

ShreeWaranaVibhagShikshanMandal's
WARANA UNIVERSITY,
WARANANAGAR

(A State Public University established under Section 3 (6) of MPUA, 2016)



Established: 2025

Structure & Syllabus For
Bachelor of Science (M.Sc.) in Mathematics
UNDER

Faculty of Science & Technology
M.Sc.Part –II (Semester- III and IV)
(As Per National Education Policy – 2020)

With effect from Academic Year 2026-27 Onwards

Sr. No.	CONTENT	Page No
1.	PREAMBLE	1
2.	GENERAL OBJECTIVES	1
3.	PROGRAMME OUTCOMES (POS)	1
4.	PROGRAMME SPECIFIC OUTCOMES (PSOS)	2
5.	ELIGIBILITY	3
6.	DURATION	3
7.	MEDIUM OF INSTRUCTION	3
8.	SCHEME OF TEACHING AND EXAMINATION	4
9.	COURSE STRUCTURE M.Sc.-II	5
10.	COURSE STRUCTURE SUBJECT SPECIFIC	5
11.	STRUCTURE OF PROGRAMME	5-6
12.	SYLLABUS	7-20
13.	SCHEME OF EXAMINATION	21-22

Abbreviations:

POs	Program Outcomes
PSOs	Program Specific Outcomes
COs	Course Outcomes
MMT	Major Mandatory Theory
MMPR	Major Mandatory Practical
MET	Major Elective Theory
MEPR	Major Elective Practical
RP	Research Project

PREAMBLE:

The M.Sc. II Mathematics programme is designed in accordance with the objectives of the National Education Policy (NEP) 2020 with emphasis on advanced mathematical knowledge, research orientation, skill development, and interdisciplinary learning. The curriculum aims to provide students with a strong foundation in pure and applied mathematics along with computational and analytical skills required for higher education, research, industry, and competitive examinations.

Keeping in view the rapid developments in science, technology, data science, artificial intelligence, and interdisciplinary applications of mathematics, the syllabus has been framed to meet contemporary academic and industrial needs. The programme focuses on developing logical reasoning, abstract thinking, problem-solving ability, mathematical modelling, and effective communication of mathematical ideas. It also encourages students to apply mathematical techniques to real-life problems arising in science, engineering, economics, computer science, and allied fields.

The curriculum includes core courses, such as Real and Complex Analysis, Functional Analysis, Integral Equations, Partial Differential Equations, Classical Mechanics, Advanced Discrete Mathematics and emerging fields including Data Science, Artificial Intelligence, and Machine Learning applications in Mathematics, elective papers, seminars, projects, and research-based activities to enhance employability and promote innovation. The programme also emphasizes the use of mathematical software, computational tools, and modern teaching-learning methodologies.

The syllabus structure has been developed following the guidelines of NEP-2020 and UGC curriculum frameworks to ensure academic flexibility, outcome-based learning, and global competitiveness in mathematical education.

GENERAL OBJECTIVES OF THE COURSE

The general objectives of the M.Sc.Part-II Course are

To provide advanced and in-depth knowledge in various branches of Mathematics.

To develop analytical, computational, and research skills among students.

To encourage interdisciplinary and application-oriented learning.

To prepare students for higher studies, research, teaching, and industrial careers.

To promote critical thinking, scientific attitude, and ethical values.

To enhance students' abilities in mathematical communication, seminars, and project work.

To Create opportunities for skill development in emerging areas such as Data Science, Artificial Intelligence, Machine Learning, Optimization, and Computational Mathematics.

PROGRAMME OUTCOMES (POs)-M.Sc. Mathematics

After successful completion of the M.Sc. Mathematics programme, students will be able to:

PO 1. Acquire Advanced Mathematical Knowledge

Develop in-depth understanding of pure and applied mathematics including Algebra, Analysis, Topology, Differential Equations, Numerical Methods, Operations Research, and related areas.

PO 2. Enhance Logical and Analytical Thinking

Apply logical reasoning, critical thinking, and analytical skills to solve complex mathematical problems.

PO 3. Develop Problem Solving Ability

Formulate, analyze, and solve theoretical as well as real-life problems using mathematical techniques and computational methods.

PO 4. Apply Mathematical Modelling

Use mathematical models and quantitative techniques in interdisciplinary areas such as Physics, Computer Science, Economics, Engineering, Data Science, and Artificial Intelligence.

PO 5. Strengthen Research Competency

Develop research aptitude, mathematical investigation skills, and the ability to undertake independent research projects.

PO 6. Use Computational and Technological Tools

Utilize mathematical software, programming languages, and computational tools for numerical analysis, simulation, and data interpretation.

PO 7. Promote Communication Skills

Communicate mathematical ideas, proofs, and research findings effectively through oral presentations, seminars, and technical writing.

PO 8. Develop Ethical and Professional Values

Demonstrate professional ethics, academic integrity, teamwork, and social responsibility in teaching, research, and professional practices.

PO 9. Prepare for Careers and Higher Studies

Gain competency for careers in teaching, research, industry, banking, data analytics, actuarial science, and competitive examinations, as well as higher education and doctoral studies.

PO 10. Encourage Lifelong Learning

Develop self-learning ability and adaptability to emerging trends in mathematics, computing, AI, and interdisciplinary sciences.

PROGRAMME SPECIFIC OUTCOMES (PSOs) M.Sc. Mathematics

After completion of the M.Sc. Mathematics programme, students will be able to:

PSO 1. Understand Core Areas of Mathematics

Gain mastery in advanced topics such as Real Analysis, Complex Analysis, Abstract Algebra, Topology, Functional Analysis, Differential Equations, and Discrete Mathematics.

PSO 2. Apply Mathematical Techniques in Real-Life Situations

Use mathematical and statistical methods for solving industrial, scientific, and societal problems.

PSO 3. Develop Research and Proof Writing Skills

Construct rigorous mathematical proofs, analyze mathematical structures, and conduct independent research work.

PSO 4. Use Computational Mathematics and Programming

Apply numerical methods, optimization techniques, and computer programming for mathematical computations and simulations.

PSO 5. Integrate Mathematics with Emerging Technologies

Apply mathematical concepts in Artificial Intelligence, Machine Learning, Cryptography, Data Science, and Computational Modelling.

PSO 6. Enhance Teaching and Academic Skills

Develop competency in mathematical communication, pedagogy, curriculum design, and academic leadership.

PSO 7. Prepare for Competitive Examinations and Employment

Build strong conceptual foundations required for NET/SET/GATE examinations, research opportunities, and careers in academia and industry.

PSO 8. Promote Interdisciplinary and Innovative Thinking

Integrate mathematical knowledge with other disciplines and develop innovative approaches for problem-solving and research.

ELIGIBILITY FOR ADMISSION

As per guide lines obtained from Warana University, Warananagar by following rules and regarding reservations by Govt. of Maharashtra

i) Any candidate who has successfully completed Post Graduate Diploma (Level 6.0) in Mathematics of this University or of any other statutory University recognized by UGC, New Delhi.

OR

ii) Any candidate who has successfully completed Bachelor's Degree (Honours/ Honours with Research)(Level6.0) with principal/major subject Mathematics of this University or of any other statutory University recognized by UGC, New Delhi. **OR**

iii) Completed all requirements of the relevant Post Graduate Diploma (Level 6.0) in Mathematics.

DURATION

The course shall be a fulltime course. Second Year, Semester III and IV

MEDIUM OF INSTRUCTION

The Medium of instruction shall be English

SCHEME OF TEACHING AND EXAMINATION:

[The scheme of teaching and examination should be given as applicable to the course/paper concerned.]

M.Sc. Program Structure for Level 6.5 of M.Sc.-II Semester III												
Teaching Scheme						Examination Scheme						
Sr. No.		Theory (TH) & Practical (P)				Semester-end Examination (SEE)			Internal Assessment (IA)			
		Course Type	Lectures + S/T/PSSI (per week)	Practical Hours (per week)	Credits	Max. Marks	Min.. Marks	Exam. Hours	Internal	Max. Marks	Min.. Marks	Exam. Hours
1.	Major Mandatory	MMT-301	4 + 1	--	4	80	32	3	Assessment	20	8	1
2.		MMT-302	4 + 1	--	4	80	32	3		20	8	1
3.		MMT-303	4 + 1	--	4	80	32	3		20	8	1
4		MMT-304	2 + 1	--	2	40	16	2		10	4	½
5.	Major Elective	MMT-305	4 + 1	--	4	80	32	3		20	8	1
6.	Research Project	RP-307	--	4	4	80	32	3		20	8	1
Total					22	Total SEE = 440			Total SEE = 110			
						Total Semester –III = 550						

M.Sc. Program Structure for Level 6.5 of M.Sc.-II Semester IV													
Teaching Scheme						Examination Scheme							
Sr. No.		Theory (TH) & Practical (P)				Semester-end Examination (SEE)			Internal Assessment (IA)				
		Course Type	Lectures + S/T/PSSI (per week)	Practical Hours (per week)	Credits	Max. Marks	Min.. Marks	Exam. Hours	Internal	Max. Marks	Min.. Marks	Exam.Hours	
1.	Major Mandatory	MMT-401	4 + 1	--	4	80	32	3	Assessment	20	8	1	
2.		MMT-402	4 + 1	--	4	80	32	3		20	8	1	
3.		MMT-403	4 + 1	--	4	80	32	3		20	8	1	
4		MMT-404	--	--	--	40	16	2		10	4	½	
5.	Major Elective	MMT-405	4 + 1	--	4	80	32	3		20	8	1	
6.	Research Project	RP-407	--	6	6	80	32	3		20	8	1	
Total					22	Total SEE = 420			Total SEE = 130				
						Total Semester –IV = 550							

COURSE STRUCTURE M.Sc.-II

Credit Distribution Structure for M.Sc.-II in Mathematics with Multiple Entry and Multiple Exit Options:

COURSE CATEGORY	ABBREVIATION (Only 2 Letters)	DESCRIPTION	Sem.-III Credit	Sem.-IV Credit
Major Mandatory Theory	MMT	Discipline Specific Course	4x3=12 2x1=02	4x3=12
Major Elective Theory	MET	Discipline Specific Elective Course	4x1=04	4x1=04
Research Project	RP	Discipline Specific Research Project Course	4x1=04	6x1=06
			22	22
			Total 44	

Master of Science in MATHEMATICS

Credit Framework

Second Year (M. Sc. II- MATHEMATICS)

	WARANA UNIVERSITY, WARANANAGAR NEP-2020: Credit Framework for PG (M. Sc.) Programme under Faculty of Science and Technology			
SEM (Level)	COURSES		Research Project	Total Credits
	Major Mandatory Theory	Major Elective Theory (any one)		
SEM III (6.5)	MMT-301 (4)	MMT-405 (4)	RP-407 (4)	22
	MMT-302 (4)	MMT-406 (4)		
	MMT-303 (4)			
	MMT-304 (2)			
SEM IV (6.5)	MMT-401(4)	MET-405 (4)	RP-407 (6)	22
	MMT-402 (4)	MET-406 (4)		
	MMT-403 (4)			
	MMT-404 (--)			
Credits	26	08	10	44

Course Code Table**M.Sc.-II: SEMESTER-III (TOTALCREDITS-22):** (Note: Put '—' wherever 'Not Applicable')

COURSE CATEGORY		COURSE NAME	COURSE CODE	CREDITS
Major Mandatory Theory	MMT-301	Complex Analysis	2602PSMTMMT301	4
	MMT-302	Functional Analysis	2602PSMTMMT302	4
	MMT-303	Classical Mechanics	2602PSMTMMT303	4
	MMT-304	Advanced Discrete Mathematics	2602PSMTMMT304	2
Major Elective Theory (any One)	MET-305	Fuzzy Set Theory-I	2602PSMTMET305	4
	MET-306	Software Engineering And Project Management	2602PSMTMET306	
Research Project	RP-307	Research Project	2602PSMTRP307	4
CREDITS FOR B.Sc.-II, SEM-III .				22

M.Sc.-II: SEMESTER-IV (TOTALCREDITS-22): (Note: Put '—' wherever 'Not Applicable')

COURSE CATEGORY		COURSE NAME	COURSE CODE	CREDITS
Major Mandatory Theory	MMT-401	Field Theory	2602PSMTMMT401	4
	MMT-402	Integral Equations	2602PSMTMMT402	4
	MMT-403	Partial Differential Equations	2602PSMTMMT403	4
	MMT-404	--	2602PSMTMMT404	--
Major Elective Theory (any One)	MET-405	Fuzzy Set Theory-II	2602PSMTMET405	4
	MET-406	Internet of Things	2602PSMTMET406	
Research Project	RP-407	Research Project	2602PSMTRP407	6
CREDITS FOR B.Sc.-II, SEM-IV .				22

SEMESTER - III

Mathematics MAJOR MANDATORY THEORY PAPER MMT301: Complex Analysis (2602PSMTMMT301)

CREDITS: 4, LECTURE HOURS: (4+1) PER WEEK, MARKS: 80

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	compute the region of convergence for power series,
CO2	prove the Cauchy-Riemann equations and apply them to complex functions in order to examine differentiability and analyticity of complex functions,
CO3	evaluate complex integration along the curve via Cauchy's theorem and integral formula
CO4	prove the Cauchy residue theorem and apply it to several kinds of real integrals.
CO5	compute the Taylor series and Laurent series expansions of complex functions and apply it to for checking the nature of singularities and calculating residues,

SYLLABUS

UNIT-1: Powerseries, Radius of convergence, Analytic functions, Cauchy-Riemann equations, Harmonic functions, Conformal mappings, Mobius Transformations. **15 Lectures**

UNIT- 2: Line integral, Power series representation of analytic functions, zeros of an analytic function, Liouville's Theorem, Fundamental theorem of algebra, Maximum modulus theorem. **15 Lectures**

UNIT-3: The index of a closed curve, Cauchy's theorem and integral formula, Morera's Theorem, Counting zeros, open Mapping theorem, Goursat's Theorem, classification of singularities, Laurent series development, Casorati-Weierstrass theorem. **15 Lectures**

UNIT-4: Residues, residue theorem, evaluation of real integrals, The argument principle, Rouché's theorem, Schwarz's lemma and its application to characterize conformal maps. **15 Lectures**

S/T/PSS/GD: Seminars, Tutorials, Problem Solving Session and Group Discussions on above units

Recommended Book:

1. J.B. Conway: Functions of One Complex Variable, 3rd Edition, Narosa Publishing House, 1973.

Reference Books:

1. S. Ponnusamy, Foundations of Complex Analysis, 2nd Edition, Narosa Publishing House, 2015
2. Alfors L. V.: Complex Analysis, McGraw Hill, 1979.
3. S. Ponnusamy, H Silverman, Complex Variables with Applications, Birkhauser Boston, 2006
4. J. Brown, R. Churchill, Complex Variables and Applications, Mac Graw Hill (India). (8th Edition, 2014.
5. Serge Lang, Complex Analysis, Fourth Edition, Springer, 1999.
6. Steven G. Krantz, Complex Analysis, A Geometric view Point, Second Edition, The Carus Mathematical Monographs, Number 23, Second Edition, 2004.
7. T.W. Gamelin, Complex Analysis, Springer, 2001.

Mathematics MAJOR MANDATORY
THEORY PAPER MMT302: Functional Analysis (2602PSMTMMT302)

CREDITS: 4, LECTURE HOURS: (4+1) PER WEEK, MARKS: 80

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	under stand the fundamental topics, principles and methods of functional analysis.
CO2	demonstrate the knowledge of normed spaces, Banach spaces, Hilbert space.
CO3	define continuous linear transformations between linear spaces, bounded linear functionals.
CO4	apply finite dimensional spectral theorem.
CO5	identify normal, self adjoint, unitary, normal operators.

SYLLABUS

UNIT– I : Normed linear spaces, Banach spaces, quotient spaces, continuous linear transformations, equivalent norms, finite dimensional normed spaces and properties, conjugate space and separability, The Hahn-Banach theorem and its consequences. **15 Lectures**

UNIT –II: Second conjugate space, the natural embedding of the normed linear space in its second conjugate space, reflexivity of normed spaces, the open mapping theorem, projection on Banach space, the closed graph theorem, the conjugate of an operator, the uniform boundedness principle. **15 Lectures**

UNIT –III: Hilbert spaces: examples and elementary properties, orthogonal complements, the projection theorem, orthogonal sets, the Bessel's inequality, Fourier expansion and Parseval's equation, separable Hilbert spaces, the conjugate of Hilbert space, Riesz's theorem, the adjoint of an operator. **15 Lectures**

UNIT – IV: Self adjoint operators, normal and unitary operators, projections, eigen values and eigenvectors of an operator on a Hilbert space, the determinants and spectrum of an operator, the spectral theorem on a finite dimensional Hilbert space. **15 Lectures**

S/T/PSS/GD: Seminars, Tutorials, Problem Solving Session and Group Discussions on above units

Recommended Book(s):

G.F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw Hill, 1963.

Reference Books:

1. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons, 1978.
2. A.E. Taylor, Introduction to Functional analysis, John Wiley and sons, 1958.
3. J.B. Conway, A course in Functional Analysis, Springer-Verlag, 1985.
4. G. Bachelman and L. Narici, Functional Analysis, Academic Press, 1972.
5. B.V. Limaye, Functional Analysis, New age international, 1996.

Mathematics MAJOR MANDATORY
THEORY PAPER MMT303: Classical Mechanics (2602PSMTMMT303)

CREDITS: 4, LECTURE HOURS: (4+1) PER WEEK, MARKS: 80

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	Discuss the motion of system of particle using Lagrangian and Hamiltonian approach.
CO2	Solve extremization problems using variational calculus.
CO3	Discuss the motion of rigid body.
CO4	Construct Hamiltonian using Routh process.
CO5	Use infinitesimal and finite rotations to analyze motion of rigid body.

SYLLABUS

UNIT–I : Mechanics of a particle, Mechanics of a system of particles, conservation theorems, constraints, Generalized coordinates, D’Alembert’s Principle, Lagrange’s equations of motion, Simple applications of Lagrangian formulation, Cyclic co-ordinates and generalised momentum, conservation theorems. **15 Lectures**

UNIT–II: Euler- Lagrange’s equations, first integrals of Euler- Lagrange’s equations, the problem of Brachistochrone, Hamilton’s Principle, Derivation of Hamilton’s principle from D’Alembert’s principle, Lagrange’s equations from Hamilton’s principle. Extension of Hamilton’s principle to nonholonomic systems, Lagrange’s equations of motion for nonconservative systems (Method of Lagrange’s undetermined multipliers) **15 Lectures**

UNIT–III: Hamiltonian function, Hamilton’s canonical equations of motion, cyclic co-ordinates and Routh’s procedure, Derivation of Hamilton’s equations from variational principle, Physical significance of Hamiltonian, The principle of least action. Equations of canonical transformation, generating function, examples of canonical transformations. **15 Lectures**

UNIT– IV: The Kinematics of rigid body motion: The independent co-ordinates of a rigid body, the Eulerian angles, Euler’s theorem on the motion of a rigid body, infinitesimal rotations, rate of change of a vector, Angular momentum and kinetic energy of a rigid body about a point, the inertia tensor and moment of inertia, Euler’s equations of motion. **15 Lectures**

S/T/PSS/GD: Seminars, Tutorials, Problem Solving Session and Group Discussions on above units

Recommended Book(s):

1. Goldstein, H. Classical Mechanics. (1998), Narosa Publishing House, New Delhi.
2. Herbert Goldstein, Charles Poole, John Safko, Classical Mechanics (2013) Pearson, Delhi

Reference Books:

1. Whittaker, E. T. A Treatise on the Analytical Dynamics of Particles and Rigid Bodies. (1965), Cambridge University Press.
2. Gupta, A. S. Calculus of Variations with Applications (1997), Prentice Hall of India.
3. Gelfand, I. M. and Fomin, S. V. Calculus of Variations (1963), Prentice Hall of India.
4. Rana, N. C. and Joag, P. S. Classical Mechanics. (1991) Tata McGraw Hill, New Delhi

Mathematics MAJOR MANDATORY
THEORY PAPER MMT304: Advanced Discrete Mathematics (2602PSMTMMT304)
CREDITS: 2, LECTURE HOURS: (2+1) PER WEEK, MARKS: 40

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	classify the graphs and apply to real world problems.
CO2	simplify the graphs using matrix.
CO3	simplify the Boolean identities and apply to switching circuits.
CO4	learn applications of discrete mathematics including lattices and Boolean Algebra.

. SYLLABUS

UNIT– I : Graph: Definition, examples, isomorphism, simple graph, bipartite graph, complete bipartite graph, vertex degrees, regular graph, sub-graphs, complement of a graph, self complementary graph, paths and cycles in a graph, the matrix representation of a graph. Definition and simple properties of a tree, Bridges. **15 Lectures**

UNIT –II: Posets: Definition, examples, Hasse diagrams of posets, supremum and infimum, isomorphic ordered sets, duality. Lattices: Definition, examples, sublattices. Ideals: Definition, examples, bounded lattices, distributive lattices, modular lattices, complemented lattices, Boolean algebra, basic definitions, basic theorems, Boolean algebras as lattices, CNF, DNF, applications of Boolean algebra to switching circuit. **15 Lectures**

S/T/PSS/GD: Seminars, Tutorials, Problem Solving Session and Group Discussions on above units

Recommended Book(s):

1. John Clark and Derek Holton, A first look at Graph Theory, Allied Publishers Ltd., 1991.
2. G. Gratzner, General Lattice Theory, Birkhauser, 2002.
3. J. Eldon Whitesitt, Boolean Algebra and Its Applications, Addison-Wesley Publishing Company, Inc., 1961.

Reference Books:

1. Seymour Lipschutz and Mark Lipson, Discrete Mathematics (second edition) Tata Mc Graw Hill Publishing Company Ltd. New Delhi.
2. Garrett Birkhoff: Lattice Theory, American mathematical society, 1940.

Mathematics MAJOR ELECTIVE (any One)
THEORY PAPER MMT305: Fuzzy Set Theory-I (2602PSMTMET305)

CREDITS: 4, LECTURE HOURS: (4+1) PER WEEK, MARKS: 80

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	acquire the knowledge of notion of crisp sets and fuzzy sets,
CO2	understand the basic concepts of crisp set and fuzzy set,
CO3	develop the skill of operation on fuzzy sets and fuzzy arithmetic
CO4	demonstrate the techniques of fuzzy sets and fuzzy numbers.
CO5	apply the notion of fuzzy set, fuzzy number in various problems

SYLLABUS

Unit I: Fuzzy sets and crisp sets, examples of fuzzy sets, types of fuzzy sets, standard operations, cardinality, degree of subset hood, level cuts and its properties, representation of fuzzy sets, decomposition theorems, extension principle, properties of direct and inverse images of fuzzy sets. **20 Lectures**

Unit II: Operations on fuzzy sets, types of operations, fuzzy complement, equilibrium and dual point, Increasing and decreasing generators, fuzzy intersection: t-norms. **15 Lectures**

Unit III: Fuzzy union t-conorms, characterization theorem of t-conorm, combination of operators, aggregation operations, ordered weighted averaging operations. **15 Lectures**

Unit IV: Fuzzy numbers, characterization theorem, linguistic variables, arithmetic operations on intervals, arithmetic operations on fuzzy numbers, lattice of fuzzy numbers, fuzzy equations. 10 Lectures

S/T/PSS/GD: Seminars, Tutorials, Problem Solving Session and Group Discussions on above units

Recommended Books:

1. George J. Klir, Bo Yuan, Fuzzy sets and Fuzzy Logic Theory and Applications, PHI, Ltd. 2000

Reference Books:-

1. M. Grabish, Sugeno, and Murofushi Fuzzy Measures and Integrals: Theory and Applications, PHI, 1999.

2. H. J. Zimmermann, Fuzzy Set Theory and its Applications, Kluwer, 1984.

3. M. Hanss, Applied Fuzzy Arithmetic, An Introduction with engineering Applications, Springer-Verlag Berlin Heidelberg 2005.

4. M. Ganesh, Introduction to Fuzzy Sets & Fuzzy Logic; PHI Learning Private Limited, New Delhi 2011.

5. Bojadev and M. Bojadev, Fuzzy Logic and Application, World Scientific Publication Pvt. Ltd. 2007.

Mathematics MAJOR ELECTIVE (any One)
THEORY PAPER MMT305: Software Engineering and Project Management (2602PSMTMET306)

CREDITS: 4, LECTURE HOURS: (4+1) PER WEEK, MARKS: 80

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	understand various models of Software Development.
CO2	understand requirement gathering and requirement modelling.
CO3	explore concepts and models in software design.
CO4	understand the testing and debugging methods for software

SYLLABUS

Unit I: Introduction: Software problem, Software Engineering problem, Software Engineering approach. Software process: Software process, characteristics, Software development process: A Process Step Specification, Waterfall Model, Prototyping Model, Iterative Enhancement, The Spiral Model, project management process, Software configuration management process, process management process. **15 Lectures**

Unit II : Software requirement analysis and specification: Software requirement, problem analysis, requirement specification, Validation, Matrices: Size Measures, case study. Planning a Software project: Cost estimation, Project scheduling, Staffing and personal planning, Quality assurance plan: Verification and Validation, Inspections and Reviews, project maintaining plans, Risk management: Risk Management Overview, Risk Assessment, Risk Control. **15 Lectures**

Unit III: Function oriented design: Design principles: Problem Partitioning and Hierarchy, Abstraction, Modularity, Top-Down and Bottom-Up Strategies, Modulo level concepts: Coupling, Cohesion, Design notation and specification: Structure Charts, Structured design Methodology, Verification, Metrics: Network Metrics, Stability Metrics, Information Flow Metrics, Object oriented design – object oriented analysis and design, UML, design methodology, Metrics. **15 Lectures**

Unit IV: Detailed design: modulo specification, Detailed design verification: Design Walkthroughs, Critical Design Review, Consistency Checkers, Testing: Testing fundamentals: Error, Fault, and Failure, White box and black box testing, Functional Testing: Equivalence Class Partitioning, Boundary Value Analysis, Structural Testing, testing object oriented program, Stubs and Drivers, Testing process: Comparison of Different Techniques, Levels of Testing, STLC: Phases of STLC, Software Bug, Defect Life cycle, Defect Removal Efficiency **15 Lectures**

S/T/PSS/GD: Seminars, Tutorials, Problem Solving Session and Group Discussions on above units.

Recommended Books:

1. An interpreted approach to software engineering- Pankaj Jalote

Reference Books:

1. Software Engineering – A Practitioners Approach 5th and 6th edition, Roger Pressman

2. Software engineering concepts – Richard Fairley

3. The Practical guide to Structural design – Miller Paige Jones

4. Software Engineering – Martin Shooman

RP307: Research Project (2602PSMTRP307)

CREDITS: 4, LECTURE HOURS: (4+1) PER WEEK, MARKS: 80

The research topic shall be chosen by the student or allotted by the research project supervisor..

SEMESTER - IV

Mathematics MAJOR MANDATORY THEORY PAPER MMT401: Field Theory (2602PSMTMMT401)

CREDITS: 4, LECTURE HOURS: (4+1) PER WEEK, MARKS: 80

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	determine the basis and degree of a field over its subfield.
CO2	construct splitting field for the given polynomial over the given field.
CO3	find primitive n th roots of unity and n th cyclotomic polynomial.
CO4	make use of fundamental theorem of Galois theory and fundamental theorem of Algebra to solve problems in Algebra.
CO5	apply Galois theory to constructions with straight edge and compass.

SYLLABUS

UNIT-I: Algebraic extensions of fields: Adjunction of roots, Algebraic extensions, Algebraically closed fields. **15 Lectures**

UNIT-II: Normal extensions: Splitting fields, Normal extensions, Multiple roots, Finite fields. **15 Lectures**

UNIT-III: Separable extensions and Galois theory: Separable extensions, Automorphism groups and fixed fields, Fundamental theorem of Galois theory, Fundamental theorem of algebra. **15 Lectures**

UNIT – IV: Applications of Galois theory: Roots of unity and cyclotomic polynomials, Cyclic extensions, Symmetric functions, Ruler and compass constructions. **15 Lectures**

S/T/PSS/GD: Seminars, Tutorials, Problem Solving Session and Group Discussions on above units.

Recommended Book(s):

1. Bhattacharya, Jain and Nagpal, Basic Abstract Algebra, second edition, Cambridge University Press.

Reference Books:

1. Joseph Rotman, Galois Theory, second edition, Springer.
2. Nathan Jacobson, Basic Algebra I, second edition, W.H. Freeman and company, New York
3. U.M. Swamy, A.V.S.N. Murthy, Algebra: Abstract and Modern, Pearson Education, 2012
4. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd.
5. John Fraleigh, A first course in Abstract Algebra (3rd edition) Narosa publishing house, New Delhi
6. I.T. Adamson, Introduction to Field Theory, second edition, Cambridge University Press, 1982.
7. M. Artin, Algebra, PHI, 1996.
8. Ian Stewart, Galois Theory, CRC Publication.

Mathematics MAJOR MANDATORY
THEORY PAPER MMT402: Integral Equations (2602PSMTMMT402)

CREDITS: 4, LECTURE HOURS: (4+1) PER WEEK, MARKS: 80

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	classify the linear integral equations and demonstrate the techniques of converting the initial and boundary value problem to integral equations and vice versa.
CO2	develop the technique to solve the Fredholm integral equations with separable kernel
CO3	develop and demonstrate the technique of solving integral equation by Successive approximations, using Laplace and Fourier transforms.
CO4	to analyze the properties of symmetric kernel.
CO5	to prove Hilbert Schmidt theorem and solve the integral equation by applying it

SYLLABUS

UNIT– I : Classification of linear integral equations, Conversion of initial value problem to Volterra integral equation, Conversion of boundary value problem to Fredholm integral equation, Separable kernel, Fredholm integral equation with separable kernel, Fredholm alternative. Homogeneous Fredholm equations and eigen functions. **15 Lectures**

UNIT –II: Solutions of Fredholm integral equations by: Successive approximations Method, Successive substitution Method, Adomian decomposition method, Modified decomposition method, Resolvent kernel of Fredholm equations and its properties, Solutions of Volterra integral equations: Successive approximations method, Neumann series, Successive substitution Method. **15 Lectures**

UNIT –III: Solution of Volterra integral equations by Adomian decomposition method, and the modified decomposition method, Resolvent kernel of Volterra equations and its properties, Convolution type kernels, Applications of Laplace and Fourier transforms to solutions of Volterra integral equations, Symmetric Kernels: Fundamental properties of eigen values and eigen functions for symmetric kernels, expansion in eigen functions and bilinear form. **15 Lectures**

UNIT – IV: Hilbert Schmidt Theorem and its consequences, Solution of symmetric integral equations, Operator method in the theory of integral equations, Solution of Volterra and Fredholm integro-differential equations by Adomian decomposition method, Green's function: Definition, Construction of Green's function and its use in solving boundary value problems. **15 Lectures**

S/T/PSS/GD: Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended Book(s):

1. R.P.Kanwal, Linear Integral Equation: Theory and Technique, Academic Press, 1971.
2. Abdul-Majid Wazwaz, Linear and Nonlinear Integral Equations: Methods and Applications, Springer, 2011

Reference Books:

1. L.G.Chambers, Integral Equations-A Short Course, International Text Book Company, 1976.
2. M.A,Krasnov, et.al. Problems and exercises in Integral equations, Mir Publishers, 1971.
3. J. A. Cochran, The Analysis of Linear Integral Equations, Mc Graw Hill Publications, 1972.
4. C.D.Green, Integral Equation Methods, Thomas Nelson and sons, 1969.

Mathematics MAJOR MANDATORY
THEORY PAPER MMT403: Partial Differential Equations (2602PSMTMMT403)

CREDITS: 4, LECTURE HOURS: (4+1) PER WEEK, MARKS: 80

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	classify partial differential equations and transform into canonical form
CO2	solve linear partial differential equations of both first and second order.
CO3	solve boundary value problems for Laplace's equation, the heat equation, the wave equation by separation of variables, in Cartesian, polar, spherical and cylindrical ordinates.
CO4	apply method of characteristics to find the integral surface of a quasi linear partial differential equations.
CO5	establish uniqueness of solutions of partial differential equations.

SYLLABUS

UNIT– I : Curves and surfaces, First order Partial Differential Equations, classification of first order partial differential equations, classifications of Integrals, Linear equations of first order. Pfaffian differential equations, Criteria of Integrability of a Pfaffian differential equation. Compatible systems of first order partial differential equations. **15 Lectures**

UNIT –II: Charpits method, Jacobi method of solving partial differential equations, Cauchy Problem, Integral surfaces through a given curve for a linear partial differential equations, for a non-linear partial differential equations. Method of characteristics to find the integral surface of a quasi linear partial differential equations. **15 Lectures**

UNIT –III: Second order Partial Differential Equations. Origin of Partial differential equation, wave equations, Heat equation. Classification of second order partial differential equation, Vibration of an infinite string (both ends are not fixed), Physical Meaning of the solution of the wave equation. Vibration of an semiinfinite string, Vibration of a string of finite length, Method of separation of variables, Uniqueness of solution of wave equation. Heat conduction Problems with finite rod and infinite rod. **15 Lectures**

UNIT – IV: Families to equipotential surfaces, Laplace equation, Solution of Laplace equation, Laplace equation in polar form, Laplace equation in spherical polar coordinates. Kelvin's inversion theorem. Boundary Value Problems: Dirichlet problems and Neumann problems, Maximum and minimum principles, Stability theorem. Dirichlet Problems and Neumann problems for a circle, for a rectangle and for a upper half plane, Duhamel's Principle. **15 Lectures**

S/T/PSS/GD: Seminars, Tutorials, Problem Solving Session and Group Discussions on above units.

Recommended Book(s):

1. T. Amarnath: A elementary course in Partial differential equations, 2nd edition, Narosa publishing House (2012).

Reference Books:

1. Mark Pinsky: Partial differential equations and boundary-value problems with applications, AMS, 3rd edition (2011).
2. I. N. Sneddon: Elements of Partial Differential Equations, McGraw Hill Int.
3. Fritz John: Partial Differential Equations, Springer (1952).

Mathematics MAJOR MANDATORY
THEORY PAPER MET405: Fuzzy Set Theory-II(2602PSMTMET405)

CREDITS: 4, LECTURE HOURS: (4+1) PER WEEK, MARKS: 80

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	acquire the concept of fuzzy relations.
CO2	understand the basic concepts of fuzzy logic.
CO3	develop the skills of solving fuzzy relation equations.
CO4	construct approximate solutions of fuzzy relation equations.
CO5	solve problems in Engineering and medicine.

SYLLABUS

Unit I : Projections and cylindrical extensions, binary fuzzy relations on single set, fuzzy equivalence relations, fuzzy compatibility relations, fuzzy ordering relations, fuzzy morphisms sup-i composition and inf-wi composition.
25 Lectures

UnitII: Fuzzy relation equations, problem partitioning, solution methods, fuzzy relational equations based on sup-i and inf-wi compositions, approximate solutions.
15 Lectures

Unit III : Fuzzy propositions, fuzzy quantifiers, linguistic edges, inference from conditional fuzzy propositions, qualified and quantified propositions.
10 Lectures

Unit IV: Approximate reasoning : fuzzy expert systems, fuzzy implications, selection of fuzzy implications, multi-conditional approximate reasoning, the role of fuzzy relation equations, internal valued approximate reasoning.
10Lectures

S/T/PSS/GD: Seminars, Tutorials, Problem Solving Session and Group Discussions on above units.

Recommended Books:

1. GeorgeJKlir,BoYuan,FuzzySetsandFuzzyLogic:Theoryandapplications,PHI. Ltd.(2000)

Reference Books:

1. M.Grabish,Sugeno,andMurofushi,FuzzyMeasuresandIntegrals:TheoryandApplications PHI, 1999.
2. H. J. Zimmerermann, Fuzzy set:Theory and itsApplications, Kluwer,1984.
- 3.M. Ganesh, Introduction to Fuzzy sets & Fuzzy Logic;PHI Learning Private Limited, New Delhi. 2011.
4. John Mordeson, Fuzzy Mathematics, Springer,2001

Mathematics MAJOR MANDATORY
THEORY PAPER MET406: Internet of Things (2602PSMTMET406)

CREDITS: 4, LECTURE HOURS: (4+1) PER WEEK, MARKS: 80

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	understand the basic concepts, principles ,and components of the Internet of Things.
CO2	apply IoT to different applications
CO3	analysis and evaluate protocols used in IoT
CO4	design smart city in IoT.
CO5	analysis data received through sensors in IoT

SYLLABUS

Unit-I : Basics of IoT: Understanding IoT fundamentals, IOT Architecture and protocols, Various Platforms for IoT, Real time Examples of IoT, Overview of IoT components and IoT Communication Technologies, Challenges in IOT Arduino Simulation Environment: Arduino Uno Architecture, Setup the IDE, Writing Arduino Software, Arduino Libraries, Basics of Embedded C programming for Arduino, Interfacing LED, push button and buzzer with Arduino, Interfacing Arduino with LCD **15 Lectures**

Unit-II: Sensor & Actuators with Arduino: Overview of Sensors working, Analog and Digital Sensors, Interfacing of Temperature, Humidity, Motion, Light and Gas Sensor with Arduino, Interfacing of Actuators with Arduino, Interfacing of Relay Switch and Servo Motor with Arduino Basic Networking with ESP8266 WiFi module: Basics of Wireless Networking, Introduction to ESP8266 Wi-Fi Module, Various Wi-Fi library, Web server- introduction, installation, configuration, Posting sensor(s) data to web server **15 Lectures**

Unit-III: Cloud Platforms for IOT: Virtualization concepts and Cloud Architecture, Cloud computing, benefits, Cloud services -- SaaS, PaaS, IaaS, Cloud providers & offerings, Study of IOT Cloud platforms, ThingSpeak API and MQTT, Interfacing ESP8266 with Web services Architecture for IoT: Domain model specification, Information Model Specification, Service specification, IoT Level specification, Functional view, Operational view, Device and Component Integration, User centred design, Open source development, End user programming, Tools for IoT. **15 Lectures**

Unit-IV: Developing IoT solutions: Introduction to Python, Introduction to different IoT tools, Introduction to Arduino and Raspberry Pi Implementation of IoT with Arduino and Raspberry, Cloud Computing, Fog Computing, Connected Vehicles, Data Aggregation for the IoT in Smart Cities, Privacy and Security Issues in IoT **15 Lectures**

S/T/PSS/GD: Seminars, Tutorials, Problem Solving Session and Group Discussions on above units.

References:

1. JanHoller,VlasiosTsiatsis,CatherineMulligan,StefanAvesand,StamatisKarnouskos,David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age

- of Intelligence”, 1st Edition, Academic Press, 2014
2. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on Approach)”, 1st Edition, VPT, 2014
 3. Honbo Zhou, “The Internet of Things in the Cloud: A Middleware Perspective”, CRC Press, 2012. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), “Architecting the Internet of Things”, Springer, 2011
 4. David Hanes, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Cisco Press, ISBN-13: 978-1-58714-456-1, ISBN-10: 1-58714-456-5, 2017

RP407: Research Project (2602PSMTRP407)

CREDITS: 6, LECTURE HOURS: (6+1) PER WEEK, MARKS: 120

The research topic shall be chosen by the student or allotted by the research project supervisor..

Scheme of Teaching

4. In a week for each Theory Course 4 lectures and 1 Seminar/Tutorial/Problem Solving Session/ Group Discussion shall be conducted.
5. Each theory lecture shall be of 60 minutes.
6. Seminar/Tutorial/Problem Solving Session/ Group Discussion shall be taken batch wise..Each batch shall be of not more than 15 students.

Examination Pattern

Theory:

- **For 4 credit course:**
University examinations shall be of 80 marks and internal examination of 20 marks
- **For 2 credit course:**
University examinations shall be of 40 marks and internal examination of 10 marks

Research Project:

- **For 4 credit course:**
Assessment criteria of research project shall be based on final report/dissertation, presentation and oral examinations. University examinations shall be of 80 marks and internal examination of 20 marks.
 1. Research project viva by university appointed external and internal examiners.
 2. Internal evaluation will be carried out by internal supervisor.
 3. Research Project Evaluation:

Internal evaluation	20 Marks
Final report/dissertation	50 Marks
Presentation and oral examinations	30 Marks
Total	100 Marks

- **For 6 credit course:**
Assessment criteria of research project shall be based on final report/dissertation, presentation and oral examinations. University examinations shall be of 100 marks and internal examination of 50 marks.
 1. Research project viva by university appointed external and internal examiners.
 2. Internal evaluation will be carried out by internal supervisor.
 3. Research Project Evaluation:

Internal evaluation	50 Marks
Final report/dissertation	70 Marks
Presentation and oral examinations	30 Marks
Total	150 Marks

Nature of Question Paper and Scheme of Marking: End Semester Assessment:

Theory:

(I) Nature of the Theory Question Papers for courses of 4 credits:

1. There shall be 7 questions each carrying 16 marks.
2. Question No.1 is compulsory. It consists of objective type questions.
3. Students have to attempt any four questions from Question No.2 to Question No.7.
4. Question No.2 to Question No.7 shall consist of short/descriptive-answer type sub-questions.
5. Duration of university theory examination of 80 marks shall be of 3 hours.

(II) Nature of the Theory Question Papers for courses of 2 credits:

1. There shall be 4 questions.
2. Question No.1 is compulsory of objective type questions carrying 8 marks.
3. Students have to attempt any two questions from Question No.2 to Question No.4.
Each question carries 16 marks.
4. Duration of university theory examination of 40 marks shall be of 2 hours.

Internal Assessment:

(I) Nature of the Internal Question Papers for courses of 4 credits:

The internal examination shall be of 20 marks and may consist of objective, short, descriptive type questions.

(II) Nature of the Internal Question Papers for courses of 2 credits:

The internal examination shall be of 10 marks and may consist of objective, short, descriptive type questions.