AVS

COLLEGE OF ARTS & SCIENCE

(AUTONOMOUS)

Attur Main Road, Ramalingapuram, Salem - 106.

(Recognized under section 2(f) & 12(B) of UGC Act 1956 and

Accredited by NAAC with 'A' Grade)

(Co - Educational Institution | Affiliated to Periyar University, Salem

ISO 9001 : 2015 Certified Institution)

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Syllabus for

M.Sc., MATHEMATICS

CHOICE BASED CREDIT SYSTEM –

LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK

(CBCS – LOCF)

(Applicable to the Candidates admitted from 2023-24 onwards)

VISION

- To attain excellence in the field of education by creating competent scholars with a touch of human values.

MISSION

- To accomplish eminence in the academic domain.
- To provide updated infrastructure.
- To educate value based education.
- To impart skills through efficient training programs.
- To cultivate culture and tradition with discipline and determination.

REGULATIONS

1. Eligibility for Admission:

A candidate who has passed B.Sc., Mathematics / B.Sc., Mathematics (Computer Applications) degree of this University or any of the above degree of any other University accepted by the Syndicate equivalent thereto, subject to such condition as may be prescribed therefore are eligible for admission to M.Sc., Degree Programme and shall be permitted to appear and qualify for the Master of Science (M.Sc.) Degree Examination in Mathematics of this University

2. Duration:

The course of study of Master of Science in Mathematics shall consist of two academic years divided into four semesters. Each Semester consists of 90 working days.

3. Eligibility for award of degree:

The degree of Master in Science will be awarded to any student who has completed the appropriate programme of study and passed examinations as a student at the College in accordance with such other Regulations for Students of the College as may be applicable.

4. Course of Study:

The course of study for the degree shall be in Branch I-Mathematics (under Choice Based Credit System) with internal assessment according to syllabi prescribed from time to time.

5. Scheme of Examination:

The examination shall be of Three Hours duration for each paper at the end of each semester. The candidate failing in any subject(s) will be permitted to appear for each failed subject(s) in the subsequent examination. Practical examinations for PG course should be conducted at the end of the even semester only. At the end of fourth semester viva-voce will be conducted on the basis of the Dissertation/ Project report by one internal and one external examiner.

6. Passing Rules:

Theory Course: For theory courses there shall be three tests conducted by the faculty concerned and the average of the best two can be taken as the Continuous Internal Assessment (CIA) for a maximum of 25 marks

i) Theory

The candidate shall be declared to have passed the examination if the candidate secures not less than 50 marks in total (CIA mark + Theory Exam mark) with minimum of 38 marks in the Theory Exam conducted by the University. The Continuous Internal Assessment (CIA) Mark 25 is distributed to

four components viz., Tests, Assignment, Seminar and Attendance as 10, 05, 05 and 05 marks, respectively.

ii) Practical

A minimum of 50 marks out of 100 marks in the University examination and the record notebook taken together is necessary for a pass. There is no passing minimum for the record notebook. However submission of record notebook is a must.

iii) **Project Work/Dissertation and Viva-Voce**: A candidate should secure 50% of the marks for pass. The candidate should attend viva-voce examination to secure a pass in that paper. Candidate who does not obtain the required minimum marks for a pass in a Paper / Practical/ Project/Dissertation shall be declared Re-Appear (RA) and he / she has to appear and pass the same at a subsequent appearance.

Programme Outcomes (POs) On successful completion of the **M.Sc., Mathematics**	
PO1	**Problem Solving Skill** Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context.
PO2	**Decision Making Skill** Foster analytical and critical thinking abilities for data-based decision-making.
PO3	**Ethical Value** Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities.
PO4	**Communication Skill** Ability to develop communication, managerial and interpersonal skills.
PO5	**Individual and Team Leadership Skill** Capability to lead themselves and the team to achieve organizational goals**.**
PO6	**Employability Skill** Inculcate contemporary business practices to enhance employability skills in the competitive environment.
PO7	**Entrepreneurial Skill** Equip with skills and competencies to become an entrepreneur.

PO8	**Contribution to Society** Succeed in career endeavours and contribute significantly to society
PO9	**Multicultural competence** Possess knowledge of the values and beliefs of multiple cultures and a global perspective.
PO10	**Moral and ethical awareness/reasoning** Ability to embrace moral/ethical values in conducting one's life.

Program Specific Outcomes (PSOs) After the successful completion of **M.Sc., Mathematics** programme the students are expected to	
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.
PSO2	**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 researches 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.
PSO5	**Contribution to the Society** To contribute to the development of the society by collaborating with stakeholders for mutual benefit

Programme Educational Objectives (PEOs) The **M.Sc., Mathematics** programme describe accomplishments that graduates are expected to attain within five to seven years after graduation.	
PEO1	Apply their knowledge in modern industry or teaching, or secure acceptance in high quality graduate programs in mathematics.
PEO2	Development in their chosen profession and/or progress toward an advanced degree
PEO3	The trust and respect of others as effective and ethical team members.
PEO4	Graduates will become effective collaborators and innovators, leading or participating in efforts to address social, technical and business challenges.
PEO5	Promote the culture of interdisciplinary research among all disciplines and applied mathematics.

CREDIT DISTRIBUTION FOR 2 YEARS M.Sc. MATHEMATICS PROGRAMME

Part	Course Type	Credits per Course	No. of Papers	Total Credits
Part I	Core Courses	5	9	45
	Core Courses	4	3	12
	Elective Courses	3	6	18
	Core Project with VIVA-VOCE	7	1	7
			Total	**82**
Part II	Non Major Elective	2	2	4
	Professional Competency Skill Enhancement Course	2	1	2
	Internship	2	1	2
	Human Rights	1	1	1
	MOOC/ SWAYAM/ NPTEL Courses	-	-	-
			Total	**09**
Part III	Extension Activity (NSS/NCC/Physical Education)	1	1	1
Total				**1**
			Total Credits	**92**

CONSOLIDATED SEMESTER WISE AND COMPONENT WISE CREDIT DISTRIBUTION FOR 2 YEARS M.Sc. MATHEMATICS PROGRAMME

Parts	Semester I	Semester II	Semester III	Semester IV	Total Credits
Part I	**20**	**20**	**22**	**20**	**82**
Part II	**-**	**3**	**4**	**2**	**9**
Part III	**-**	**-**	**-**	**1**	**1**
Total	**20**	**23**	**26**	**23**	**92**

*Part I and II components will be separately taken into account for CGPA calculation and classification for the post graduate programmes and the other components part III have to completed during the duration of the programmes as per the norms, to be eligible for obtaining the PG degree.

METHOD OF EVALUATION

Evaluation	Components		Marks
Internal Evaluation	Continuous Internal Assessment Test	15	25 Marks
	Assignments	3	
	Class Participation	2	
	Distribution of marks for Attendance (in percentage) 96 – 100: 5 Marks 91 – 95: 4 Marks 86 – 90: 3 Marks 81 – 85: 2 Marks	5	
External Evaluation	End Semester Examination		75 Marks
Total			**100 Marks**

Note: PG Programmes- A candidate must score minimum 13 marks in Internal and 38 marks in External Evaluation.

CONTINUOUS INTERNAL ASSESSMENT

Categorizing Outcome Assessment Levels Using Bloom's Taxonomy

level	Cognitive Domain	Description
K1	Remember	It is the ability to remember the previously learned concepts or ideas.
K2	Understand	The learner explains concepts or ideas.
K3	Apply	The learner uses existing knowledge in new contexts.
K4	Analyze	The learner is expected to draw relations among ideas and to compare and contrast.
K5	Evaluate	The learner makes judgments based on sound analysis.
K6	Create	The learner creates something unique or original.

Question Paper Blue Print for Continuous Internal Assessment – I & II

Duration: 2 Hours							Maximum: 50 marks
Section	K level						Marks
	K1	K2	K3	K4	K5	K6	
A (no choice)	10						10 X 1 =10
B (no choice)		1	1				2 X 5 =10
C (either or choice)				3			3 x 10 = 30
Total							50 marks

Note: K4 and K5 levels will be assessed in the Model Examination whereas K5 and K6 Levels will be assessed in the End Semester Examinations.

Question Paper Blue Print for Continuous Internal Assessment - I

Time: 2 Hours Total Marks: 50 Marks Minimum Pass: 20 Marks

Unit	Section - A	Section - B	Section - C
I	Q.N. 1, 2, 3, 4, 5	Q.N. 11	Q.N. 13 A, 13 B
I or II	-	-	Q.N. 14 A, 14 B
II	Q.N. 6, 7, 8, 9, 10	Q.N. 12	Q.N. 15 A, 15 B

SECTION – A (10 X 1 = 10 Marks)

ANSWER ALL THE QUESTIONS

SECTION – B (2 X 5 = 10 Marks)

ANSWER ALL THE QUESTIONS

SECTION – C (3 X 10 = 30 Marks)

ANSWER ALL THE QUESTIONS (Either or Choice)

Question Paper Blue Print for Continuous Internal Assessment - II

Time: 2 Hours Total Marks: 50 Marks Minimum Pass: 20 Marks

Unit	Section - A	Section - B	Section - C
III	Q.N. 1, 2, 3, 4, 5	Q.N. 11	Q.N. 13 A, 13 B
III or IV	-	-	Q.N. 14 A, 14 B
IV	Q.N. 6, 7, 8, 9, 10	Q.N. 12	Q.N. 15 A, 15 B

SECTION – A (10 X 1 = 10 Marks)

ANSWER ALL THE QUESTIONS

SECTION – B (2 X 5 = 10 Marks)

ANSWER ALL THE QUESTIONS

SECTION – C (3 X 10 = 30 Marks)

ANSWER ALL THE QUESTIONS (Either or Choice)

Question Paper Blue Print for Model Examination & End Semester Examination

Duration: 3 Hours								Maximum: 75 marks
Section		K level						Marks
		K1	K2	K3	K4	K5	K6	
A (no choice, three questions from each unit)		15						15 X 1 =15
B (choice, one question from each unit)			1	1				2 X 5 =10
C (either or choice & two questions from each unit)	*Courses with K4 as the highest cognitive level*				4	1		5 x 10 = 50
	Course with K5 as the highest cognitive level wherein three K4 questions and two K5 questions are compulsory.				3	2		
	Course with K6 as the highest cognitive level wherein two questions each on K4, K5 and one question on K6 are compulsory.				2	2	1	
Total								75 marks

Question Paper Blue Print for Model Examination & End Semester Examination

Time: 2 Hours Total Marks: 75 Marks Minimum Pass: 30 Marks

Unit	Section - A	Section - B	Section - C
I	Q.N. 1, 2, 3	Q.N. 16	Q.N. 21 A, 21 B
II	Q.N. 4, 5, 6	Q.N. 17	Q.N. 22 A, 22 B
III	Q.N. 7, 8, 9	Q.N. 18	Q.N. 23 A, 23 B
IV	Q.N. 10, 11, 12	Q.N. 19	Q.N. 24 A, 24 B
V	Q.N. 13, 14, 15	Q.N. 20	Q.N. 25 A, 25 B

SECTION – A (15 X 1 = 15 Marks)

ANSWER ALL THE QUESTIONS

SECTION – B (2 X 5 = 10 Marks)

ANSWER ANY TWO QUESTIONS

SECTION – C (5 X 10 = 50 Marks)

ANSWER ALL THE QUESTIONS (Either or Choice)

Question Paper Blue Print for Model Practical Examination & End Semester Examination (Practical)

Time: 3 Hours Total Marks: 60 Marks Minimum Pass: 24 Marks

Practical Marks	Maximum Mark	Minimum Mark
Internal	40	16
External	60	24
Total	100	40

Evaluation for End Semester Examinations (Practical)

Record	10 marks
Formula with expansion	05 marks
Observation with data	20 marks
Viva-voce	05 marks
Calculation	15 marks
Result with units	05 marks
TOTAL	**60 MARKS**

*Submission of record with due certification is a must for external practical examinations.

**A student should complete all requires experiments to get 10 marks for the record.

Scheme of Examination for M.Sc. Mathematics

First Year – Semester - I

Part	Course Code	Course Title	Ins. Hrs	Credit	CIA	ESE	Total
I	23PMACO1	Core – I Algebraic Structure	6	5	25	75	100
I	23PMACO2	Core – II Real Analysis– I	6	5	25	75	100
I	23PMACO3	Core – III Ordinary Differential Equation	5	4	25	75	100
I	23PMAE02	Elective – I Graph Theory and Applictions	4	3	25	75	100
I	23PMAE08	Elective – II Discrete Mathematics	4	3	25	75	100
Total			**25**	**20**	**125**	**375**	**500**

First Year – Semester - II

Part	Course Code	Course Title	Ins. Hrs	Credit	CIA	ESE	Total
I	23PMACO4	Core – IV Advanced Algebra	5	5	25	75	100
I	23PMACO5	Core – V Real Analysis –II	5	5	25	75	100
I	23PMACO6	Core – VI Partial Differential Equations	5	4	25	75	100
I	23PMAE10	Elective – III Mathematical Statistics	3	3	25	75	100
I	23PMAE14	Elective – IV Modelling and Simulation with Excel	4	3	25	75	100
II	23PSOCCC01	Fundamentals of Human Rights	1	1	25	75	100
II	23PCMNE02	Non Major Elective Course - Business Communication	2	2	25	75	100
Total			**25**	**23**	**175**	**525**	**700**

Second Year – Semester - III

Part	Course Code	Course Title	Ins. Hrs	Credit	CIA	ESE	Total
I	23PMACO7	Core – VII Complex Analysis	5	5	25	75	100
I	23PMACO8	Core – VIII Probability Theory	5	5	25	75	100
I	23PMACO9	Core – IX Topology	5	5	25	75	100
I	23PMAC10	Core – X Machine Learning	4	4	25	75	100
I	23PMAE20	Elective –V Mathematical Python	3	3	25	75	100
II	23PMAI01	Internship	-	2	25	75	100
II	NME-II	Professional communication skill - Term paper & Seminar presentation	3	2	25	75	100
Total			**25**	**26**	**175**	**525**	**700**

Second Year – Semester - IV

Part	Course Code	Course Title	Ins. Hrs	Credit	CIA	ESE	Total
I	23PMACO11	Core – XI Functional Analysis	5	5	25	75	100
I	23PMACO12	Core – XII Differential Geometry	5	5	25	75	100
I	23PMAE23	Elective –VI Resourse Management Techniques	3	3	25	75	100
I	23PMAPR01	Core Project with viva– voce	10	7	-	-	100
II	SEC	SEC – Mathematical documentation using LATEX/ other package	2	2	25	75	100
III		Extension Activity	-	1	25	75	100
Total			**25**	**23**	**125**	**375**	**600**

****Ins. Hrs –** Instructional Hours**, CIA-** Continuous Internal Assessment**, ESE-** End Semester Examination

Semester: I	Course Code: 23PMAC01	Hours/Week: 6	Credit: 5

COURSE TITLE: CORE – I ALGEBRAIC STRUCTURES

Course Overview:

1. The course focuses on basic algebraic concepts which arise in various areas of advanced mathematics, and emphasizes on the underlying algebraic structures which are common to various concrete mathematical examples.

Learning Objectives:

1. To introduce the concepts and to develop working knowledge on class equation, solvability of groups, finite abelian groups, linear transformations, real quadratic forms

Unit - I	Counting Principle	09 Hours

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	Solvable groups	09 Hours

Direct products-Finite abelian groups- Modules

Chapter 5: Section 5.7 (Lemma 5.7.1 ,Lemma 5.7.2, Theorem 5.7.1)

Chapter 2: Section 2.13 and 2.14 (Theorem 2.14.1 only)

Chapter 4: Section 4.5

Unit - III	Linear Transformations	09 Hours

Canonical forms–Triangular form - Nilpotent transformations.

Chapter 6:Sections 6.4, 6.5

Unit - IV	Jordan form	09 Hours

Rational canonical form.

Chapter 6 : Sections 6.6 and 6.7

Unit - V	Trace and transpose	09 Hours

Hermitian, unitary, normal transformations, real quadratic form.

Chapter 6 :Sections 6.8, 6.10 and 6.11 (Omit 6.9)

Text Book(s):

1. N. Her stein. Topics in Algebra (II Edition) Wiley Eastern Limited, New Delhi, 1975.

Reference Books:

1. M.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, Vo l. II–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.

Web Resources:

1. https://nptel.ac.in/courses/106105192
2. https://onlinecourses.swayam2.ac.in/cec24_ma02/preview

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Recall basic counting principle, define class equations to solve problems, explain Sylow's theorems and apply the theorem to find number of Sylow subgroups	K1
CO2	Define Solvable groups, define direct products, examine the properties of finite abelian groups, define modules	K2
CO3	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.	K3
CO4	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.	K4
CO5	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	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)									
	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	S	L	S	M	S	S	S	M	L
CLO2	M	L	S	L	S	S	S	M	L
CLO3	S	M	S	L	S	S	S	M	L
CLO4	L	M	S	M	S	S	S	M	L
CLO5	S	L	S	S	S	S	S	M	L

S - Strong, M – Medium, L – Low

Semester: I	Course Code: 23PMAC02	Hours/Week: 6	Credit: 5
COURSE TITLE: CORE – II REAL ANALYSIS - I			

Course Overview:

1. Real Analysis is an area of mathematics that was developed to formalise the study of numbers and functions and to investigate important concepts such as limits and continuity.

Learning Objectives:

1. To work comfortably with functions of bounded variation, Riemann- Stieltjes Integration, convergence of infinite series, infinite product and uniform convergence and its interplay between various limiting operations.

Unit - I	Functions of bounded variation	09 Hours

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 : Sections6.1 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.

Chapter8 : Sections8.8, 8.15, 8.17, 8.18

Unit - II	The Riemann- Stieltjes Integral	09 Hours

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 : Sections7.1 to 7.14

Unit - III	The Riemann- Stieltjes Integral	09 Hours

Integrators of bounded variation-Sufficient conditions for the existence of Riemann-Stieltjes integrals-Necessary conditions for the existence of R Sintegrals-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 criteria on for existence of Riemann integrals. Chapter-

7:7.15 to 7.26

Unit - IV	Infinite Series and infinite Products	09 Hours

Double sequences - Double series - Rearrangement theorem for double series - A sufficient condition for equality of iterated series - Multiplication of series – Cesarosummability - Infinite products. Chapter-8 Sec, 8.20, 8.21 to 8.26.

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

Chapter9 : Sections 9.14, 9.15, 9.19, 9.20, 9.22, 9.23

Unit - V	Sequences of Functions	09 Hours

Point wise 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 9.1to 9.6, 9.8,9.9,9.10,9.11, 9.13

Text Book(s):

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

Reference Books:

1. M. Bartle, R.G. Real Analysis, John Wiley and SonsInc., 1976.
2. Rudin, W. Principles of Mathematical Analysis, 3rdEdition.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.

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc20_ma51/preview
2. https://www.mooc-list.com/tags/real-analysis

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Analyze and evaluate functions of bound edvariation and Rectifiable Curves. number of Sylow subgroups	K1
CO2	Describe the concept of Riemann-Stielt jesintegralandits properties.	K2
CO3	Demonstrate the concept of step function, upper function, Lebesgue function and their integrals.	K3
CO4	Construct various mathematical proof using the properties of Lebesgue integrals and establish the Levi monotone convergence theorem. .	K4
CO5	Formulate the concept and properties of inner products, norms and measurable functions.	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)									
	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	S	L	S	M	S	S	S	M	L
CLO2	M	L	S	L	S	S	S	M	L
CLO3	S	M	S	L	S	S	S	M	L
CLO4	L	M	S	M	S	S	S	M	L
CLO5	S	L	M	S	S	S	S	M	L

S - Strong, M – Medium, L – Low

Semester: I	Course Code: 23PMAC03	Hours/Week: 5	Credit: 4
COURSE TITLE: CORE – III ORDINARY DIFFERENTIAL EQUATIONS			

Course Overview:

1. The laws of nature are expressed as differential equations. Scientists and engineers must know how to model the world in terms of differential equations, and how to solve those equations and interpret the solutions. This course focuses on linear differential equations and their applications in science and engineering.

Learning Objectives:

1. To develop strong background on finding solutions to linear differential equations with constant and variable coefficients and also with singular points, to study existence and uniqueness of the solutions of first order differential equations

Unit - I	Linear equations with constant coefficients	09 Hours

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	09 Hours

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	09 Hours

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	09 Hours

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	09 Hours

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)

Text Book(s):

1. 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
1. George F Simmons, Differential equations with applications and historical notes, Tata McGraw Hill, New Delhi, 1974.
2. N.N. Lebedev, Special functions and their applications, Prentice Hall of India, New Delhi, 1965.
3. W.T. Reid. Ordinary Differential Equations, John Wiley and Sons, New York, 1971
4. M.D. Raisinghania, Advanced Differential Equations, S. Chand & Company Ltd. New Delhi 2001
5. B. Rai, D.P. Choudary and H.I. Freedman, A Course in Ordinary Differential Equations, Narosa Publishing House, New Delhi, 2002.

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc24_ma37/preview
2. https://www.my-mooc.com/en/mooc/introduction-to-ordinary-differential-equations/

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Establish the qualitative behavior of solutions of systems of differential equations.	K1
CO2	Recognize the physical phenomena modeled by differential equations and dynamical systems.	K2
CO3	Analyze solutions using appropriate methods and give examples.	K3
CO4	Formulate Green's function for boundary value problems.	K4
CO5	Understand and use various theoretical ideas and results that underlie the mathematics in this course	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)

	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	L	S	M	S	S	S	M	L
CLO2	M	L	S	L	S	S	S	M	L
CLO3	S	M	S	L	S	S	S	M	L
CLO4	L	M	S	M	S	S	S	M	L
CLO5	S	L	M	S	S	S	S	M	L

S - Strong, M – Medium, L – Low

Semester: I	Course Code: 23PMAE02	Hours/Week: 4	Credit: 3
COURSE TITLE: ELECTIVE – I GRAPH THEORY AND APPLICATIONS			

Course Overview:

1. This course deals with some basic concepts in graph theory like properties of standard graphs, Eulerian graphs, Hamiltonian graphs, Chordal graphs, Distances in graphs, Planar graphs, graph connectivity and Colouring of graphs.

Learning Objectives:

1. To understand and apply the fundamental concepts in graph theory.
   To apply graph theory based tools in Solving practical problems

Unit – I	Basic Results	09 Hours

Introduction-Basic Concepts- Subgraphs Degrees of Vertices - Paths and Connectedness - Automorphism of a Simple Graph. (Chapter 1: Sections 1.1 - 1.6). Directed Graphs: Introduction-Basic Concepts-Tournaments.
(Chapter 2 : Sections 2.1 - 2.3).

Unit - II	Connectivity and Trees	09 Hours

Connectivity: Introduction-Vertex cut and Edge Cut-Connectivity and Edge Connectivity.(Chapter 3: Sections 3.1- 3.3). Trees: Introduction-Definition, Characterization and Simple Properties-Centers and Centroids- Cutting the Number of Spanning Trees-Cayley‘s Formula.
(Chapter 4: Sections 4.1- 4.5).

Unit - III	Independent Sets, Matchings and Cycles	09 Hours

Independent Sets and Matchings: Introduction-Vertex-Independent Sets and Vertex Coverings-Edge-Independent sets-Matchings and Factors-Matchings in Bipartite Graphs.
(Chapter 5: Sections 5.1- 5.5) . Cycles: Introduction Eulerian Graphs Hamiltonian Graphs. (Chapter 6: Sections 6.1- 6.3) .

Unit - IV	Graph Colorings	09 Hours

Introduction-Vertex colorings-Critical Graphs-Edge colorings of Graphs- Kirkman‘s Schoolgirl- Problem Chromatic Polynomials.
(Chapter 7: Sections 7.1, 7.2, 7.3 (7.2.1 & 7.2.3 only), 7.6, 7.8, and 7.9).

Unit – V	Planarity	09 Hours

Introduction- Planar and Nonplanar Graphs –Euler Formula and its Consequences K and K ,3 are Nonplanar Graphs – Dual of a Plane Graph- The Four-Color Theorem 5 3 and the Heawood Five- Color Theorem-Hamiltonian Plane Graphs-Tait Coloring.
(Chapter 8: Sections 8.1 - 8.6, 8.8 and 8.9).

Text Book(s):

1. R. Balakrishnan and K. Ranganathan, Text Book of Graph Theory, (2nd Edition), Springer, New York, 2012.

Reference Books:

1. J.A. Bondy and U.S.R. Murty, Graph Theory with Applications, North Holland, New York, 1982.
2. Narasing Deo, Graph Theory with Application to Engineering and Computer Science, Prentice Hall of India, New Delhi. 2003.
3. F. Harary, Graph Theory, Addison – Wesely Pub. Co. The Mass. 1969.
4. L. R. Foulds, Graph Theory Application, Narosa Publ. House, Chennai, 1933.

Web Resources:

1. https://onlinecourses.swayam2.ac.in/cec20_ma03/preview
2. https://onlinecourses.nptel.ac.in/noc22_cs17/preview

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Understand and explore the basics of graph theory.	K1
CO2	Analyze the significance of graph theory in different engineering disciplines.	K2
CO3	Demonstrate algorithms used in interdisciplinary engineering domains.	K3
CO4	Evaluate or synthesize any real world applications using graph theory.	K4
CO5	apply principles and concepts of graph theory in practical situations.	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)									
	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	S	S	S	S	S	S	S	S
CLO2	S	L	S	L	M	M	S	M	S
CLO3	S	S	S	M	S	S	S	S	S
CLO4	S	L	S	S	S	S	S	M	S
CLO5	S	M	S	S	S	S	S	S	S

S - Strong, M – Medium, L – Low

Semester: I	Course Code: 23PMAE08	Hours/Week: 4	Credit: 3
COURSE TITLE: ELECTIVE – II DISCRETE MATHEMATICS			

Course Overview:

1. This course will discuss fundamental concepts and tools in discrete mathematics with emphasis on their applications to computer science. Topics include logic and Boolean circuits, sets, functions, relations, deterministic algorithms and randomized algorithms, analysis techniques based on counting methods and recurrence relations.

Learning Objectives:

1. To introduce the concepts of mathematical logic.
   To perform the operations associated with sets, functions, and relations.

Unit – I	The Foundations	09 Hours

Logic and Proofs: Propositional - Applications of Propositional -Propositional Equivalences - Predicates and Quantifiers. (Chapter 1: Sections 1.1 - 1.3). Algorithms: The Growth of Functions.
(Chapter 3: Section 3.2)

Unit - II	Counting	09 Hours

The Basics of Counting- The Pigeonhole Principle -Permutations and Combinations - Generalized Permutations and Combinations - Generating Permutations and Combinations.
(Chapter 5: Sections 5.1- 5.3, 5.5 and 5.6).

Unit - III	Advanced Counting Techniques	09 Hours

Applications of Recurrence Relations - Solving Linear Recurrence Relations Generating Functions. (Chapter 6: Sections 6.1, 6.2 and 6.4). 5.1- 5.5).

Unit - IV	Boolean Algebra	09 Hours

Boolean Functions- Representing Boolean Functions - Logic Gates - Minimization of Circuits. (Chapter 10: Sections 10.1 -10.4).

Unit – V	Modeling Computation	09 Hours

Finite-State machines with Output Finite-State machines with No Output-Turing Machines. (Chapter 12: Sections 12.2, 12.3 and 12.5)

Text Book(s):

1. Kenneth H. Rosen, Discrete Mathematics and it‘s Applications,7th Edition, WCB / McGraw Hill Education, New York, 2008..

Reference Books:

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

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc22_cs33/preview

2. https://onlinecourses.swayam2.ac.in/cec23_ma06/preview

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Ability to apply mathematical logic to solve problems.	K1
CO2	Understand sets, relations, functions and discrete structures.	K2
CO3	Able to use logical notations to define and reason about fundamental mathematics.	K3
CO4	Able to formulate problems and solve recurrence relations.	K4
CO5	Able to model and solve real world problems using graphs and trees.	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)

	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	S	S	S	S	S	S	S	S
CLO2	S	M	M	L	M	M	S	M	S
CLO3	S	S	S	M	S	S	S	S	S
CLO4	S	L	S	S	S	S	S	M	S
CLO5	S	M	S	S	S	S	S	S	S

S - Strong, M – Medium, L – Low

Semester: II	Course Code: 23PMAC04	Hours/Week: 5	Credit: 5

COURSE TITLE: CORE - IV ADVANCED ALGEBRA

Course Overview:

1. Advance Algebra is meant to follow Algebra and precede Geometry.
2. Topics studied include properties of Solving linear equations and inequalities, absolute value functions, graphing, systems of linear equations and inequalities, properties of exponents, quadratic equations, polynomials, rational equations, exponential and logarithmic functions, radicals, probability and statistics, and sequences and series.

Learning Objectives:

1. To study field extension, roots of polynomials, Galois Theory, finite fields, division rings, solvability by radicals and to develop Computational skill in abstract algebra.

Unit - I	Ring theory	09 Hours

Ring theory - Polynomial Rings - Polynomials over the Rational field - Polynomial Rings over commutative Rings. Chapter 3 (sections 3.9 to 3.11)

Unit - II	Extension fields	09 Hours

Extension fields –Transcendence of e.

Chapter5: Section 5.1 and 5.2

Unit - III	Roots or Polynomials	09 Hours

Roots or Polynomials.-More about roots

Elements of Galois theory

Chapter5: Sections 5.3 and 5.5, 5.6

Unit - IV	Finite fields	09 Hours

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

Chapter7: Sections7.1and7.2 (Theorem7.2.1 only)

Unit - V	Solvability by radicals	09 Hours

Solvability by radicals - A theorem of Frobenius - Integral Quaternions and the Four - Square theorem. Chapter 5: Section 5.7 (omit Lemma 5.7.1, Lemma 5.7.2 and Theorem 5.7.1) Chapter 7 : Sections 7.3 and 7.4

Text Book(s):

1. 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); Vo l .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.

Web Resources:

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

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Prove theorems applying algebraic ways of thinking.	K1
CO2	Connect groups with graphs and understanding about Hamiltonian graphs	K2
CO3	Compose clear and accurate proofs using the concepts of Galois Theory.	K3
CO4	Bring out insight into Abstract Algebra with focus on axiomatic theories.	K4
CO5	Demonstrate knowledge and understanding of fundamental concepts including extension fields, Algebraic extensions, Finite fields, Class equations and Sylow's theorem.	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)									
	POs						PSOs		
	1	2	3	4	5	6	1	2	3
CLO1	S	L	S	M	S	S	S	M	L
CLO2	M	L	S	L	S	S	S	M	L
CLO3	S	M	S	L	S	S	S	M	L
CLO4	L	M	S	M	S	S	S	M	L
CLO5	S	L	M	S	S	S	S	M	L

S - Strong, M – Medium, L – Low

Semester: II	Course Code: 23PMAC05	Hours/Week: 6	Credit: 5
COURSE TITLE: CORE - V REAL ANALYSIS - II			

Course Overview:

1. To do this requires knowledge of so-called "analysis", which in many respects is just Calculus in very general settings.

Learning Objectives:

1. To introduce measure on the real line, Lebesgue measurability and integrability, Fourier Series and Integrals, in-depth study in Multivariable calculus.

Unit – I	Measure on the Real line	09 Hours

Lebesgue Outer Measure - Measurable sets - Regularity - Measurable Functions - Borel and Lebesgue Measurability

Chapter-2 Sec2.1to 2.5 (de Barra)

Unit – II	Integration of Functions of a Real variable	09 Hours

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	09 Hours

Fourier Series and Fourier Integrals - Introduction - Orthogonal system of functions - The theorem on best approximation- The Fourier series of a function relative to an orthonormal system - Properties of Fourier Coefficients - The Riesz-Fischer Thorem – The convergence and representation problems in for trigonometric series - The Riemann - Lebesgue Lemma - The Dirichlet Integrals – An integral representation for the partial sums of Fourier series -
Riemann's localization theorem - Sufficient conditions for convergence of a Fourier series at a particular point – Cesarosummability of Fourier series- Consequences of Fejes's theorem - The Weierstrass approximation theorem
Chapter 11 : Sections 11.1 to 11.15 (Apostol)

Unit – IV	Multivariable Differential Calculus	09 Hours

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 Chapter12 :Section 12.1 to12.14 (Apostol)

Unit – V	Implicit Functions and Extremum Problems	09 Hours

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)

Text Book(s):

1. G.de Barra, Measure Theory and Integration, Wiley Eastern Ltd., New Delhi, 1981. (for Units I)
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. Bur kill, J .C .The Lévesque Integral, Cambridge University Press, 1951.

2. Munroe, M. E. Measure and Integration. Addison-Wesley, Mass.1971.
3. Rudin, W. Principles of Mathematical Analysis, Mc Graw Hill Company, New York, 1979.
4. Malik, S .C. and Savita Arora. Mathematical Analysis, Wiley Eastern Limited. New Delhi, 1991.
5. Sanjay Arora and BansiLal, Introduction to Real Analysis, Satya Prakashan, New Delhi,1991
6. Roydon, H.L. Real Analysis, Macmillan Pub. Company, New York, 1988.

Web Resources:

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

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:

Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Understand and describe the basic concepts of Fourier series and Fourier integrals with respect to orthogonal system.	K1
CO2	Analyze the representation and convergence problems of Fourier series.	K2
CO3	Analyze and evaluate the difference between transforms of various functions.	K3
CO4	Formulate and evaluate complex contour integrals directly and by the fundamental theorem.	K4
CO5	Apply the Cauchy integral theorem in its various versions to compute contour integration.	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)									
	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	L	S	M	S	S	S	M	L
CLO2	M	L	S	L	S	S	S	M	L
CLO3	S	M	S	L	S	S	S	M	L
CLO4	L	M	S	M	S	S	S	M	L
CLO5	S	L	M	S	S	S	S	M	L

S - Strong, M – Medium, L – Low

Semester: II	Course Code: 23PMAC06	Hours/Week: 5	Credit: 4

COURSE TITLE: CORE - VI PARTIAL DIFFERENTIAL EQUATIONS

Course Overview:

1. Partial differential equations in science and engineering. Topics include initial- and Boundary-value problems for parabolic, hyperbolic, and elliptic second-order equations. Emphasis is placed on separation of variables, special functions, transform methods, and numerical techniques**.**

Learning Objectives:

1. To classify the second order partial differential equations and to study Cauchy problem, method of separation of variables ,boundary value problems

Unit - I	Mathematical Models and Classification of second order equation	09 Hours

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.

Chapter2 : Sections2.1 to 2.6

Chapter3: Sections3.1to 3.4(Omit 3.5)

Unit - II	Cauchy Problem	09 Hours

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.

Chapter4 : Sections4.1 to 4.11

Unit - III	Method of separation of variables	09 Hours

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	09 Hours

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	09 Hours

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 to10.9

Text Book(s):

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

Reference Books:

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

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc21_ma51/preview
2. https://www.mooc-list.com/tags/partial-differential-equation

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	To understand and classify second order equations and find general solutions	K1
CO2	To analyze and solve wave equations in different polar coordinates	K2
CO3	To solve Vibrating string problem, Heat conduction problem, to identify and solvable place and beam equations	K3
CO4	To apply maximum and minimum principle's and solve Dirichlet, Neumann problems for various boundary conditions	K4
CO5	To apply Green's function and solve Dirichlet, Laplace problems, to apply Helmholtz operation and to solve Higher dimensional problem	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)

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

S - Strong, M – Medium, L – Low

Semester: II	Course Code: 23PMAE10	Hours/Week: 3	Credit: 3

COURSE TITLE: ELECTIVE – III MATHEMATICAL STATISTICS

Course Overview:

1. This course provides students with decision theory, estimation, confidence intervals, and hypothesis testing. It introduces large sample theory, asymptotic efficiency of estimates, exponential families, and sequential analysis.

Learning Objectives:

1. Standardize a normally distributed random variable, use normal distribution tables to find probabilities for normally distributed random variables and the t-distribution, and use the Central Limit Theorem to find probabilities for sampling distributions

Unit - I	Probability and Random Variables	09 Hours

Probability and Random Variables : Probability – Axioms – Combinatorics, Probability on finite sample spaces – Conditional probability and Baye‘s theorem - Independence of events – Random variables – Probability distribution of a random variable – Discrete and continuous random variables – Function of a random variable. (Chapter 1: Sections 1.3 to 1.6 and Chapter 2: Sections 2.2 to 2.5)

Unit - II	Moments and Generating Functions	09 Hours

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

Unit - III	Multiple Random Variables	09 Hours

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

Unit - IV	Multiple Random Variables (Contd.)	09 Hours

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

Unit - V	Limit Theorems	09 Hours

Limit Theorems: Modes of convergence – Weak law of large numbers – Strong law of large numbers – Central limit theorems. (Chapter 6: Sections 6.2 to 6.4 and 6.6)

Text Book(s):

1.V.K. Rohatgi and A. K. MD EhsanesSaleh An introduction to probability and Statistics, John Wiley Pvt, Singapore, 2001.

Reference Books:

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

Web Resources:

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

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:

Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Understand the random experiments in real life situations	K1
CO2	Understand the axioms of probability in real life situations.	K2
CO3	Compute Bernoulli trials and understand the rare case population	K3
CO4	Learn the usage of central tendencies, dispersion and skewness.	K4
CO5	Obtain the relationship between two random variables.	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)

	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	S	S	S	S	S	S	S	S
CLO2	S	M	M	L	M	M	S	M	S
CLO3	S	S	S	M	S	S	S	S	S
CLO4	S	L	S	S	S	S	S	M	S
CLO5	S	M	S	S	S	S	S	S	S

S - Strong, M – Medium, L – Low

Semester: II	Course Code: 23PMAE14	Hours/Week: 4	Credit: 3

COURSE TITLE: ELECTIVE – IV MODELLING AND SIMULATION WITH EXCEL

Course Overview:

1. This course is designed to enhance participants' proficiency in data analysis techniques, advanced Excel functionalities, and modeling approaches.

Learning Objectives:

1. The primary objective of this course is to equip participants with the knowledge and skills to effectively analyze data, build models, and perform simulations
2. Simulation involves building physical or analytical/mathematical models that attempt to duplicate real-world systems or problems.

Unit - I	Important Elements of a Model	09 Hours

Introduction- How Do We Classify Models? - An Example of Deterministic Modeling -Understanding the Important Elements of a Model

Unit - II	Model Building with Excel	09 Hours

Model Building with Excel - Basic Model - Sensitivity Analysis - Controls from the Forms Control Tools- Scroll Bars .

Unit - III	Modeling and Simulation	09 Hours

Modeling and Simulation: Types of Simulation and Uncertainty -Incorporating Uncertain Processes in Models -The Monte Carlo Sampling Methodology-Implementing Monte Carlo Simulation Methods-A Word About Probability Distributions -Modeling Arrivals with the Poisson Distribution-VLOOKUP and HLOOKUP Functions.

Unit - IV	A Financial Example	09 Hours

A Financial Example—Income Statement -An Operations Example—Autohaus -Status of Autohaus Model -Building the Brain Worksheet - Building the Calculation Worksheet-Variation in Approaches to Poisson Arrivals—Consideration of Modeling Accuracy.

Unit - V	Sufficient Sample Size	09 Hours

Sufficient Sample Size - Building the Data Collection Worksheet -Solver—Constrained Optimization - Example—York River Archaeology Budgeting –Scenarios

Text Book(s):

1. Hector Guerrero, Excel Data Analysis Modeling and Simulation, Springer Heidelberg Dordrecht London New York.

Reference Books:

1. Mathematical modeling with excel second edition Brian Albright William P. Fox

Web Resources:

1. https://www.mooc-list.com/tags/excel
2. https://www.mooc-list.com/tags/simulation

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Describe the role of important elements of discrete event simulation and modeling paradigm	K1
CO2	Conceptualize real world situations related to systems development decisions, originating from source requirements and goals.	K2
CO3	Develop skills to apply simulation software to construct and execute goal-driven system models.	K3
CO4	Interpret the model and apply the results to resolve critical issues in a real world environment.	K4
CO5	Develop a simulation to solve real world problems using programming language or tools such as Arena or MATLAB.	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)

	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	L	S	M	S	S	S	M	L
CLO2	M	L	S	L	S	S	S	M	L
CLO3	S	M	S	L	S	S	S	M	L
CLO4	L	M	S	M	S	S	S	M	L
CLO5	S	L	M	S	S	S	S	M	L

S - Strong, M – Medium, L – Low

Semester: II	Course Code: 23PCMNE02	Hours/Week: 2	Credit: 2

COURSE TITLE: NON-MAJOR ELECTIVE COURSE - BUSINESS COMMUNICATION

Course Overview:

1. Introductory programming course in Python providing a foundational background for programming in a mathematical setting.

Learning Objectives:

1. To demonstrate Problem Solving Techniques, Algorithmic Problem Solving, Understanding of basic Python and Python functions in mathematical problem Solving.
   To develop the students to understand about trade enquiries.

Unit – I	Introduction to Business Communication	09 Hours

Definition – Meaning – Importance of Effective Communication – Modern Communication Methods – Barriers to Communication – E-Communication - Business Letters: Need - Functions – Essentials of Effective Business Letters – Layout

Unit - II	Trade Enquiries	09 Hours

Trade Enquiries – Orders and their Execution – Credit and Status Enquiries – Complaints and Adjustments – Collection Letters – Sales Letters – Circular Letters

Unit - III	Banking Correspondence	09 Hours

Banking Correspondence – Types – Structure of Banking Correspondence – Elements of a Good Banking Correspondence – Insurance – Meaning and Types – Insurance Correspondence – Difference between Life and General Insurance – Meaning of Fire Insurance – Kinds – Correspondence Relating to Marine Insurance – Agency Correspondence – Introduction – Kinds – Stages of Agent Correspondence – Terms of Agency Correspondence

Unit - IV	Secretarial Correspondence	09 Hours

Company Secretarial Correspondence – Introduction – Duties of Secretary – Classification of Secretarial Correspondence – Specimen letters – Agenda and Minutes of Report writing – Introduction – Types of Reports – Preparation of Report Writing

Unit - V	Application Letters	09 Hours

Application Letters – Preparation of Resume – Interview: Meaning – Objectives and Techniques of Various Types of Interviews – Public Speech – Characteristics of a Good Speech

Text Book(s):

1. Rajendra Pal & J.S. Korlahalli, Essentials of Business Communication-Sultan Chand & Sons- New Delhi.
2. Gupta and Jain, Business Communication, Sahityabahvan Publication, New Delhi.
3. K.P. Singha, Business Communication, Taxmann, New Delhi.
4. R. S. N. Pillai and Bhagavathi. S, Commercial Correspondence, Chand Publications, New Delhi.
5. M. S. Ramesh and R. Pattanshetty, Effective Business English and Correspondence, S. Chand & Co, Publishers, New Delhi.
6. Sundar .K and Kumararaj.A, Business Communication, Vijay Nicole Imprints Private Limited, Chennai

Reference Books:

1. V.K. Jain and Om Prakash, Business communication, S. Chand, New Delhi.
2. Rithika Motwani, Business communication, Taxmann, New Delhi.
3. Shirley Taylor, Communication for Business-Pearson Publications - New Delhi.
4. Bovee, Thill, Schatzman, Business Communication Today - Pearson Education, Private Ltd-New Delhi.
5. Penrose, Rasbery, Myers, Advanced Business Communication, Bangalore.

Web Resources:

1. https://accountingseekho.com/, https://bachelors.online.nmims.edu/degree-programs
2. https://www.testpreptraining.com/business-communications-practice-exam-questions

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Acquire the basic concept of business communication.	K1
CO2	Exposed to effective business letter	K2
CO3	Paraphrase the concept of various correspondences.	K3
CO4	Prepare Secretarial Correspondence like agenda, minutes and various business reports.	K4
CO5	Acquire the skill of preparing an effective resume.	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)									
	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	S	S	S	S	S	S	S	S
CLO2	S	M	M	L	M	M	S	M	S
CLO3	S	S	S	M	S	S	S	S	S
CLO4	S	L	S	S	S	S	S	M	S
CLO5	S	M	S	S	S	S	S	S	S

S - Strong, M – Medium, L – Low

Semester: III	Course Code: 23PMAC07	Hours/Week: 5	Credit: 5
COURSE TITLE: CORE – VII COMPLEX ANALYSIS			

Course Overview:

1. This is a first course in Complex Analysis focusing on holomorphic functions and its basic properties like Cauchy's theorem and residue theorems, the classification of singularities, and the maximum principle.

Learning Objectives:

1. To Study Cauchy integral formula, local properties of analytic functions, general form of Cauchy‘s theorem and evaluation of Definite integral and harmonic functions.

Unit – I	Cauchy’s Integral Formula	09 Hours

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.

Chapter4 : Section 2:2.1 to 2.3

Chapter4 : Section 3:3.1 to 3.4

Unit – II	The general form of Cauchy's Theorem	09 Hours

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.

Chapter4 : Section 4:4.1 to 4.7

Chapter4 : Section 5:5.1and 5.2

Unit – III	Evaluation of Definite Integrals and Harmonic Functions	09 Hours

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

Chapter4 : Sections 6: 6.1 to 6.3

Unit – IV	Harmonic Functions and Power Series Expansions	09 Hours

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	09 Hours

Partial Fractions and Entire Functions: Partial fractions - Infinite products – Canonical products – Gamma Function- Jensen's formula – Hadamard's Theorem

Chapter 5 : Sections2.1 to 2.4

Chapter 5 : Sections 3.1 and 3.2

Text Book(s):

1. Lars V. Ahlfors, Complex Analysis,(3rd edition)McGraw Hill Co., NewYork,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.
M. Heins, Complex function Theory, Academic Press,NewYork,1968
4. M. Heins, Complex function Theory, Academic Press, New York, 1968.

Web Resources:

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

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Analyze and evaluate local properties of analytical functions and definite integrals.	K1
CO2	Describe the concept of definite integral and harmonic functions.	K2
CO3	Demonstrate the concept of the general form of Cauchy's theorem	K3
CO4	Develop Taylor and Laurent series.	K4
CO5	Explain the infinite products, canonical products and Jensen's formula.	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)

	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	L	S	M	S	S	S	M	L
CLO2	M	L	S	L	S	S	S	M	L
CLO3	S	M	S	L	S	S	S	M	L
CLO4	L	M	S	M	S	S	S	M	L
CLO5	S	L	M	S	S	S	S	M	L

S - Strong, M – Medium, L – Low

Semester: III	Course Code: 23PMAC08	Hours/Week: 5	Credit: 5

COURSE TITLE: CORE – VIII PROBABILITY THEORY

Course Overview:

1. This course provides axiomatic definition of probability, random variable, distributions, moments, modes of convergences, descriptive statistics, sampling distribution, point and interval estimations, hypothesis testing and analysis of correlation and regression.

Learning Objectives:

1. 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.

Unit – I	Random Events and Random Variables	09 Hours

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	09 Hours

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	09 Hours

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 Functions	09 Hours

Some Probability distributions: One point , two point , Binomial – Polya – Hyper geometric – 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	09 Hours

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)

Text Book(s):

1. 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

3. R. Durrett, Probability : Theory and Examples, (2nd Edition) Duxbury Press, New York, 1996.

4. V.K. Rohatgi An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi, 1988(3rd Print).

5. S.I. Resnick, A Probability Path, Birhauser, Berlin, 1999.

6. B.R. Bhat , Modern Probability Theory (3rd Edition), New Age International (P)Ltd, New Delhi, 1999

Web Resources:

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

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	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.	K1
CO2	To define Expectation, Moments and Chebyshev Inequality, to solve Regression of the first and second types.	K2
CO3	To define Characteristic functions, to define distribution function, to find probability generating functions, to solve problems applying characteristic functions	K3
CO4	To define One point, two-point, Binomial distributions, to solve problems of Hyper geometric and Poisson distributions, to define Uniform, normal, gamma, Beta distributions, to solve problems on Cauchy and Laplace distributions	K4
CO5	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	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)

	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	L	S	M	S	S	S	M	L
CLO2	M	L	S	L	S	S	S	M	L
CLO3	S	M	S	L	S	S	S	M	L
CLO4	L	M	S	M	S	S	S	M	L
CLO5	S	L	M	S	S	S	S	M	L

S - Strong, M – Medium, L – Low

Semester: III	Course Code: 23PMAC09	Hours/Week: 5	Credit: 5

COURSE TITLE: CORE – IX TOPOLOGY

Course Overview:

1. Topology is the study of spaces and sets and can be thought of as an extension of geometry. It is an investigation of both the local and the global structure of a space or set.

Learning Objectives:

1. To study topological spaces, continuous functions, connectedness, compactness, countability and separation axioms.

Unit - I	Topological spaces	09 Hours

Topological spaces : Topological spaces – Basis for a Y –×topology – The order topology – The product topology on X The subspace topology – Closed

Chapter 2 : Sections 12 to 17

Unit - II	Continuous functions	09 Hours

Continuous functions: Continuous functions – the product topology – The metric topology.

Chapter 2 : Sections 18 to 21 (Omit Section 22)

Unit - III	Connectedness	09 Hours

Connectedness: Connected spaces- connected subspaces of the Real line – Components and local connectedness. Chapter 3: Sections 23 to 25.

Unit - IV	Compactness	09 Hours

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

Chapter 3: Sections 26 to 29.

Unit - V	Count ability and Separation Axiom	09 Hours

Count ability and Separation Axiom: The Count ability Axioms – The separation Axioms – Normal spaces – The Urysohn Lemma – The Urysohnmetrization Theorem – The Tietz extension theorem.

Chapter 4: Sections 30 to 35.

Text Book(s):

1. 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 No strand, Reinhold Co., New York
4. L. Steen and J. Sub hash, Counter Examples in Topology, Holt, Rinehart and Winston, New York, 1970.
5. S. Willard, General Topology, Addison - Wesley, Mass., 1970

Web Resources:

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

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Define and illustrate the concept of topological spaces and the basic definitions of open sets, neighborhood, interior, exterior, closure and their axioms for defining topological space Conditional.	K1
CO2	Understand continuity, compactness, connectedness, homeomorphism and topological properties.	K2
CO3	Analyze and apply the topological concepts in Functional Analysis.	K3
CO4	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.	K4
CO5	Develop qualitative tools to characterize connectedness, compactness, second countable, Hausdorff and develop tools to identify when two are equivalent (homeomorphic).	K5
K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create		

Mapping (COs vs POs)									
	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	L	S	M	S	S	S	M	L
CLO2	M	L	S	L	S	S	S	M	L
CLO3	S	M	S	L	S	S	S	M	L
CLO4	L	M	S	M	S	S	S	M	L
CLO5	S	L	M	S	S	S	S	M	L

S - Strong, M – Medium, L – Low

Semester: III	Course Code: 23PMAC10	Hours/Week: 4	Credit: 4

COURSE TITLE: CORE – X MACHINE LEARNING [ADVANCEMENTS IN INDUSTRY 4.0]

Course Overview:

1. Machine learning (ML) has a well-established reputation for successfully enabling automation through its scalable predictive power. Industry 4.0 encapsulates a new stage of industrial processes and value chains driven by smart connection and automation.

Learning Objectives:

1. To understand the basic theory underlying machine learning. To be able to formulate machine learning problems corresponding to different applications.
2. To understand a range of machine learning algorithms along with their strengths and weaknesses. To be able to apply machine learning algorithms to solve problems of moderate complexity.
3. To apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.

Unit - I	Machine Learning	09 Hours

Machine Learning : Introduction -Definition –Types of Machine Learning -Supervised , Unsupervised, Reinforcement Learning Algorithms for Machine Learning – problems solved by Machine Learning – Tools for Machine Learning – Applications

Unit - II	Robotic Process Automation (RPA)	09 Hours

Robotic Process Automation(RPA):Introduction to RPA –Need for automation programming constructs in RPA- Robots and Softbots – RPA architecture and process methodologies –Industries best suited for RPA

Unit - III	Cloud	09 Hours

Cloud Computing : Need-Definition –Types of Cloud -Types of services –Saas

Unit - IV	Cyber	09 Hours

Cyber Security: Cyber Crime and Information security – Classification of cyber Crime Types.

Unit - V	Virtual	09 Hours

Virtual Reality: Definition- Types of Head Mounted Displays-Tools for Reality

Text Book(s):

1. Higher Education for industry 4.0 and Transformation to Education5.0 by P. Kaliraj and T. Devi

Reference Books:

1. Hands-On Machine Learning with Scikit-Learn, Keras, and Tensor Flow by Geron Aurelien
2. Machine Learning for Hackers by Drew Conway and John Myles White

Web Resources:

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

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Learn the basics of learning problems with hypothesis and version spaces	K1
CO2	Understand the features of machine learning to apply on real world problems	K2
CO3	Characterize the machine learning algorithms as supervised learning and unsupervised learning and Apply and Analyze the various algorithms of supervised and unsupervised learning	K3
CO4	Analyze the concept of neural networks for learning linear and non-linear activation functions	K4
CO5	Learn the concepts in Bayesian analysis from probability models and methods	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)

	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	L	S	M	S	S	S	M	L
CLO2	M	L	S	L	S	S	S	M	L
CLO3	S	M	S	L	S	S	S	M	L
CLO4	L	M	S	M	S	S	S	M	L
CLO5	S	L	M	S	S	S	S	M	L

S - Strong, M – Medium, L – Low

Semester: III	Course Code: 23PMAE20	Hours/Week: 3	Credit: 3

COURSE TITLE: ELECTIVE – V MATHEMATICAL PYTHON

Course Overview:

1. Introductory programming course in Python providing a foundational background for programming in a mathematical setting.

Learning Objectives:

1. To demonstrate Problem Solving Techniques, Algorithmic Problem Solving , Understanding of basic Python and Python functions in mathematical problem Solving

Unit – I	Problem Solving Techniques	09 Hours

Problem Solving Techniques – Algorithm, flowchart, pseudo code, programming; Algorithms: properties, quality (time, space); building blocks of algorithms - statements, state, control flow, functions, notation (pseudo code, flow chart, programming language)

Unit - II	Algorithmic Problem Solving	09 Hours

Algorithmic problem Solving, simple strategies for developing algorithms (iteration, recursion), pseudo code for some Mathematical Problems – greatest of two numbers, print n natural numbers, greatest common divisor, Fibonacci sequence up to terms. Practical applications of algorithms.

Unit - III	Introduction To Python	09 Hours

Introduction to Python, Python interpreter, Modes of Python Interpreter, Values and Data Types, Variables, Keywords, Identifiers, Statements and Expressions, Input and Output, Comments, Docstring, Lines and Indentation, Quotation, Tuple Assignment, Operators and Types of Operators, Operator Precedence.

Unit - IV	Python Functions	09 Hours

Functions, Types of function, Function definition (Sub program), Flow of Execution, Function Prototypes, Parameters and Arguments; Modules; Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Fruitful functions: return values, parameters, local and global scope, function composition, recursion.

Unit - V	String, Lists, Tuples In Python	09 Hours

Strings: string slices, immutability, string functions and methods, string module; Lists as arrays. Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value.

Text Book(s):

1. Allen B. Dowley, Think Python: How to Think like a Computer Scientist, 2 nd Edition.

Reference Books:

1. Wes McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython, O'Reilly, 2nd Edition, 2018.
2. Jake Vander Plas, Python Data Science Hand Book: Essential Tools for working with Data, O'Reilly, 2017.
3. Wesley J. Chun, Core Python Programming, Prentice Hall, 2006.

Web Resources:

1. https://www.mooc-list.com/tags/python
2. https://onlinecourses.swayam2.ac.in/cec22_cs20/preview

Teaching Methodology: Videos, Audios, PPT, Role Play, Quiz, Field Visit, Seminar, Chalk & Talk, Lecturing, Case Study, Demonstration, Problem Solving, Group Discussion, Flipped Learning

Learning Outcomes:
Upon successful completion of this course, the student will be able to:

COs	Statements	Bloom's Level
CO1	Give mathematical model for real world problems	K1
CO2	Design algorithms for mathematical models, analyze the efficiency and correctness of algorithms	K2
CO3	Design implementable programs in Python.	K3
CO4	Define and demonstrate the use of functions and looping using Python.	K4
CO5	Design and implement a program to solve a real-world problem.	K5

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping (COs vs POs)

	POs						PSOs		
	1	2	3	4	5	6	7	8	9
CLO1	S	S	S	S	S	S	S	S	S
CLO2	S	M	M	L	M	M	S	M	S
CLO3	S	S	S	M	S	S	S	S	S
CLO4	S	L	S	S	S	S	S	M	S
CLO5	S	M	S	S	S	S	S	S	S

S - Strong, M – Medium, L – Low