ANNAMALAI UNIVERSITY

(Affiliated Colleges)

401 - M.Sc. Mathematics

Programme Structure and Scheme of Examination (under CBCS)

(Applicable to the candidates admitted from the academic year 2023 - 2024 onwards)

Part	Course Code	Study Components & Course Title	Credit	Hours/ Week	Maximum Marks		
					CIA	ESE	Total
		SEMESTER – I					
A	23PMATC11	**Core - I:** Algebraic Structures.	5	7	25	75	100
	23PMATC12	**Core - II:** Real Analysis I	5	7	25	75	100
	23PMATC13	**Core - III:** Ordinary Differential Equations	4	6	25	75	100
	23PMATE14-1 23PMATE14-2 23PMATE14-3	**Elective – I:** Graph Theory and Applications (or) Programming in C++ Formal Languages and Automata Theory	3	5	25	75	100
	23PMATE15-1 23PMATE15-2 23PMATE15-3	**Elective-II :** Discrete Mathematics (or) Fuzzy Sets and Applications/ (or) Optimization Techniques	3	5	25	75	100
		Total	**20**	**30**			**500**
		SEMESTER – II					
A	23PMATC21	**Core – IV:** Advanced Algebra	5	6	25	75	100
	23PMATC22	**Core – V:** Real Analysis II	5	6	25	75	100
	23PMATC23	**Core – VI:** Partial Differential Equations	4	6	25	75	100
	23PMATE24-1 23PMATE24-2 23PMATE24-3	**Elective – III :** Mathematical Statistics (or) Tensor Analysis and Relativity Theory (or) Algebraic Topology	3	4	25	75	100
	23PMATE25-1 23PMATE25-2 23PMATE25-3	**Elective – IV :** Wavelets (or) Mathematical Modelling (or) Calculus of Variations and Integral Equations	3	4	25	75	100
B (i)	23PMATS26	**Skill Enhancement Course (SEC-I):** Mathematical Documentation using LATEX)	2	4	25	75	100
		Total	**22**	**30**			**600**

		SEMESTER – III					
A	23PMATC31	**Core -VII:** Complex Analysis	5	6	25	75	100
	23PMATC32	**Core - VIII:** Probability Theory	5	6	25	75	100
	23PMATC33	**Core - IX:** Topology	5	6	25	75	100
	23PMATC34	**Core – X :** Mechanics	4	6	25	75	100
	23PMATE35-1 23PMATE35-2	**Elective – V:** Stochastic Processes (or) Advanced Numerical Analysis	3	3	25	75	100
B(i)	23PMATS36	**Skill Enhancement Course (SEC-II):** Statistics with SCILAB	2	3	25	75	100
B(ii)	23PMATI37	Summer Internship*	2	-	25	75	100
		Total	**26**	**30**			**700**
		SEMESTER – IV					
A	23PMATC41	**Core -XI:** Functional Analysis	5	6	25	75	100
	23PMATC42	**Core – XII:** Differential Geometry	5	6	25	75	100
	23PMATD43	Project with Viva -Voce	7	10	25	75	100
	23PMATE44-1 23PMATE44-2	**Elective – VI :** Resource Management Techniques (or) Python Programming (20% Theory + 80% Practical)**	3	4	25	75	100
B (i)	23PMATS45	**Skill Enhancement Course (SEC-III)/ Professional Competency Skill:** Mathematics for Competitive Examinations	2	4	25	75	100
C	23PMATX46	Extension Activity	1	-	100	-	100
		Total	**23**	**30**			**600**
			91				**2400**

* Students should complete two weeks of internship before the commencement of III semester.

** Evaluation is to be done both for theory (15 marks) and practical (60 marks) components separately by the examiners who will be conducting the practical and the marks should be awarded out of 75. Questions for the theory and practical are to be set by the concerned examiner.

Component-wise Credit Distribution

Part	Courses	Sem I	Sem II	Sem III	Sem IV	Total
A	Core (including Practical and Project)	14	14	19	17	**64**
	Elective	6	6	3	3	**18**
B(i)	Skill Enhancement Course	-	2	2	2	**6**
B(ii)	Summer Internship	-	-	2	-	**2**
C	Extension Activity	-	-	-	1	**1**
						91

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

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 endeavors 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.

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										

SEMESTER: I PART: A CORE– I	23PMATC11: ALGEBRAIC STRUCTURES	CREDIT:5 HOURS:7

Objectives of the Course	To introduce the concepts and to develop working knowledge on class equation, solvability of groups, finite abelian groups, linear transformations, real quadratic forms
Course Outline	**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)**
	UNIT-II : Direct products - Finite abelian groups- Modules **Chapter 2: Section 2.13 and 2.14 (Theorem 2.14.1 only)** **Chapter 4: Section 4.5**
	UNIT-III : Linear Transformations: Canonical forms –Triangular form - Nilpotent transformations. **Chapter 6: Sections 6.4, 6.5**
	UNIT-IV : Jordan form - rational canonical form. **Chapter 6 : Sections 6.6 and 6.7**
	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)**
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	I.N. Herstein. *Topics in Algebra* (II Edition) Wiley Eastern Limited, New Delhi, 1975.
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

SEMESTER: I PART: A CORE– II	23PMATC12: REAL ANALYSIS I	CREDIT:5 HOURS:7

Objectives of the Course	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.
Course Outline	**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
	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
	UNIT-III : The Riemann-Stieltjes Integral - Integrators of bounded variation-Sufficient conditions for the existence of Riemann-Stieltjes integrals-Necessary conditions for the existence of RS integrals- Mean value theorems -integrals as a function of the interval – Second fundamental theorem of integral calculus-Change of variable -Second Mean Value Theorem for Riemann integral- Riemann-Stieltjes integrals depending on a parameter- Differentiation under integral sign-Lebesgue criterion for existence of Riemann integrals. Chapter - 7 : 7.15 to 7.26
	UNIT-IV : Infinite Series and infinite Products - Double sequences - Double series - Rearrangement theorem for double series - A sufficient condition for equality of iterated series - Multiplication of series – Cesaro summability. **Chapter - 8 Sec, 8.20, 8.21 to 8.25** **Power series** - Multiplication of power series - The Taylor's series generated by a function - Bernstein's theorem - Abel's limit theorem. **Chapter 9 : Sections 9.14 9.15, 9.19, 9.20, 9.22**

	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

SEMESTER: I PART: A CORE COURSE – III	23PMATC13: ORDINARY DIFFERENTIAL EQUATIONS	Credit:4 Hours:6

Objectives of the Course	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
Course Outline	**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**
	UNIT-II : Linear equations with constant coefficients(Continued) 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**.
	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)**
	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)**
	UNIT-V : Existence and uniqueness of solutions to first order equations: Equation with variable separated – Exact equation – method of successive approximations – the Lipschitz condition – convergence of the successive approximations and the existence theorem. **Chapter 5 : Sections 1 to 6 (Omit Sections 7 to 9)**
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Text	E.A.Coddington, *A introduction to ordinary differential equations* (3rd Printing) Prentice-Hall of India Ltd., New Delhi, 1987.
Reference Books	1. Williams E. Boyce and Richard C. DI Prima, *Elementary differential equations and boundary value problems*, John Wiley and sons, New York, 1967. 2. George F Simmons, *Differential equations with applications and historical notes*, Tata McGraw Hill, New Delhi, 1974. 3. N.N. Lebedev, *Special functions and their applications*, Prentice Hall of India, New Delhi, 1965. 4. W.T. Reid. *Ordinary Differential Equations*, John Wiley and Sons, New York, 1971 5. M.D.Raisinghania, *Advanced Differential Equations*, S.Chand & Company Ltd. New Delhi 2001 6. B.Rai, D.P.Choudary and H.I. Freedman, *A Course in Ordinary Differential Equations*, Narosa Publishing House, New Delhi, 2002.
Website and e-Learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

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

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

CLO3: Analyze solutions using appropriate methods and give examples.

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

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

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

SEMESTER: I PART: A CORE COURSE – III Elective -I	23PMATE14-1: GRAPH THEORY AND APPLICATIONS	Credit:3 Hours:5

Objectives of the Course	To understand and apply the fundamental concepts in *graph theory.*
Course Outline	**UNIT-I : Basic Concepts**: Graphs – Subgraphs – Degrees of vertices – Paths and connectedness – Automorphism of a simple graph, Line Graphs.Connectivity:Vertex cuts and Edge cuts – Connectivity and edge – connectivity.
	UNIT-II: Trees – Characterization and Simple properties-Independent sets and Matchings: Vertex Independent sets and Vertex Coverings – Edge-Independent Sets – Matchings and Factors, Matchings in Bipartite Graphs (except the proof of Tutte's 1-factor theorem).
	UNIT-III : Eulerian Graphs - Hamiltonian Graphs.
	UNIT-IV : Graph Colorings: Vertex Colorings – Critical Graphs – Brooks' Theorem.EdgeColorings of Graphs – Vizing's Theorem – Chromatic Polynomials.
	UNIT-V: Planar Graphs: Planar and Nonplanar Graphs – Euler's Formula and its Consequences – $K_5$and $K_{3,3}$areNonplanar graphs – Dual of a Plane Graph – The Four Color Theorem and the Heawood Five-Color Theorem.
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.R. Balakrishnan and K. Ranganathan, A Textbook of Graph Theory(Universitext), Second Edition, Springer, New York, 2012.
Reference Books	1. Douglas B. West, Introduction to Graph Theory, Second Edition, PHI Learning Private Ltd, New Delhi, 2011. 2. J.A. Bondy and U.S.R. Murty, Graph Theory, Springer, 2008. 3. M.Murugan, Graph Theory and Algorithms, Second Edition, Muthali Publishing House, Annanagar, Chennai, 2018.
Website and e-Learning Source	

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO 1: Understand the basics of graph theory and their various properties.

CLO 2: Develop Models using graphs and to solve the problems algorithmically.

CLO 3: Apply graph theory concepts to solve real world applications like routing, TSP/traffic control, etc.

CLO 4: Analyse the significance of graph theory in different engineering disciplines.

CLO 5: Understand the applications of duality and planarity of graphs.

	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

SEMESTER: I PART: A CORE COURSE – III Elective -I	23PMATE14-2: PROGRAMMING in C++	Credit:3 Hours:5

Objectives of the Course	The main objective of this course are 1. To learn the basic knowledge of C language as pre-requisites 2. To enable the students to write the C++ programs using classes, functions and interfaces 3. To develop programming skills in C++ with its object-oriented concepts To make applications using C++ programs.
Course Outline	**UNIT-I : Tokens, Expressions and Control Structure** Basic Concept of Object– Oriented Programming– Benefits of OOP– Applications of OOP – Tokens, Expressions and Control Structure: Introduction – Tokens– Keywords – Identifiers and Constants – Basic Data Types – User Defined Data Types – Storage Classes – Derived Data Types – Symbolic Constants – Type Compatibility – Declaration of Variables – Dynamic Initialization of Variables – Reference variables – Operators in C++ – Scope Resolution Operators – Operator Over Loading – Control Structures. Chapter I (Sections: 1.5,1.6 and 1.8) Chapter III (Sections: 3.1 to 3.15, 3.23 and 3.25)
	UNIT-II: Functions C++ Introduction– The Main Function – Function Prototyping – Call by Reference – Return by Reference – Inline Functions – Default Arguments – Const Arguments –Recursion – Function over Loading – Friend and Virtual Functions – Math Library Functions. Chapter IV (Sections: 4.1 to 4.12)
	UNIT-III : Classes and Objects & Constructors and Destructors **Classes and Objects:** Introduction – C Structures Revised – Specifying a Class – Defining Member Functions – C++ program with class– Making an Outside Function Inline – Nesting of Member Functions – Private Member Functions – Arrays Within a Class – Arrays of Objects – Objects as Function Arguments – Friendly Functions. **Constructors and Destructors:** Introduction – Constructors – Parameterized Constructors – Multiple Constructors in a Class – Constructors with Default Arguments – Dynamic Initializations of Objects – Copy Constructors – Destructors. Chapter V (Sections: 5.1 to 5.9 and 5.13 to 5.15) Chapter VI (Sections: 6.1 to 6.7 and 6.11)

	UNIT-IV : Operator Overloading, Inheritance and Extending Class **Operator Overloading:** Introduction – Defining operators Overloading – Overloading Unary Operators – Overloading Binary Operators – Overloading Binary Operators Using Friends – Manipulating of Strings Using Operators – Rules for Overloading Operators. **Inheritance and Extending Classes:** Introduction – Defining Derived Classes – Single Inheritance – Making a Private Member Inheritable – Multilevel Inheritance – Multiple Inheritance – Hierarchical Inheritance – Hybrid Inheritance. Chapter VII (Sections: 7.1 to7.6 and 7.8) Chapter VIII (Sections: 8.1 to8.8)
	UNIT-V: Streams and Working with files **Streams:** Introduction – C++ Streams – C++ Stream Classes. **Working with files:**Classes for File Stream Operations – Opening and Closing a File – Detecting End-of-File – File Modes – File Pointers and their Manipulations – Sequential Input and Output Operations – Random Access. Chapter X (Sections:10.1 to 10.3) Chapter XI (Sections: 11.1 to 11.8)
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. Balaguruswamy, Object – Oriented Programming with C++, 6thEdition, Tata McGraw – Hill Publishing Company Limited, New Delhi, 2013.
Reference Books	1. Programming with C++ BY D. Ravichandran, Tata McGraw – Hill Publishing Company Limited New Delhi, 2006. 2. Object – Oriented Programming with C++ by S.S Vinod Chandra, New age. 3. H. Schildt, The Complete Reference of C++ , Tata – McGraw – Hill Publishing Company Limited, New Delhi, 2003.
Website and e-Learning Source	

	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

SEMESTER: I PART: A CORE COURSE – III Elective -I	23PMATE14-3: FORMAL LANGUAGES AND AUTOMATA THEORY	Credit:3 Hours:5

Objectives of the Course	1.Identify the role of switch as simple nontrivial finite automata 2. Describe states, deterministic and non – deterministic nature of transition 3. Differentiate various languages and the corresponding Machines which accepts them 4. Ascertain the limitations of automata
Course Outline	**UNIT-I : Introduction to the theory of Computation: Three basic concepts**. **Finite automata:** Deterministic Finite Accepters – Nondeterministic Finite Accepters –Equivalence of deterministic and non-deterministic finite accepters – reduction of the number of states in finite automata. **Chapter1**(1.2) , Chapter2(2.1–2.4)
	UNIT-II : Regular Languages and Regular Grammars: Regular Expressions-Connection between Regular Expressions and Regular Languages – Regular Grammars. **Chapter3**(3.1–3.3)
	UNIT-III : Properties of Regular Languages: Closure properties of Regular Languages–Elementary questions about regular languages–identifying non-regular languages. **Chapter4**(4.1–4.3)
	UNIT-IV : Context Free Languages: Context Free Grammars(CFG). **Simplification of CFG and Normal Forms:** Methods for transforming Grammars-Two important Normal Forms. **Chapter 5**(5.1),Chapter6 (6.1,6.2)
	UNIT-V: Pushdown Automata: Nondeterministic pushdown automata–Pushdown Automata and CFL – Deterministic Pushdown Automata and Deterministic CFL. **Properties of CFL**: Two Pumping Lemmas. **Chapter 7**(7.1–7.3),Chapter8(8.1)

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	Contents and treatment as in An introduction to Formal Languages and Automata by Peter Linz, 4thedition(2006), Narosa Publishing house.
Reference Books	**1**. Introduction to Automata Theory,Languages,and Computation by John E.Hopcroft,Rajeev Motwani and Jeffrey D.Ullman, 3 rdedition,Prentice Hall. 2.A Course in Formal Languages , Automata and Groups by Ian M.Chiswell,1 stEdition,(2009),Springer 3.Introduction to Languages and the Theory of Computation by John C Martin, 4 thedition(2010), McGraw-Hill. 4. Introduction to Formal Languages, Automata Theory and Computation by Kamala Krithivasan and Rama R, (2009),Pearson. 5. Formal Languages and Automata by Rani Siromoney(1979), The Christian Literature Society.
Website and e-Learning Source	

Course Objectives

Students will be able to

CLO 1: Identify the role of switch as simple nontrivial finite automata

CLO 2: Describe states, deterministic and non – deterministic nature of transition

CLO 3: Differentiate various languages and the corresponding Machines which accepts them

CLO 4: Ascertain the limitations of automata.

Course Learning Outcome (for Mapping with POs and PSOs)

	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

SEMESTER: I PART: A CORE COURSE – III Elective -II	23PMATE15-1: DISCRETE MATHEMATICS	CREDIT:3 HOURS:5

Pre-requisite	-
Objectives of the Course	1. To explore the knowledge in Lattices and their applications. 2. To develop applications of switching circuits. 3. To understand mathematical reasoning in order to read, comprehend and construct mathematical arguments. 4. To develop mathematical foundations to understand and create mathematical arguments in crpto systems. 5. To motivate students how to solve practical problems using Discrete Mathematics.
Course Outline	**UNIT-I : Lattices** Properties and examples of Lattices – Distributive lattices – Boolean algebras – Boolean polynomials – Minimal Forms of Boolean Polynomials.
	UNIT-II: Applications of Lattices Switching Circuits - Applications of Switching Circuits – More Applications of Boolean Algebras.
	UNIT-III : Coding Theory Introduction to Coding – Linear Codes – Cyclic Codes – Special Cyclic Codes.
	UNIT-IV : Cryptology Classical Cryptosystems – Public key Cryptosystems – Discrete Logarithms and other Ciphers.
	UNIT-V: Applications of Algebra Semigroups – Semigroups and Automata –Semigroups and Formal Languages –Semigroups and Biology.
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. Rudolf Lidl& Gunter Pilz. APPLIED ABSTRACT ALGEBRA, Springer Verlag, N Second Indian Reprint 2006.
Reference Books	1. J.P. Tremblay & R. Manohar, A First Course in Discrete Structures with Applications to Computer Science, McGraw Hill, 1987. 2. Kenneth H. Rosen, Discrete Mathematics and it's Applications, 7th Edition/ McGraw Hill Education, New York, 2012. 3. Liu C.L, Elements of Discrete Mathematics, McGraw Hill, New York, 1978.
Website and e-Learning Source	

Course Learning Outcome (for Mapping with POs and PSOs)

CLO 1: Understand how Lattices can be used as a tool and mathematical model in the study of networks and circuits.

CLO 2: Construct mathematical arguments using logical connectives and quantifiers.

CLO 3: Apply codes to develop Mathematical Models.

CLO 4: Explore Applications of crypto systems in modern technology.

CLO 5: Learn how to work with some of the discrete structures which include semigroups and its applications.

	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

SEMESTER: I PART: A CORE COURSE – III ELECTIVE -II	23PMATE15-2: FUZZY SETS AND APPLICATIONS	CREDIT:3 HOURS:5

Objectives of the Course	Familiarize the students with the fundamentals of fuzzy sets, operations on these sets and concept of membership function. Familiar with fuzzy relations and the properties of these relations .To know the concept of a fuzzy number and how it is defined. Become aware of the use of fuzzy inference systems in the design of intelligent systems
Course Outline	**UNIT-I : Fuzzy Sets** Fuzzy sets – Basic types – basic concepts – Characteristics – Significance of the paradigm shift – Additional properties of α–cuts. **Chapter 1:** 1.3 - 1.5 and **Chapter 2:** 2.1
	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:** 2.2 - 2.3 and **Chapter 3:** 3.1 - 3.2
	UNIT-III : Operations on Fuzzy sets Fuzzy intersection – t-norms, fuzzy unions – t-conorms – Combinations of operations – Aggregation operations. **Chapter 3:** 3.3 - 3.6
	UNIT-IV : Fuzzy Arithmetic Fuzzy numbers – Linguistic variables – Arithmetic operation on intervals – Lattice of fuzzy numbers. **Chapter 4:** 4.1 - 4.4
	UNIT-V: Constructing Fuzzy Sets Methods of construction on 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:**10.1 - 10.7.
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	G.J Klir and Bo Yuan, Fuzzy sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India Ltd, New Delhi, 2005.

Reference Books	H.J Zimmemann, 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	

Course Learning Outcome (for Mapping with POs and PSOs)

Course Outcome: At the completion of the Course, the Students will able to

CLO1	Understand the concepts of Fuzzy sets and its types – Characteristics – Significance of the paradigm shift.
CLO2	Be able to distinguish between the crisp set and fuzzy set concepts through the learned differences between the crisp set characteristic function and the fuzzy set membership function.
CLO3	To know Fuzzy intersection – t-norms, fuzzy unions – t-conorms. Combinations of operations – Aggregation operations.
CLO4	Apply the concept of a fuzzy number and apply in real world problems
CLO5	Student practice to construct various methods of fuzzy sets using sample data.

	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

SEMESTER: I PART: A CORE COURSE: III Elective: II	23PMATE15-3: OPTIMIZATION TECHNIQUES	CREDIT:3 HOURS:5

Objectives of the Course	1. To enlighten the students in the field of operations research. 2. To help the students to apply OR techniques in business and management problems. 3. To provide a mathematical programming for finding applications in diverse fields Including engineering, computer science and economics.
Course Outline	**UNIT-I :** Integer programming algorithms –Branch and bound algorithm-cutting plane algorithm-computational considerations in ILP – travelling salesman problem – heuristic algorithms – B & B solution algorithm – cutting plane algorithm. Chapter 9, Sections 9.2.1 to 9.2.3, 9.3.1 to 9.3.3
	UNIT-II: Dynamic programming – Recursive nature of computations in DP – forward and backward recursion – knapsack/fly away/cargo – loading model – work force size model – equipment replacement model – investment model – inventory model. Chapter 10, Sections 10.1 to 10.3, 10.3.1 to 10.3.5
	UNIT-III : Decision analysis and Games – Decision making under certainty – analytic hierarchy process – decision making under risk – decision tree – based expected value criterion – variations of the expected value criterion – decision under uncertainty – game theory – optimal solution of two person zero sum games – solutions of mixed strategy games. Chapter 13, Sections 13.1, 13.2, 13.2.1, 13.2.2, 13.3, 13.4, 13.4.1, 13.4.2.
	UNIT-IV : Classical optimization theory – unconstrained problems – necessary and sufficient conditions – the Newton Raphson method – constrained problems – equality constraints – inequality constraints – Karush Kuhn Tucker conditions Chapter 18, Sections 18.1, 18.1.1, 18.1.2, 18.2, 18.2.1, 18.2.2.
	UNIT-V: Non-Linear Programming algorithms – unconstrained algorithms – direct search method – gradient method – constrained algorithms – seperable programming – quadratic programming. Chapter 19, Sections 19.1, 19.1.1, 19.1.2, 19.2, 19.2.1, 19.2.2
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	Hamdy A. Taha, Operations Research (8thEdn.), McGraw Hill Publications, New Delhi, 2006.
Reference Books	[1]O.L. Mangasarian, Non Linear Programming, McGraw Hill, New York. [2]Mokther S. Bazaraa and C.M. Shetty, Non Linear Programming, Theoryand Algorithms, Willy, New York. [3] Prem Kumar Gupta and D.S. Hira, Operations Research : An Introduction ,S. Chand and Co., Ltd. New Delhi. [4]S.S. Rao, Optimization Theory and Applications, Wiley Eastern Limited, New Delhi.
Website and e-Learning Source	

Course Learning Outcome (for Mapping with POs and PSOs)

On successful completion of the course, the student will be able to,

CO1: Ability to apply the theory of optimization methods and algorithms to develop and For solving various types of optimization problems.
CO2: Ability to go in research by applying optimization techniques in real value problems
CO3: Analyze decision making under certainty and uncertainty by game theory.

	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

SEMESTER: II PART: A CORE COURSE – IV	23PMATC21: ADVANCED ALGEBRA	CREDIT:5 HOURS:6

Objectives of the Course	To study field extension, roots of polynomials, Galois Theory, finite fields, division rings, solvability by radicals and to develop computational skill in abstract algebra.
Course Outline	**UNIT-I :**Extension fields – Transcendence of e. **Chapter 5: Section 5.1 and 5.2**
	UNIT-II : Roots or Polynomials.- More about roots **Chapter 5: Sections 5.3 and 5.5**
	UNIT-III : Elements of Galois theory. **Chapter 5 : Section 5.6**
	UNIT-IV : Finite fields - Wedderburn's theorem on finite division rings. **Chapter 7: Sections 7.1 and 7.2 (Theorem 7.2.1 only)**
	UNIT-V : A theorem of Frobenius - Integral Quaternions and the Four - Square theorem. **Chapter 7 : Sections 7.3 and 7.4**
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	I.N. Herstein. *Topics in Algebra* (II Edition) Wiley EasternLimited, New Delhi, 1975.
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

SEMESTER: II PART: A CORE COURSE – V	23PMATC22: REAL ANALYSIS II	Credit:5 Hours:6

Objectives of the Course	To introduce measure on the real line, Lebesgue measurability and integrability, Fourier Series and Integrals, in-depth study in multivariable calculus.
Course Outline	**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)**
	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)**
	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 – Consequences of Fejes's theorem - The Weierstrass approximation theorem **Chapter 11 : Sections 11.1 to 11.12,11.14 &11.15 (Apostol)**
	UNIT-IV : Multivariable Differential Calculus - Introduction - The Directional derivative - Directional derivative and continuity - The total derivative - The total derivative expressed in terms of partial derivatives - The matrix of linear function - The Jacobian matrix - The chain rule - Matrix form of chain rule - The mean - value theorem for differentiable functions - A sufficient condition for differentiability - A sufficient condition for equality of mixed partial derivatives - Taylor's theorem for functions of R^n to R^1 **Chapter 12 : Section 12.1 to 12.14 (Apostol)**
	UNIT-V : Implicit Functions and Extremum Problems : Functions with non-zero Jacobian determinants – The inverse function theorem-The Implicit function theorem-Extrema of real valued functions of severable variables-Extremum problems with side conditions. **Chapter 13 : Sections 13.1 to 13.7 (Apostol)**
Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)

Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill
Recommended Text	1. G. de Barra, *Measure Theory and Integration*, Wiley Eastern Ltd., New Delhi, 1981. (for Units I and II) 2. Tom M.Apostol : *Mathematical Analysis*, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974. (for Units III, IV and V)
Reference Books	1. Burkill,J.C.*The Lebesgue Integral*, Cambridge University Press, 1951. 2. Munroe,M.E.*Measure and Integration*. Addison-Wesley, Mass.1971. 3. Roydon,H.L.*Real Analysis*, Macmillan Pub. Company, New York, 1988. 4. Rudin, W. *Principles of Mathematical Analysis*, McGraw Hill Company, New York,1979. 5. Malik,S.C. and Savita Arora. *Mathematical Analysis*, Wiley Eastern Limited. New Delhi, 1991. 6. Sanjay Arora and Bansi Lal, *Introduction to Real Analysis*, Satya Prakashan, New Delhi, 1991
Website and e-Learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

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

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

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

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

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

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

SEMESTER: II PART: A CORE COURSE – VI	23PMATC23: PARTIAL DIFFERENTIAL EQUATIONS	Credit:4 Hours:6

Objectives of the Course	To classify the second order partial differential equations and to study Cauchy problem, method of separation of variables, boundary value problems.
Course Outline	**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)**
	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**
	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)**
	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**
	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**
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

SEMESTER: II PART: A Elective - III	23PMATE24-1: MATHEMATICAL STATISTICS	Credit:3 Hours:4

Objectives of the Course	1. To study random variables and its applications. 2. To explore probability distributions. 3. To understand moments and their functions. 4. To introduce significance tests. 5. Concepts of ANOVA
Course Outline	**UNIT-I : Random Variables** The concepts of random variables – The distribution function – Random variable of the discrete type and the continuous type – Functions of random variables – Marginal distributions – Conditional distributions – Independent random variables.
	UNIT-II: Some Probability Distributions The Binomial Distribution – The Poisson Distribution – The Uniform Distribution – The Normal Distribution – The Gamma Distribution – The Beta Distribution.
	UNIT-III : Sample Moments and Their Functions Notion of a sample and a statistic - Distribution of the arithmetic mean of independent normally distributed random variables – The χ^2-distribution – The distribution of the statistics ($\bar{X}$, S) – Student's t - distribution - Fisher's Z – distribution.
	UNIT-IV : Significance tests Concept of a statistical test – Parametric tests for small samples and large samples - χ^2 test - Tests of Kolmogorov and Smirnov type – Independence Tests by contingency tables.
	UNIT-V: Analysis of Variance One-way Classification and two-way Classification. **Hypotheses Testing:** The Power functions and OC function – Most Powerful test – Uniformly most powerful test – unbiased tests.
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 Your, 1967.

Reference Books	1. E.J.Dudewicz and S.N.Mishra ,Modern Mathematical Statistics, John Wiley and So York, 1988. 2. V.K.RohatgiAn Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern New Delhi, 1988(3rd Edn). 3. B.L.VanderWaerden, Mathematical Statistics, G.Allen& Unwin Ltd., London, 196
Website and e-Learning Source	

Course Learning Outcome (for Mapping with POs and PSOs)

After completion of this course the student will be able to

CLO 1: Apply the concepts of random variables in real life situations.

CLO 2: Identify the type of statistical situation to which different distributions can be applied.

CLO 3: Calculate moments and their functions.

CLO 4: Explore knowledge in the various significance tests for statistical data.

CLO 5: Analyze statistical data using ANOVA.

	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

SEMESTER: II PART: A Elective - III	23PMATE24-2: Tensor Analysis and Relativity theory	Credit:3 Hours:4

Objectives of the Course	The main purpose of the course is to introduce students to understand the subject of differential geometry, where you talk about manifolds, one difficulty is that the geometry is described by coordinates, but the coordinates do not have meaning. They are allowed to undergo transformation. And in order to handle this kind of situation, an important tool is the so-called tensor analysis, which was new to mathematicians.
Course Outline	**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 tensors – 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 1: 1.1 – 1.3,1.7 & 1.8 , Chapter 2 : 2.1 – 2.9(Text Book -1)
	Unit II: Tensor Calculus Riemannian space – Christoffel symbols and their properties. Chapter 3: 3.1 – 3.2(Text Book -1)
	Unit III: Tensor Calculus (Contd …) Covariant differentiation of tensors – Riemann-Christoffel curvature tensor – Intrinsic differentiation. Chapter 3: 3.3 – 3.5 (Text Book -1)
	Unit IV: Special Theory of Relativity Galilean transformation – Maxwell's equations – The Ether theory – The principle of Relativity. **Relativistic Kinematics:** Laurent's 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: 7.1 – 7.2 (Text Book -2)
	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: 7.3 – 7.4(Text Book -2)

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.U.C. De, Absos Ali Shaikh &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 &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	

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1-Understand Tensor Algebra terminologies and different orders – Summation convention– Kronecker symbols – Transformation of coordinates in Sn. Invariants – Covariant and Contravariant vectors and arithmetic's law related to tensor.

CLO2 - Discuss the Riemannian space – Christoffel symbols and their properties.

CLO3 -Tensor calculus fundamentals on covariant differentiation of tensors – Riemann Christoffel curvature tensor – Intrinsic differentiation are carried out.

CLO4 -Focus on special theory of relativity concepts of Laurent's transformation equations, Einstein train – Time dilation – Longitudinal contraction – Invariant interval – Twin paradox.

CLO5- Study the application of theory relativistic dynamics on Momentum-Energy four vector– Force – Conservation of energy – Principle of equivalence – Lagrangian and Hamiltonian formulations.

	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

SEMESTER: II PART: A Elective - III	23PMATE24-3: ALGEBRAIC TOPOLOGY	Credit:3 Hours:4

Objectives of the Course	To introduce the ideas of algebraic topology to other branches of Mathematics.
Course Outline	**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: (a) to (b); Chapter – 3: (a) to (d)
	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)
	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)
	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 fro De Rham Cohomology. Chapter 14: (a) to (d); Chapter 15: (a) to (d)
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	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, 1992. 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. Munkres, Topology, Prentica Hall of India, New Delhi, 2002, [3rd Indian Print]
Website and e-Learning Source	

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1- Understand the concepts of Calculus in the plane.

CLO2- Understand the concepts cohomology and homology.

CLO3 –Understand holes integrals and Homology.

CLO4 -Analyse covering spaces and fundamental groups.

CLO5- G-Coverings from the Universal Covering , Patching Coverings together , The Van Kampen Theorem ,Cohomology.

	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

SEMESTER: II PART: A Elective - IV	23PMATE25-1: WAVELETS	Credit:3 Hours:4

Objectives of the Course	To introduce the basic notions and techniques of Wavelets Theory and to establish the Concepts to understand and use wavelets from Fourier to wavelet analysis.
Course Outline	**Unit I : An Overview** Fourier analysis to wavelet analysis - Integral Wavelet Transform and Time-frequency analysis - Inversion formulas and duals - Classification of Wavelets –Multiresolution analysis - Splines and Wavelets – Wavelet decompositions and reconstructions. Chapter 1: Sections 1.1 to 1.6
	Unit II : Fourier Analysis Fourier and Inverse Fourier Transforms – Continuous-time convolution and the delta function - Fourier Transform of square-integrable functions- Fourier Series - Basic Convergence Theory - Poisson Summation Formula. Chapter 2: 2.1 and 2.5
	Unit III : Wavelet Transforms & Time Frequency Analysis The Gabor Transform – Short-time Fourier Transforms and the uncertainty principle - The integral Wavelet Transform - Dyadic Wavelets and Inversions - Frames - Wavelet Series. Chapter 3: Section 3.1 to 3.6
	Unit IV : Cardinal Spline Analysis Cardinal Spline spaces. – B-Splines and their basic properties - The two-scale relation and an interpolatory graphical display algorithm - B-Net representations and computation of cardinal splines - Construction of cardinal splines - construction of spline application formulas - Construction of Spline interpolation formulas. Chapter 4: Sections 4.1 to 4.6
	Unit V: Scaling Functions And Wavelets Multiresolution analysis - Scaling functions with finite two scale relations – Direction sum Decompositions of L 2 (R) - Wavelets and their duals. Chapter 5: Sections 5.1 to 5.4
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	Charles K.Chui , An Introduction to Wavelets, Academic Press, New York, 1992.
Reference Books	1. Chui. C.K. (ed) Approximation theory and Fourier Analysis, Academic Press Boston, 1991. 2. Daribechies,I. Wavelets, CBMS-NSF Series in Appl.. math. SIAM. Philadelphia, 1992. 3. Schumaker,L.L. Spline Functions: Basic Theory , Wiley, New York 1981. 4. Nurnberger, G. Applications to Spline Functions, Springer Verlag, New York. 1989.5. Walnut,D.F. Introduction to Wavelet Analysis, Birhauser, 2004.
Website and e-Learning Source	

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: Understand the terminologies that are used in the wavelets, from Fourier analysis to wavelet analysis.

CLO2: Determine the concepts of the Fourier and Inverse Fourier Transforms.

CLO3: know the Wavelet Transforms and Time Frequency Analysis.

CLO4: Learn the concepts on Cardinal Spline Analysis.

CLO5: Study the Scaling Functions and Wavelets theory.

	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

SEMESTER: II PART: A Elective - IV	23PMATE25-2: MATHEMATICAL MODELLING	Credit:3 Hours:4

Objectives of the Course	To study the mathematical models through ODE and difference equations and to train the students to get essential knowledge to develop mathematical models in real life problems.
Course Outline	**Unit-1 Mathematical Modelling : Need, Techniques, Classification and Simple Illustrations** Simple Situations Requiring Mathematical Modelling-The Techniques of Mathematical Modelling- Classification of Mathematical Models-Some Characteristics of Mathematical Models-Mathematical Modelling Through Geometry-Mathematical Modelling Through Algebra- Mathematical Modelling Through Trigonometry- Mathematical Modelling through Calculus-Limitations of Mathematical Modelling . Chapter 1
	Unit-II Mathematical Modelling through Ordinary Differential Equations of First Order Mathematical Modelling through Differential Equations- Linear Growth and Decay Models-Non- Linear Growth and Decay Models-Compartment Models-Mathematical Modelling in Dynamics Through Ordinary Differential Equations of First Order- Mathematical Modelling of Geometrical Problems Through Ordinary Differential Equations of First Order. Chapter 2
	Unit-III Mathematical Modelling through Systems of Ordinary Differential Equations of the First Order Mathematical Modelling in Population Dynamics- Mathematical Modelling of Epidemics Through Systems of Ordinary Differential Equations of First Order-Compartment Models Systems of Ordinary Differential Equations- Mathematical Modelling in Economics through Systems of Ordinary Differential Equations of First Order- Mathematical Models in Medicine, Arms Race, Battles and International Trade in Terms of Systems of Ordinary Differential Equations- Mathematical Modelling in Dynamics Through Ordinary Differential Equations of First Order. Chapter 3

	Unit-IV Mathematical Modelling Through Difference Equations. The need for Mathematical Modelling through Difference Equations: Some Simple Models- Basic Theory of Linear Difference Equations With Constant Coefficients- Mathematical Modelling through Difference Equations in Economics and Finance- Mathematical Modelling through Difference Equations in Population Dynamics and Genetics- Mathematical Modelling through Difference Equations in Probability Theory- Miscellaneous Examples of Mathematical Modelling through Difference Equations. Chapter 5
	Unit-V Mathematical Modelling Through Functional Integral , Delay – Differential and Differential- Difference Equations Mathematical Modelling Through Functional Equations- Mathematical Modelling Through Integral Equations- V Mathematical Modelling Through Delay – Differential and Differential- Difference Equations. Chapter 8
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	Mathematical Modelling –J.N.Kapur, Wiley Eastern Limited
Reference Books	1. D.J.G.James and J.J.Macdonald, Casestudies in Mathematical Modelling, StanlyThames,Cheltonham. 2. M.Cross and A.O.Moscrcadini, The art of Mathematical Modelling, EllisHarwood and John Wiley. 3. C.Dyson, Elvery, Principles of Mathematical Modelling, AcademicPress, NewYork. 4. D.N.Burghes, Modelling with Difference Equations, EllisHarwood and John Wiley.
Website and e-Learning Source	http://www.mathfoundation.com

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1: To learn the concepts of Mathematical Modelling Techniques.

CLO2: To understand the ideas of Mathematical Modelling through ODE of first order.

CLO3: To develop the Mathematical Models through systems of ODE of first order.

CLO4: To know the techniques of Mathematical Modelling through Difference equations.

CLO5: To study the Mathematical Models through Differential - Difference equations

	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

SEMESTER: II PART: A Elective - IV	23PMATE25-3: CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS	Credit:3 Hours:4

Objectives of the Course	Introduce the concept of calculus of variation and its applications , introduce various types of integral equations and how to solve these equations.
Course Outline	**Unit I: Variational problems with fixed boundaries** The concept of variation and its properties – Euler's equation – Variational problems for Functionals – Functionals dependent on higher order derivatives – Functions of several independent variables – Some applications to problems of Mechanics. Chapter 1: 1.1 - 1.7 (Text Book - 1)
	Unit II: Variational problems with moving boundaries Movable boundary for a functional dependent on two functions – one-sided variations –Reflection and Refraction of extremals – Diffraction of light rays. Chapter 2: 2.1 - 2.5 (Text Book - 1)
	Unit III: Integral Equation Introduction – Types of Kernals – Eigen values and Eigen functions – connection with differential equations – Solution of an integral equation – Initial value problems – Boundary value problem. Chapter 1: 1.1 - 1.3 & 1.5 - 1.8 (Text Book - 2)
	Unit IV: Solution of Fredholm integral equation Second kind with separable kernel – Orthogonality and reality eigen function – Fredholm Integral equation with separable kernel – Solution of Fredholm Integral Equation by successive substitution – Successive approximation – Volterra integral equation – Solution by successive substitution. Chapter 2: 2.1 - 2.3 and Chapter 4: 4.1 - 4.5 (Text Book - 2)
	Unit V: Hilbert – Schmidt Theory Complex Hilbert space – Orthogonal system of function –Gram-Schmit Solutions of orthognalization process– Hilbert-Schmidt theorems – Fredholm of integral equation of first kind. Chapter 3: 3.1 - 3.4 & 3.8 - 3.9 (Text Book - 2)
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.A.S. Gupta, Calculus of Variations with Application, Prentice Hall of India, New Delhi,2005. 2.Sudir K. Pundir and RimplePundir, Integral Equations and Boundary Value Problems,Pragati Prakasam, Meerut, 2005.
Reference Books	1. L. Elsgolts, Differential Equations and the Calculus of Variations Mir Publishers,Moscow, 1973. 2. Ram P. Kanwal, Linear Integral Equations. Academic Press, New York, 1971.
Website and e-Learning Source	1. http://www.maths.ed.ac.uk/~jmf/Teaching/Lectures/CoV.pdf 2. https://archive.nptel.ac.in/courses/111/104/111104025/

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1 -Students know the concept and properties of variational problems with fixed and moving boundaries, functions of dependent and independent variables and also solve some applications problems in mechanics.

CLO2 - Able to solve differential equations and integral equation problems. Find the solution of eigen value, eigen functions.

CLO3 -Implementation of various methods to solve Fredholm Intergral equation.

CLO4 -Students gain acquire knowledge about Hilbert – Schmidt Theory

CLO5 -Deriving the complex Hilbert space – Orthogonal system of function and Solutions of Fredholm of Integral equation of first kind

	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

SEMESTER: II PART: B	23PMATS26: MATHEMATICAL DOCUMENTATION USING LATEX	Credit:2 Hours:4

Objectives of the Course	Inculcate the computer knowledge. Introduce the LaTeX software Train in the Preparation of Project and dissertations using LaTex. Educate the Latex coding. Understand the concepts of Cross References, Footnotes, Margin pars and Endnotes.
Course Outline	**Unit – I** Basic Document and Bibliography What is LATEX – Simple typesetting – Fonts Type size – Document class – page style – page numbering – Formatting lengths – parts of a document – Dividing the document – what next? – Introduction – natbib – The BIBTEX program – BIBTEX Style files – Creating a bibliographic database. Chapter: 1 to 4
	Unit – II Contents, Index, Glossary, Text, Row and Column Table of contents – Index – Glossary. Borrowed words – Poetry in typing – Making lists – When order matters – Description and definitions. Chapter: 5 to 6
	Unit – III Typesetting Equations and Theorems Keeping tabs – Tables – The basics – Custom commands – More on mathematics – mathematics miscellany – New operations– The many fact of mathematics – Symbols – Theory in LATEX – Designer theorem-the amsthm package – Housekeeping. Chapter: 7 to 9
	Unit – IV Several Kinds of boxes and Floats, LR boxes – Paragraph boxes – Paragraph boxes with specific height – Nested boxes – Role boxes – The figure environment – The table environment. Chapter: 10 to 11
	Unit – V Cross References in LATEX, Footnotes, Margin pars and Endnotes Why cross reference? – Let LATEX do it – Pointing to a page-the package varioref – Pointing outside-the package xr – Lost the keys? Use lables.tex – Footnotes – Marginal notes – Endnotes. Chapter: 12 to 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	A Primer, Latex Tutorials, Indian TEX users group, Trivandrum, India. www.tug.org.in
Reference Books	1. Peter Flynn, A beginner"s introduction to typesetting with LATEX,Silmaril Consultants, Textual Therapy Division, 2003. 2. George Gratzer,More Math Into LATEX, 4th Edition, Springer Science (2007). 3. Frank Mittelbach,Michel Goossens,The LaTex Companion, Second Edition, Addison-Wesley, 2004.
Website and e-Learning Source	1. https://www.latex-tutorial.com/tutorials/ 2. https://www.latex-tutorial.com/ 3. http://www.tug.org.in/tutorials.html

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1 - Understand the basic LaTeX document and the e-contents.
CLO2 - Construct the structures of contents, index, glossary and text.
CLO3 - Create the type setting equations
CLO4 - Discuss several types of boxes and floats.
CLO5 - Prepare the basic documentation.

	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

SEMESTER: III PART: A CORE– VII	23PMATC31: COMPLEX ANALYSIS	CREDIT:5 HOURS:6
Pre-requisite	UG level Complex Analysis	
Objectives of the Course	To Study Cauchy integral formula, local properties of analytic functions, general form of Cauchy's theorem and evaluation of definite integral and harmonic functions	
Course Outline	**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**	
	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**	
	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**	
	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**	
	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**	
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

SEMESTER: III PART: A CORE– VIII	23PMATC32: PROBABILITY THEORY	CREDIT:5 HOURS:6

Pre-requisite	UG level algebra and calculus
Objectives of the Course	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.
Course Outline	**UNIT-I : Random Events and Random Variables:** Random events – Probability axioms – Combinatorial formulae – conditional probability – Bayes Theorem – Independent events – Random Variables – Distribution Function – Joint Distribution – Marginal Distribution – Conditional Distribution – Independent random variables – Functions of random variables. **Chapter 1: Sections 1.1 to 1.7** **Chapter 2 : Sections 2.1 to 2.9**
	UNIT-II : Parameters of the Distribution : Expectation- Moments – The Chebyshev Inequality – Absolute moments – Order parameters – Moments of random vectors – Regression of the first and second types. **Chapter 3 : Sections 3.1 to 3.8**
	UNIT-III: Characteristic functions : Properties of characteristic functions – Characteristic functions and moments – 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**
	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)**
	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)**
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*, (2nd Edition) Duxbury Press, New York, 1996. 5. V.K.Rohatgi*An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern Ltd., New Delhi, 1988(3rd Print). 6. S.I.Resnick, *A Probability Path*, Birhauser, Berlin,1999. 7. B.R.Bhat , *Modern Probability Theory* (3rd Edition), New Age International (P)Ltd, New Delhi, 1999
Website and e-Learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, http://www.probability.net

Course Learning 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

SEMESTER: III PART: A CORE– IX	23PMATC33: TOPOLOGY	CREDIT:5 HOURS:6

Pre-requisite	Real Analysis
Objectives of the Course	To study topological spaces, continuous functions, connectedness, compactness, countability and separation axioms.
Course Outline	**UNIT-I : Topological spaces :** Topological spaces – Basis for a topology – The order topology – The product topology on $X \times Y$ – The subspace topology – Closed sets and limit points. **Chapter 2 : Sections 12 to 17**
	UNIT-II :Continuous functions: Continuous functions – the product topology – The metric topology. **Chapter 2 : Sections 18 to 21 (Omit Section 22)**
	UNIT-III :Connectedness: Connected spaces- connected subspaces of the Real line – Components and local connectedness. **Chapter 3 : Sections 23 to 25.**
	UNIT-IV : Compactness : Compact spaces – compact subspaces of the Real line – Limit Point Compactness – Local Compactness. **Chapter 3 : Sections 26 to 29.**
	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.**
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	James R. Munkres, *Topology* (2nd Edition) Pearson Education Pve. Ltd., Delhi-2002 (Third Indian Reprint)

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

SEMESTER: III PART: A CORE– X	23PMATC34: MECHANICS	CREDIT:4 HOURS:6

Pre-requisite	UG level Calculus and Differential equations.
Objectives of the Course	To study mechanical systems under generalized coordinate systems, virtual work, energy and momentum, to study mechanics developed by Newton, Langrange, Hamilton Jacobi and Theory of Relativity due to Einstein.
Course Outline	**UNIT-I :** Mechanical Systems : The Mechanical system- Generalised coordinates – Constraints - Virtual work - Energy and Momentum **Chapter 1 : Sections 1.1 to 1.5**
	UNIT-II : Lagrange's Equations: Derivation of Lagrange's equations- Examples- Integrals of motion. **Chapter 2 : Sections 2.1 to 2.3 (Omit Section 2.4)**
	UNIT-III : Hamilton's Equations : Hamilton's Principle - Hamilton's Equation - Other variational principle. **Chapter 4 : Sections 4.1 to 4.3 (Omit section 4.4)**
	UNIT – IV : Hamilton-Jacobi Theory : Hamilton Principle function – Hamilton-Jacobi Equation - Separability **Chapter 5 : Sections 5.1 to 5.3**
	UNIT-V : Canonical Transformation : Differential forms and generating functions – Special Transformations– Lagrange and Poisson brackets. **Chapter 6 : Sections 6.1, 6.2 and 6.3 (omit sections 6.4, 6.5 and 6.6)**
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	D. Greenwood, *Classical Dynamics*, Prentice Hall of India, New Delhi, 1985.
Reference Books	1. H. Goldstein, *Classical Mechanics*, (2nd Edition) Narosa Publishing House, New Delhi. 2. N.C.Rane and P.S.C.Joag, *Classical Mechanics*, Tata McGraw Hill, 1991. 3. J.L.Synge and B.A.Griffth, *Principles of Mechanics* (3rd Edition) McGraw Hill Book Co., New York, 1970.
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: Demonstrate the knowledge of core principles in mechanics.

CLO2: Interpret and consider complex problems of classical dynamics in a systematic way.

CLO3: Apply the variation principle for real physical situations.

CLO4: Explore different applications of these concepts in the mechanical and electromagnetic fields.

CLO5: Describe and apply the concept of Angular momentum, Kinetic energy and Moment of inertia of a particle

	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

SEMESTER: III PART: A Elective – V	23PMATE35-1: STOCHASTIC PROCESSES	CREDIT:3 HOURS:3
Pre-requisite		
Objectives of the Course	Acquire the skill of advanced level of mathematical sophistication and enhancing the horizons of knowledge, understanding of applicability of different concepts of stochastic processes, use of stochastic models in different areas.	
Course Outline	**UNIT – I :Stochastic Processes** Introduction – Specification of Stochastic Processes –Stationary Processes –Martingales –Markov Chains: Definition and Examples –Higher Transition Probabilities – Generalization of independent Bernoulli Trials: Sequence of Chain Dependent Trials –Classification of States and Chains. Chapter II (Sections: 1 to 4), Chapter III (Sections: 1 to 4)	
	UNIT – II :More on Markov Chains Determination of Higher Transition Probabilities – Stability of a Markov System– Markov Chain with Denumerable Number of States –Reducible Chains. Chapter III (Sections: 5,6,8 and 9)	
	UNIT – III :Markov Processes with Discrete State Space: Poisson Process and its Extensions Poisson Process – Poisson Process and Related Distributions – Generalization of Poisson Process – Birth and Death Process – Markov Process with Discrete State Space (Continuous Time Markov Chains). Chapter IV (Sections: 1 to 5)	
	UNIT – IV :Markov Chains and Markov Processes with Continuous State Space Markov Chains with Continuous State Space – Introduction: Brownian Motion – Wiener Process – Differential Equations for a Wiener Process – Kolmogorov Equations – First Passage Time Distribution for Wiener Process. Chapter III (Section: 11),Chapter V (Sections: 1 to5)	
	UNIT – V :Renewal Processes and Theory Renewal Process – Renewal Processes in Continuous Time – Renewal Equation – Stopping time: Wald's Equation – Renewal Theorems – Delayed and Equilibrium Renewal processes. Chapter VI (Sections: 1 to 6)	
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	J. Medhi, Stochastic Processes, Wiley Eastern Limited, New Delhi, (Second Edition), 1994.
Reference Books	1. S. Karlin and H.M. Taylor, A First Course in Stochastic Processes, Academic Press (second edition), New York, 2011. 2. S.M. Ross, Stochastic Processes,Wiley India Pvt., Ltd.,2nd Edition, 2008.
Website and e-Learning Source	

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO 1-Understand the concept of Stochastic Processes
CLO 2-Understand the concept of Markov Chains.
CLO 3-Understand the concept of Markov Processes with Discrete State Space
CLO 4-Understand the concept of Markov Chains and Markov Processes with Continuous State Space.
CLO 5- Know the Renewal Processes in Continuous Time, Renewal Equation, Equilibrium Renewal processes.

	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

SEMESTER: III PART: A Elective – V	23PMATE35-2: ADVANCED NUMERICAL ANALYSIS	CREDIT:3 HOURS:3
Pre-requisite		
Objectives of the Course	Introduce the derivation of numerical methods with error analysis, Study the transcendental and polynomial equations ,acquire the knowledge of system of linear algebraic equations ,understand the differentiation and integration ,Solve problems on interpolation and ordinary differential equations.	
Course Outline	**UNIT–I** Transcendental and Polynomial Equations Iterationmethodsbasedonseconddegreeequation–Rateofconvergence–Iterationmethods– Methods for complex roots– Polynomial equations. Chapter2:Sections 2.4 to 2.8	
	UNIT–II System of Linear Algebraic Equations and Eigen Value Problems Direct methods–Triangularisation, Cholesky and Partition methods–Error analysis–Iteration methods – Eigen values and Eigenvectors – Jacobi's method, Given's method, Rutishaugher method and Power method. Chapter3: Sections 3.2to 3.5.	
	UNIT–III Interpolation and Approximation Hermite Interpolations –Piecewise and Spline Interpolation–Bivariate interpolation–Approximation– Least Square approximation– Uniform approximation. Chapter4:Sections4.5to 4.10	
	UNIT–IV Differentiation and Integration Numerical Differentiation–Partial Differentiation–Numerical Integration methods based on undetermined coefficients– Double integration. Chapter5:Sections5.2,5.5, 5.6, 5.8, 5.11	
	UNIT–V Ordinary Differential Equations Numericalmethods–Singlestepmethods–Multistepmethods–Predictor–Correctormethods. Chapter6:Sections6.2 to 6.5	
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.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods For Scientific and Engineering Computation, 3rd Edition, New Age International,1993.
Reference Books	1. S.D. CorteanddeBoor, Elementary Numerical Analysis–An Algorithmic approach,3rd Edition, McGraw Hill International Book Company, 1980. 2. James B.Scarboraugh, Numerical Mathematical Analysis, Oxford &IBH Publishing Company, New Delhi. 3. F.B. Hildebrand, Introduction To Numerical Analysis, Mc Graw Hill, NewYork,1956.
Website and e-Learning Source	1. https://www.math.upenn.edu/~wilf/DeturckWilf.pdf 2. https://web.archive.org/web/20120225082123/http://kr.cs.ait.ac.th/~radok/math/mat7/stepsa.htm 3. https://ocw.mit.edu/courses/mechanical-engineering/2-993j-introduction-to-numerical-analysis-for-engineering-13-002j-spring-2005/

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO1 -Examine the solutions of transcendental and polynomial equations
CLO2 -Understand the system of linear algebraic equations
CLO3-Analyse the interpolation and extrapolation
CLO4 -Evaluate numerical differentiation and integrations
CLO5 -Solve the differential equations by single and multi-step methods

	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

SEMESTER: III PART: B (i) Skill Enhancement Course	23PMATS36: STATISTICS WITH SCILAB	CREDIT:2 HOURS:3

Pre-requisite	
Objectives of the Course	Understand the concepts of the SCILAB techniques
Course Outline	Unit-I: SCILAB Basics Overview of SCILAB – Get started – Basic elements of the language – Matrices
	Unit-II: SCILAB Programming Looping and Branching – Functions – Plotting
	Unit-III: Application into Basic Statistics Measures of Central Tendency – Descriptive Statistics – Measures of Dispersion
	Unit-IV: Application into Advanced Statistics Cumulated distribution function – Data with missing values – Hypothesis Testing
	Unit-V: Optimization Toolbox FOSSEE SCILAB Optimization Toolbox – fminsearch – fsolve – fminbnd – fmincon – linprog – intlinprog – intfmincon – quadprog – intquadprog, Genetic Algorithm (optim_ga)
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. Introduction to SCILAB – Michael Baudin From SCILAB Consortium, 2010 2. SCILAB Online Help – https://help.scilab.org/docs/5.5.2/en_US/section_33491857221a48388b878311e9f4b67e.html 3. FOSSEE SCILAB Toolbox – Optimization Toolbox https://scilab.in/fossee-scilabtoolbox/optimization-toolbox/functions 4. SCILAB Online Help – optim_ga – https://help.scilab.org/docs/5.5.2/en_US/optim_ga.html. Unit-I: Chapter 1, 2, 3, 4 of Text Book 1 Unit-II: Chapter 5, 6, 7 of Text Book 1 Unit-III: Text Book 2 Unit-IV: Text Book 2 Unit-V: Text Book 3 and 4
Reference Books	1. https://www.scilab.org/tutorials 2. SCILAB help documentation – Statistics 3. Basic Statistics and Probability with SCILAB – Gilberto E. Urroz infoclearinghouse.com https://www.scilab.org/sites/default/files/Basic%20Statistics%20and%20Probability%20w%20SCILAB%20-%20Gilberto%20E.%20Urroz%20-%202001.pdf
Website and e-Learning Source	1. https://onlinecourses.nptel.ac.in/noc19_ma29/prev 2. https://archive.nptel.ac.in/courses/111/107/111107104/ 3. https://onlinecourses.nptel.ac.in/noc21_mg74/preview 4. https://mathworld.wolfram.com/topics/Optimization.html

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO 1-Understand the basic concepts of the SCILAB .

CLO 2-Understand the concept of the Looping and branching of SCILAB.

CLO 3-Understand the concept of the measures of Central tendency measures of dispersion.

CLO 4-Understand the cumulated distribution function and hypothesis testing.

CLO 5-Understand the optimization toolbox.

	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

SEMESTER: III **PART: B (ii)**	**23PMATI37: Summer Internship**	**CREDIT:2** **HOURS:-**

(Refer to the Regulations)

SEMESTER: IV PART: A CORE XI	23PMATC41: FUNCTIONAL ANALYSIS	CREDIT:5 HOURS:6

Pre-requisite	Elements of Real Analysis
Objectives of the Course	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.
Course Outline	**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**
	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**
	UNIT-III : Finite-Dimensional Spectral Theory: Matrices – Determinants and the spectrum of an operator –The spectral theorem. **Chapter 11:Sections 60-62**
	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**
	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**
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	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

SEMESTER: IV PART: A CORE XII	23PMATC42: DIFFERENTIAL GEOMETRY	CREDIT:5 HOURS:6

Pre-requisite	Linear Algebra concepts and Calculus
Objectives of the Course	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
Course Outline	**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.**
	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.**
	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.**
	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.**
	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).**
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	T.J.Willmore, *An Introduction to Differential Geometry*, Oxford University Press,(17th Impression) New Delhi 2002. (Indian Print)

Reference 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

SEMESTER: IV **PART: A** **CORE XII**	**23PMATD43: PROJECT WITH VIVA VOCE**	**CREDIT:7** **HOURS:10**

(Refer to the Regulations)

SEMESTER: IV PART: A ELECTIVE	23PMATE44-1: RESOURCE MANAGEMENT TECHNIQUES	CREDIT:3 HOURS:4
Pre-requisite		
Objectives of the Course	Understand the concepts of the Linear Programming Problems, Artificial Variable Technique, Games and Strategies, Inventory Problems and Queueing Problems.	
Course Outline	**UNIT: I Linear Programming Problems** Introduction of Linear Programming Problems, slack, surplus, artificial variables Graphical method, Simplex method, applications of simplex method.	
	UNIT: II LPP (Continued) Formulating a Dual Problem, Dual simplex method, Big-M method, Two Phase simplex method. (simple problems only).	
	UNIT: III GAME THEORY Introduction, Some basic terms, the max min-minimax principle, game without saddle points-mixed strategies, graphical solutions of 2 x n and m x 2 games.	
	UNIT: IV INVENTORY THEORY Introduction, concept of EOQ , Deterministic inventory problems with no shortages, the fundamental problem of EOQ , Problem of EOQ with several production runs of unequal length, problem of EOQ with finite replenishment, Deterministic inventory problems with shortages (simple problems only).	
	UNIT: V QUEUEING THEORY Introduction, Queueing system, elements of a queueing system, operating characteristics of a queueing system, deterministic queueing system, classification of queueing system, (M/M/1): (∞/ FIFO) model, (M/M/1): (N/ FIFO) model, (M/M/C): (∞/ FIFO) model.	
Recommended Text	Operations Research .Kanti Swarup, P.K. Gupta, Man Mohan.(Sultan Chand & Sons) Sixteenth Thoroughly Revised Edition.	
Reference Books	1. Hamdy A. Taha, Operations Research (Sixth Edition) Prentice-Hall of India Private Limited, New Delhi, 1997. 2. Panneerselvam.R, Operations Research, 2nd Edition, PHI Learning Private Limited, Delhi, 2015. 3. PremkumarGupta.Er, Hira.D.S. , Operations Research, 7th Edition, S.Chand& Company Pvt.Ltd.2014.	
Website and e-Learning Source	1. https://onlinecourses.nptel.ac.in/noc19_ma29/prev 2. https://archive.nptel.ac.in/courses/111/107/111107104/ 3. https://onlinecourses.nptel.ac.in/noc21_mg74/preview 4. https://mathworld.wolfram.com/topics/Optimization.html	

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CLO 1-Understand the concept of the Linear Programming Problems.

CLO 2-Understand the concept of the Artificial Variable Technique.

CLO 3-Understand the concept of the Games and Strategies.

CLO 4-Understand the Inventory Problems.

CLO 5-Understand the Queueing Problems.

	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

SEMESTER: IV PART: A ELECTIVE –VI	**23PMATE44-2: PYTHON PROGRAMMING (Practical)** (20% Theory + 80% Practical)**	CREDIT:3 HOURS:4
** Evaluation is to be done both for theory (15 marks) and practical (60 marks) components separately by the examiners who will be conducting the practical and the marks should be awarded out of 75. Questions for the theory and practical are to be set by the concerned examiners.		

Pre-requisite	Linear Algebra concepts
Objectives of the Course	1. Understand the basic components of computer programming using the Python language. 2. Demonstrate significant experience with the Python program development environment. 3. To learn and know the concepts of file handling, exception handling and database connectivity.
List of Experiments	1. Program using variables, constants, I/O statements in Python. 2. Program using Operators in Python. 3. Program using Conditional Statements. 4. Program using Loops. 5. Program using Jump Statements. 6. Program using Functions. 7. Program using Recursion. 8. Program using Arrays. 9. Program using Strings. 10. Program using Modules. 11. Program using Lists. 12. Program using Tuples. 13. Program using Dictionaries. 14. Program for File Handling
Skills acquired from this course	Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill

Recommended Text	1. Allen B. Downey, Think Python: How to Think Like a Computer Scientist (Second Edition), Shroff /O'Reilly Publishers, 2016 (2. ReemaThareja, "Python Programming using problem solving approach", First Edition, 2017, Oxford University Press. 3. Dr. R. NageswaraRao, "Core Python Programming", First Edition, 2017, Dream tech Publishers http://greenteapress.com/wp/think- python/)
Reference Books	1.Charles Dierbach, Introduction to Computer Science using Python: A Computational Problem-Solving Focus, Wiley India Edition, 2013 2. John V Guttag, Introduction to Computation and Programming Using Python', Revised and expanded Edition, MIT Press, 2013. 3. Kenneth A. Lambert, Fundamentals of Python: First Programs, CENGAGE Learnin 3. Kenneth A. Lambert, Fundamentals of Python: First Programs, CENGAGE Learning, 2012.
Website and e-Learning Source	1. https://nptel.ac.in/courses/106/106/106106182/ 2. https://nptel.ac.in/courses/106/106/106106145/

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to
CLO 1- Develop algorithmic solutions to simple computational problems.
CLO 2- Read, write, execute by hand simple Python programs.
CLO 3- Represent compound data using Python lists, tuples, and dictionaries.
CLO 4- Design and implement a program to solve a real world problem.
CLO 5- Use Python lists, tuples, dictionaries for representing compound data.

	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

SEMESTER: IV PART: B Skill Enhancement Course-III	23PMATS45: MATHEMATICS FOR COMPETITIVE EXAMINATIONS (Multiple Choice Based Paper)*	CREDIT:2 HOURS:4
Pre-requisite	**Basic knowledge in Mathematical Concepts**	
Objectives of the Course	To develop strong background on different subjects in Mathematics with application skills.	
Course Outline	**UNIT-I : Algebra** Group – Subgroups – Cyclic Group – Permulation Groups – Lagrange's theorem – Normal groups – Homomorphism – Cayley's theorem – Sylow's theorems – Rings (Definitions with Examples) – Vector Space (Definitions with Examples)	
	UNIT-II : Real Analysis Sequences and series of functions – uniform convergence – Metric Space – discontinuities – Riemann Integral - Improper Integrals – Monotonic functions – Lebesgue measure – Lebesgue integral	
	UNIT-III : Complex Analysis Analytic functions – Cauchy-Riemann equations – Cauchy's integral formula – Liouville's theorem – Maximum modulus principle –Taylor series – Laurent series – Calculus of Residues.	
	UNIT-IV :Operations Research Linear programming problem – Transportation problem – Game theory – Queuing Theory – Inventory models – Network Analysis.	
	UNIT-V: Probability & Statistics Measures of Central Tendency – Measures of Dispersion – Baye's Theorem – Correlation and Regression – sampling distributions of t, F and Chi square (Definitions with Simple Problems)	
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	**Unit-I:** I.N. Herstein. *Topics in Algebra* (II Edition) Wiley Eastern Limited, New Delhi, 1975. **Chapter 2 : 2.1 to 2.12 (omit 2.3,2.5,2.8)** **Chapter 3: 3.1, 3.3. & Chapter 4: 4.1, 4.2.** **Unit-II**: Tom M.Apostol : *Mathematical Analysis*, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974. **Chapter 9: 9.1 to 9.6., Chapter 3: 3.13,** **Chapter 10: 10.3 to 10.10, 10.13, 10.19. Chapter 4: 4.22.** **Unit-III:** L.V. Ahlfors , *Complex Analysis*, Third Edition, McGraw Hill, New York, 1979. **Chapter 2: 1.2, Chapter 4: 2.1 to 2.3 & 5.1 to 5.3.** **Chapter 5: 1.2, 1.3.** **Unit-IV:** Hamdy A. Taha, *Operation Research an Introduction*, Eighth Edition, Pearson Prentice Hall. **Chapter 3: 3.3, Chapter 5: 5.1 to 5.3, Chaptre 13: 13.4.** **Chapter 15: 15.1 to 15.6, Chapter 11: 11.1 to 11.4.** **Chapter 6: 6.5** **Unit-V:** S.C. Gupta & V.K. Kapoor: *Fundamentals of Mathematical Statistics*, Sultan & sons. **Chapter 2: 2.5 to 2.7, Chapter 3: 3.4 to 3.8, 3.13, 3.14.** **Chapter 4: 4.8, Chapter 10: 10.3, 10.4, 10.7.** **Chapter 13: 13.1. Chapter 14: 14.2, 14.5.**
Reference Books	1. Arumugam.S Isaac. A.T, *Modern Algebra*, Scitech Publications. 2. Richard R.Goldberg, *Methods of Real Analysis*, Oxford &IBH Publishing Co.Pvt.Ltd, New Delhi. 3. S.Arumugam.A.Thangapandi Isaac, A. Somasundaram, *Complex Analysis*, Scitech Publications. 4. J.K.Sharma, *Operations Research Theory and Applications*, 6th Edition, Trinity Press. 5.P.R.Vital, V.Malini, *Statistical and Numerical Methods*, Margam Publications, 2019.
Website and e-Learning Source	1. https://onlinecourses.nptel.ac.in/noc19_ma29/prev 2. https://archive.nptel.ac.in/courses/111/107/111107104/ 3. https://onlinecourses.nptel.ac.in/noc21_mg74/preview 4. https://mathworld.wolfram.com/topics/Optimization.html

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to
CLO 1-Understand the concept of the Algebraic concepts.
CLO 2-Understand the concept of the Real analytical concepts.
CLO 3-Understand the concept of the Complex Analytical concepts.
CLO 4-Understand the Operations Research problems.
CLO 5-Understand the problems of Statistics and Probability.

	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

***Each Unit should be taught based on choice based system in which each unit carries 15 multiple choice based questions**

SEMESTER: IV **PART: C**	**23PMATX46: Extension Activity**	**CREDIT: 1** **HOURS: -**

(Refer to the Regulations)