G. VENKATASWAMY NAIDU COLLEGE, KOVILPATTI-628502
(AUTONOMOUS)

(Re-Accredited with "A" Grade by NAAC)

POST GRADUATE AND RESEARCH DEPARTMENT OF MATHEMATICS

(for those who joined from the Academic year 2023-2024 and onwards)

M. Sc. Mathematics

VISION

- To evolve as a center of excellence in Mathematics.
- To empower students with sound knowledge and investigate new methodologies and applications in Research.
- To equip the learners for better service towards the Society.

MISSION

- To encourage the students to conduct student centered projects and develop their analytical and logical thinking.
- To provide quality education, enhance Research and consultancy by providing highly skilled Mathematical knowledge.
- To provide excellent knowledge of Mathematical sciences for suitable career and groom them for National recognition.
- To enable the students as mathematical thinkers and become life- long learners in their chosen profession .

PROGRAMME OUTCOMES (PO)

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

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

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

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

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

PO6: Self-directed & Lifelong Learning: Ability to work independently, identify and manage a project. Ability to acquire knowledge and skills, including "learning how to learn", through self-placed and self-

directed learning aimed at personal development, meeting economic, social and cultural objectives.

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, behaviours, 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 start-ups and high potential organizations.

To encourage practices grounded in research that comply with employment laws, leading the organization towards growth and development.

GRADUATE ATTRIBUTES:

1) Knowledge:
Students having disciplinary knowledge and the capacity of demonstrating Comprehensive knowledge of Mathematics and understanding one or more disciplines.

2) Employability:
To impart qualitative inputs to the stake holders for CSIR/JRF, GATE and Competitive Examinations. Ability to employ critical thinking in understanding every area of Mathematics.

3) Subscription to Quality Research:
To acquire advanced knowledge for the higher studies and research. The students having life-long learning and ability to think, acquire knowledge and skills. To inculcate the habit of self learning.

4) Secured Technology:
To inculcate the students with the knowledge of handling technologies with secure. To access a wide range of technologies for personal, academy and professional use with secure.

5) Applied Learning:
Students will be able to apply disciplinary or inter disciplinary learning across multiple content, integrating knowledge of practice, recognize the need for information effectively search for, evaluate, manage and apply that inform in support of scientific investigation or scholarly debate.

6) Communication:
Communicate effectively on scientific achievement basic concepts and recent development with experts and with society at large. Able to comprehend and write reports, documents make effectively present by oral or written form.

7) Social Responsibilities:
To build the good citizen responsibilities and life skills to the pupil. To function as a matured democratic citizen with participation in issues of equity and gender equality. To be academically honest and spiritually inspiring citizens

G. VENKATASWAMY NAIDU COLLEGE (AUTONOMOUS), KOVILPATTI

Programme Structure for M.Sc., Mathematics

(For those admitted from the academic year 2023-24 and onwards)

Course Type	Course Code	Course Title	Contact Hours	Exam Hours	Marks			Credit
					CIA	ESE	Total Marks	
Semester-1								
Core-1	P23MA101	Algebraic Structures	7	3	25	75	100	5
Core-2	P23MA102	Real Analysis I	7	3	25	75	100	5
Core-3	P23MA103	Ordinary Differential Equations	6	3	25	75	100	4
Core Elective - I	P23MA1E1A P23MA1E1B	Programming in C++ Graph Theory and Applications	5	3	25	75	100	3
Core Elective - II	P23MA1E2A P23MA1E2B	Fuzzy Sets & Their Applications Discrete Mathematics	5	3	25	75	100	3
Ability Enhancement	P23AE101	Cyber Security	-	2	-	50	50	2
Comprehension – I (Self Study Course- Online Exam)	P23MA1C1	Comprehension in Mathematics - I	-	1	-	50	50	1
NPTEL (Course Completion before the end of the program)			-	-	-	-	Completion	1
TOTAL			**30**				**600**	**24**
Semester-II								
Core-4	P23MA204	Advanced Algebra	6	3	25	75	100	5
Core-5	P23MA205	Real Analysis II	6	3	25	75	100	5
Core-6	P23MA206	Partial Differential Equations	6	3	25	75	100	4
Core Elective – III	P23MA2E3A P23MA2E3B	R Programming Mathematical Statistics	4	3	25	75	100	3
Core Elective - IV	P23MA2E4A P23MA2E4B	Wavelets Python Language	4	3	25	75	100	3
Skill Enhancement Course – SEC 1	P23MA2SE1	Mathematical documentation using LATEX	4	3	25	75	100	2

Ability Enhancement	P232AE202	Teaching and Learning Process and Core Teaching Skills	-	2	50	-	50	1
Comprehension – II (Self Study Course-Online Exam)	P23MA2C2	Comprehension in Mathematics - II	-	1	-	50	50	1
TOTAL			**30**				**700**	**24**

M.Sc. Mathematics / Semester – I

Core-1: ALGEBRAIC STRUCTURES (P23MA101)

Lecture Hours :95 **Tutorial Hours:10**

Practical Hours :- **No. of Credit :5**

Contact Hours per Semester: 105

Contact hours per Week : 7

Internal Marks : 25

External Marks : 75

Total Marks : 100

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 Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO 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

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

CO 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.

CO 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.

CO 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

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	3	3	1	2	3	2	3	2
CO2	3	3	2	2	3	3	3	2	3
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	2	2	2	2	3	2
CO5	3	2	2	3	3	1	3	1	3
Total contribution of CO to POs	12	13	11	10	12	11	12	12	12
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	66.67	80	73.33	80	80	80

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I: Counting Principle (L – 19 + T – 2 Hrs)

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: Solvable groups (L – 19 + T – 2 Hrs)

Solvable groups - Direct products - Finite abelian groups- Modules

Chapter 5: Section 5.7 (Lemma 5.7.1, Lemma 5.7.2, Theorem 5.7.1)
Chapter 2: Section 2.13 and 2.14 (Theorem 2.14.1 only)
Chapter 4: Section 4.5

UNIT-III: Linear Transformations (L – 19 + T – 2 Hrs)

Linear Transformations: Canonical forms –Triangular form - Nilpotent transformations.

Chapter 6: Sections 6.4, 6.5

UNIT-IV: Jordan form (L – 19 + T – 2 Hrs)

Jordan form - rational canonical form.

Chapter 6: Sections 6.6 and 6.7

UNIT-V: Trace and transpose (L – 19 + T – 2 Hrs)

Trace and transpose - Hermitian, unitary, normal transformations, real quadratic form.

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

Tutorial Section:

Unit	Topic	Hours
I	Sylow's theorems	2
II	Solvable groups	2
III	Nilpotent transformations	2
IV	Rational canonical form	2
V	Trace and transpose	2

Recommended Text:

1. Herstein, I. N., *Topics in Algebra* (II Edition) Wiley Eastern Limited, New Delhi, 1975.

Reference Books:

1. Artin, M., *Algebra*, Prentice Hall of India, 1991.
2. Bhattacharya, P. B., Jain, S.K., and Nagpaul, S.R., *Basic Abstract Algebra*, (II Edition) Cambridge University Press, 1997. (Indian Edition)
3. Luther, I. S., and Passi, I.B.S., *Algebra*, Vol. I –Groups(1996); Vol. II Rings, Narosa Publishing House, New Delhi, 1999.
4. Malik, D. S., Mordeson, J. N., and Sen, M.K., *Fundamental of Abstract Algebra*, McGraw Hill (International Edition), New York. 1997.
5. Jacobson, N., *Basic Algebra*, Vol. I & II Freeman, W.H., also published by Hindustan Publishing Company, New Delhi, 1980.

Website and e-Learning Source:

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

M.Sc. Mathematics / Semester – I

Core-2: REAL ANALYSIS I (P23MA102)

Lecture Hours	**:95**	**Tutorial Hours**	**:10**
Practical Hours	**: -**	**No. of Credit**	**:5**
Contact Hours per Semester	**:105**		
Contact hours per Week	**:7**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**: 100**		

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 Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: Analyze and evaluate functions of bounded variation and Rectifiable Curves.
CO2: Describe the concept of Riemann-Stieltjes integral and its properties.
CO3: Demonstrate the concept of step function, upper function, Lebesgue function and their integrals.
CO4: Construct various mathematical proofs using the properties of Lebesgue integrals and establish the Levi monotone convergence theorem.
CO5: Formulate the concept and properties of inner products, norms and measurable functions.

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	3	3	1	2	3	2	3	2
CO2	3	3	2	2	3	3	3	2	3
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	2	2	2	2	3	2
CO5	3	2	2	3	3	1	3	1	3
Total contribution of CO to POs	12	13	11	10	12	11	12	12	12
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	66.67	80	73.33	80	80	80

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I : Functions of bounded variation (L – 19 + T – 2 Hrs)

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 (L – 19 + T – 2 Hrs)

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 (L – 19 + T – 2 Hrs)

The Riemann-Stieltjes Integral - Integrators of bounded variation-Sufficient conditions for the existence of Riemann-Stieltjes integrals-Necessary conditions for the existence of RS integrals- Mean value theorems -integrals as a function of the interval – Second fundamental theorem of integral calculus- Change of variable -Second Mean Value Theorem for Riemann integral- Riemann-Stieltjes integrals depending on a parameter-Differentiation under integralsign-Lebesgue criterion for existence of Riemann integrals.

Chapter - 7 : 7.15 to 7.26

UNIT-IV: Infinite Series and infinite Products, Power series (L – 19 + T – 2 Hrs)

Infinite Series and infinite Products - Double sequences - Double series - Rearrangement theorem for double series - A sufficient condition for equality of iterated series - Multiplication of series –Cesaro summability - Infinite products.

Chapter - 8 Sec, 8.20, 8.21 to 8.26

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

Chapter 9: Sections 9.14, 9.15, 9.19, 9.20, 9.22, 9.23

UNIT-V: Sequences of Functions (L – 19 + T – 2 Hrs)

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

Tutorial Section:

Unit	Topic	Hours
I	Absolute and conditional convergence	2
II	Comparison theorems	2
III	Mean value theorems	2
IV	Abel's limit theorem	2
V	Uniform convergence and differentiation	2

Recommended Text:

1. Tom Apostol, M. I., 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 Analysis*, Wiley Eastern Limited. New Delhi, 1991.
4. Sanjay Arora and Bansi Lal, *Introduction to Real Analysis*, Satya Prakash an, New Delhi, 1991.
5. Gelbaum, B. R., and Olmsted, J., *Counter Examples in Analysis*, Holden day, San Francisco, 1964.
6. Gupta, A. L., and Gupta, N. R., *Principles of Real Analysis*, Pearson Education, (Indian print) 2003.

Website and e-Learning Source:

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

M.Sc. Mathematics / Semester – I

Core-3: ORDINARY DIFFERENTIAL EQUATIONS (P23MA103)

Lecture Hours	**:85**	**Tutorial Hours**	**:5**
Practical Hours	**: -**	**No. of Credit**	**:4**
Contact Hours per Semester	**:90**		
Contact hours per Week	**:6**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

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 Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: Establish the qualitative behavior of solutions of systems of differential equations.

CO2: Recognize the physical phenomena modeled by differential equations and dynamical systems.

CO3: Analyze solutions using appropriate methods and give examples.

CO4: Formulate Green's function for boundary value problems.

CO5: Understand and use various theoretical ideas and results that underlie the mathematics in this course.

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	3	3	1	2	3	2	3	2
CO2	3	3	2	2	3	3	3	2	3
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	2	2	2	2	3	2
CO5	3	2	2	3	3	1	3	1	3
Total contribution of CO to POs	12	13	11	10	12	11	12	12	12
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	66.67	80	73.33	80	80	80

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I: Linear equations with constant coefficients (L – 17 + T – 1 Hrs)

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 (L – 17 + T – 1 Hrs)

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 (L – 17 + T – 1 Hrs)

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 (L – 17 + T – 1 Hrs)

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

(L – 17 + T – 1 Hrs)

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)

Tutorial Section:

Unit	Topic	Hours
I	Linear dependence and independence	2
II	Initial value problems	2
III	Wronskian and linear dependence	2
IV	Second order equations with regular singular points	2
V	Exact equation	2

Recommended Text:

1. Coddington, I.E.A., *An introduction to ordinary differential equations*, (3rd Printing) Prentice-Hall of India Ltd.,New Delhi, 1987.

Reference Books

1. Williams Boyce, E., and Richard, D.I., Prima,C., *Elementary differential equations and boundary value problems*, John Wiley and sons, New York, 1967.
2. George Simmons,F., *Differential equations with applications and historical notes*, Tata McGraw Hill, New Delhi, 1974.
3. Lebedev, N.N., *Special Functions And Their Applications*, Prentice Hall of India, New Delhi, 1965.
4. Reid, W.T., *Ordinary Differential Equations*, John Wiley and Sons, New York, 1971.
5. Raisinghania, M. D., *Advanced Differential Equations*, Chand, S., & Company Ltd. New Delhi 2001.
6. Rai, B., Choudary,D.P. and Freedman,H.I., *A Course in Ordinary Differential Equations*, Narosa Publishing House, New Delhi, 2002.

Website and e-Learning Source

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

M.Sc. Mathematics / Semester – I

Elective I: PROGRAMMING IN C++ (P23MA1E1A)

Lecture Hours	**:70**	**Tutorial Hours**	**:5**
Practical Hours	**:-**	**No. of Credit**	**:3**
Contact Hours per Semester	**:75**		
Contact hours per Week	**:5**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

- The course provides ffundamentals of Programming in C++, get knowledge about the Functions in C++, understand the concepts of List and String methods and gain idea about exception handling and Classes.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: Remember and understand the basic concepts of Oops functions, constructors, inheritance and files

CO2: Describe about the keywords, function prototype, call and reliun by function multiple and copy constructors, single and multiple inheritance opening and closing files

CO3: Apply the concepts of symbolic constants, arrays of objects, constructing two dimensional arrays, Hierarchal inheritance input and output operation in files

CO4: Analyse variables and control structures, returning objects operator overloading, hybrid inheritance error handling clearing file operations

CO5: Develop C++ programs for various applications in Mathematics.

CO-PO Mapping (Course Articulation Matrix)

COs	**Program Outcomes (POs)**						**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3	3	3	2	3	2	3	3
CO2	3	3	2	3	2	3	3	2	3
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	3	2	2	2	3	3
CO5	3	2	2	2	1	1	3	1	2
Total contribution of CO to POs	12	13	11	13	9	11	12	12	13
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	86.67	60	73.33	80	80	86.67

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT I: Basic concepts of C++ program (L – 14 + T – 1 Hrs)

Object-Oriented Programming Paradigm – Basic concepts of Object-oriented Programming – What is C++ – A simple C++ program – More C++ statements – An example with class – Structure of C++ program – Keywords – Identifiers and Constants – Basic Data types – User defined data types – Derived data types – Symbolic constants – Declaration of variables – Reference variables – Operators in C++ - Scope resolution operators – Expressions and their types – Control structures.

Chapter 1 - 1.4,1.5; Chapter 2 – 2.1, 2.3, 2.4, 2.5, 2.6; Chapter 3 – 3.3 to 3.8; 3.10, 3.12, 3.13, 3.14, 3.19, 3.24

UNIT-II : Functions in C++ (L – 14 + T – 1 Hrs)

Functions in C++ - The main function – Function prototyping – Call by reference – Return by reference – Inline functions – Function overloading – Specifying a class – Defining member functions – Nesting of member functions – Private member functions – Arrays within a class – Arrays of Objects – Objects as function arguments – Friendly functions – Returning Objects – Pointers to members.

Chapter 4 – 4.2 to 4.6; 4.9; Chapter 5 – 5.3, 5.4, 5.7, 5.8, 5.9, 5.13 to 5.16; 5.18

UNIT-III : Constructors (L – 14 + T – 1 Hrs)

Constructors – Parameterized constructors – Multiple constructors in a class – constructors with default arguments – Copy constructor – constructing two-dimensional arrays – Destructors – Defining operator overloading – Overloading unary operators - Overloading binary operators – Overloading binary operators using friends.

Chapter 6 – 6.2 to 6.5; 6.7, 6.9, 6.11, Chapter 7 – 7.2 to 7.5

UNIT-IV: Inheritance (L – 14 + T – 1 Hrs)

Inheritance – Defining derived classes – Single inheritance – Making a private member inheritable – Multilevel inheritance – Multiple inheritance – Hierarchical inheritance – Hybrid inheritance – Virtual base classes.

Chapter 8 – 8.2 to 8.9

UNIT-V: Working with files (L – 14 + T – 1 Hrs)

Working with files – Introduction – classes for file stream operations – Opening and closing a file – Detecting End-of-File – File pointers and their manipulations – Sequential input and output operations – Updating a file: Random access – Error handling during file operations – Command-Line-Arguments.

Chapter 11 – 11.1 to 11.4; 11.6 to 11.10

Tutorial Section:

Unit	Topic	Hours
I	Declaration of variables – Reference variables	1
II	Function overloading	1
III	Copy constructor	1
IV	Single inheritance	1
V	File pointers and their manipulations	1

Recommended Text:

1. Balagurusamy, E., *Object Oriented Programming with C++*, Tata McGraw-Hill, Delhi 2008.

Reference Books

1. Chandra Babu, A., Joshuva Devadass, T., *Programming with C++*, Narosha Publishing House Ltd., 2008.
2. Pandiyaraja, P., *Object Oriented Programming with C++*, Viswanathan, S., Pvt.,Ltd.,2008.

Website and e-Learning Source

1. https://youtu.be/otky1bBhwgM
2. https://youtu.be/chdr2aj4FUc

M.Sc. Mathematics / Semester – I

Elective I: GRAPH THEORY AND APPLICATIONS (P23MA1E1B)

Lecture Hours	**:70**	**Tutorial Hours**	**:5**
Practical Hours	**:-**	**No. of Credit**	**:3**
Contact Hours per Semester	**:75**		
Contact hours per Week	**:5**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

- The course deals with the graph theoretical concepts connectivity, planarity and distance that help to model real life situations.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: To understand the fundamental concepts in Graph Theory.

CO2: Acquire the knowledge of Eulerian and Hamiltonian graphs

CO3: Understand the concept of colourings and their implications

CO4: To apply graph theory based tools in solving practical problems.

CO5: To pursue research in discrete mathematics

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	3	3	1	2	3	2	3	3
CO2	3	3	2	2	2	3	3	2	3
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	2	2	3	2	3	3
CO5	3	2	2	3	1	2	3	1	2
Total contribution of CO to POs	12	13	11	10	9	13	12	12	13
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	66.67	60	86.67	80	80	86.67

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I : Graphs and Simple Graphs (L – 14 + T – 1 Hrs)

Graphs and simple graphs, graph isomorphism, the incidence and adjacency matrices, subgraphs, vertex degrees, path and connection, cycles.

Chapter 1 - Sections: 1.1 – 1.7

UNIT-II : Trees and Blocks (L – 14 + T – 1 Hrs)

Trees, cut edges and bonds, cut vertices, Cayley formula, connectivity, blocks. Euler Tours and Hamilton cycles and applications.

Chapter 2, 3, 4 - Sections: 2.1 - 2.4, 3.1, 3.2, 4.1 - 4.4

UNIT-III : Matching & Edge Colouring (L – 14 + T – 1 Hrs)

Matching, matching and coverings in bipartite graphs, perfect matchings, edge colourings, Vizing's Theorem.

Chapter 5 & 6 - Sections: 5.1 - 5.3, 6.1 & 6.2

UNIT-IV: Independent Sets and Cliques (L – 14 + T – 1 Hrs)

Independent sets and cliques, Ramsey's theorem, Turan's Theorem.

Chapter 7 - Sections: 7.1 - 7.3

UNIT-V: Vertex Colourings (L – 14 + T – 1 Hrs)

Vertex Colourings, Chromatic number, Brookes Theorem, Hajos Conjecture, Chromatic polynomials, Girth and Chromatic numbers.

Chapter 8 - Sections: 8.1 - 8.5

Tutorial Section:

Unit	Topic	Hours
I	Cycles	1
II	Cut edges and Bonds, Cayley's Formula	1
III	Euler's Tour and Hamilton's cycle	1
IV	Vizing Theorem	1
V	Ramsey's Theorem, Turan's Theorem	1

Recommended Text:

1. Bondy, I. J. A., and Moorty, U. S. R., *Graph Theory with Applications*, The MacMillan Press Ltd, 1976.

Reference Books

1. Douglas, B., West, *Introduction to Graph Theory*, Prentice, Hall of India, Singapore, 2001.
2. Chartrand, G., *Introductory Graph Theory*, Dover Publications, 1985.

Website and e-Learning Source

1. https://youtu.be/otky1bBhwgM
2. https://youtu.be/chdr2aj4FUc

M.Sc. Mathematics / Semester – I

Elective II: FUZZY SETS & THEIR APPLICATIONS (P23MA1E2A)

Lecture Hours	**:70**	**Tutorial Hours**	**:5**
Practical Hours	**:-**	**No. of Credit**	**:3**
Contact Hours per Semester	**:75**		
Contact hours per Week	**:5**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

- The course provides the knowledge about fuzzy concepts to the students. To facilitate the students to study fuzzy operations and fuzzy numbers.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: remember the basic concepts of crisp sets and understand the concepts of fuzzy sets, representation of fuzzy sets, fuzzy set operations, fuzzy arithmetic and fuzzy decision making

CO2: apply the concept of fuzzy set operations, fuzzy arithmetic and fuzzy decision making
CO3: analyze the concept of fuzzy set operations, fuzzy arithmetic and fuzzy decision making
CO4: evaluate α-cut, strong α-cut of fuzzy sets, fuzzy union, fuzzy intersection, fuzzy complement, fuzzy arithmetic and fuzzy decision making
CO5: solve fuzzy linear programming problems and find α-cut, strong α-cut of fuzzy sets, fuzzy union, fuzzy intersection, fuzzy compleme

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	3	3	1	3	3	2	3	3
CO2	3	3	2	2	2	3	3	2	2
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	2	2	2	2	3	2
CO5	3	2	2	3	2	1	3	1	2
Total contribution of CO to POs	12	13	11	10	11	11	12	12	11
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	66.67	73.33	73.33	80	80	73.33

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I : Crisp Sets Vs Fuzzy Sets (L – 14 + T – 1 Hrs)

Crisp Sets – Fuzzy Sets – Basic Types – Basic Concepts
Chapter 1 – Sections: 1.2 – 1.4

UNIT-II : Representation of Fuzzy Sets (L – 14 + T – 1 Hrs)

Additional properties of α-cuts – representations of fuzzy sets – Extension principle for fuzzy sets.
Chapter 2 – Sections: 2.1 – 2.3

UNIT-III : Fuzzy set operations (L – 14 + T – 1 Hrs)

Fuzzy complements – Fuzzy intersections : t-norms – Fuzzy Unions : t-conorms.
Chapter 3 – Sections: 3.2 - 3.4

UNIT-IV : Fuzzy set operations & Fuzzy Arithmetic (L – 14 + T – 1 Hrs)

Fuzzy set operations: Combinations of operations – Aggregation operations.
Fuzzy Arithmetic: Linguistic variables – Arithmetic operations on intervals
Chapter 3 – Sections: 3.5, 3.6 & Chapter 4 – Sections: 4.2, 4.3

UNIT-V : Fuzzy Decision Making (L – 14 + T – 1 Hrs)

Individual Decision Making – Multi-person decision making – Fuzzy linear Programming.
Chapter 15 – Sections: 15.2, 15.3 & 15.7

Tutorial Section:

Unit	Topic	Hours
I	Fundamental Properties of crisp sets, Theorems and problems on fuzzy sets	1
II	Additional properties of α-cuts, Extension principle for fuzzy sets	1
III	Fuzzy complements, t-norms, t-conorms	1
IV	Combinations of operations, Aggregation operations.	1
V	Fuzzy Decision Making, Fuzzy Linear programming problems	1

Recommended Text:

1. George, J., Klir and Bo Bo Yuan, *Fuzzy sets and Fuzzy Logic Theory Applications*, Prentice Hall of India, New Delhi, 2002.

Reference Books:

1. George, J., Klir and Tina, A., Folger, Fuzzy sets, uncertainty and Informations – Prentice Hall of India, New Delhi, 2003.
2. Pundir. Pundir, *Fuzzy Sets and Their Applications*, Pragathi Prakashan, Meerut, 2015.

Website and e-Learning Source

1. *Introduction to Fuzzy Set Theory*, Arithmetic and Logic - Course (nptel.ac.in)
2. *FUZZY COMPLEMENT* (slideshare.net)

M.Sc. Mathematics / Semester – I

Elective II: DISCRETE MATHEMATICS (P23MA1E2B)

Lecture Hours	**:70**	**Tutorial Hours**	**:5**
Practical Hours	**:-**	**No. of Credit**	**:3**
Contact Hours per Semester	**:75**		
Contact hours per Week	**:5**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

- This course deals with basics of counting, permutation and combination, array relations and their properties.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: To understand the basic concepts of counting

CO2: Acquire the knowledge of generalized permutation and combination
CO3: To understand of concept of relations and their properties
CO4: To apply the discrete mathematics concept to study Logic Gates and Boolean functions
CO5: To pursue research in Discrete Mathematics.

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	3	3	1	2	3	2	3	3
CO2	3	3	2	2	2	3	3	2	2
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	2	2	2	2	3	2
CO5	3	2	2	3	1	1	3	1	2
Total contribution of CO to POs	12	13	11	10	9	11	12	12	11
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	66.67	60	73.33	80	80	73.33

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I : Propositional Logic (L – 14 + T – 1 Hrs)

Propositional Logic – Propositional equivalence – Predicates and quantifiers
Sections: 1.1 – 1.3
Problems: Section 1.1 (1 – 38), Section 1.2 (1 – 35) and Section 1.3 (1 - 34)

UNIT-II : The Basic Of Counting (L – 14 + T – 1 Hrs)

The basic of counting – The Pigeonhole principle – Generalized permutation and combination
Sections: 5.1, 5.2 and 5.5
Problems: Section 5.1 (1 – 40), Section 5.2 (1 – 22) and Section 5.5 (1 - 9)

UNIT-III : Relation And Their Properties (L – 14 + T – 1 Hrs)

Relation and their properties – n-ary relations and their applications – representing relation – closures of relations
Sections: 7.1 - 7.4 except Warshall's algorithm
Problems: Section 7.1 (All exercise problems), Section 7.2 (1 – 27), Section 7.3 (1 - 22) and Section 7.4 (1 -22)

UNIT-IV :Boolean Functions (L – 14 + T – 1 Hrs)

Boolean functions – Representing Boolean functions
Sections: 10.1 and 10.2
Problems: All exercise problems.

UNIT-V : Logic Gates **(L – 14 + T – 1 Hrs)**

Logic Gates - Minimization

Sections: 10.3 and 10.4

Problems: All exercise problems.

Tutorial Section:

Unit	Topic	Hours
I	Predicates and quantifiers	1
II	The Pigeonhole principle	1
III	n-ary relations and their applications	1
IV	Boolean functions	1
V	Logic Gates	1

Recommended Text:

1. Kenneth, H., Rosen, *Discrete Mathematics and its Applications* (sixth Edition) –. WCB/ McGraw Hill Publications, .

Website and e-Learning Source

1. https://youtu.be/otky1bBhwgM
2. https://youtu.be/chdr2aj4FUc.

M.Sc. Mathematics / Semester – II

Core-4: ADVANCED ALGEBRA (P23MA204)

Lecture Hours	**:85**	**Tutorial Hours**	**:5**
Practical Hours	**: -**	**No. of Credit**	**:5**
Contact Hours per Semester	**: 90**		
Contact hours per Week	**:6**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

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.

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Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

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

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	3	3	1	3	3	2	3	1
CO2	3	3	2	2	3	3	3	2	2
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	2	3	2	2	3	2
CO5	3	2	2	3	2	1	3	1	2
Total contribution of CO to POs	12	13	11	10	13	11	12	12	10
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	66.67	86.67	73.33	80	80	66.67

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I : Extension Fields (L – 17 + T – 1 Hrs)

Extension fields – Transcendence of e.
Chapter 5: Section 5.1 and 5.2

UNIT-II : Roots Or Polynomials (L – 17 + T – 1 Hrs)

Roots or Polynomials.- More about roots
Chapter 5: Sections 5.3 and 5.5 .

UNIT-III : Galois Theory (L – 17 + T – 1 Hrs)

Elements of Galois theory.
Chapter 5 : Section 5.6

UNIT-IV : Finite Fields (L – 17 + T – 1 Hrs)

Finite fields - Wedderburn's theorem on finite division rings.
Chapter 7: Sections 7.1 and 7.2 (Theorem 7.2.1 only)

UNIT-V : Solvability by radicals (L – 17 + T – 1 Hrs)

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

Tutorial Section:

Unit	Topic	Hours
I	Transcendence of e	1
II	Roots of Polynomials	1
III	Elements of Galois theory.	1
IV	Finite fields	1
V	Integral Quaternions	1

Recommended Text:

1. Herstein, I. N., *Topics in Algebra* (II Edition) Wiley Eastern Limited, New Delhi, 1975.

Reference Books

1. Artin, M., *Algebra*, Prentice Hall of India, 1991.
2. Bhattacharya, P.B., Jain, S.K., and Nagpaul, S.R., *Basic Abstract Algebra* (II Edition) Cambridge University Press, (Indian Edition), 1997.
3. Luther, I.S., and Passi, I.B.S., *Algebra, Vol. I –Groups* (1996); *Vol. II Rings*, Narosa Publishing House , New Delhi, 1999.
4. Malik, D.S., Mordeson, J.N., and Sen, M.K., *Fundamental of Abstract Algebra*, McGraw Hill (International Edition), New York, 1997.
5. Jacobson, N., *Basic Algebra*, Vol. I & II , Hindustan Publishing Company, New Delhi, 2009.

Website and e-Learning Source

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

M.Sc. Mathematics / Semester – II

Core-5: REAL ANALYSIS II (P23MA205)

Lecture Hours	**: 85**	**Tutorial Hours**	**:5**
Practical Hours	**: -**	**No. of Credit**	**:5**
Contact Hours per Semester	**:90**		
Contact hours per Week	**:6**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

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 Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: Understand and describe the basic concepts of Fourier series and Fourier integrals with respect to orthogonal system.
CO2: Analyze the representation and convergence problems of Fourier series.
CO3: Analyze and evaluate the difference between transforms of various functions.
CO4: Formulate and evaluate complex contour integrals directly and by the fundamental theorem.
CO5: Apply the Cauchy integral theorem in its various versions to compute contour integration.

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	3	3	1	2	3	2	3	3
CO2	3	3	2	2	2	3	3	2	3
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	2	2	3	2	3	3
CO5	3	2	2	3	1	2	3	1	2
Total contribution of CO to POs	12	13	11	10	9	13	12	12	13
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	66.67	60	86.67	80	80	86.67

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I :Measure On The Real Line (L – 17 + T – 1 Hrs)

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

Chapter - 2 Sec 2.1 to 2.4, Chapter-3 Sec 3.1, 3.2 (Royden H.L., Fitzpatrick P. M.)

UNIT-II : Integration Of Functions Of A Real Variable (L – 17 + T – 1 Hrs)

Integration of Non- negative functions - The General Integral - Riemann and Lebesgue Integrals

Chapter - 4 Sec 4.1 to 4.4 (Royden H.L., Fitzpatrick P. M.)

UNIT-III : Fourier Series And Fourier Integrals (L – 17 + T – 1 Hrs)

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 (L – 17 + T – 1 Hrs)

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 (L – 17 + T – 1 Hrs)

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)

Tutorial Section:

Unit	Topic	Hours
I	Measurable Functions	1
II	Lebesgue Integrals	1
III	The convergence and representation problems in for trigonometric series	1
IV	The mean - value theorem for differentiable functions	1
V	Implicit function theorem	1

Recommended Text:

1. Roydon, H.L., *Real Analysis*, Pearson Education Inc. IV Edition, Delhi, 2013. (for Units I, II)
2. Tom Apostol, M., *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. Rudin, W., *Principles of Mathematical Analysis*, McGraw Hill Company, New York,1979.
4. Malik, S.C., and Savita Arora, *Mathematical Analysis*, Wiley Eastern Limited. New Delhi, 1991.
5. Sanjay Arora and Bansi Lal, *Introduction to Real Analysis*, SatyaPrakashan, New Delhi, 1991

Website and e-Learning Source

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

M.Sc. Mathematics / Semester – II

Core-6: PARTIAL DIFFERENTIAL EQUATIONS (P23MA206)

Lecture Hours	**:85**	**Tutorial Hours**	**:5**
Practical Hours	**: -**	**No. of Credit**	**:4**
Contact Hours per Semester	**:90**		
Contact hours per Week	**:6**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

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 Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: To understand and classify second order equations and find general solutions.

CO2: To analyse and solve wave equations in different polar coordinates.

CO3: To solve Vibrating string problem, Heat conduction problem, to identify and solve Laplace and beam equations.

CO4: To apply maximum and minimum principle's and solve Dirichlet, Neumann problems for various boundary conditions.

CO5: To apply Green's function and solve Dirichlet, Laplace problems, to apply Helmholtz operation and to solve Higher dimensional problem.

CO-PO Mapping (Course Articulation Matrix)

COs	**Program Outcomes (POs)**						**Program Specific Outcomes (PSOs)**		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3	3	3	2	3	3	3	1
CO2	3	3	2	3	2	3	3	2	2
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	3	2	2	3	3	2
CO5	3	2	2	2	1	1	2	1	2
Total contribution of CO to POs	12	13	11	13	9	11	13	12	10
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	86.67	60	73.33	86.67	80	66.67

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I :Mathematical Models and Classification of second order Equation (L – 17 + T – 1 Hrs)

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 (L – 17 + T – 1 Hrs)

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 (L – 17 + T – 1 Hrs)

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 (L – 17 + T – 1 Hrs)

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 (L – 17 + T – 1 Hrs)

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

Tutorial Section:

Unit	Topic	Hours
I	Vibrating membrane	2
II	Non-homogeneous boundary conditions	2
III	Vibrating string problem	2
IV	Dirichlet Problem for a circle	2
V	Neumann Problem	2

Recommended Text:

1. TynMyint U., LokenathDebnath, *Partial Differential Equations for Scientists and Engineers* (4th Edition), North Hollan, New York, 1987.

Reference Books

1. Smirnov M.M., *Second Order partial Differential Equations*, Leningrad, 1964.
2. Sneddon I.N., *Elements of Partial Differential Equations*, McGraw Hill, New Delhi, 1983.
3. Dennemeyer R., *Introduction to Partial Differential Equations and Boundary Value Problems*, McGraw Hill, New York, 1968.
4. Raisinghania M.D. ,*Advanced Differential Equations*, Chand S., & Company Ltd., New Delhi, 2001.
5. Sankar Rao S., *Partial Differential Equations*, 2nd Edition, Prentice Hall of India, New Delhi. 2004.

Website and e-Learning Source

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

M.Sc. Mathematics / Semester – II

Elective - 3: R PROGRAMMING (P23MA2E3A)

Lecture Hours	**:55**	**Tutorial Hours**	**:5**
Practical Hours	**: -**	**No. of Credit**	**:3**
Contact Hours per Semester	**:4**		
Contact hours per Week	**:60**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

- The course deals to enhance problem solving and programming skills in R with extensive programming exercises.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: remember and understand the concepts of various statistical concepts that were used in a program and their relevance

CO2: predict or describe the patterns in data using machine learning techniques in R

CO3: discover errors in a R program and to fix them using proper tools and methodology

CO4: critique a R program and describe ways to improve it

CO5:create an algorithm for a given problem and implement the same in R

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3	3	3	2	3	2	3	3
CO2	3	3	2	3	2	3	3	2	3
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	3	2	2	2	3	3
CO5	3	2	2	2	1	1	3	1	2
Total contribution of CO to POs	12	13	11	13	9	11	12	12	13
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	86.67	60	73.33	80	80	86.67

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I : Evolution of programming methodologies **(L – 11 + T – 1 Hrs)**

Evolution of programming methodologies, Introduction to R and its basic features, Basic components of R, Program and program structure, Compiling and executing R program, Data Science Overview, Introduction To Business Analytics, Business Decisions And Analytics, Types of Business Analytics, Applications Of Business Analytic.

UNIT-II : Importance of R **(L – 11 + T – 1 Hrs)**

Importance of R, Data Types And Variables In R, Operators In R, Conditional Statements in R,Loops In R, R Script, Functions In R.

UNIT-III : Data Structures **(L – 11 + T – 1 Hrs)**

Overview of Data Structures, Identifying Data Structures, Demo Identifying Data Structures, Assigning Values To Data Structures, Data Manipulation, Demo Assigning Values And Applying Functions

UNIT-IV : Data Visualization **(L – 11 + T – 1 Hrs)**

Introduction to Data Visualization, Data Visualization Using Graphics In R, Ggplot2, File Formats of Graphic Outputs.

UNIT-V : Limiting Distributions **(L – 11 + T – 1 Hrs)**

Introduction to Hypothesis, Types Of Hypothesis, Data Sampling, Confidence and Significance Levels C.

Tutorial Section:

Unit	Topic	Hours
I	Compiling and executing R program	1
II	Data Types And Variables In R	1
III	Demo Identifying Data Structures	1
IV	Data Visualization Using Graphics In R	1
V	Data Sampling	1

Recommended Text:

1. Arthur Charpentier, *Computational Actuarial Science with R*, Chapman & Hall/CRC The R Series, 2014.

Reference Books

1. Grolemund G., Wickham H., *R for Data Science*, O'Reilly Media, 2017.

Website and e-Learning Source

1. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi0jYPksan1AhUm4jgGHVotDtwQwqsBegQIVRAB&url=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3D_V8eKsto3Ug&usg=AOvVaw2IwyyNLLClfQ3RNsv2ucSe
2. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi0jYPksan1AhUm4jgGHVotDtwQwqsBegQIUhAB&url=https%3A%

M.Sc. Mathematics / Semester – II

Elective - 3: MATHEMATICAL STATISTICS (P23MA2E3B)

Lecture Hours	**:55**	**Tutorial Hours**	**:5**
Practical Hours	**: -**	**No. of Credit**	**:3**
Contact Hours per Semester	**:4**		
Contact hours per Week	**:60**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

- This course provides basic knowledge about conditional probability, stochastic independence and some special distributions. How to transform the variables and know the change of variable technique and the m.g.f. technique, also acquire knowledge to solve the problems and to familiarize the limiting distributions.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: Familiar with the concept of probability and independence
CO2: Transform the variable technique, the m.g.f. technique
CO3: Understand the different distributions
CO4: Solve the problems using distributions
CO5: Apply the different techniques

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	3	3	3	2	3	2	3	1
CO2	3	3	2	3	2	3	3	2	2
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	3	2	2	2	3	2
CO5	3	2	2	2	1	1	3	1	2
Total contribution of CO to POs	12	13	11	13	9	11	12	12	10
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	86.67	60	73.33	80	80	66.67

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I : Conditional Probability and Stochastic Independence (L – 11 + T – 1 Hrs)

Chebyshev's inequality - Conditional Probability – marginal and conditional distributions – correlation coefficient - Stochastic Independence.

Chapter 1 - Section: 1.11 & Chapter 2

UNIT-II : Some special Distributions (L – 11 + T – 1 Hrs)

The Binomial, Trinomial and multinomial distributions – The Poisson distributions – The Gamma and Chi – Square distributions - the normal distribution – the Bivariate normal distribution.

Chapter 3

Exercise Problems - Chapter 3: 3.1 - 3.54 & 3.62 - 3.65

UNIT-III : Transformation of Variables (L – 11 + T – 1 Hrs)

Sampling Theory – Transformation of variables of discrete type – Transformation of variables of continuous type – The t and F distributions.

Chapter 4 - Sections: 4.1 - 4.4

Exercise Problems - Chapter 4: 4.1 - 4.41

UNIT-IV : Distributions of Functions of random variables (L – 11 + T – 1 Hrs)

Extension of change of variable Technique – Distributions of order statistics – The moment generating function technique – The distributions of X and $\frac{nS^2}{\sigma^2}$ - Expectations of functions of random variables.

Chapter 4 - Sections: 4.5 - 4.9

Exercise Problems - Chapter 4: 4.42, 4.43, 4.50 - 4.60, 4.68 - 4.74 & 4.83 - 4.98

UNIT-V : Limiting Distributions (L – 11 + T – 1 Hrs)

Limiting Distributions – Stochastic Convergence – Limiting Moment generating functions – The Central Limit Theorem – Some theorems on Limiting distributions.

Chapter 5

Exercise Problems - Chapter 5 : 5.1 - 5.16, 5.20 - 5.27 & 5.30 - 5.35

Tutorial Section:

Unit	Topic	Hours
I	Conditional Probability	1
II	Chi – Square distributions	1
III	Transformation of variables of discrete type	1
IV	The distributions of X and $\frac{nS^2}{\sigma^2}$	1
V	Stochastic Convergence	1

Recommended Text:

1. Robert Hogg V., and Allen Craig T., *Introduction to Mathematical Statistics*, Fourth Edition, Pearson Education Asia.

Reference Books

2. Gupta .S.C., and Kapoor V.K., *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons, New Delhi, 2002.
3. Irwin Miller & Maryless Miller, Johns Freunds, *Mathematical Statistics*, Pearson Education, India, 2004.

Website and e-Learning Source

1. https://www.khanacademy.org/math/statistics-probability
2. nptel.ac.in>courses Mathematics –Probability and statistics

M.Sc. Mathematics / Semester – II

Elective IV: WAVELETS (P23MA2E4A)

Lecture Hours	**:55**	**Tutorial Hours**	**:5**
Practical Hours	**: -**	**No. of Credit**	**:3**
Contact Hours per Semester	**:60**		
Contact hours per Week	**:4**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

- To introduce the basic notions and techniques of Wavelets Theory

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: To understand the basic concepts of Fourier and Wavelet transform
CO2: Acquire the knowledge of Fourier analysis
CO3: To understand the concept of Cardinal spline analysis
CO4: To Apply wavelet transforms to study real life applications
CO5: To pursue research in Wavelet Analysis.

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	3	3	3	2	3	2	3	3
CO2	3	3	2	3	2	3	3	2	3
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	3	2	2	2	3	3
CO5	3	2	2	2	1	1	3	1	2
Total contribution of CO to POs	12	13	11	13	9	11	12	12	13
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	86.67	60	73.33	80	80	86.67

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I : An Overview (L – 11 + T – 1 Hrs)

Fourier to Wavelets - Integral Wavelet Transform and Time-frequency analysis -Inversion formulas and duals - Classification of Wavelets - Multiresolution analysis - Splines and Wavelets. Fourier Analysis: Fourier and Inverse Fourier Transforms - Continuous time convolution - The delta function - Fourier Transform of square integrable functions.

Chapter 1: Sections 1.1 to 1.6 Chapter 2: Sections 2.1 to 2.3

UNIT-II : Fourier Analysis (Cont) (L – 11 + T – 1 Hrs)

Fourier Series - Basic Convergence Theory - Poisson Summation Formula. Wavelet Transforms and Time Frequency Analysis: The Gabor Transform - Short time Fourier Transforms and the uncertainty principle - The integral Wavelet Transform - Dyadic Wavelets - Inversions - Frames - Wavelet Series.

Chapter 2: 2.4 and 2.5 Chapter 3: Section 3.1 to 3.6

UNIT-III : Cardinal Spline Analysis (L – 11 + T – 1 Hrs)

Cardinal Spline spaces. - B-Splines and their basic properties - The time scale relation and an interpolating graphical display algorithm - B-Net representations and computation of cardinal splines - Construction of cadrdinal splines - construction of spline aaplication formulas - Construction of Spline interpolation formulas.

Chapter 4: Sections 4.1 to 4.6

UNIT-IV : Scaling Functions And Wavelets (L – 11 + T – 1 Hrs)

Multiresolution analysis - Scaling functions with finite two scale relation - Direction sum Decompositions of L2 (R) - Wavelets and their duals.

Chapter 5: Sections 5.1 to 5.4 (omit 5.5 and 5.6)

UNIT-V : Cardinal Spline Wavelets (L – 11 + T – 1 Hrs)

Interpolating splines wavelets - Compactly supported spline - Wavelets - Computation of Cardinal spline Wavelets - Euler - Frebenious Polynomials. Orthogonal Wavelets: Examples of orthogonal Wavelets - Identification of orthogonal two scale symbols - Construction of compactly supported orthogonal wavelets.

Chapter 6 : Sections 6.1 to 6.4 (omit 6.5 and 6.6) Chapter 7: Sections 7.1 to 7.3 (omit 7.4 and 7.5)

Tutorial Section:

Unit	Topic	Hours
I	Classification of Wavelets	1
II	The Gabor Transform	1
III	Construction of cadrdinal splines	1
IV	Wavelets and their duals	1
V	Euler - Frebenious Polynomials	1

Recommended Text:

1. Charles Chui K., *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

1. https://youtu.be/otky1bBhwgM
2. https://youtu.be/chdr2aj4FUc.

M.Sc. Mathematics / Semester – II

Elective - 3: PYTHON LANGUAGE (P23MA2E4B)

Lecture Hours	**:55**	**Tutorial Hours**	**:5**
Practical Hours	**: -**	**No. of Credit**	**:3**
Contact Hours per Semester	**:4**		
Contact hours per Week	**:60**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

- The course provides ffundamentals of Python Programming, get knowledge about the Functions in Python, understand the concepts of List and String methods and gain idea about exception handling and Classes.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: to implement basic concepts of operators and functions.
CO2: to Review various string, list, tuple and dictionaries
CO3: to analyze the concept of classes and objects
CO4: to evaluate the functionality of an exception handling.

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3	3	1	3	3	2	3	1
CO2	3	3	2	2	3	3	3	2	2
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	2	3	2	2	3	2
CO5	3	2	2	3	2	1	3	1	2
Total contribution of CO to POs	12	13	11	10	13	11	12	12	10
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	66.67	86.67	73.33	80	80	66.67

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I : Introduction to Python **(L – 11 + T – 1 Hrs)**

Introduction to Python: Introduction – Python Overview – Getting Started with Python –Comments Python Identifiers – Reserved Keywords – Variables – Standard Data types.

UNIT-II : Types of Operators **(L – 11 + T – 1 Hrs)**

Types of Operators - Statement and Expressions – String Operations – Boolean Expressions – Control Statements – Iteration While Statement – Input from Keyboard.

UNIT-III : Functions introduction **(L – 11 + T – 1 Hrs)**

Functions introduction – Built-in Functions – Composition of Functions – User defined Functions Parameters and Arguments –Function Calls- The return statement – Python Recursive Functions The Anonymous function – Writing Python Scripts

UNIT-IV : Introduction about Strings and Lists **(L – 11 + T – 1 Hrs)**

Introduction about Strings and Lists: Strings - Lists. Tuples and Dictionaries: Tuples – Dictionaries.

UNIT-V : Limiting Distributions **(L – 11 + T – 1 Hrs)**

Files and Exceptions introduction - Text Files – Directories – Exceptions – Exceptions with Arguments- User defined Exceptions- Classes and Objects.

Tutorial Section:

Unit	Topic	Hours
I	Standard Data types	1
II	Input from Keyboard	1
III	Python Recursive Functions	1
IV	Tuples	1
V	Classes and Objects	1

Recommended Text:

1. Balagurusamy, *Problem Solving and Python Programming*, first edition McGraw-Hill, Delhi, 2017.

Reference Books

1. Ashok Namdev Kamthane, Amit Ashok Kamthane, *Programming and Problem Solving with Python*, 2017.
2. John B., Schneider Shira Lynn Broschat, Jess Dahmen**,** *Algorithmic Problem Solving with Python,* Washington State University 2015.

Website and e-Learning Source

3. https://www.programiz.com/python-programming/online-compiler/
4. https://www.codecademy.com/catalog/language/python

M.Sc. Mathematics / Semester – II

Skill Enhancement Course -1 - MATHEMATICAL DOCUMENTATION USING LATEX (P23MA2SE1)

Lecture Hours	**:55**	**Tutorial Hours**	**:5**
Practical Hours	**: -**	**No. of Credit**	**:2**
Contact Hours per Semester	**:60**		
Contact hours per Week	**:4**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

- This paper provides knowledge about basics of LATEX and provides system oriented knowledge.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO1: Recall the basics of LATEX software while preparing a Document
CO2: Understand the Mathematical formulas and Drawing tools of LATEX
CO3: Develop the knowledge of investigating and learning new LATEX
CO4: Set page style and Constructing
CO5: Commands names and arguments

CO-PO Mapping (Course Articulation Matrix)

COs	Program Outcomes (POs)						Program Specific Outcomes (PSOs)		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	2	3	3	1	2	2	2	3	3
CO2	3	3	2	2	2	3	3	2	2
CO3	2	2	2	2	2	2	2	3	2
CO4	2	3	2	2	2	2	2	3	2
CO5	3	2	2	3	1	3	3	1	2
Total contribution of CO to POs	12	13	11	10	9	12	12	12	11
Weighted Percentage of COs contribution to Pos	80	86.67	73.33	66.67	60	80	80	80	73.33

No Correlation 0 Weak 1 Moderate 2 Strong 3

Course Content

UNIT-I : Introduction **(L – 11 + T – 1 Hrs)**

Text formatting - Just what is LATEX? ; Markup Languages – Tex and its offspring's - Basic of a LATEX file.

UNIT-II : Text, Symbols and Commands **(L – 11 + T – 1 Hrs)**

Commands names and arguments – Environments - Declarations – Lengths - Rubber lengths; Special characters - Exercise – Fine-tuning text.

UNIT-III : Document Layout and Organization **(L – 11 + T – 1 Hrs)**

Document class – page style – Parts of the document – Table of contents; Displayed Text: Changing font - Centering and indenting - Lists - Theorem-like declarations – Tabulator stops.

UNIT-IV : Boxes **(L – 11 + T – 1 Hrs)**

LR boxes – parboxes and minipages – problem with vertical placement - paragraph boxes of specific height – Rule boxes; Tables: Constructing tables – Table style parameter – Table example.

UNIT-V : **Document preparation** **(L – 11 + T – 1 Hrs)**

Letter writing – Question Paper settings - Article formation

Recommended Text:

1. Kopka H., Daly P.W., *A Guide to LATEX***,** Fourth Edition Addison Wesley Longman Ltd, England, 2004.

Reference Books

1. Lamport L., *LATEX – A Document preparation system*, Reading MA: Addision – Wesley, 1985.
2. Lamport L., *LATEX – A Document preparation system*, Reading, Second Edition, for LATEX2e, Reading MA: Addison-Wesley,1994.
3. Schwarz N., *Introduction to TEX*, Reading MA: Addision-Wesley, 1990.
4. Snow W., *TEX for the Beginner*, Reading MA: Addision-Wesley, 1992.

Website and e-Learning Source

1. https://www.latex-tutorial.com/tutorials/
2. http://www.docs.is.ed.ac.uk/skills/documents/3722/3722-2014.pdf