M.Sc., MATHEMATICS

SYLLABUS 2023-2024 ONWARDS

PERIYAR UNIVERSITY
PERIYAR PALKALAI NAGAR
SALEM – 636011

NEW INITIATIVE IN MODERNISING POST GRADUATE PROGRAMME IN MATHEMATICS

CONTENTS

INTRODUCTION

M.Sc. Mathematics : Programme Outcome, Programme Specific Outcome and Course Outcome

Mathematics is the study of quantity, structure, space and change, focusing on problem solving, with wider scope of application in science, engineering, technology, social sciences etc. The key core areas of study in Mathematics include Algebra, Analysis (Real & Complex), Differential Equations, Geometry, and Mechanics. The Master Degree M.Sc. Mathematics is awarded to the students on the basis of knowledge, understanding, skills, attitudes, values and academic achievements expected to be acquired by learners at the end of the Programme. Learning outcomes of Mathematics are aimed at facilitating the learners to acquire these attributes, keeping in view of their preferences and aspirations for gaining knowledge of Mathematics.

Master degree in Mathematics is the culmination of in-depth knowledge of algebra, Real analysis, geometry, differential equations and several other branches of Mathematics. This also leads to study of related areas like Computer science, Financial Mathematics, Mathematical Statistics and many more. Thus, this programme helps learners in building a solid foundation for higher studies in Mathematics. The skills and knowledge gained have intrinsic aesthetics leading to proficiency in analytical reasoning. This can be utilised in Mathematical modelling and solving real life problems.

Students completing this programme will be able to present Mathematics clearly and precisely, make abstract ideas precise by formulating them in the language of Mathematics, describe Mathematical ideas from multiple perspectives and explain fundamental concepts of Mathematics to non-Mathematicians.

Completion of this programme will also enable the learners to join teaching profession, enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

Programme	**M.Sc., MATHEMATICS**
Programme Code	
Duration	**PG - 2 years**
Programme Outcomes (Pos)	**PO1: Problem Solving Skill** Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context. **PO2: Decision Making Skill** Foster analytical and critical thinking abilities for data-based decision-making. **PO3: Ethical Value** Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities. **PO4: Communication Skill** Ability to develop communication, managerial and interpersonal skills. **PO5: Individual and Team Leadership Skill** Capability to lead themselves and the team to achieve organizational goals. **PO6: Employability Skill** Inculcate contemporary business practices to enhance employability skills in the competitive environment. **PO7: Entrepreneurial Skill** Equip with skills and competencies to become an entrepreneur. **PO8: Contribution to Society** Succeed in career endeavours and contribute significantly to society. **PO 9 Multicultural competence** Possess knowledge of the values and beliefs of multiple cultures and a global perspective. **PO 10: Moral and ethical awareness/reasoning** Ability to embrace moral/ethical values in conducting one's life.
Programme Specific Outcomes (PSOs)	**PSO1 – Placement** To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.

	PSO 2 - Entrepreneur To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations. **PSO3 – Research and Development** Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development. **PSO4 – Contribution to Business World** To produce employable, ethical and innovative professionals to sustain in the dynamic business world. **PSO 5 – Contribution to the Society** To contribute to the development of the society by collaborating with stakeholders for mutual benefit.

CREDIT DISTRIBUTION FOR PG PROGRAMME

Semester–I	**Credit**	**Hours**	**Semester-II**	**Credit**	**Hours**	**Semester-III**	**Credit**	**Hours**	**Semester–IV**	**Credit**	**Hours**
1.1. Core-I	5	7	2.1. Core-IV	5	6	3.1. Core-VII	5	6	4.1. Core-XI	5	6
1.2 Core-II	5	7	2.2 Core-V	5	6	3.2 Core-VIII	5	6	4.2 Core-XII	5	6
1.3 Core – III	4	6	2.3 Core – VI	4	6	3.3 Core – IX	5	6	4.3 Project with viva voce	7	10
1.4 Discipline Centric Elective -I	3	5	2.4 Discipline Centric Elective – III	3	4	3.4 Core – X	4	6	4.4Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	3	4
1.5 Generic Elective-II:	3	5	2.5 Generic Elective - IV:	3	4	3.5 Discipline Centric Elective - V	3	3	4.5 Skill Enhancement course / Professional Competency Skill	2	4
			2.6 NME I	2	3	3.6 NME II	2	3	4.6 Extension Activity	1	
			2.7 Human Rights	2	1	3.7 Internship/ Industrial Activity	2	-			
	20	**30**		**24**	**30**		**26**	**30**		**23**	**30**
Total Credit Points -93											

COMPONENT WISE CREDIT DISTRIBUTION

Credits	Sem I	Sem II	Sem III	Sem IV	Total
Part A	20	20	22	20	82
Part B (i) Discipline – Centric / Generic Skill		2	2		4
(ii) Soft Skill				2	6
(iii) Summer Internship / Industrial Training		2	2		
Part C				1	1
Total	20	24	26	23	93

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

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										

LEARNING AND TEACHING ACTIVITIES

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
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%

CREDIT DISTRIBUTION FOR PG PROGRAMME IN MATHEMATICS

M.Sc Mathematics

First Year

Semester-I

	Courses	Credit	Hours per Week(L/T/P)
Part A	Core Courses3 (CC1, CC2, CC3)	14	20
	Elective Courses 2(Generic / Discipline Specific) EC1, EC2	6	10
		20	**30**

Semester-II

	Courses	Credit	Hours per Week(L/T/P)
Part A	Core Courses3 (CC4, CC5, CC6)	14	18
	Elective Course 2 (Generic / Discipline Specific) EC3, EC4	6	9
Part B	NME-I & Human Rights	4	3
		24	**30**

Second Year

Semester-III

	Courses	Credit	Hours per Week(L/T/P)
Part A	Core Courses3 (CC7, CC8, CC9)	15	18
	Elective Course 3 (Generic / Discipline Specific) EC5	3	3
	Machine Learning (CC10)	4	6
Part B	NME-II	2	3
	Internship	2	
		26	**30**

Semester-IV

Part	Courses	Credit	Hours per Week(L/T/P)
Part A	Core Courses3 (CC11, CC12)	10	12
	Elective Course 1 (Generic / Discipline Specific) EC6	3	4
	Project with Viva voce (CC13)	7	10
Part B	Skill Enhancement Course	2	4
Part C	Extension Activity (Can be carried out from Sem II to Sem IV)	1	
		23	**30**

CREDIT DISTRIBUTION FOR PG PROGRAMME IN MATHEMATICS

M.SC MATHEMATICS

S.NO	Subject Code	Subject Title	Hours	University Examination			Credits
				Internal (25%)	External (75%)	Total	
1	23PMACO1	Algebraic Structure	7	25	75	100	5
2	23PMACO2	Real Analysis – I	7	25	75	100	5
3	23PMACO3	Ordinary Differential Equation	6	25	75	100	4
4	ELECTIVE –I	From Group 'A'	5	25	75	100	3
5	ELECTIVE –II	From Group 'B'	5	25	75	100	3
SEMESTER II							
6	23PMACO4	Advanced Algebra	6	25	75	100	5
7	23PMACO5	Real Analysis – II	6	25	75	100	5
8	23PMACO6	Partial Differential Equation	6	25	75	100	4
9	ELECTIVE –III	From Group 'C'	4	25	75	100	3
10	ELECTIVE –IV	From Group 'D'	4	25	75	100	3
11	23PMAHR01	Human Rights	1	25	75	100	2
12	NME-I	Operations Research for Management	3	25	75	100	2
SEMESTER III							
13	23PMACO7	Complex Analysis	6	25	75	100	5
14	23PMACO8	Probability Theory	6	25	75	100	5
15	23PMACO9	Topology	6	25	75	100	5
16	23PMAC10	Machine Learning	6	25	75	100	4
17	ELECTIVE –V	From Group 'E'	3	25	75	100	3
18	23PMAI01	Internship	-	-	-	-	2
19	NME-II	- Professional communication skill - Term paper & Seminar presentation	3	25	75	100	2

SEMESTER IV							
20	23PMACO11	Functional Analysis	6	25	75	100	5
21	23PMACO12	Differential Geometry	6	25	75	100	5
22	ELECTIVE –VI	From Group ‘F’	4	25	75	100	3
23	23PMAPR01	Core Project with viva – voce	10	25	75	100	7
24	SEC	From Group ‘G’	4	25	75	100	2
25		Extension Activity	-				1
		TOTAL	120			2300	93

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. Number Theory and Cryptography -23PMAE11
2. Graph Theory and Applications -23PMAE12
3. Formal Languages and Automata Theory -23PMAE13
4. Programming in C++ and Numerical Methods -23PMAE14

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

1. Lie Groups and Lie Algebras -23PMAE15
2. Mathematical Programming -23PMAE16
3. Fuzzy Sets and Their Applications -23PMAE17
4. Discrete Mathematics -23PMAE18

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

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

1. Algebraic Topology -23PMAE21
2. Mathematical Statistics -23PMAE22
3. Statistical Data Analysis using R Programming -23PMAE23
4. Tensor Analysis and Relativity -23PMAE24

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

1. Wavelets -23PMAE25
2. Modelling and Simulation with Excel -23PMAE26
3. Machine Learning and Artificial Intelligence -23PMAE27
4. Neural Networks -23PMAE28

Semester III : Elective V

Elective V to be chosen from Group E.

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

1. Algebraic Number Theory -23PMAE31
2. Fluid Dynamics -23PMAE32
3. Stochastic Processes -23PMAE33
4. Mathematical Python -23PMAE34

Semester IV : Elective VI

Elective VI to be chosen from Group F.

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

1. Algebraic Geometry -23PMAE41
2. Financial Mathematics -23PMAE42
3. Resource Management Techniques -23PMAE43
4. Mathematical Python -23PMAE44

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:

1.Computational Mathematics using SageMath -23PMASEC01

2. Mathematical documentation using LATEX / other packages -23PMASEC02

3. Office Automation and ICT Tools -23PMASEC03

4. Numerical analysis using SCILAB -23PMASEC04

5. Differential equations using SCILAB -23PMASEC05

6. Industrial Mathematics /Statistics using latest programming packages -23PMASEC06

7. Research Tools and Techniques -23PMASEC07

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,

[CO1 : K2] Question xxxx
[CO3 : K1] Question xxx

MINIMUM MARKS FOR PASSING:

a). **Theory Papers:**

The candidate shall be declared to have passed the examination if the candidate secures not less than 50 marks in total (CIA mark + Theory Exam mark) with minimum of 38 marks in the Theory Exam conducted by the University. The Continuous Internal Assessment (CIA) Mark 25 is distributed to four components viz., Tests, Assignment, Seminar and Attendance as 10, 05, 05 and 05 marks, respectively.

b). **Practical paper:**

A minimum of 50 marks out of 100 marks in the University examination and 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.

c). **Project Work/Dissertation and Viva-Voce:**

A candidate should secure 50% of the marks for pass. The candidate should attend viva-voce examination to secure a pass in that paper.

Candidate who does not obtain the required minimum marks for a pass in a Paper / Practical/ Project/Dissertation shall be declared Re-Appear (RA) and he / she has to appear and pass the same at a subsequent appearance.

CLASSIFICATION OF SUCCESSFUL CANDIDATES:

Candidates who secure not less than 60% of the aggregate marks in the whole examination shall be declared to have passed the examination in First Class. All other successful candidate shall be declared to have passed in the Second Class. Candidates who obtain 75% of the marks in the aggregate shall be deemed to have passed the examination in the First Class with Distinction provided they pass all the examinations prescribed for the course at the first appearance. Candidates who pass all the examinations prescribed for the course in the first instance and within a period of two academic years from the year of admission to the course only are eligible for University Ranking.

MAXIMUM DURATION FOR THE COMPLETION OF THE PG PROGRAMME:

The maximum duration for completion of the PG Programme shall not exceed Four Years from the year of admission.

TRANSITORYPROVISION:

Candidates who were admitted to the PG course of study before 2023-2024 shall be permitted to appear for the examinations under those regulations for a period of three years, that is, up to end inclusive of the examination of April / May 2024. Thereafter, they will be permitted to appear for the examination only under the regulations then in force.

DIFFERENT TYPES OF COURSES

(i) Core Courses (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

(ii) Elective Courses (ED within the Department Experts) (Illustrative)

1. Discrete Mathematics
2. Number Theory and Cryptography
3. Formal Languages and Automata Theory
4. Programming in C++ and Numerical Methods
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

(iii)Elective Courses (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.

SYLLABUS FOR DIFFERENT COURSES OF M.Sc MATHEMATICS

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">ALGEBRAIC STRUCTURES</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>Course Code</td><td rowspan="2">23PMAC01</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>6</td><td colspan="2">1</td><td colspan="2">--</td><td>7</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 : Counting Principle - Class equation for finite groups and its applications - Sylow's theorems (For theorem 2.12.1, First proof only).
Chapter 2: Sections 2.11 and 2.12 (Omit Lemma 2.12.5)</td></tr>
<tr><td colspan="6">UNIT-II : Solvable groups - Direct products - Finite abelian groups- Modules
Chapter 5 : Section 5.7 (Lemma 5.7.1, Lemma 5.7.2, Theorem 5.7.1)
Chapter 2: Section 2.13 and 2.14 (Theorem 2.14.1 only)
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 Eastern Limited, 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 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 and to verify whether the transformation in Hermitian, unitary and normal

	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

Strong: Medium: Low:

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">REAL ANALYSIS I</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">CORE II</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td>Credits</td><td>5</td><td>Course Code</td><td>23PMAC02</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td colspan="2">Lecture
6</td><td colspan="2">Tutorial
1</td><td colspan="2">Lab Practice
--</td><td>Total
7</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">UG level real analysis concepts</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">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">Course Outline</td><td colspan="8">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="2"></td><td colspan="8">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>
<tr><td colspan="2"></td><td colspan="8">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 criteriaon for existence of Riemann integrals. Chapter - 7 : 7.15 to 7.26</td></tr>
</table>

	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 – Cesaro summability - 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

<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">4</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAC03</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">5</td><td colspan="2">1</td><td>--</td><td>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="5">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>
<tr><td colspan="6">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)</td></tr>
</table>

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* (3^{rd} 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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">ADVANCED ALGEBRA</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">CORE IV</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">23PMAC04</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 colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">5</td><td colspan="2">1</td><td>--</td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Algebraic Structures</td></tr>
<tr><td colspan="2">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 colspan="2" 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 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 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

<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">23PMAC05</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 colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">5</td><td colspan="2">1</td><td>--</td><td>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">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>
<tr><td colspan="6">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)</td></tr>
<tr><td colspan="6">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)</td></tr>
</table>

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

<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>Credits</td><td>4</td><td>Course Code</td><td>23PMAC06</td></tr>
<tr><td>Semester</td><td>II</td><td colspan="4"></td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td colspan="2">Lecture
5</td><td colspan="2">Tutorial
1</td><td>Lab Practice
--</td><td>Total
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">Course Outline</td><td colspan="6">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
Chapter 2 : Sections 2.1 to 2.6
Chapter 3 : Sections 3.1 to 3.4 (Omit 3.5)</td></tr>
<tr><td colspan="2"></td><td colspan="6">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.
Chapter 4 : Sections 4.1 to 4.11</td></tr>
<tr><td colspan="2"></td><td colspan="6">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
Chapter 6 : Sections 6.1 to 6.6 (Omit section 6.7)</td></tr>
<tr><td colspan="2"></td><td colspan="6">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.
Chapter 8 : Sections 8.1 to 8.9</td></tr>
<tr><td colspan="2"></td><td colspan="6">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.
Chapter 10 : Section 10.1 to 10.9</td></tr>
</table>

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	TynMyint-U and Lokenath Debnath, *Partial Differential Equations for Scientists and Engineers* (Third Edition), North Hollan, New York, 1987.
Reference Books	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 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

.

	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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">COMPLEX ANALYSIS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">CORE VII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAC07</td></tr>
<tr><td>Semester</td><td>III</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 Complex Analysis</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To Study Cauchy integral formula, local properties of analytic functions, general form of Cauchy’s theorem and evaluation of definite integral and harmonic functions</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">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.
Chapter 4 : Section 2 : 2.1 to 2.3
Chapter 4 : Section 3 : 3.1 to 3.4</td></tr>
<tr><td colspan="2"></td><td colspan="6">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.
Chapter 4 : Section 4 : 4.1 to 4.7
Chapter 4 : Section 5: 5.1 and 5.2</td></tr>
<tr><td colspan="2"></td><td colspan="6">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.
Chapter 4 : Section 5 : 5.3
Chapter 4 : Sections 6 : 6.1 to 6.3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-IV :Harmonic Functions and Power Series Expansions:
Schwarz theorem - The reflection principle - Weierstrass theorem – Taylor’s Series – Laurent series .
Chapter 4 : Sections 6.4 and 6.5
Chapter 5 : Sections 1.1 to 1.3</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-V: Partial Fractions and Entire Functions: Partial fractions - Infinite products – Canonical products – Gamma Function- Jensen’s formula – Hadamard’s Theorem
Chapter 5 : Sections 2.1 to 2.4
Chapter 5 : Sections 3.1 and 3.2</td></tr>
</table>

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	Lars V. Ahlfors, *Complex Analysis*, (3rd edition) McGraw Hill Co., New York, 1979
Reference Books	1. H.A. Presfly, *Introduction to complex Analysis*, Clarendon Press, oxford, 1990. 2. J.B. Conway, *Functions of one complex variables* Springer - Verlag, International student Edition, Naroser Publishing Co.1978 3. E. Hille, *Analytic function Thorey* (2 vols.), Gonm& Co, 1959. 4. 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 Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: Analyze and evaluate local properties of analytical functions and definite integrals.

CLO2: Describe the concept of definite integral and harmonic functions.

CLO3: Demonstrate the concept of the general form of Cauchy's theorem

CLO4: Develop Taylor and Laurent series .

CLO5 Explain the infinite products, canonical products and jensen's formula .

	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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">PROBABILITY THEORY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">CORE VIII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAC08</td></tr>
<tr><td>Semester</td><td>III</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="2">Total</td></tr>
<tr><td>5</td><td>1</td><td>--</td><td colspan="2">6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level algebra and calculus</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To introduce axiomatic approach to probability theory, to study some statistical characteristics, discrete and continuous distribution functions and their properties, characteristic function and basic limit theorems of probability.</td></tr>
<tr><td colspan="2">Course Outline</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</td></tr>
<tr><td colspan="2"></td><td colspan="6">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</td></tr>
<tr><td colspan="2"></td><td colspan="6">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.
Chapter 4 : Sections 4.1 to 4.7</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-IV : Some Probability distributions: One point , two point , Binomial – Polya – Hypergeometric – Poisson (discrete) distributions – Uniform – normal gamma – Beta – Cauchy and Laplace (continuous) distributions.
Chapter 5 : Section 5.1 to 5.10 (Omit Section 5.11)</td></tr>
<tr><td colspan="2"></td><td colspan="6">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 Theroem – Borel-Cantelli Lemma - Kolmogorov Inequality and Kolmogorov Strong Law of large numbers.
Chapter 6 : Sections 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)</td></tr>
</table>

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	M. Fisz, *Probability Theory and Mathematical Statistics*, John Wiley and Sons, New York, 1963.
Reference Books	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*, (2^{nd} Edition) Duxbury Press, New York, 1996. 5. V.K.Rohatgi*An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern Ltd., New Delhi, 1988(3^{rd} Print). 6. S.I.Resnick, *A Probability Path*, Birhauser, Berlin,1999. 7. B.R.Bhat , *Modern Probability Theory* (3^{rd} 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 Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: To define Random Events, Random Variables, to describe Probability, to apply Bayes, to define Distribution Function, to find Joint Distribution function, to find Marginal Distribution and Conditional Distribution function, to solve functions on random variables.

CLO2: To define Expectation, Moments and Chebyshev Inequality, to solve Regression of the first and second types.

CLO3: To define Characteristic functions, to define distribution function, to find probability generating functions, to solve problems applying characteristic functions

CLO4: To define One point, two-point, Binomial distributions, to solve problems of Hypergeometric and Poisson distributions, to define Uniform, normal, gamma, Beta distributions, to solve problems on Cauchy and Laplace distributions

CLO5: To discuss Stochastic convergence, Bernaulli law of large numbers, to elaborate Convergence of sequence of distribution functions, to prove Levy-Cramer Theorems and de Moivre-Laplace Theorems, to explain Poisson, Chebyshev, Khintchine Weak law of large numbers, to explain and solve problems on Kolmogorov Inequality and Kolmogorov Strong Law of large numbers.

	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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">TOPOLOGY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">CORE IX</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAC09</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">5</td><td colspan="2">1</td><td>--</td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Real Analysis</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To study topological spaces, continuous functions, connectedness, compactness, countability and separation axioms.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT-I : Topological spaces : Topological spaces – Basis for a topology – The order topology – The product topology on X × Y – The subspace topology – Closed sets and limit points.
Chapter 2 : Sections 12 to 17</td></tr>
<tr><td colspan="6">UNIT-II :Continuous functions: Continuous functions – the product topology – The metric topology.
Chapter 2 : Sections 18 to 21 (Omit Section 22)</td></tr>
<tr><td colspan="6">UNIT-III :Connectedness: Connected spaces- connected subspaces of the Real line – Components and local connectedness.
Chapter 3 : Sections 23 to 25.</td></tr>
<tr><td colspan="6">UNIT-IV : Compactness : Compact spaces – compact subspaces of the Real line – Limit Point Compactness – Local Compactness.
Chapter 3 : Sections 26 to 29.</td></tr>
<tr><td colspan="6">UNIT-V: Countability and Separation Axiom: The Countability Axioms – The separation Axioms – Normal spaces – The Urysohn Lemma – The Urysohnmetrization Theorem – The Tietz extension theorem.
Chapter 4 : Sections 30 to 35.</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">James R. Munkres, Topology (2nd Edition) Pearson Education Pve. Ltd., Delhi-2002 (Third Indian Reprint)</td></tr>
</table>

Reference Books	1. J. Dugundji ,*Topology* , Prentice Hall of India, New Delhi, 1975. 2. George F.Sinmons, *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 Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: Define and illustrate the concept of topological spaces and the basic definitions of open sets, neighbourhood, interior, exterior, closure and their axioms for defining topological space. **CLO2**: Understand continuity, compactness, connectedness, homeomorphism and topological properties.

CLO3: Analyze and apply the topological concepts in Functional Analysis.

CLO4: Ability to determine that a given point in a topological space is either a limit point or not for a given subset of a topological space.

CLO5: Develop qualitative tools to characterize connectedness, compactness, second countable, Hausdorff and develop tools to identify when two are equivalent(homeomorphic).

	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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">MACHINE LEARNING [Advancements in industry 4.0]</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">CORE X</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">4</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAC10</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">5</td><td colspan="2">1</td><td colspan="2"></td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">Basic Knowledge computer science</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8"></td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="8">UNIT-I : MACHINE LEARNING
Machine Learning : Introduction -Definition –Types of Machine Learning -Supervised , Unsupervised ,Reinforcement Learning-Algorithms for Machine Learning – problems solved by Machine Learning – Tools for Machine Learning – Applications</td></tr>
<tr><td colspan="8">UNIT-II :ROBOTIC PROCESS AUTOMATION(RPA)
Robotic Process Automation(RPA):Introduction to RPA –Need for automation programming constructs in RPA- Robots and Softbots – RPA architecture and process methodologies –Industries best suited for RPA.</td></tr>
<tr><td colspan="8">UNIT-III :CLOUD
Cloud Computing : Need-Definition –Types of Cloud -Types of services –Saas</td></tr>
<tr><td colspan="8">UNIT-IV : CYBER
Cyber Security: Cyber Crime and Information security – Classification of cyber Crime Types.</td></tr>
<tr><td colspan="8">UNIT-V: VIRTUAL
Virtual Reality: Definition- Types of Head Mounted Displays-Tools for Reality</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="8">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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="8">Higher Education for industry 4.0 and Transformation to Education5.0 by P. Kaliraj and T.Devi</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="8"></td></tr>
<tr><td colspan="2">Website and e-Learning Source</td><td colspan="8">http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org , http://en.wikipedia.org</td></tr>
</table>

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">Functional Analysis</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">CORE XI</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAC11</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">5</td><td colspan="2">1</td><td colspan="2">--</td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">Elements of Real Analysis</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">To provide students with a strong foundation in functional analysis, focusing on spaces, operators and fundamental theorems. To develop student’s skills and confidence in mathematical analysis and proof techniques.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="8">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.
Chapter 9:Sections 46-51</td></tr>
<tr><td colspan="8">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.
Chapter10:Sections52-59</td></tr>
<tr><td colspan="8">UNIT-III : Finite-Dimensional Spectral Theory: Matrices – Determinants and the spectrum of an operator –The spectral theorem.
Chapter 11:Sections 60-62</td></tr>
<tr><td colspan="8">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.
Chapter 12:Sections 64-69</td></tr>
<tr><td colspan="8">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.
Chapter 13:Sections 70-73</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="8">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>
</table>

Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill
Recommended Text	G.F.Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Education (India)Private Limited, New Delhi, 1963.
Reference Books	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 Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: Understand the Banach spaces and Transformations on Banach Spaces.
CLO2: Prove Hahn Banach theorem and open mapping theorem.
CLO3: Describe operators and fundamental theorems.
CLO4: Validate orthogonal and orthonormal sets.
CLO5: Analyze and establish the regular and singular elements.

	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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">DIFFERENTIAL GEOMETRY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">CORE XII</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAC12</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">5</td><td colspan="2">1</td><td colspan="2">--</td><td>6</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">Linear Algebra concepts and Calculus</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">This course introduces 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</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="8">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.
Chapter I : Sections 1 to 9.</td></tr>
<tr><td colspan="8">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.
Chapter II: Sections 1 to 9.</td></tr>
<tr><td colspan="8">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.
Chapter II: Sections 10 to 18.</td></tr>
<tr><td colspan="8">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.
Chapter III: Sections 1 to 8.</td></tr>
<tr><td colspan="8">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.
Chapter IV : Sections 1 to 8 (Omit 9 to 15).</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="8">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>
</table>

Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill
Recommended Text	T.J.Willmore, *An Introduction to Differential Geometry*, Oxford University Press,(17th Impression) New Delhi 2002. (Indian Print)
RefereEce Books	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 Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: Explain space curves, Curves between surfaces, metrics on a surface, fundamental form of a surface and Geodesics.

CLO2: Evaluate these concepts with related examples.

CLO3: Compose problems on geodesics.

CLO4: Recognize applicability of developable.

CLO5: Construct and analyze the problems on curvature and minimal surfaces

	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

Title of the Course		**PROJECT WITH VIVA VOCE**					
Paper Number		**CORE IVX**					
Category	Core	**Year**	II	**Credits**	7	**Course Code**	**23PMAPR01**
		Semester	IV				

Instructional Hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	10		--	10
Pre-requisite	UG Level Mathematics			

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)

Title of the Course		**NUMBER THEORY AND CRYPTOGRAPHY**					
Paper Number		**ELECTIVE**					
Category	Elective	**Year**	I	**Credits**	3	**Course Code**	**23PMAE11**
		Semester	I				

Instructional Hours per week	**Lecture**	**Tutorial**	**Lab Practice**	**Total**
	4	1	--	5

Pre-requisite	UG level Number Theory
Objectives of the Course	• To understand fundamental number-theoretic algorithms such as the Euclidean algorithm, the Chinese Remainder algorithm, binary powering, and algorithms for integer arithmetic. • To understand fundamental algorithms for symmetric key and public-key cryptography. • To understand the number-theoretic foundations of modern cryptography and the principles behind their security. • To implement and analyze cryptographic and number-theoretic algorithms.
Course Outline	**UNIT I:**Elementary Number Theory: Time Estimates for doing arithmetic – divisibility and Euclidean algorithm – Congruences – Application to factoring. Chapter 1
	UNITII : Introduction to Classical Crypto systems – Some simple crypto systems – Enciphering matrices DES Chapter 3
	UNITIII : Finite Fields, Quadratic Residues and Reciprocity (Chapter 2)
	UNITIV: Public Key Cryptography Chapter 4
	UNITV: Primality, Factoring, Elliptic curves and Elliptic curve crypto systems (Chapter 5, sections 1,2,3 &5 (omit section 4), Chapter 6, sections 1& 2 only)
Extended Professional Component	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. Neal Koblitz, A Course in Number Theory and Cryptography, Springer-Verlag, New York,1987
Reference Books	1. I.Niven and H.S.Zuckermann, An Introduction to Theory of Numbers (Edn. 3), Wiley Eastern Ltd., New Delhi,1976 2. David M.Burton, Elementary Number Theory, Brown Publishers, Iowa,1989 3. K.Ireland and M.Rosen, A Classical Introduction to Modern Number Theory, Springer Verlag, 1972 4. N.Koblitz, Algebraic Aspects of Cryptography, Springer 1998.
Website and e-Learning Source	1. https://nptel.ac.in/courses/111101137 2. https://archive.nptel.ac.in/courses/106/103/106103015/ 3. https://onlinecourses-archive.nptel.ac.in/noc17_cs36/preview

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO 1: Illustrate the implications of properties of divisibility and primes

CLO 2: Distinguish the DES and the AES.

CLO 3: Understanding the Law of Quadratic Reciprocity & Quadratic Residues.

CLO 4: Define the fundamentals of cryptography, such as encryption, Authentication and digital signature.

CLO 5: Explain how elliptic curves are used in certain Crypto-graphic algorithms.

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">GRAPH THEORY AND APPLICATIONS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</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">23PMAE12</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td colspan="2"></td><td>4</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">UG level Graph Theory</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">UNIT I Basic Results: Introduction-Basic Concepts-Subgraphs-Degrees of Vertices - Paths and Connectedness - Automorphism of a Simple Graph. (Chapter 1: Sections 1.1 - 1.6). Directed Graphs: Introduction-Basic Concepts-Tournaments.
(Chapter 2 : Sections 2.1 - 2.3).</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT II Connectivity and Trees: Connectivity: Introduction-Vertex cut and Edge Cut-Connectivity and Edge Connectivity.(Chapter 3: Sections 3.1- 3.3). Trees: Introduction-Definition, Characterization and Simple Properties-Centers and Centroids- Cutting the Number of Spanning Trees-Cayley’s Formula. (Chapter 4: Sections 4.1- 4.5).</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT III Independent Sets, Matchings and Cycles: Independent Sets and Matchings: Introduction-Vertex-Independent Sets and Vertex Coverings-Edge-Independent sets-Matchings and Factors-Matchings in Bipartite Graphs. (Chapter 5: Sections 5.1- 5.5) . Cycles: Introduction-Eulerian GraphsHamiltonian Graphs. (Chapter 6: Sections 6.1- 6.3) .</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT IV Graph Colorings: Introduction-Vertex colorings-Critical Graphs-Edge colorings of Graphs-Kirkman’s Schoolgirl- Problem-Chromatic Polynomials.(Chapter 7: Sections 7.1 ,7.2 ,7.3 (7.2.1 & 7.2.3 only) ,7.6, 7.8, and 7.9).</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT V Planarity: Introduction- Planar and Nonplanar Graphs –Euler Formula and its Consequences K and K ,3 are Nonplanar Graphs – Dual of a Plane Graph- The Four-Color Theorem 5 3 and the Heawood Five- Color Theorem-Hamiltonian Plane Graphs-Tait Coloring.(Chapter 8: Sections 8.1 - 8.6 ,8.8 and 8.9).</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">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>
</table>

Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill
Recommended Text	1. R.Balakrishnan and K.Ranganathan, Text Book of Graph Theory, (2nd Edition), Springer, New York,2012.
Reference Books	1. J.A.Bondy and U.S.R. Murty, Graph Theory with Applications, North Holland, New York, 1982. 2. Narasing Deo, Graph Theory with Application to Engineering and Computer Science, Prentice Hall of India, New Delhi. 2003. 3. F. Harary, Graph Theory, Addison – Wesely Pub. Co. The Mass. 1969. 4. L. R.. Foulds, Graph Theory Application, Narosa Publ. House, Chennai, 1933.
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

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

<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">ELECTIVE</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">23PMAE13</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="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 colspan="2"></td><td>4</td><td colspan="2">1</td><td colspan="2">--</td><td>5</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">• To teach the student to identify different formal language classes and their relationships
• To teach the student the theoretical foundation for designing compilers.
• To teach the student to use the ability of applying logical skills.
• Teach the student to prove or disprove theorems in automata theory using its properties
• To teach the student the techniques for information processing.
• Understand the theory behind engineering applications.</td></tr>
<tr><td colspan="2" rowspan="2">Course Outline</td><td colspan="6">UNIT I Fundamentals: Strings, Alphabet, Language, Operations, Finite state machine, definitions, finite automaton model, acceptance of strings, and languages, FA, transition diagrams and Language recognizers.
Finite Automata: Deterministic finite automaton, Non deterministic finite automaton and NFA with Є transitions - Significance, acceptance of languages. Conversions and Equivalence : Equivalence between NFA with and without Є transitions, NFA to DFA conversion, minimization of FSM, equivalence between two FSMs, Finite Automata with output- Moore and Melay machines.</td></tr>
<tr><td colspan="6">UNIT II Regular Languages: Regular sets, regular expressions, identity rules, Conversion finite Automata for a given regular expressions, Conversion of Finite Automata to Regular expressions. Pumping lemma of regular sets, closure properties of regular sets (proofs not required).</td></tr>
</table>

	UNIT III Grammar Formalism: Regular grammars-right linear and left linear grammars, equivalence between regular linear grammar and FA, inter conversion, Context free grammar, derivation trees, sentential forms. Right most and leftmost derivation of strings. **Context Free Grammars:** Ambiguity in context free grammars. Minimisation of Context Free Grammars. Chomsky normal form, Greibach normal form, Pumping Lemma for Context Free Languages. Enumeration of properties of CFL (proofs omitted).
	UNIT IV Push Down Automata: Push down automata, definition, model, acceptance of CFL, Acceptance by final state and acceptance by empty state and its equivalence. Equivalence of CFL and PDA, interconversion. (Proofs not required). Introduction to DCFL and DPDA. LINEAR BOUNDED AUTOMATA(LBA):LBA,context sensitive grammars ,CS languages
	UNIT V Turing Machine: Turing Machine, definition, model, design of TM, Computable functions, recursively enumerable languages. Church's hypothesis, counter machine, types of Turing machines (proofs not required). **Computability Theory:** Chomsky hierarchy of languages, linear bounded automata and context sensitive language, LR(0) grammar, decidability of, problems, Universal Turing Machine, undecidability of posts. Correspondence problem, Turing reducibility, Definition of P and NP problems, NP complete and NP hard problems.
Extended Professional Component	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. "Introduction to Automata Theory Languages and Computation". Hopcroft H.E. and Ullman J. D. Pearson Education. 2. Introduction to Theory of Computation - Sipser 2nd edition Thomson

Reference Books	1. Introduction to Computer Theory, Daniel I.A. Cohen, John Wiley. 2. Introduction to languages and the Theory of Computation ,John C Martin, TMH 3. "Elements of Theory of Computation", Lewis H.P. & Papadimition C.H. Pearson /PHI. 4. Theory of Computer Science and Automata languages and computation -Mishra and Chandrashekaran, 2nd edition, PHI. 5. Theory of Computation, By K.V.N. Sunitha and N.Kalyani
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)

Student will have the ability to

- Apply knowledge in designing or enhancing compilers.
- Design grammars and automata (recognizers) for different language classes.
- Apply knowledge in developing tools for language processing or text processing.

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">PROGRAMMING IN C++ AND NUMERICAL ANALYSIS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</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">23PMAE14</td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td colspan="2">Lecture
4</td><td colspan="2">Tutorial
1</td><td colspan="2">Lab Practice
--</td><td>Total
5</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">This courses introduces a higher level language C++ and numerical methods for hands-on experience on computers. Stress is also given on the error analysis.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">UNIT-I Principles of OOP-Tokens-Expressions, Control Structures-Functions-Classes and Objects-constructors and destructors.
Chapter 1 to 6</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT-II Operator Overloading and type Conversions - Inheritance - Pointers, Virtual Functions and Polymorphism-Managing Console I/O Operations-Working with Files .
Chapter 7 to 11</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT-III Finite Digit Arithmetic and Errors Floating point arithmetic - Propagated Error - Generated Error - Error in Evaluation of a function f(x). - Non-linear Equations: Bisection method- Secant Method - Regula Falsi Method - Newton’s method - Muller’s method - Fixed Point method - Chapters 1,2 : Only 2.1 to 2.6</td></tr>
<tr><td colspan="2"></td><td colspan="8">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 Differentiation and Integration: Numerical Differentiation - Numerical Integration - Newton-Cotes Formulas - Gaussian Quadrature - Double Integral Chapter 3 and 5 : 5.1 to 5.5 and 5.7 (omit 5.6)</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT V Ordinary Differential Equations: Difference equation - Differential Equations:Single Step method-Runge-Kutta Method-Multi-step methods Chapter 6: 6.1 to 6.4 (omit 6.5)</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
</table>

Recommended Text	1. E. Balagurusamy, Object Oriented Programming with C++, Tata McGraw Hill, New Delhi, 1999. 2. Devi Prasad, An Introduction to Numerical Analysis (3rd edn) Narosa Publishing House, New Delhi, 2006.
Reference Books	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 Edn.), Prentice Hall, New Delhi, 2000
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

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

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

<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">ELECTIVE</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td>Credits</td><td>3</td><td>Course Code</td><td>23PMAE15</td></tr>
<tr><td>Semester</td><td>I</td><td colspan="4"></td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td>Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td colspan="2"></td><td>4</td><td colspan="2">1</td><td>--</td><td colspan="2">5</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level linear algebra and matrix groups.</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. In physics, Lie groups appear as symmetry groups of physical systems, and their Lie algebras (tangent vectors near the identity) may be thought of as infinitesimal symmetry motions.
2. Lie algebras and their representations are used extensively in physics, notably in quantum mechanics and particle physics.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNITI:Matrix Lie Groups
Chapter 1</td></tr>
<tr><td colspan="6">UNITII:The Matrix Exponential
Chapter 2</td></tr>
<tr><td colspan="6">UNITIII:Lie Algebras
Chapter 3</td></tr>
<tr><td colspan="6">UNITIV:Basic Representation Theory
Chapter 4</td></tr>
<tr><td colspan="6">UNITV:Semisimple Lie Algebras
Chapter 7</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / 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">1. Brain Hall, Lie Groups, Lie Algebras and Representations: An Elementary Introduction (Second Edition), Springer, USA, 2015.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. V. S. Varadarajan, Lie groups, Lie algebras and their representations, Sringer 1984.
2. Brian Hall, Lie groups, Lie algebras and representations, Springer 2003.
3. Barry Simon, Representations of finite and compact groups, AMS 1996.
4. A. W. Knapp, Representation theory of semismiple Lie groups. An overview based on examples, Princeton university press 2002.
5. S. Kumaresan S, A course in differential geometry and Lie groups, Texts and Readings in Mathematics, 22. Hindustan Book Agency, New Delhi, 2002.</td></tr>
</table>

Website and e-Learning Source	1. https://archive.nptel.ac.in/courses/111/108/111108134/ 2. https://www.digimat.in/nptel/courses/video/111108134/L42.html

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO 1: demonstrate systematic understanding of key aspects of Matrix Lie Groups and Lie Lie groups

CLO 2: Determine the exponential of a matrix.

CLO 3: Differentiate Lie groups and Lie Algebras

CLO 4: Find the representation of $s_l(2 ; C)$.

CLO 5: Explain reductive Lie algebra

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">MATHEMATICAL PROGRAMMING</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</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">23PMAE16</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 colspan="2">Total</td></tr>
<tr><td>4</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">5</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">This course introduces advanced topics in Linear and non-linear Programming</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">UNIT-I INTEGER LINEAR PROGRAMMING: Types of Integer Linear Programming Problems - Concept of Cutting Plane - Gomory’s All Integer Cutting Plane Method - Gomory’s mixed Integer Cutting Plane method - Branch and Bound Method. - Zero-One Integer Programming. Dynamic Programming: Characteristics of Dynamic Programming Problem - Developing Optimal Decision Policy - Dynamic Programming Under Certainty - DP approach to solve LPP.
Chapter-7: 7.1 - 7.7 Chapter-20: 20.1 - 20.5</td></tr>
<tr><td colspan="8">UNIT-II CLASSICAL OPTIMIZATION METHODS: Unconstrained Optimization - Constrained Multi-variable Optimization with Equality Constraints - Constrained Multi-variable Optimization with inequality Constraints Non-linear Programming Methods: Examples of NLPP - General NLPP - Graphical solution - Quadratic Programming - Wolfe’s modified Simplex Methods - Beale’s Method
Chapter-23: 23.1 - 23.4 Chapter-24: 24.1 - 24.4</td></tr>
<tr><td colspan="8">UNIT-III THEORY OF SIMPLEX METHOD: Canonical and Standard form of LP - Slack and Surplus Variables - Reduction of any Feasible solution to a Basic Feasible solution - Alternative Optimal solution - Unbounded solution - Optimality conditions - Some complications and their resolutions - Degeneracy and its resolution.
Chapter-25: 25.1 - 25.4, 25.6-25.9</td></tr>
<tr><td colspan="8">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 LP problem: The simplex algorithm
Chapter-26: 26.1 - 26.4 Chapter-28: 28.1, 28.2</td></tr>
<tr><td colspan="8">UNIT-V PARAMETRIC LINEAR PROGRAMMING: Variation in the coefficients cj , Variations in the Right hand side, bi . 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.
Chapter-29: 29.1 - 29.3</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC / 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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
</table>

Recommended Text	1.J.K.Sharma, Operations Research, Theory and Applications, Third Edition (2007) Macmillan India Ltd.
Reference Books	1. Hamdy A. Taha, Operations Research, (seventh edition) Prentice - Hall of India Private Limited, New Delhi, 1997. 2. F.S. Hillier & J.Lieberman Introduction to Operation Research (7th Edition) TataMcGraw Hill ompany, 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. New Delhi. 1990
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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">FUZZY SETS AND THEIR APPLICATIONS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</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">23PMAE17</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 colspan="2">Total</td></tr>
<tr><td>4</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">5</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">This course introduces advanced topics in Linear and non-linear Programming</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">Unit I Fuzzy sets: Fuzzy sets – Basic types – Basic concepts - Characteristics – Significance of the paradigm shift – Additional properties of α - Cuts (Chapter 1: Sections 1.3 to 1.5 and Chapter 2: Sections 2.1)</td></tr>
<tr><td colspan="2"></td><td colspan="8">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. (Chapter 2: Sections 2.2 to 2.3 and Chapter 3: Sections 3.1 to 3.2)</td></tr>
<tr><td colspan="2"></td><td colspan="8">Unit III Operations on Fuzzy Sets: Fuzzy intersection – t-norms, Fuzzy unions – t conorms – Combinations of operations – Aggregation operations. (Chapter 3: Sections 3.3 to 3.6)</td></tr>
<tr><td colspan="2"></td><td colspan="8">Unit IV Fuzzy Arithmetic:Fuzzy numbers – Linguistic variables – Arithmetic operation on intervals – Lattice of Fuzzy numbers. (Chapter 4: Sections 4.1 to 4.4)</td></tr>
<tr><td colspan="2"></td><td colspan="8">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. (Chapter 10: Sections 10.1 to 10.7)</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC / 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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="8">1. G.J. Klir, and Bo Yuan, Fuzzy Sets and fuzzy Logic: Theory and Applications, Prentice Hall of India Ltd., New Delhi, 2005.</td></tr>
</table>

Reference Books	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.
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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">DISCRETE MATHEMATICS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</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">23PMAE18</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 colspan="2">Total</td></tr>
<tr><td>4</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">5</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8"></td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">UNIT I The Foundations: Logic and Proofs : Propositional - Applications of Propositional -Propositional Equivalences - Predicates and Quantifiers. (Chapter 1: Sections 1.1 - 1.3). Algorithms: The Growth of Functions. (Chapter 3: Section 3.2).</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT II Counting: The Basics of Counting- The Pigeonhole Principle -Permutations and Combinations - Generalized Permutations and Combinations - Generating Permutations and Combinations . (Chapter 5: Sections 5.1- 5.3, 5.5 and 5.6).</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT III Advanced Counting Techniques: Applications of Recurrence Relations - Solving Linear Recurrence Relations Generating Functions . (Chapter 6: Sections 6.1, 6.2 and 6.4).</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT IV Boolean Algebra: Boolean Functions- Representing Boolean Functions - Logic Gates - Minimization of Circuits. (Chapter 10: Sections 10.1 -10.4).</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT V Modeling Computation: Finite-State machines with Output-Finite-State machines with No Output-Turing Machines. (Chapter 12: Sections 12.2, 12.3 and 12.5).</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC / 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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="8">1. Kenneth H.Rosen, Discrete Mathematics and it’s Applications,7th Edition, WCB / McGraw Hill Education ,New York,2008.</td></tr>
</table>

Reference Books	1. J.P. Trembley and R.Manohar, Discrete Mathematical Structures applications to Computer Science, Tata McGraw Hills, New Delhi. 2. T.Veerarajan,Discrete Mathematics with Graph Theory and Combinatorics, Tata McGraw Hills Publishing Company Limited ,7th Reprint,2008.
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

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

Semester II : Elective III and 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)

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">ALGEBRAIC TOPOLOGY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</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">23PMAE21</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 colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">To introduce the ideas of algebraic topology to other branches of Mathematics</td></tr>
<tr><td colspan="2" rowspan="3">Course Outline</td><td colspan="8">UNIT I CALCULUS IN THE PLANE: PATH INTEGRALS Angles and Deformations - Differential forms and path Integrals - Independence of Path - Criterion for exactness. Angles and Deformations: Angle functions and Winding numbers - Reparametrizing and Deforming the Paths. Winding Numbers. Definition - Homotopy and Reparametrization - Varying the Point - Degrees and Local Degrees.
Chapter 1 : (a) to (c); Chapter 2: only (a) and (b) Chapter 3 : (a) to (d)</td></tr>
<tr><td colspan="8">UNIT II COHOMOLOGY AND HOMOLOGY De Rham Cohomology and the Jordan Curve Theorem. Definition of the De Rham Graphs - The Coboundary map - the Jordon Curve Theorem - Applications and Variations. Homology: Chains, Cycles, and H0U - Boundaries, H1U , and Winding Numbers - Chains on Grids - Maps and Homology - The First Homology Group for General Spaces. Chapter 5: (a) to (d) Chapter 6: (a) to (e)</td></tr>
<tr><td colspan="8">UNIT III HOLES AND INTEGRALS Multiply connected regions - Integrations over continuous Paths and Chains - Periods of Integrals - Complex Integration Mayer-Victoris: The Boundary map - Mayer-Victoris for Homology - Variations and applications - Mayer-Victoris for Cohomology
Chapter 9: (a) to (d) Chapter 10: (a) to (d)</td></tr>
</table>

	UNIT IV COVERING SPACES AND FUNDAMENTAL GROUPS Covering Spaces: Definition - Lifting paths and Homotopies - G-coverings - Covering Transformations. The Fundamental Groups: Definitions and Basic Properties - Homotopy - Fundamental Group and Homology. Fundamental Groups and Covering Spaces: Fundamental Group and Coverings - Automorphisms of Coverings - The Universal Covering - Coverings and Subgroups of the Fundamental Group Chapter 11 : (a) to (d) Chapter 12 : (a) to (c) Chapter 13: (a) to (d)
	UNIT V THE VAN KAMPEN THEOREM G-Coverings from the Universal Covering - Patching Coverings together - The Van Kampen Theorem Cohomology: Patching Coverings and Cech cohomology - Cech Cohomology and Homology - De Rham Cohomology and Homology - Proof of Mayer -Victoris for De Rham Cohomology. Chapter 14 : (a) to (d) ; Chapter 15: (a) to (d)
Extended Professional Component	Questions related to the above topics, from various competitive examinations UPSC / 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.William Fulton, Algebraic Topology - A First Course, Springer-Verlag, New York, 1995
Reference Books	1. M.K.Agoston, Algebraic topology- A First Course, Marcel Dekker, 1962 2. Satya Deo, Algebraic Topology, Hindustan Book Agency, New Delhi, 2003. 3. M.Greenberg and Harper, Algebraic Topology-A First course, Benjamin/Cummings, 1981. 4. C.F. Maunder, Algebraic topology, Van Nastrand, New York, 1970 5. J.R. Mukres, Topology, Prentica Hall of India, New Delhi, 2002 (3rd Indian Print)
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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">MATHEMATICAL STATISTICS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td>Credits</td><td>3</td><td>Course Code</td><td colspan="2">23PMAE22</td></tr>
<tr><td>Semester</td><td>II</td><td colspan="4"></td></tr>
<tr><td colspan="2" rowspan="2">Instructional Hours per week</td><td colspan="2">Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td colspan="2">--</td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">UG level Mathematical Statistics</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">Unit I Probability and Random Variables: Probability – Axioms – Combinatorics, Probability on finite sample spaces – Conditional probability and Baye’s theorem - Independence of events – Random variables – Probability distribution of a random variable – Discrete and continuous random variables – Function of a random variable. (Chapter 1: Sections 1.3 to 1.6 and Chapter 2: Sections 2.2 to 2.5)

Unit II Moments and Generating Functions: Moments of a distribution function – Generating functions – Some moment inequalities. (Chapter 3: Sections 3.2 to 3.4)

Unit III Multiple Random Variables: Multiple random variables – Independent random variables – Functions of several random variables. (Chapter 4: Sections 4.2 to 4.4)

Unit IV Multiple Random Variables (Contd.): Covariance, Correlation and moments – Conditional expectation – Some discrete distributions – Some continuous distributions. (Chapter 4: Sections 4.5 and 4.6 and Chapter 5: Sections 5.2 to 5.3)

Unit V Limit Theorems: Modes of convergence – Weak law of large numbers – Strong law of large numbers – Central limit theorems. (Chapter 6: Sections 6.2 to 6.4 and 6.6)</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC / 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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="8">1. V.K. Rohatgi and Statistics, John Wiley Pvt, Singapore, 2001.</td></tr>
</table>

Reference Books	1. G.G. Roussas, A First Course in Mathematical Statistics, Addition Wesley Publ. Co. Mass, 1973. 2. M. Fisz, Probability Theory and Mathematical Statistics, John Wiley, New York, 1963. 3. E.J. Dudewisg and S.N. Mishra, Modern Mathematical Statistics, John Wiley, New York, 1988.
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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">STATISTICAL DATA ANALYSIS USING R- PROGRAMMING</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">ELECTIVE</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">23PMAE23</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 colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basic knowledge in Computer and Statistics</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6"></td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">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.</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / TNPSC / others to be solved
(To be discussed during the Tutorial hour)</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">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”, Cambridge University Press, New Delhi.</td></tr>
<tr><td colspan="2">Website and e-Learning Source</td><td colspan="6">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</td></tr>
</table>

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">TENSOR ANALYSIS AND RELATIVITY THEORY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</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">23PMAE24</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 colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td colspan="2">3</td><td colspan="2">1</td><td colspan="2">--</td><td>4</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">The course aims to introduce vector algebra and vector calculus and special relativity and relativistic kinematics, dynamics and accelerated systems.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">Unit I TENSOR ALGEBRA Systems of Different orders - Summation Convention - Kronecker Symbols - Transformation of coordinates in Sn - Invariants - Covariant and Contravariant vectors - 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.

Chapter I : I.1 - I.3, I.7 and I.8 and Chapter II : II.1 - II.19</td></tr>
<tr><td colspan="8">Unit II TENSOR CALCULUS Riemannian Space - Christoffel Symbols and their properties

Chapter III: III.1 and III.2</td></tr>
<tr><td colspan="8">Unit III TENSOR CALCULUS (CONTD) Covariant Differentiation of Tensors - Riemann - Christoffel Curvature Tensor - Intrinsic Differentiation.
Chapter III: III.3 - III.5</td></tr>
<tr><td colspan="8">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. Chapter 7 : Sections 7.1 and 7.2</td></tr>
</table>

	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 . Chapter 7 : Sections 7.3 and 7.4
Extended Professional Component	Questions related to the above topics, from various competitive examinations UPSC / 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.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.
Reference Books	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.
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

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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">WAVELETS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</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">23PMAE25</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 colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">UG level Differential Equations, Fourier transform and Linear Algebra</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">To establish the theory necessary to understand and use wavelets and related constructions.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">UNIT-I:Signals and Systems
Basic concepts of signals and systems, Frequency spectrum of signals; Classification of signals: Discrete time signals and continuous time signals, periodic and non-periodic signals; Classification of systems: Linear, nonlinear, time-variant, time-invariant, stable and unstable systems.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT-II:: Haar Scaling Function and Wavelet
Time-Frequency Analysis Orthogonal functions, Orthonormal functions, Function spaces, Orthogonal basis functions, Haar scaling function, Haar spaces: Haar space, general Haar space V□; Haar wavelet, Haar wavelet spaces: Haar wavelet space general Haar wavelet space ; Decomposition and reconstruction, Time-frequency analysis, Orthogonal and orthonormal bases</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT-III:Fourier Transforms and Wavelets
Discrete Fourier transform of a digital signal, Complex form of a Fourier series, Inverse discrete Fourier transform, Window Fourier transform, short time Fourier transform, Admissibility condition for a wavelet, Classes of wavelets: Haar, Morlet, Maxican hat, Meyer and Daubechies wavelets; Wavelets with compact support.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT-IV:Discrete Wavelet Transforms
Stationary and non-stationary signals, Haar transform, 1-level Haar transform, Multi-level Haar transform, Conservation and compaction of energy, Multiresolution analysis, Decomposition and reconstruction of signals using discrete wavelet transform (DWT).</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT-V:Applications
Wavelet series expansion using Haar and other wavelets, Applications in signal compression, Analysis and classification of audio signals using DWT, Signal de-noising: Image and ECG signals</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC / 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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="8">Charles K. Chui, An Introduction to Wavelets. Academic Press, 1992.</td></tr>
</table>

Reference Books	1. Ingrid Daubechies, Ten Lectures on Wavelets. SIAM, 1999. 2. Michael W. Frazier, An Introduction to Wavelets Through Linear Algebra. Springer-Verlag, 1999. 3. Stéphane Mallat, A Wavelet Tour of Signal Processing (3rd edition). Academic Press, 2008. 4. M.J. Roberts, Signals and Systems: Analysis Using Transform Methods and MATLAB. McGraw-Hill Education, 2004 5. David K. Ruch & Patrick J. Van Fleet, Wavelet Theory: An Elementary Approach with Applications. John Wiley & Sons, 2009 6. James S. Walker, A Primer on Wavelets and Their Scientific Applications (2nd edition). Chapman & Hall/CRC, Taylor & Francis, 2008.
Website and e-Learning Source	1. https://archive.nptel.ac.in/courses/108/101/108101093/ 2. https://onlinecourses.nptel.ac.in/noc23_ee32/preview

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO 1: Know basic concepts of signals and systems.

CLO 2: Understand the concept of Haar spaces.

CLO 3: Learn Fourier transform and wavelet transform of digital signals.

CLO 4: Learn applications of wavelets to the real-world problems.

CLO 5: Apply wavelets in signal processing and image processing.

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">MODELING AND SIMULATION WITH EXCEL</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">ELECTIVE</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">23PMAE26</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="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 colspan="2"></td><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td>4</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT I Introduction- How Do We Classify Models? - An Example of Deterministic Modeling -Understanding the Important Elements of a Model</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT II Model Building with Excel - Basic Model - Sensitivity Analysis - Controls from the Forms Control Tools- Scroll Bars .</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT III Modeling and Simulation: Types of Simulation and Uncertainty -Incorporating Uncertain Processes in Models -The Monte Carlo Sampling Methodology-Implementing Monte Carlo Simulation Methods-A Word About Probability Distributions -Modeling Arrivals with the Poisson Distribution-VLOOKUP and HLOOKUP Functions.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT-IV A Financial Example—Income Statement -An Operations Example—Autohaus -Status of Autohaus Model -Building the Brain Worksheet - Building the Calculation Worksheet-Variation in Approaches to Poisson Arrivals—Consideration of Modeling Accuracy.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT V Sufficient Sample Size - Building the Data Collection Worksheet -Solver—Constrained Optimization -Example—York River Archaeology Budgeting –Scenarios</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC /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">1. Hector Guerrero , Excel Data Analysis Modeling and Simulation ,Springer Heidelberg Dordrecht London New York.</td></tr>
<tr><td colspan="2">Website and e-Learning Source</td><td colspan="6">http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com</td></tr>
</table>

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">MACHINE LEARNING AND ARTIFICAL INTELLIGENCE</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">ELECTIVE</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">23PMAE27</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 colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td>Total</td></tr>
<tr><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">To Learn about Machine Intelligence and Machine Learning applications
To implement and apply machine learning algorithms to real-world applications.
To identify and apply the appropriate machine learning technique to classification, pattern recognition, optimization and decision problems.
To understand how to perform evaluation of learning algorithms and model selection.
To understand about the basic theory of problem solving paradigms and search strategies in artificial intelligence
To make the students familiar with knowledge representation, planning, learning, natural language processing and robotics</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT I INTRODUCTION:Learning Problems – Perspectives and Issues – Concept Learning – Version Spaces and Candidate Eliminations – Inductive bias – Decision Tree learning – Representation – Algorithm – Heuristic Space Search.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT II NEURAL NETWORKS AND GENETIC ALGORITHMS: Neural Network Representation – Problems – Perceptrons – Multilayer Networks and Back Propagation Algorithms – Advanced Topics – Genetic Algorithms– Hypothesis Space Search – Genetic programming –Models of Evaluation and Learning.</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT - III BAYESIAN AND COMPUTATIONAL LEARNING: Bayes Theorem – Concept Learning – Maximum Likelihood – Minimum Description Length Principle – Bayes Optimal Classifier – Gibbs Algorithm – Naïve Bayes Classifier –Bayesian Belief Network – EM Algorithm – Probability Learning – Sample Complexity –Finite and Infinite Hypothesis Spaces – Mistake Bound Model.</td></tr>
</table>

	UNIT – IV Introduction - Intelligent Agents- Problem Solving - by Searching - Informed Search Strategies-Optimization Problems - Adversarial Search-Knowledge and Reasoning - Logical Agents - First-Order Logic - Inference in First-Order Logic - Knowledge Representation
	UNIT – V Planning – Planning and Acting in the Real World - Uncertain knowledge and reasoning - Uncertainty - Probabilistic Reasoning - Probabilistic Reasoning over Time - Making Simple Decisions - Making Complex Decisions
Extended Professional Component	Questions related to the above topics, from various competitive examinations UPSC /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. Tom M. Mitchell,―Machine Learning, McGraw-Hill Education (India) Private Limited, 2013. 2. Stuart Russell, Peter Norvig, "Artificial Intelligence: A Modern Approach," Third Edition, Prentice Hall of India, New Delhi, 2010.
Reference Books	1. Ethem Alpaydin,―Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press 2004. 2. Stephen Marsland,―Machine Learning: An Algorithmic Perspective, CRC Press,2009. 3. Michael Affenzeller, Stephan Winkler, Stefan Wagner, Andreas Beham, "Genetic Algorithms and Genetic Programming",CRC Press Taylor and Francis Group. 4. Elaine Rich, Kevin Knight, B. Nair, "Artificial Intelligence," Third Edition, Tata McGraw-Hill, New Delhi, 2017. 5. Eugene Charniak, Drew McDermott, "Introduction to Artificial Intelligence," Pearson, 2002.
Website and e-Learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

OUTCOMES:

On completion of the course students will be expected to:

• Have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc

• Have an understanding of the strengths and weaknesses of many popular machine learning approaches

• Appreciate the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and unsupervised learning

• Be able to design and implement various machine learning algorithms in a range of real-world applications

• Understand the computation intelligence

• Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">NEURAL NETWORKS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">ELECTIVE</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">23PMAE28</td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td colspan="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 colspan="2"></td><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. enable students to understand important concepts and theories of artificial neural networks (ANNs)
2. enable students to understand how ANNs can be designed and trained
3. enable students to calculate simple examples of ANNs</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT I:Introductory Concepts:‘Neurons’ and their basic function- Math review- Mathematical Machinery and Review- How and Why Perceptron’s Can Compute Logic Statements- Training Perceptron’s Using Supervised Learning Techniques- Training Multi-layer.</td></tr>
<tr><td colspan="6">UNIT II:Neural Networks Using Supervised Learning Techniques: Recurrent Neural Networks and Unsupervised Learning: Optimization Techniques-Implementation and Performance Considerations-Variations on the Hopfield Network-A Stochastic Version of the Hopfield Network:</td></tr>
<tr><td colspan="6">UNIT III:The Boltzmann Machine-A Stochastic Version of the Binary Associative Memory: Restricted Boltzmann Machines-Competitive Learning and Self-Organizing Maps-Neural Network Modifications and Applications-Cellular Neural Networks and the Future of Massively Parallel Computation</td></tr>
<tr><td colspan="6">UNIT IV: Introduction to Machine Learning Techniques: Types of learning, hypothesis space and inductive bias, evaluation, cross-validation. Linear regression, Decision trees, overfitting.</td></tr>
<tr><td colspan="6">UNIT V: Support Vector Machine, Kernel function and Kernel SVM. Neural network: Perceptron, multilayer network, backpropagation, introduction to deep neural network.</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC /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">1. Raul Rojas, Neural Networks - A Systematic Introduction, Springer-Verlag, Berlin, NewYork,1996.
2. Koch, Christof, Biophysics of Computation: Information Processing in Single Neurons, Oxford University Press, 2004.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. G. Dreyfus, Neural Networks Methodology and Applications, Springer, Berlin, Heidelberg, 2004.
2. James A. Freeman David M. Skapura, Neural Networks Algorithms, Applications, and Programming Techniques, Addison-Wesley Publishing Company, New York, 1991.</td></tr>
</table>

Website and e-Learning Source	1. https://nptel.ac.in/courses/117105084 2. https://www.digimat.in/nptel/courses/video/127105006/L01.html 3. https://www.youtube.com/watch?v=NeMAxhDvSak&list=PLgMDNELGJ1CZn1399dV7_U4VBNJflRsua 4. https://www.youtube.com/watch?v=QlhHqMnd9Wo

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO 1: Learn different types of neural networks and different types of learning models

CLO 2: Determine the mathematical foundations of neural network models

CLO 3: Implement of neural networks using training algorithms such as the feed-forward, back-propagation algorithm

CLO 4: Design neural networks for practical purposes

CLO 5: Build neural networks for practical purposes

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

Semester III : Elective V

Elective V to be chosen from Group E

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

<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">ELECTIVE</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAE31</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="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 colspan="2"></td><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">The course aims to provide a study on modules over rings, finite fields, algebraic extensions, number fields and cyclotomic fields, Noetherian rings and modules and Dedekind rings.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT I ALGEBRAIC BACKGROUND Rings and Fields- Factorization of Polynomials - Field Extensions - Symmetric Polynomials - Modules - Free Abelian Groups.

Chapter 1: Sec. 1.1 to 1.6</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT II ALGEBRAIC NUMBERS Algebraic numbers - Conjugates and Discriminants - Algebraic Integers - Integral Bases - Norms and Traces - Rings of Integers.

Chapters 2: Sec. 2.1 to 2.6</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT III QUADRATIC AND CYCLOTOMIC FIELDS Quadratic fields and cyclotomatic fields : Factorization into Irreducibles : Trivial factorization - Factroization into irreducibles - Examples of non-unique factorization into irreducibles.

Chapter 3: Sec. 3.1 and 3.2 ; Chapter 4: Sec. 4.2 to 4.4</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT IV Prime Factroization - Euclidean Domains - Euclidean Quadratic fields - Consequences of unique factorization - The Ramanujan -Nagell Theorem.

Chapter 4: Sec. 4.5 to 4.9</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT V IDEALS Prime Factorization of Ideals - The norms of an Ideal - Non-unique Factorization in Cyclotomic Fields..

Chapter 5 : Sec. 5.2 to 5.4</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC /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>
</table>

Recommended Text	1. I. Steward and D.Tall. Algebraic Number Theory and Fermat's Last Theorem (3rd Edition) A.K.Peters Ltd., Natrick, Mass. 2002.
Reference Books	1. Z.I.Bosevic and I.R.Safarevic, Number Theory, Academic Press, New York, 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. 5. A.Weil. Basic Number Theory, Springer, New York, 1967.
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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">FLUID DYNAMICS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAE32</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td colspan="2">Lecture
3</td><td colspan="2">Tutorial
1</td><td colspan="2">Lab Practice
--</td><td>Total
4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8"></td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">UNIT I Kinematics of Fluids in Motion: Real fluids and Ideal fluids - Velocity of a fluid at a point –Stream lines and path lines - Steady and Unsteady flows - The Velocity Potential - The Vorticity Vector - Local and Particle Rates of Change - The Equation of Continuity - Worked Examples. (Chapter 2: Sections 2.1 - 2.8).

UNIT II Equations of Motion of a Fluid: Pressure at a point in a fluid at rest - Pressure at a point in a moving fluid - Euler’s equations of Motion - Bernoulli’s equation -Worked Examples - Discussion of the case of steady motion under Conservative Body Forces - Some flows involving axial symmetry(examples 1 and 2 only). (Chapters 3: Sections 3.1, 3.2,3.4 - 3.7, 3.9).

UNIT III Some Three-Dimensional Flows: Introduction - Sources, Sinks and Doublets-Images in rigid infinite plane - Images in solid spheres – Axis symmetric flows. (Chapter 4: Sections 4.1 - 4.4).

UNIT IV Some Two-Dimensional Flows: The Stream Function - The Complex Velocity Potential for Two Dimensional Irrotational, Incompressible Flow - Complex Velocity Potentials for Standard TwoDimensional Flows - Some Worked Examples - Two Dimensional Image Systems - The Milne-Thomson Circle Theorem. (Chapter 5: Sections 5.3 - 5.8).</td></tr>
</table>

	UNIT V Viscous Fluid: Stress components in a real fluid - Relation between Cartesian Components of Stress - Translational motion of fluid element – The Coefficient of Viscosity and Laminar flow - The Navier- Stokes equation of a viscous fluid - Some solvable problems in viscous flow - Steady motion between parallel planes only. (Chapter 8: Sections 8.1 - 8.3, 8.8, 8.9 and 8.10.1).
Extended Professional Component	Questions related to the above topics, from various competitive examinations UPSC /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. Frank Chorlton, Textbook of Fluid Dynamics, CBS Publishers & Distributors, 2004.
Reference Books	1. L.M. Milne-Thomson, Theoretical Hydrodynamics, Macmillan, London, 1955. 2. G.K. Batchelor, An Introduction to Fluid Dynamics Cambridge Mathematical Library, 2000.
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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">STOCHASTIC PROCESSES</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAE33</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td colspan="2"></td><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8"></td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">UNIT I Introduction to stochastic process (SP) – classification of SP according to state space and time domain. countable state markov chain (MC). Chapman- Kolmogorov equations. Calculation of 'n' step transition probability.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT II Discrete state space – continuous time MC. Kolmogorov differential equations. Poisson process, birth and death process .Application to queues and storage problem. Random walk.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT III Markov process – continuous time and continuous state space - time homogenous markov process – Kolmogorov's equation. Wiener process as a limit of random walk, first passage time Diffusion process with Wiener process.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT IV Stationary process and time series- wide sense and strict sense stationary process – moving average and auto regressive process. Covariance function - Bochner's function (statement), Khintchine's representation of wide sense stationary process.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT V Renewal theory – renewal function and its properties – Elementary and key renewal theorems.</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC /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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
</table>

Recommended Text	1. Medhi.J. (1982) Stochastic process, Wiley Eastern. 2. Basu. A.K. (2003) Introduction to stochastic processes, Newsa Publishing House.
Reference Books	1. Ross. S.M. (1983) Stochastic Process, Wiley, New York. 2. Karlin and First course in Stochastic Process-Vol.I&II, Academic Press. Taylor.H.M. (1975)
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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">MATHEMATICAL PYTHON</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAE34</td></tr>
<tr><td>Semester</td><td>III</td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td colspan="2">Lecture
3</td><td colspan="2">Tutorial
1</td><td colspan="2">Lab Practice
--</td><td>Total
4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">This course aims
➢ To introduce to students Python programming.
➢ To learn python coding to implement algorithms for Mathematical problems.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">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).</td></tr>
<tr><td colspan="2"></td><td colspan="8">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.</td></tr>
<tr><td colspan="2"></td><td colspan="8">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.</td></tr>
</table>

	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.
Extended Professional Component	Questions related to the above topics, from various competitive examinations UPSC /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. 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
Reference Books	
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

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

Semester IV : Elective VI
Elective VI to be chosen from Group F

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">ALGEBRAIC GEOMETRY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAE41</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td colspan="2"></td><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8"></td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">Unit I: Affine algebraic sets
Affine spaces and algebraic sets, Noetherian rings, Hilbert basis theorem, affine algebraic sets as finite intersection of hypersurfaces; Ideal of a set of points, coordinate ring, morphism between algebraic sets, isomorphism. Integral extensions, Noether’s normalization lemma</td></tr>
<tr><td colspan="2"></td><td colspan="8">Unit II: Hilbert’s Nullstellensatz and applications
Correspondence between radical ideals and algebraic sets, prime ideals and irreducible algebraic sets, maximal ideals and points, contrapositive equivalence between affine algebras with algebra homomorphisms and algebraic sets with morphisms, between affine domains and irreducible algebraic sets, decomposition of an algebraic set into irreducible components. Zariski topology on affine spaces, algebraic subsets of the plane.</td></tr>
<tr><td colspan="2"></td><td colspan="8">Unit III: Projective spaces
Homogeneous coordinates, hyperplane at infinity, projective algebraic sets, homogeneous ideals and projective Nullstellensatz; Zariski topology on projective spaces. Twisted cubic in P_3(k). Local properties of plane curves: multiple points and tangent lines, multiplicity and local rings, intersection numbers; projective plane curves: Linear systems of curves, intersections of projective curves: Bezout’s theorem and applications; group structure on a cubic.</td></tr>
</table>

	Unit IV: Introduction to sheaves of affine varieties Examples of presheaves and sheaves, stalks, sheafification of a presheaf, sections, structure sheaf, generic stalk and function fields, rational functions and local rings, Affine tangent spaces; Projective varieties and morphisms; Hausdorff axiom.
	Unit V: Prime spectrum of a ring: Zariskitopology, structiureaheaf, affine schemes, morphism of affine schemes. Elementary Dimension Theory, Fibres of a morphism, complete varieties, nonsingularity and regular local rings, Jacobian criterion, nonsingular curves and DVR's.
Extended Professional Component	Questions related to the above topics, from various competitive examinations UPSC /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. W.Fulton Algebraic Curves: An introduction to algebraic geometry 2. C. G. Gibson – Elementary Geometry of Algebraic Curves, CUP, 3. D. S. Dummitt and R. M. Foote – Abstract Algebra, Wiley, Ch. 15.
Reference Books	1. J. Harris Algebraic Geometry, A first course, Springer 2. M. Reid Undergraduate algebraic geometry, LMS 12, CUP 3. K. Kendig – Elementary Algebraic Geometry, Springer 4. D. Mumford – The Red Book of Varieties and Schemes, Springer 5. I. R. Shafarevich – Basic Algebraic Geometry, Springer
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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">FINANCIAL MATHEMATICS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAE42</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td colspan="2"></td><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">•In this course, the students are on posed to The basic concepts of Probability theory, The Central limit theorem.
• The concepts of Geometric Brownian motion, Option pricing.
• The derivatives of Blackschole formula and its applications.
• The concept of call option on Dividend paying securities, estimating the volatility parameter.
•The limitations of Arbitrage pricing, the portfolio selection problem.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">UNIT I Stochastic Order Relations

First-Order Stochastic Dominance -Using Coupling to Show Stochastic Dominance - Likelihood Ratio Ordering -A Single-Period Investment Problem-Second-Order Dominance.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT II Optimization Models

Introduction- A Deterministic Optimization Model -Probabilistic Optimization Problems</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT III Stochastic Dynamic Programming

The Stochastic Dynamic Programming Problem - Infinite Time Models - Optimal Stopping Problems</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT IV Exotic Options

Introduction -Barrier Options - Asian and Lookback Options - Monte Carlo Simulation -Pricing Exotic Options by Simulation - More Efficient Simulation Estimators</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT V Beyond Geometric Brownian Motion Models

Introduction -Crude Oil Data - Models for the Crude Oil Data - Final Comments.</td></tr>
</table>

Extended Professional Component	Questions related to the above topics, from various competitive examinations UPSC /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. An Elementary Introduction to Mathematical Finance,2nd Edition Sheldon M.Ross Cambridge University press 2005
Reference Books	1. A First Course in Probability, S.M.Ross, Englewood cliffs Prentice HallNJ 2002 2. Option Market , J.Cox M.Rubinstein, Englewood cliffs Prentice HallNJ 1985 3. Theory of Financial decision Making ,J.E.Ingersill ,Lanjarn MD Rowerman of Little Fields 1987
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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">RESOURCE MANAGEMENT TECHNIQUES</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAE43</td></tr>
<tr><td>Semester</td><td>IV</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 colspan="2">Total</td></tr>
<tr><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8"></td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">UNIT I LINEAR PROGRAMMING
Principal components of decision problem – Modeling phases – LP Formulation and graphic solution –Resource allocation problems – Simplex method – Sensitivity analysis.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT II DUALITY AND NETWORKS
Definition of dual problem – Primal – Dual relation ships – Dual simplex methods – Post optimality analysis – Transportation and assignment model - Shortest route problem.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT III INTEGER PROGRAMMING
Cutting plan algorithm – Branch and bound methods, Multistage (Dynamic) programming.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT IV CLASSICAL OPTIMISATION THEORY
Unconstrained external problems, Newton – Ralphson method – Equality constraints – Jacobean methods – Lagrangian method – Kuhn – Tucker conditions – Simple problems.</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT V OBJECT SCHEDULING
Network diagram representation – Critical path method – Time charts and resource leveling – PERT.</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC /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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="8">1. H.A. Taha, “Operation Research”, Prentice Hall of India, 2002.</td></tr>
</table>

Reference Books	1. Paneer Selvam, 'Operations Research', Prentice Hall of India, 2002 2. Anderson 'Quantitative Methods for Business', 8th Edition, Thomson Learning, 2002. 3. Winston 'Operation Research', Thomson Learning, 2003. 4. Vohra, 'Quantitative Techniques in Management', Tata Mc Graw Hill, 2002. 5. Anand Sarma, 'Operation Research', Himalaya Publishing House, 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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">MATHEMATICAL PYTHON</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">ELECTIVE</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>II</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2">23PMAE44</td></tr>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td colspan="2"></td><td>3</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">This course aims
➢ To introduce to students Python programming.
➢ To learn python coding to implement algorithms for Mathematical problems.</td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">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).</td></tr>
<tr><td colspan="2"></td><td colspan="8">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.</td></tr>
<tr><td colspan="2"></td><td colspan="8">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.</td></tr>
</table>

	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.
Extended Professional Component	Questions related to the above topics, from various competitive examinations UPSC /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. 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
Reference Books	
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

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

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">MATHEMATICAL COMPUTATION WITH SAGEMATH</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">SEC</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td></td><td>Credits</td><td>2</td><td>Course Code</td><td></td></tr>
<tr><td>Semester</td><td></td><td colspan="4"></td></tr>
<tr><td colspan="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 colspan="2"></td><td>1</td><td colspan="2">1</td><td colspan="2">--</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6"></td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="6">UNIT I First Steps
The Sage Program -Sage as a Calculator</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT II Analysis and Algebra
Symbolic Expressions and Simplification – Equations – Analysis - Basic Linear Algebra</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT III Programming and Data Structures
Syntax –Algorithmics -Lists and Other Data Structures</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT IV Graphics
2D Graphics - 3D Curves</td></tr>
<tr><td colspan="2"></td><td colspan="6">UNIT V Computational Domains
Sage is Object-Oriented- Elements, Parents, Categories-Domains with a Normal Form-Expressions vs Computational Domains</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC /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">1. Mathematical Computation with SageMath ,Paul Zimmermann Alexandre Casamayou.</td></tr>
</table>

Reference Books	1.Uri M. Ascher and Linda R. Petzold, Computer Methods for Ordinary Differential Equations and Differential-Algebraic Equations. Society for Industrial and Applied Mathematics, 1998, ISBN 0898714128. 2. Noga Alon and Joel H. Spencer, The Probabilistic Method. Wiley-Interscience, 2000, ISBN 0471370460. 3. Bernard Beauzamy, Robust mathematical methods for extremely rare events. On-line, 2009. http://www.scmsa.eu/RMM/BB_rare_ events_2009_08.pdf, 20 pages.
Website and e-Learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">ADVANCED LATEX</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">SEC</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></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 colspan="2">Total</td></tr>
<tr><td>1</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">The course aims
➢ 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.</td></tr>
<tr><td colspan="2" rowspan="2">Course Outline</td><td colspan="8">Unit – I :Introduction and the Structure of a LaTeX Document Installation of the software LaTeX - Environments and commands - Classes and packages – Errors - Files created - How to use LAEX at CUED - Document Classes - Arara- Counters and Length parameters - Document and page organization – Page breaks, footnotes. Environments , Matrix-like environments . Chapter - 1 and 2 in I & Chapter - 1 in II ; Chapter – 4 in I & Chapter – 5 in II; Chapter -8 (Section 8.3) in III</td></tr>
<tr><td colspan="8">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 Chapter – 8 (Section 8.2, 8.5, 8.6 and 8.9) in III</td></tr>
</table>

	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 . Chapter – 8, 9 and 12 in II .
	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. (5.1-5.7)
Extended Professional Component	Questions related to the above topics, from various competitive examinations UPSC /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	I. Advanced LATEX by Tim Love, 2006 II.http://www.h.eng.cam.ac.uk/help/documentation/docsource/latex_advanced.pdf III. LaTeX for Administrative Work by Nicola L. C. Talbot, Dickimaw Books, 2015, http://www.dickimaw-books.com/latex/admin/ IV. The LaTeX Companion by Frank Mittelbach and Michel Goossens, Addison-Wesley, Library of Congress Cataloging-in-Publication Data (Second Edition) V. Nicola L. C. Talbot, LATEX for Complete Novices Version 1.4, Dickimaw Books http://www.dickimaw-books.com/2012.

Reference Books	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
Website and e-Learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

Learning Outcomes:

This course will enable the students to:

- ➢ Create and typeset a LaTeX document
- ➢ Typeset a mathematical document
- ➢ Draw pictures in LaTeX
- ➢ Create beamer presentations
- ➢ Prepare the projects or dissertations in LaTeX

Title of the Course		**OFFICE AUTOMATION AND ITC TOOLS**					
Paper Number		**SEC**					
Category	Elective	**Year**		**Credits**	2	**Course Code**	
		Semester					
Instructional Hours per week		**Lecture**	**Tutorial**	**Lab Practice**	**Total**		
		1	1	--	2		
Objectives of the Course							
Course Outline		**UNIT I** Office Automation-Office and Office Automation					
		UNIT II Computer Mail Systems - Telecommunication and Word Processor					
		UNIT III WP Hardware Configuration					
		UNIT IV Reprographics-Electronic Mail and Electronic-Filing					
		UNIT V Facsimile Transmission and Micrographics -Voice Technology					
Extended Professional Component		Questions related to the above topics, from various competitive examinations UPSC /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.Office Automation Tools and Technology (Unit I & Unit-II) 2. Office Automation Tools ,Yatendra kumar & suitha varshney , Naveen prakashan pvt .Ltd					
Reference Books		1.Office Automation Tools ,Dr.Rizwan Ahmed , Naveen prakashan pvt .Ltd 2.Office Automation Tools, Dr.Babasaheb Ambedkar					
Website and e-Learning Source		http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com					

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="7">NUMERICAL ANALYSIS USING SCILAB</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="7">SEC</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></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>1</td><td colspan="2">1</td><td colspan="2">--</td><td>2</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="7"></td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="7">UNIT I
Transcendental and Polynomial Equations</td></tr>
<tr><td colspan="7">UNIT II
System of Linear Algebric Equations and Eigenvalue Problems</td></tr>
<tr><td colspan="7">UNIT III
Interpolation and Approximation</td></tr>
<tr><td colspan="7">UNIT IV
Differentiation and Integration</td></tr>
<tr><td colspan="7">UNIT V
Ordinary Differential Equations Initial Value Problems</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="7">Questions related to the above topics, from various competitive examinations UPSC /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="7">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="7">1.Numerical Methods For Scientific And Engineering Computation by M. K. Jain, S. R. K. Iyengar And R. K. Jain.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="7">1. Numerical Methods and principles analysis and algorithms ,S.Pal ,Oxford University Press</td></tr>
<tr><td colspan="2">Website and e-Learning Source</td><td colspan="7">http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com</td></tr>
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<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">DIFFERENTIAL EQUATIONS USING SCILAB</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">SEC</td></tr>
<tr><td>Category</td><td>Elective</td><td>Year</td><td></td><td>Credits</td><td>2</td><td>Course Code</td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td>Semester</td><td></td><td colspan="4"></td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td colspan="2"></td><td>1</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8"></td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="8">UNIT I
An Introduction to Scilab – Matrices</td></tr>
<tr><td colspan="8">UNIT II
Scilab Programming</td></tr>
<tr><td colspan="8">UNIT III
Functions –Plotting</td></tr>
<tr><td colspan="8">UNIT IV
Solving Ordinary Differential Equations</td></tr>
<tr><td colspan="8">UNIT V
Polynomials in Scilab</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC /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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="8">1. PROGRAMMING USING SCILAB, AKHILESH KUMAR</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="8">1.Ordinary Differential Equations with Scilab by Gilberto E.Urroz</td></tr>
<tr><td colspan="2">Website and e-Learning Source</td><td colspan="8">http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com</td></tr>
</table>

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="7">INDUSTRIAL MATHEMATICS USING LATEST PROGRAMMING PACKAGES</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="7">SEC</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></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>1</td><td colspan="2">1</td><td colspan="2">--</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="7"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="7"></td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="7">UNIT I
Mathematics in industry- Overview of the case studies-Units and dimensions - Diffusion equations - Heat conduction equations</td></tr>
<tr><td colspan="7">UNIT II
Boundary conditions -Solving the heat/diffusion equation -Scaling equations - Dimensional analysis</td></tr>
<tr><td colspan="7">UNIT III
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</td></tr>
<tr><td colspan="7">UNIT IV
Water Filtration - Introduction to the case study problem -Stretching transformations - Diffusion from a point source -Solving the water filtration case study</td></tr>
<tr><td colspan="7">UNIT V
Laser Drilling -Introduction to the case study problem - Method of perturbations -Boundary perturbations - Solving the laser drilling case study</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="7">Questions related to the above topics, from various competitive examinations UPSC /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="7">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="7">Industrial Mathematics Case Studies in the Diffusion of Heat and Matter , GLENN R. FULFORD PHILIP BROADBRIDGE</td></tr>
</table>

Reference Books	
Website and e-Learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">RESEARCH TOOLS AND TECHNIQUES</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8">SEC</td></tr>
<tr><td>Category</td><td>Elective</td><td>Year</td><td></td><td>Credits</td><td>2</td><td>Course Code</td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td>Semester</td><td></td><td colspan="4"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Instructional Hours per week</td><td>Lecture</td><td colspan="2">Tutorial</td><td colspan="2">Lab Practice</td><td colspan="2">Total</td></tr>
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<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8"></td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="8">UNIT I
Research Process- Research Design</td></tr>
<tr><td colspan="8">UNIT II
Research Problem-Variables and Their Types</td></tr>
<tr><td colspan="8">UNIT III
Formulation of Hypothesis– Sampling- Tools of Data Collection</td></tr>
<tr><td colspan="8">UNIT IV
Data Analysis- Interpretation of Data</td></tr>
<tr><td colspan="8">UNIT V
Research Methods - Descriptive or Survey Method - Experimental Method</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC /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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="8">1.RESEARCH METHODOLOGY: TOOLS AND TECHNIQUES Dr. Prabhat Pandey Dr. Meenu Mishra Pandey © Bridge Center, 2015</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="8">1. Ackoff, Russell L. (1961). The Design of Social Research, University of Chicago Press: Chicago.
2. Allen, T. Harrell, (1978). New Methods in Social Research, Praeger Publication: New York.
3. Baker, R.P. & Howell, A.C. (1958). The Preparation of Reports, Ronald Press: New York.
4. Barzun, Jacques & Graff. F. (1990).The Modern Researcher, Harcourt, Brace Publication: New York.
5. Berelson Conard & Colton, Raymond. (1978). Research and Report Writing for Business and Economics, Random House: New York.</td></tr>
</table>

Website and e-Learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

EXTRA DISCIPLINARY COURSES FOR OTHER DEPARTMENTS (NOT FOR MATHEMATICS STUDENTS)

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">MATHEMATICS FOR LIFE SCIENCES</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">ED I</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED I</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></td></tr>
<tr><td colspan="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 colspan="2"></td><td>2</td><td colspan="2">1</td><td colspan="2">--</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">Basic Mathematics</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. The focus of the course is on scientific study of normal functions in living systems. The emphasis is on exposure to nonlinear differential equations with examples such as heartbeat, chemical reactions and nerve impulse transmission.
2. The basic concepts of the probability to understand molecular evolution and genetics have also been applied.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNITI:Cell Growth-Exponential growth and Decay – Determination of growth or decay rates- The method of least squares – Nutrient Uptake by a cell –Inhomogeneous Differential equations.</td></tr>
<tr><td colspan="6">UNITII:Growth of a Microbial colony – Growth in a Chemo stat – Interacting Populations – Mutation and Reversion in Bacterial growth.</td></tr>
<tr><td colspan="6">UNITIII:Enzyme Kinematics: The Michaelis – Menton Theory – Enzyme Substrate – Inhibitor system – Cooperative dimmer – Allosteric enzymes – Other alloseteric theories.</td></tr>
<tr><td colspan="6">UNITIV:The Cooperative dimmer – Allosteric enzymes – Other alloseteric theories.</td></tr>
<tr><td colspan="6">UNITV:Hemoglobin – Graph theory and Steady state Enzyme Kinetics – Enzyme – Substrate – Modifier system – Enzyme Substrate – Activator system.</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="6">Questions related to the above topics, from various competitive examinations UPSC / TRB / 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, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="6">S. I. Rubinow, Introduction Mathematical Biology, Dover publications, New York, 1975.
Chapter I and Chapter 2 (Sections 2.1,2.3, to 2.11).</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6"></td></tr>
<tr><td colspan="2">Website and e-Learning Source</td><td colspan="6">http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com</td></tr>
</table>

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO 1: analysis and interpretation of bio mathematical models such as population growth, cell division, and predator-prey models.

CLO 2: apply the basic concepts of probability to molecular evolution and genetics.

CLO 3: Identify and appreciate the unifying influence of mathematical modelling in different disciplines

CLO 4: Explain Allosteric enzymes

CLO 5: Analyze and translate a real-world problem into a mathematical problem

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">MATHEMATICS FOR SOCIAL SCIENCES</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED II</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></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 colspan="2">Total</td></tr>
<tr><td>2</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">3</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="8">Basic Mathematics</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8"></td></tr>
<tr><td colspan="2">Course Outline</td><td colspan="8">UNIT I Propositional Logic and set Theory
Propositional Logic Propositional Logic -Open propositions and quantifiers -Arguments and Validity - Set Theory</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT II Functions
The real number system - Solving equations and inequalities; linear and quadratic equations -Review of relations and functions</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT III
Real valued functions and their properties -Types of functions and inverse of a function - Polynomials, zeros of polynomials, rational functions and their graphs</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT IV
Definition and basic properties of logarithmic, exponential, trigonometric functions and their graph</td></tr>
<tr><td colspan="2"></td><td colspan="8">UNIT V Matrices and determinant
Definition of a matrix -Matrix Algebra -Types of matrices - Elementary row operations - Row echelon form and reduced row echelon form of a matrix</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC / TRB / 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="8">Knowledge, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="8">1.Mathematics for Social Sciences , Dr. Berhanu Bekele, Ato Mulugeta Naizghi</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="8"></td></tr>
<tr><td colspan="2">Website and e-Learning Source</td><td colspan="8">http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com</td></tr>
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<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">STATISTICS FOR LIFE AND SOCIAL SCIENCES</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="8"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED III</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></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 colspan="2">Total</td></tr>
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<tr><td colspan="2">Pre-requisite</td><td colspan="8"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8"></td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="8">UNIT I
Definitions, and Scope of Statistics -Approach to Data Collection - Introduction to Set Theory I & II -Concepts of Logic</td></tr>
<tr><td colspan="8">UNIT II
Diagrammatic Presentation of Data -Frequency Distribution - Graphical Presentation of Data - Measures of Central Tendency</td></tr>
<tr><td colspan="8">UNIT III
Probability Theory I&II - Permutation Theorem -Combination - Binominal Distribution</td></tr>
<tr><td colspan="8">UNIT IV
Nature and Importance of Statistical Inquiries - Basic Research Methodology I & II</td></tr>
<tr><td colspan="8">UNIT V
Nature of Science -Some Basic Concepts in Social Statistics</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="8">1.BASIC STATISTICS FOR SOCIAL SCIENCES ,Dr. Henry Obasogie (Course Reviewer) – Benson Idahosa University Dr. Moses Etila Shaibu (Course Editor) – NOUN</td></tr>
</table>

Reference Books	1.Osuala, E.C. (1982). Introduction to Research Methodology. Awka Rd Onitsha, Nigeria: Africana-Fep Publisher Limited. 2.Okoro, E. (2002). Quantitative Techniqes in Urban Analysis. Ibadan: Kraft Books Ltd. Kerlinger, Fred N. (1964). . 3.Foundations of Behavioural Research. New York: Holt, Rinehart and Winton. Whitney, F.L. (1968). 4. The Elements of Research. New York: Prentice- Hall.
Website and e-Learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">GAME THEORY and STRATEGY</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6">ED IV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED IV</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></td></tr>
<tr><td colspan="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 colspan="2"></td><td>2</td><td colspan="2">1</td><td colspan="2">--</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6">UG level Linear programming</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6">1. It focuses on fundamentals of game theory including basic concepts and techniques, various ways of describing and solving games, and various applications in economics, political sciences, and business.
2. It will help students sharpen their understanding of strategic behavior in different situations involving many individuals. T
3. The students will learn how to recognize and model strategic situations, to predict when and how their action will have an influence on others, and to exploit strategic situations for the benefit of their own.</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT I: Game, Strategy and Saddle Point: Introduction- Description of a game of strategy- Relations among expectations- Saddle points-Game with perfect information’s

Chapter 1</td></tr>
<tr><td colspan="6">UNIT II: The Fundamentals: Game without saddle points-mixed strategies- Graphical representation of mixed strategies – the minimax theorem – optimal mixed strategy – graphical representation of minimax theorem and proof of minimax theorem

Chapter 2</td></tr>
<tr><td colspan="6">UNIT III: Properties of Optimal Strategies: Many optimal strategies – some properties of an optimal strategies – convex set of optimal strategies- operation on games – dominated strategies – all strategies active.

Chapter 3 (Section 3.1 to 3.6)</td></tr>
<tr><td colspan="6">UNIT IV: Method of Solving games: Solving for optimal strategies – Guess and verify – Examination of submatrices – Successive approximations – Graphical solutions of 3 x 3 games.

Chapter 5 (Section 5.1 to 5.5)</td></tr>
<tr><td colspan="6">UNIT V: Mapping method for solving games with constraints – Mapping method for solving games – solution of reconnaissance game by mapping method.

Chapter 5 (Section 5.6 to 5.8)</td></tr>
<tr><td colspan="2">Extended Professional Component</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>
</table>

Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill
Recommended Text	Melvin Dresher, Game of Strategy Theory and Application, Prentice-Hall-Inc, USA, 1961
Reference Books	1. Kanti Swarup, P.K.Gupta and Man Mohan, "Operations Research, Eighth Edition", Sultan Chand & Sons, New Delhi, 1999. 2. S.Hillier and J.Liebermann, Operations Research, Sixth Edition, Mc Graw Hill Company, 1995. 3. J. K. Sharma, Operations Research problems and solution, Third edition, Mackmillan Publishers India Ltd, India, 2012. 4. Guillermo Owen, Game Theory, 2nd edition, Academic Press, 1982. 5. Philip D. Straffin, Game Theory and Strategy, The Mathematical Association of America, USA, 1993.
Website and e-Learning Source	1. https://nptel.ac.in/courses/110101133 2. https://archive.nptel.ac.in/courses/110/104/110104063/

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO 1: distinguish a game situation from a pure individual's decision problem

CLO 2: explain graphical representation of mixed strategies.

CLO 3:explain concepts of dominant, dominated, and rationalizable strategies, pure and mixed strategies, and best responses

CLO 4: Analyse economic situations using game theoretic techniques

CLO 5: Solve simple games using mapping method.

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

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="6">HISTORY OF MATHEMATICS</td></tr>
<tr><td colspan="2">Paper Number</td><td colspan="6"></td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">ED V</td><td>Year</td><td></td><td rowspan="2">Credits</td><td rowspan="2">2</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td></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>2</td><td colspan="2">1</td><td colspan="2">--</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisite</td><td colspan="6"></td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="6"></td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="6">UNIT I
Early Number Systems and Symbols</td></tr>
<tr><td colspan="6">UNIT II
Mathematics in Early Civilizations</td></tr>
<tr><td colspan="6">UNIT III
The Beginnings of Greek Mathematics</td></tr>
<tr><td colspan="6">UNIT IV
The Alexandrian School: Euclid</td></tr>
<tr><td colspan="6">UNIT V
The Twilight of Greek Mathematics: Diophantus</td></tr>
<tr><td colspan="2">Extended Professional Component</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">1.The History of Mathematics , Seventh Edition David M. Burton University of New Hampshire</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="6">1. Aczel, Amer. The Artist and the Mathematician: The Story of Nicolas Bourbaki, the Genius Mathematician Who Never Existed. New York: Thunder’s Mouth Press, 2006.
2.Appel, Kenneth, and Haken, Wolfgang. “Every Planar Map Is Four Colorable.” Journal of Recreational Mathematics 9 (1976–1977): 161–169.</td></tr>
<tr><td colspan="2">Website and e-Learning Source</td><td colspan="6">http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com</td></tr>
</table>

<table>
<tr><td colspan="2">Title of the Course</td><td colspan="8">OPERATIONS RESEARCH FOR MANAGEMENT</td></tr>
<tr><td>Category</td><td>NME-I</td><td>Year</td><td>I</td><td>Credits</td><td>2</td><td>Course Code</td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td>Semester</td><td>II</td><td colspan="4"></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 colspan="2">Total</td></tr>
<tr><td>2</td><td colspan="2">1</td><td colspan="2">--</td><td colspan="2">3</td></tr>
<tr><td colspan="2">Objectives of the Course</td><td colspan="8">This course introduces advanced topics in Linear and non-linear Programming</td></tr>
<tr><td colspan="2" rowspan="5">Course Outline</td><td colspan="8">UNIT-I
Decision Analysis-Decision making problem – Decision making process – Decision making Environment – Decision under uncertainty – Decision under Risk – Decision – Tree Analysis.</td></tr>
<tr><td colspan="8">UNIT-II
Games Theory-Two person zero-Sum Games – The maximin – Minimax Principle-Games without saddle points - Graphic solution of 2xn and mx2 Games.</td></tr>
<tr><td colspan="8">UNIT-III
Mixed Strategy Games-Dominance property - Arithmetic method for nxn games – General solution of mxn Rectangular Games using linear programming.</td></tr>
<tr><td colspan="8">UNIT-IV
Dynamic Programming – Product Allocation Problem – Cargo – Loading Model – workforce size model.</td></tr>
<tr><td colspan="8">UNIT-V
Sequencing problem – processing n jobs through Two machines – processing n jobs through k machines – processing 2 jobs through k machines.</td></tr>
<tr><td colspan="2">Extended Professional Component</td><td colspan="8">Questions related to the above topics, from various competitive examinations UPSC / 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="8">Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill</td></tr>
<tr><td colspan="2">Recommended Text</td><td colspan="8">1. KantiSwarup, P.K. Gupta, Manmohan, Operations Research, Sultan Chand & Sons, Reprint 2009.(Units I, II, III & V)
2. HamdyA.Taha, Operations Research and Introduction, Seventh Edition, Prentice – Hall of India, New Delhi.,2009.</td></tr>
<tr><td colspan="2">Reference Books</td><td colspan="8"></td></tr>
<tr><td colspan="2">Website and e-Learning Source</td><td colspan="8">http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com</td></tr>
</table>

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

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