1to 8</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-II:FuzzyGraphs

Chapter II:Sec. 10 to 18</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-III :FuzzyRelations

Chapter II: Sec.19 to29</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-IV:FuzzyLogic

ChapterIII:Sec.31 to 40(omitSec. 37, 38,41)</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-V:The LawsofFuzzyComposition

ChapterIV:Sec.43 to49</td></tr>
<tr><td colspan="2">RecommendedText</td><td colspan="6">A.Kaufman,Introduction tothe theoryofFuzzysubsets,Vol.I, AcademicPress,NewYork,1975.</td></tr>
<tr><td colspan="2">ReferenceBooks</td><td colspan="6">1. H.J.Zimmermann, Fuzzy Set Theory and its Applications, Allied Publishers,Chennai,1996
2. George J.Klir and Bo Yuan, Fuzzy sets and Fuzzy Logic-Theory andApplications,PrenticeHallIndia, NewDelhi,2001.</td></tr>
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UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">LIE GROUPS AND LIE ALGEBRAS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E1E</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT–I : Introduction - Lie groups of transformations - infinitesimal transformations</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-II : Extended group transformations and infinitesimal transformations (one independent and one dependent variables).</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT–III : Basic Concepts of Lie Algebras</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT–IV: Ideals and homomorphisms and Solvable and nilpotent Lie algebras</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-V : Semisimple Lie algebras : Theorems of Lie and Cartan, Killing form and Complete reducibility of representations and representation of sl(2,F).</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. G.W. Bluman and S. Anco, Symmetry and Integration for Differential Equations, Springer, (Berlin)2002.
2. P.J. Olver, Applications of Lie groups to Differential equations, Springer (1998) Berlin</td></tr>
</table>

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">TitleoftheCourse</td><td colspan="6">DISCRETEMATHEMATICS</td></tr>
<tr><td colspan="2">PaperNumber</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E1G</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Elementaryalgebra</td></tr>
<tr><td colspan="2" rowspan="5">CourseOutline</td><td colspan="6">UNIT-I : Lattices: Properties of Lattices:Lattice definitions – Modular anddistributivelattice;Booleanalgebras:Basicproperties– Booleanpolynomials,Ideals;Minimalforms ofBoolean polynomials.
Chapter 1:§1AandB§2Aand B. §3</td></tr>
<tr><td colspan="6">UNIT-II :Applications of Lattices: Switching Circuits: Basic Definitions -Applications
Chapter 2:§1AandB</td></tr>
<tr><td colspan="6">UNIT-III:Finite Fields
Chapter 3:§ 2</td></tr>
<tr><td colspan="6">UNIT-IV :Polynomials : IrreduciblePolynomials over Finite fields – FactorizationofPolynomials
Chapter3:§3 and §4</td></tr>
<tr><td colspan="6">UNIT-V:CodingTheory: Linear CodesandCyclic Codes
Chapter 4§ 1 and2</td></tr>
<tr><td colspan="2">RecommendedText</td><td colspan="6">RudolfLidland GunterPilz,AppliedAbstractAlgebra,Spinger-Verlag,New York,1984.</td></tr>
<tr><td colspan="2">ReferenceBooks</td><td colspan="6">1. A.Gill, Applied Algebra for Computer Science, Prentice Hall Inc., NewJersey.
2. J.L.Gersting, Mathematical Structures for Computer Science(3rd Edn.),ComputerSciencePress, NewYork.
3. S.Wiitala,DiscreteMathematics-AUnifiedApproach, McGrawHillBookCo.</td></tr>
</table>

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">FINANCIAL MATHEMATICS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td>Course</td><td rowspan="2">428E1H</td></tr>
<tr><td>Semester</td><td>I</td><td>Code</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Stochastic Processes</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT – I : Single Period Models: Definitions from Finance – Pricing of a Forward – One – step Binary Model
Chapter 1 : Sections 1.1 to 1.3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – II : Single Period Models ; A characterization of no arbitrage – Risk – Neutral Probability Measure
Chapter 1 : Sections 1.5 and 1.6</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III : Binomial trees and Discrete parameter Martingales:Multi period Binary Model – American options
Chapter 2: Sections 2. 1 and 2.2</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV : Binomial trees and Discrete parameter Martingales: Discrete parameter martingales and Markov processes – Martingale theorems
Chapter 2 : Sections 2.3 and 2.4</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – V: Brownian Motion : Definition of the process – Levy’s construction of Brownian Motion
Chapter 3 : Sections 3.1 and 3.2</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">A.Etheridge, A course in Financial Calculus, Cambridge University Press, 2002</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">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)</td></tr>
</table>

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td>Title of the Course</td><td colspan="6">ALGEBRA II</td></tr>
<tr><td>Paper Number</td><td colspan="6">CORE IV</td></tr>
<tr><td rowspan="2">Category Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2">428C2A</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td rowspan="2">Instructional Hours per week</td><td>Lecture</td><td>Tutorial</td><td>Lab Practice</td><td colspan="3">Total</td></tr>
<tr><td>5</td><td>1</td><td>--</td><td colspan="3">6</td></tr>
<tr><td>Pre-requisite</td><td colspan="6">Algebraic Structures</td></tr>
<tr><td>Objectives of the Course</td><td colspan="6">To study field extension, roots of polynomials, Galois Theory, finite fields, division rings, solvability by radicals and to develop computational skill in abstract algebra.</td></tr>
<tr><td rowspan="5">Course Outline</td><td colspan="6">UNIT-I :Extension fields – Transcendence of e.
Chapter 5: Section 5.1 and 5.2</td></tr>
<tr><td colspan="6">UNIT-II : Roots or Polynomials.- More about roots
Chapter 5: Sections 5.3 and 5.5</td></tr>
<tr><td colspan="6">UNIT-III : Elements of Galois theory.
Chapter 5 : Section 5.6</td></tr>
<tr><td colspan="6">UNIT-IV : Finite fields - Wedderburn's theorem on finite division rings.
Chapter 7: Sections 7.1 and 7.2 (Theorem 7.2.1 only)</td></tr>
<tr><td colspan="6">UNIT-V :Solvability by radicals - A theorem of Frobenius - Integral Quaternions and the Four - Square theorem.
Chapter 5: Section 5.7 (omit Lemma 5.7.1, Lemma 5.7.2 and Theorem 5.7.1)
Chapter 7 : Sections 7.3 and 7.4</td></tr>
<tr><td>Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)</td><td colspan="6">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)</td></tr>
<tr><td>Skills acquired from this course</td><td colspan="6">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td>Recommended Text</td><td colspan="6">I.N. Herstein. Topics in Algebra (II Edition) Wiley EasternLimited, New Delhi, 1975.</td></tr>
</table>

Reference Books	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 Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: Prove theorems applying algebraic ways of thinking.

CLO2: Connect groups with graphs and understanding about Hamiltonian graphs.

CLO3: Compose clear and accurate proofs using the concepts of Galois Theory.

CLO4: Bring out insight into Abstract Algebra with focus on axiomatic theories.

CLO5: Demonstrate knowledge and understanding of fundamental concepts including extension fields, Algebraic extensions, Finite fields, Class equations and Sylow's theorem.

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

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">REAL ANALYSIS II</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">CORE V</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2">428C2B</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td>Tutorial</td><td>Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td colspan="2">5</td><td>1</td><td>--</td><td colspan="2">6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Elements of Real Analysis</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To introduce measure on the real line, Lebesgue measurability and integrability, Fourier Series and Integrals, in-depth study in multivariable calculus.</td></tr>
<tr><td colspan="2" rowspan="3">Course Outline</td><td colspan="6">UNIT-I :Measure on the Real line - Lebesgue Outer Measure - Measurable sets - Regularity - Measurable Functions - Borel and Lebesgue Measurability
Chapter - 2 Sec 2.1 to 2.5 (de Barra)</td></tr>
<tr><td colspan="6">UNIT-II : Integration of Functions of a Real variable - Integration of Non- negative functions - The General Integral - Riemann and Lebesgue Integrals
Chapter - 3 Sec 3.1,3.2 and 3.4 (de Barra)</td></tr>
<tr><td colspan="6">UNIT-III : Fourier Series and Fourier Integrals - Introduction - Orthogonal system of functions - The theorem on best approximation - The Fourier series of a function relative to an orthonormal system - Properties of Fourier Coefficients - The Riesz-Fischer Thorem - The convergence and representation problems in for trigonometric series - The Riemann - Lebesgue Lemma - The Dirichlet Integrals - An integral representation for the partial sums of Fourier series - Riemann's localization theorem - Sufficient conditions for convergence of a Fourier series at a particular point –Cesarosummability of Fourier series- Consequences of Fejes's theorem - The Weierstrass approximation theorem
Chapter 11 : Sections 11.1 to 11.15 (Apostol)</td></tr>
</table>

	UNIT-IV : 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 **Chapter 12 : Section 12.1 to 12.14 (Apostol)**
	UNIT-V : 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. **Chapter 13 : Sections 13.1 to 13.7 (Apostol)**
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 this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill
Recommended Text	1. G. de Barra, *Measure Theory and Integration*, Wiley Eastern Ltd., New Delhi, 1981. (for Units I and II) 2. Tom M.Apostol :*Mathematical Analysis*, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974. (for Units III, IV and V)

Reference Books	1. Burkill,J.C.*The Lebesgue Integral*, Cambridge University Press, 1951. 2. Munroe,M.E.*Measure and Integration*. Addison-Wesley, Mass.1971. 3. Roydon,H.L.*Real Analysis*, Macmillan Pub. Company, New York, 1988. 4. Rudin, W. *Principles of Mathematical Analysis*, McGraw Hill Company, New York,1979. 5. Malik,S.C. and Savita Arora. *Mathematical Analysis*, Wiley Eastern Limited. New Delhi, 1991. 6. Sanjay Arora and Bansi Lal, *Introduction to Real Analysis*, Satya Prakashan, New Delhi, 1991
Website and e-Learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: Understand and describe the basic concepts of Fourier series and Fourier integrals with respect to orthogonal system.

CLO2: Analyze the representation and convergence problems of Fourier series.

CLO3: Analyze and evaluate the difference between transforms of various functions.

CLO4: Formulate and evaluate complex contour integrals directly and by the fundamental theorem.

CLO5: Apply the Cauchy integral theorem in its various versions to compute contour integration.

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

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">PARTIAL DIFFERENTIAL EQUATIONS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">CORE VI</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2">428C2C</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td>Lecture</td><td>Tutorial</td><td>Lab Practice</td><td colspan="3">Total</td></tr>
<tr><td>5</td><td>1</td><td>--</td><td colspan="3">6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level partial differential equations</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To classify the second order partial differential equations and to study Cauchy problem, method of separation of variables, boundary value problems.</td></tr>
<tr><td colspan="2" rowspan="3">Course Outline</td><td colspan="6">UNIT-I

Partial Differential Equations of First Order: Formation and solution of PDE- Integral surfaces – Cauchy Problem order eqn Orthogonal surfaces – First order non-linear – Characteristics – Compatible system – Charpit method. Fundamentals: Classification and canonical forms of PDE.
Chapter 0: 0.4 to 0.11 (omit 0 .1,0.2,0.3 and 0.11.1)
Chapter 1: 1.1 to 1.5</td></tr>
<tr><td colspan="6">UNIT-II

Elliptic Differential Equations: Derivation of Laplace and Poisson equation – BVP – Separation of Variables – Dirichlet’s Problem and Newmann Problem for a rectangle – Interior and Exterior Dirichlets’s problems for a circle – Interior Newmann problem for a circle – Solution of Laplace equation in Cylindrical – Examples.
Chapter 2: 2.1, 2. 2 ,2.5 to 2.11&2.13 (omit 2.3 and 2.4&2.12 and Examples)</td></tr>
<tr><td colspan="6">UNIT-III

Parabolic Differential Equations: Formation and solution of Diffusion equation – Dirac-Delta function – Separation of variables method – Solution of Diffusion Equation in Cylindrical .
Chapter 3: 3.1 to 3.6 and 3.9 (omit 3.7,3.8 & 3.10)</td></tr>
</table>

	UNIT-IV **Hyperbolic Differential equations:** Formation and solution of one-dimensional wave equation – canocical reduction – IVP-d'Alembert's solution – Vibrating string – Forced Vibration – IVP and BVP for two-dimensional wave equation – Periodic solution of one-dimensional wave equation in cylindrical and spherical coordinate systems – vibration of circular membrane – Uniqueness of the solution for the wave equation **Chapter 4:** 4.1 to 4.8,4.10&4.11(omit 4.9,4.12&4.13)
	UNIT-V **Green's Function:** Green's function for laplace Equation – methods of Images – Eigen function Method – Green's function for the wave and Diffusion equations. Laplace Transform method: Solution of Diffusion and Wave equation by Laplace Transform. **Chapter 5:** 5.1 to 5.6 Chapter 6: 6.13.1 and 6.13.2 only (omit (6.14)
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 this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill
Recommended Text	S, Sankar Rao, Introduction to Partial Differential Equations, 2nd Edition, Prentice Hall of India, New Delhi. 2005.

Reference Books	1. R.C.McOwen, Partial Differential Equations, 2nd Edn. Pearson Eduction, New Delhi, 2005. 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.
Website and e-Learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: To understand and classify second order equations and find general solutions

CLO2: To analyse and solve wave equations in different polar coordinates

CLO3: To solve Vibrating string problem, Heat conduction problem, to identify and solve Laplace and beam equations

CLO4: To apply maximum and minimum principle's and solve Dirichlet, Neumann problems for various boundary conditions

CLO5: To apply Green's function and solve Dirichlet, Laplace problems, to apply Helmholtz operation and to solve Higher dimensional problem

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

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">TitleoftheCourse</td><td colspan="6">PROBABILITY THEORY</td></tr>
<tr><td colspan="2">PaperNumber</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E2B</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">ProbabilityatUGlevel</td></tr>
<tr><td colspan="2">CourseOutline</td><td colspan="6">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 .
Chapter 1 : Sections 1.1 to 1.7
Chapter 2: Sections 2.1 to 2.9

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.
Chapter 3 : Sections 3.1 to 3.8

UNIT – III Characteristic Functions : Properties of characteristic functions - Characteristic functions and moments – Semi invariants – 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
Chapter 4 : Sections 4.1 to 4.7

UNIT – IV Some Probability distribution : One point, two point, Binomial – Polya – Hypergeometric – Poisson (discrete) distributions – Uniform – Normal gamma – Beta – Cauchy and Laplace (continuous) distribution.

Chapter 5 : Section 5.1 to 5.10

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 – lapunov theorem – Borel – Cantelli lemma - Kolmogorov inequality and Kolmogorov strong law of large numbers.</td></tr>
</table>

	Chapter 6 : Sections 6.1 to 6.4, 6.6 to 6.9, 6.11 and 6.12
RecommendedText	M.Fisz, Probability Theory and Mathematical Statistics, Third edition –John Wiley and Sons, New York ,1963.
ReferenceBooks	1. R.B.Ash,Real Analysisand Probability,AcademicPress, NewYork ,1972 2. R.Durrett, Probability: Theoryand Examples, [2nd Edition] , DuxpuryPress,NewYork, 1996 3. V.K.Rohatgi,AnIntroductiontoProbability:TheoryandMathematicalStatistics,WeileyEasternLtd.,NewDelhi, 1988[3rd Print]. 4. S.I.Resnick,AProbabilityPath,Birhauser,Berlin,1999. 5. B.R.Bhat , Modern Probability Theory ,[3rd Edition] , New Age International (P) Ltd, New Delhi ,1999. 6. M.Fisz,ProbabilityTheoryandMathematicalStatistics,JohnWileyandSons,NewYork,1963.

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">ALGEBRAIC TOPOLOGY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E2A</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Algebra, Topology</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT-I : Homotopy of paths - Fundamental Group – Covering space -The Fundamental Group of the circle – Retractions and Fixed points

Chapter 9: Sections 51 – 55.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-II : The Fundamental Theorem of Algebra – Borsuk–Ulam Theorem – Deformation Retracts and Homotopy Type – The Fundamental Group of S^n - Fundamental Groups of some surfaces.

Chapter 9 : Sections 56 – 60</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-III : Direct sums of Abelian Groups – Free products of Groups – Free Groups – The Seifert–van Kampen Theorem – The Fundamental Group of a wedge of circles.

Chapter 11 : Sections 67 -71.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-IV : Fundamental groups of surfaces – Homology of surfaces – cutting and pasting – The classification theorem – constructing compact surfaces.

Chapter 12 : Sections 74 – 78</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-V : Equivalence of covering spaces – The Universal covering space– covering transformations – Existence of covering spaces

Chapter 13 : Sections 79 – 82</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">J.R.Munkres, Toplogy, Pearson Education Asia , Second Edition 2002.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. M.K.Agoston, Algebraic topology – A First Course, Marcel Dekker,1962.
2. Satya Deo, Algebraic Topology , Hindustan Book Agency, NewDelhi, 2003.
3. M.Greenberg and Harper, Algebraic Topology – A First course,Benjamin/Cummings, 1981.
4. C.F. Maunder, Algebraic topology, Van Nostrand, New York, 1970.
5. A.Hatcher, Algebraic Topology, Cambridge University Press, SouthAsian Edition 2002.
6. W.S.Massey, Algebrai Topology : An Introduction, Springer 1990</td></tr>
</table>

UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">MODELLING AND SIMULATION WITH EXCEL</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td>Category</td><td>Elective</td><td>Year
Semester</td><td>I
II</td><td>Credits</td><td>3</td><td>Course Code</td><td>428E2C</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">Unit–I : Presentation of Quantitative Data: Introduction-Data Classification-Data Context and Data Orientation-Types of Charts and Graphs-An Example of Graphical Data Analysis and Presentation.
Analysis of Quantitative Data : Introduction-Data Analysis Tools-Data Analysis for Two Data Sets-Analysis of Time Series Data—Forecasting/Data Relationship Tools-Analysis of Cross-Sectional Data—Forecasting/Data Relationship Tools.</td></tr>
<tr><td colspan="6">Unit- II : Presentation of Qualitative Data : Introduction-Essentials of Effective Qualitative Data Presentation-Data Entry and Manipulation-Data queries with Sort, Filter, and Advanced Filter.
Analysis of Qualitative Data : Introduction-Essentials of Qualitative Data Analysis-PivotChart or PivotTable Reports.</td></tr>
<tr><td colspan="6">Unit–III : Inferential Statistical Analysis of Data : Introduction-χ 2—Chi-Square Test of Independence for Categorical Data-z-Test and t-Test of Categorical and Interval Data-An Example-ANOVA-Experimental Design.</td></tr>
<tr><td colspan="6">Unit–IV : Modeling and Simulation: Part 1 : Introduction-An Example of Deterministic Modeling-Understanding the Important Elements of a Model-Model Building with Excel.</td></tr>
<tr><td colspan="6">Unit-V : Modeling and Simulation: Part 2 : Types of Simulation and Uncertainty-The Monte Carlo Sampling Methodology-A Financial Example—Income Statement-An Operations Example—Autohaus.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">Excel data analysis modelling and simulation, Hector Guerrero, Springer-Verlag Berlin Heiddelberg 2010.</td></tr>
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UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">TitleoftheCourse</td><td colspan="6">NEURAL NETWORKS</td></tr>
<tr><td colspan="2">PaperNumber</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">CourseCode</td><td rowspan="2">428E2D</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">CourseOutline</td><td colspan="6">UNIT-I : Single-layer perceptron classifiers

Classification model, Features & Decision regions; training & classification using discrete perceptron, algorithm, single layer continuous perceptron networks for linearly separable classifications.</td></tr>
<tr><td colspan="2" rowspan="4"></td><td colspan="6">UNIT-II : Multilayer feedforward networks

Linearly non-separable pattern classification, Delta learning rule for multi-perceptron layer, Generalized delta learning rule, Error back-propagation training, learning factors, Examples.</td></tr>
<tr><td colspan="6">UNIT-III:Single layer feedback Networks

Basic Concepts, Hopfield networks, Training & Examples.
Associative memories: Linear Association, Basic Concepts of recurrent.</td></tr>
<tr><td colspan="6">UNIT-IV : Auto associative memory

Retrieval algorithm, storage algorithm; By directional associative memory, Architecture, Association encoding & decoding, Stability.</td></tr>
<tr><td colspan="6">UNIT-V : Self organizing networks

UN supervised learning of clusters, winner-take-all learning, recall mode, Initialization of weights, seperability limitations.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">Introduction to Artificial Neural systems – Jacek M. Zurada, 1994, Jaico Publ. House</td></tr>
<tr><td colspan="2">ReferenceBooks</td><td colspan="6">1.Neural Networks :A Comprehensive formulation – Simon Haykin, 1998, AW
2.Neural Networks – Kosko, 1992, PHI.
3.Neural Network Fundamentals – N.K. Bose , P. Liang, 2002, M.H
4.Neural Network – T.N.Shankar, University Science Press
5.Neuro Fuzzy Systems – Lamba, V.K., University Science Press</td></tr>
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UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">ALGEBRAIC NUMBER THEORY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course code</td><td rowspan="2">428E2E</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Algebra and Linear Algebra</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT – I : Algebraic back ground : Rings and Fields
Factorization of Polynomials – Field extensions – Symmetric polynomials –Modules – Free Abelian groups.
Chapter 1 : Sections – 1.1 to 1.6</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – II : Algebraic numbers – Conjugate and Discriminant – Algebraic integers.
Chapter 2 : Sections – 2.1 – 2.3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III : Integral bases – Norms and traces – Rings of integers
Chapter 2 : Sections – 2.4 to 2.6</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV : Quadratic fields – Cyclotomic fields
Chapter 3 : Sections – 3.1 – 3.2</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – V : Historical background – trivial factorization – factorization into irreducibles
Chapter 4 : Sections – 4.1 – 4.3</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">I.Stewart and D.Tall. Algebraic number theory and Fermat’s Last theorem (3rd edition) A.K Peters Ltd,Natrick, Mass. 2002</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Z. I. Borevic and I.R.Safarevic, Number theory, Academic Press, NY, 1966.
2. J.W.S.cassels and A.Frohlich, Algebraic , Number theory, Academic Press, New York, 1967.
3. P. Ribenboim, Algebraic numbers, Wiley, New York, 1972.
4. P.Samuel, Algebraic Theory of Numbers, Houghton Mifflin company, Boston, 1970</td></tr>
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UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

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<table>
<tr><td colspan="2">Titleofthecourse</td><td colspan="6">NUMERICAL METHODS WITH C++ PRACTICALS</td></tr>
<tr><td colspan="2">PaperNumber</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E2F</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">CourseOutline</td><td colspan="6">UNIT–I: The solution of Nonlinear Equations f(x)=0
Iteration for solving x=g(x) – Bracketing methods for locating a root – Initial approximations and convergence criteria – Newton-Raphson and secant methods- Aitken’s and Steffensen’s and Muller’s methods</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT -II : The solution of Linear systems AX= B
Upper triangular linear systems-Gaussian elimination and pivoting-Matrix inversion- Triangular factorization- Interpolation-Lagrange approximation – Newton polynomials</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT–III: Numerical Differentiation, Integration and optimization
Approximating a derivative – Numerical differentiation formulae – quadrature – Composite trapezoidal and Simpson’s rule – recursive rules – Romberg Integration – Minimisation of a function.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV :Solution of Differential Equations
Differential Equations – Euler’s method – Heun method- Taylor series method – Runga-Kutta methods – Predictor-Corrector methods.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-V:Solution to Partial differential methods
Hyperbolic quations – Parabolic equations – Elliptic equations.</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">John H.Mathews, Numerical Methods for Mathematics, Science and Engineering (2nd Edn.), Prentice Hall, New Delhi, 2000</td></tr>
<tr><td colspan="2">ReferenceBooks</td><td colspan="6">1.Gerald, C.F. and Wheatley, P.O. (1994) : Applied Numerical Analysis, Addison Wesley, New York, 5th Ed.
2.Press, W.B., Flannery, S. Teuddsky and Vetterling, W. (1989) : Numerical Recipes in C : The art of Scientific computing. Rev. 1st ed., Cambridge University Press.
3.Rice, John, R. (1983) : Numerical Methods, Software and Analysis McGraw Hill, New York.
4.Atkinson, K.E. (1978) : An introduction to Numerical Analysis, Wiley & Sons, New York.
5.Sastry, S.S. (1987) : Introductory methods of numerical analysis, Prentice Hall of India, New Delhi, (10th printing).</td></tr>
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UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">STOCHASTIC PROCESSES</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E2G</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Probability Theory</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT – I : Markov Chains : Classification of general stochastic processes – markov chain – Examples – Transition probability matrix – Classification of states – Recurrence

Chapter 1 : Section 3 only and Chapter 2 : sections 1 to 5.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - II : Limit theorems of Markov chains : Discrete renewal equation and its proof – Absorption probabilities – criteria for recurrence – Queuing models

Chapter 3 : Sections 1 to 7</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III : Continuous time Markov Chains : Poisson process – Pure Birth process – Birth and Death process - Birth and Death process with absorbing states

Chapter 1 : Section 2 (Poisson process)
Chapter 4 : Sections 1, 2 and 4to 7 (omit sections 3 and 8)</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV : Renewal processes : Definition and related concepts – Some special renewal processes

Chapter 5 : sections 1 – 3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - V : Brownian Motion : Definition – Joint probabilities for Brownian Motion – Continuity of paths and the maximum variables – Variations and extensions

Chapter 1 : Section 2 (Brownian Motion)
Chapter 6 : sections 1 to 4 and 7A only</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">S.Karlin and H.M. taylor, A first course in stochastic processes (2nd edition) Academic Press, New York, 1975</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. E. Cinler, Introduction to stochastic processes, Prentice HallInc, New Delhi, 1975
2. D.R.Cox and H.D.Miller, Theory of stochastic processes (3rd Edition) Chapman and hall, London, 1983
3. D.Kannan, An introduction to stochastic processes, North-Holland, New York, 1979
4. S.M. Ross, Stochastic processes, John Wiley and Sons,New York, 1983
5. H.W. Taylor nd S.Karlin, An introduction to stochastic modeling (3rd Edition), Academic Press, New York, 1998</td></tr>
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UNIVERSITY OF MADRAS

M.Sc. DEGREE PROGRAMME IN MATHEMATICS

SYLLABUS WITH EFFECT FROM 2023-2024

<table>
<tr><td colspan="2">Title of the course</td><td colspan="6">DATA ANALYSIS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">428E2H</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT – I : Introduction
Pandas Data Frame Basics – loading, sub setting rows and columns, grouped and aggregated, Basic Plot, Pandas Data Structures – creating a series and data frame, Boolean sub setting: series, broadcasting, marketing changes to series and data frames, exporting and importing data.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - II : Introduction to Plotting
Introduction, matplotlib, statistical graphics using matplotib, seaborn, Pandas objects, seaborn themes and styles. Data manipulation: data assembly, missing data, tidy data.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – III : Data Mining
Data types, converting types, categorical data, string and text data, string methods, string formatting, regular expressions – match, find, substituting and compiling a pattern.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT – IV : Data Modeling
Linear Models – introduction, simple linear regression, multiple regressions, generalized linear models – logistic regression, poisson regression, survival analysis.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT -V : Model Diagnostics
Residuals, comparing multiple models, k-fold cross validation, regularization – LASSO regression, ridge regression, clustering – k-means, hierarchical clustering.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Pandas for everyone – Python Data Analysis by D.Y. Chen, Pearson.
2. Think Python How to Think Like a Computer Scientist by A. Downey, Green Tea Press
3. Online source: Python for Beginners- https://www.python.org/about/gettingstarted</td></tr>
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