Estd. 1962
"A++" Accredited by
NAAC (2021)
With CGPA 3.52

SHIVAJI UNIVERSITY, KOLHAPUR - 416004, MAHARASHTRA

PHONE:EPABX-2609000, www.unishivaji.ac.in, bos@unishivaji.ac.in

शिवाजी विद्यापीठ, कोल्हापूर -४१६००४,महाराष्ट्र

दूरध्वनी-ईपीएबीएक्स -२६०९०००, अभ्यासमंडळे विभाग दुरध्वनी ०२३१—२६०९०९४
०२३१—२६०९४८७

SU/BOS/Science/09 **Date: 02/01/2024**

To,

The Principal, All Concerned Affiliated Colleges/Institutions Shivaji University, Kolhapur	The Head/Co-ordinator/Director All Concerned Department (Science) Shivaji University, Kolhapur.

Subject: Regarding syllabi of M.Sc. Part-II (Sem. III & IV) as per NEP-2020 (1.0) degree programme under the Faculty of Science and Technology.

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the revised syllabi, nature of question paper and equivalence of M.Sc. Part-II (Sem. III & IV) as per NEP-2020 (1.0) degree programme under the Faculty of Science and Technology.

M.Sc.-II (Sem. III & IV) as per NEP-2020 (1.0)			
1.	Mathematics	9.	Gen Microbiology
2.	Mathematics (Distance Mode)	10.	Pharmaceutical Microbiology (HM)
3.	Mathematics (Online Mode)	11.	Alcohol Technology
4.	MSc.(Mathematics With Computer Application)	12.	Sugar Technology
5.	Statistics	13.	Geology
6.	Applied Statistics and Informatics	14.	AGPM
7.	Electronics	15.	Geoinformatics
8.	Microbiology (HM)	16.	Physics

This syllabus, nature of question and equivalence shall be implemented from the academic year 2024-2025 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website www.unishivaji.ac.in,NEP-2020 (Online Syllabus).

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October /November 2024 & March/April 2025. These chances are available for repeater students, if any.

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Dy Registrar
Dr. S. M. Kubal

Copy to:

1	The Dean, Faculty of Science & Technology	4	P.G Admission / Eligibility Section
2	The Chairman, Respective Board of Studies	5	Computer Centre/ Eligibility Section
3	B.Sc. Exam/ Appointment Section	6	Affiliation Section (U.G.) (P.G.)

SHIVAJI UNIVERSITY, KOLHAPUR

Established: 1962

A++ Accredited by NAAC (2021) with CGPA 3.52

Structure and Syllabus in Accordance with

National Education Policy - 2020

with Multiple Entry and Multiple Exit

Master of Science (Mathematics)(Online Mode)

Part –II (Level-6.5) (Semester III and IV)

under
Faculty of Science and Technology

(To Be Implemented From Academic Year 2024-25)

INDEX

1. Preamble

The Department of Mathematics was established in the year 1964. Since then it has been consistently endeavoring to strengthen the academic foundations by exploring new areas of higher learning and research. Well qualified faculty, specialized in various disciplines is the strength of the Department. Faculty members are actively engaged in the teaching, research and extension activities. The department has its own library with around 6000 books funded by the NBHM, well equipped computer lab with internet facilities and the well-furnished Ramanujan hall having hundred seating capacity.

2. Duration:

The M.Sc. (Mathematics) will be a full-time TWO years (4 semesters) programme.

3. Eligibility for Admission:

Eligibility for level 6:

i) Any candidate who has successfully completed B. Sc. with a principal subject Mathematics or with a subsidiary subject Mathematics of this University or of any other statutory University recognized by UGC, New Delhi.

OR

ii) Any candidate who has successfully completed the Bachelor's degree with Mathematics courses at Second Year of Bachelor's degree of this University or of any other statutory University recognized by UGC, New Delhi.

OR

iii) Any candidate who has successfully completed level 5.5 with major or minor subject as Mathematics of this University or of any other statutory University recognized by UGC, New Delhi.

Eligibility for level 6.5:

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) (Level 6.0) 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.

4. Medium of Instruction:

The medium of Instruction will be English.

5. Programme Structure

Structure in Accordance with National Education Policy - 2020
With Multiple Entry and Multiple Exit Options
M.Sc. (Mathematics) (Online Mode) Part – I (Level-6.0)

	Course Code	Credit	Examination Scheme					
			University Assessment (UA)			Internal Assessment (IA)		
			Maximum Marks	Minimum Marks	Exam. Hours	Maximum Marks	Minimum Marks	Exam. Hours
Semester-I								
Major Mandatory	MMT-101	4	80	32	3	20	8	1
	MMT -102	4	80	32	3	20	8	1
	MMT-103	4	80	32	3	20	8	1
	MMT -104	2	40	16	2	10	4	1/2
Major Elective	MET-105	4	80	32	3	20	8	1
Research Methodology	RM-106	4	80	32	3	20	8	1
Total		22	440			110		
Semester-II								
Major Mandatory	MMT-201	4	80	32	3	20	8	1
	MMT -202	4	80	32	3	20	8	1
	MMT -203	4	80	32	3	20	8	1
	MMT -204	2	40	16	2	10	4	1/2
Major Elective	MET-205	4	80	32	3	20	8	1
OJT/FP	OJT-206	4	80	32	3	20	8	1
Total		22	440			110		
Total (Sem I + Sem II)		44						

• MMT – Major Mandatory Theory • MMPR – Major Mandatory Practical • MET – Major Elective Theory • MEPR – Major Elective Practical • RM - Research Methodology • OJT/FP- On Job Training/ Field Project	• Total Marks for M.Sc.-I : **1100** • Total Credits for M.Sc.-I (Semester I & II) : 44 • ***Separate passing is mandatory for University and Internal Examinations***
*Evaluation scheme for OJT/FP shall be decided by concerned BOS	

- **Requirement for Entry at Level 6.0:**

1. Any candidate who has successfully completed B. Sc. with a principal subject Mathematics or with a subsidiary subject Mathematics of this University or of any other statutory University recognized by UGC, New Delhi.

OR

2. Any candidate who has successfully completed the Bachelor's degree with Mathematics courses at Second Year of Bachelor's degree of this University or of any other statutory University recognized by UGC, New Delhi.

OR

3. Any candidate who has successfully completed level 5.5 with major or minor subject as Mathematics of this University or of any other statutory University recognized by UGC, New Delhi.

- **Requirement for Exit after Level 6.0:**

Students can exit after completion of Level 6.0 with Post Graduate Diploma in Mathematics

Structure in Accordance with National Education Policy - 2020
With Multiple Entry and Multiple Exit Options
M.Sc. (Mathematics)(Online Mode) Part – II (Level-6.5)

	Course Code	Credit	Examination Scheme					
			University Assessment (UA)			Internal Assessment (IA)		
			Maximum Marks	Minimum Marks	Exam. Hours	Maximum Marks	Minimum Marks	Exam. Hours
Semester-III								
Major Mandatory	MMT-301	4	80	32	3	20	8	1
	MMT -302	4	80	32	3	20	8	1
	MMT -303	4	80	32	3	20	8	1
	MMT-304	2	40	16	2	10	4	1/2
Major Elective	MET-305	4	80	32	3	20	8	1
Research Project	RP-307	4	80	32	3	20	8	1
Total		22	440			110		
Semester-IV								
Major Mandatory	MMT-401	4	80	32	3	20	8	1
	MMT -402	4	80	32	3	20	8	1
	MMT -403	4	80	32	3	20	8	1
Major Elective	MET -405	4	80	32	3	20	8	1
Research Project	RP -407	6	100	40	3	50	20	2
Total		22	420			130		
Total (Sem III + Sem IV)		44						

- MMT – Major Mandatory Theory
- MMPR – Major Mandatory Practical
- MET – Major Elective Theory
- MEPR – Major Elective Practical
- RP- Research Project

- Total Marks for M.Sc.-II : **1100**
- Total Credits for M.Sc.-II (Semester III & IV) : 44
- ***Separate passing is mandatory for University and Internal Examinations***

Evaluation scheme for Research Project: 80% weightage for University assessment and 20% for Internal Assessment.

- **Requirement for Entry at Level 6.5:**

1. 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

2. Any candidate who has successfully completed Bachelor's Degree (Honours / Honours with Research) (Level 6.0) with principal / major subject Mathematics of this University or of any other statutory University recognized by UGC, New Delhi.

OR

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

- **Requirement for Exit after Level 6.5:**
  Students can exit after completion of Level 6.5 with Post Graduate in Mathematics.

6. Programme Outcomes (POs)

- To develop problem-solving skills and apply them independently to problems in pure and applied mathematics.
- To develop abstract mathematical thinking.
- To improve the abilities of students this will be helpful to qualify competitive examinations.
- Apply knowledge of Mathematics, in all the fields of learning including higher research.
- Work effectively as an individual, and also as a member or leader in multi-linguistic and multi-disciplinary teams.
- To qualify lectureship and fellowship exams such as NET, GATE, SET etc.
- Understand the basic concepts, fundamental principles and mathematical theories related to various courses and their relevance to other sciences.

7. Course Codes

M. Sc.(Mathematics) (Online Mode) Part I (Semester I and II)

Semester	Code	Course Code	Title of New Course
I	MMT-101	MSU0325MML827G1	Linear Algebra
I	MMT-102	MSU0325MML827G2	Real Analysis
I	MMT-103	MSU0325MML827G3	Ordinary Differential Equations
I	MMT-104	MSU0325MML827G4	Numerical Analysis-I
I	MET-105	MSU0325MEL827G1	Combinatorics
		MSU0325MEL827G7	Linear programming and its applications
I	RM-106	MSU0325RML827G	Research Methodology
II	MMT-201	MSU0325MML827H1	Algebra
II	MMT-202	MSU0325MML827H2	Topology
II	MMT-203	MSU0325MML827H3	Advanced Calculus
II	MMT-204	MSU0325MML827H4	Numerical Analysis - II
II	MET-205	MSU0325MEL827H1	Number Theory
		MSU0325MEL827H7	Quantitative techniques in operations Research
II	OJT-206 / FP-206	MSU0325OJP827H / MSU0325FPP827H	On job Training / Field project

M. Sc.(Mathematics) (Online Mode) Part II (Semester III and IV)

Semester	Code	Course Code	Title of New Course
III	MMT-301	MSU0325MML927I1	Functional Analysis
III	MMT-302	MSU0325MML927I2	Complex Analysis
III	MMT-303	MSU0325MML927I3	Classical Mechanics
III	MMT-304	MSU0325MML927I4	Advanced Discrete Mathematics
III	MET-305	MSU0325MEL927I2	Fluid Dynamics
		MSU0325MEL927I9	Fuzzy Set Theory
III	RP-306	MSU0325RPP927I	Research Project
IV	MMT-401	MSU0325MML927J1	Integral Equations
IV	MMT-402	MSU0325MML927J2	Field Theory
IV	MMT-403	MSU0325MML927J3	Partial Differential Equations
IV	MET-404	MSU0325MEL927J2	Computational Fluid Dynamics
		MSU0325MEL927J9	Fuzzy Relations and Logic
IV	RP-405	MSU0325RPP927J	Research Project

M.Sc. (Mathematics)(Online Mode) Part–I (Level-6.0)

Semester	**Mandatory Major** 4 credits	**Mandatory Major** 2 credits	**Mandatory Elective (any one)** 4 credits	**Mandatory RM and OJT/FP** 4 credits
I	1) Linear Algebra 2) Real Analysis 3) Ordinary Differential Equations	Numerical Analysis-I	1) Combinatorics 2) Linear programming and its applications	Research Methodology
II	1) Algebra 2) Topology 3) Advanced Calculus	Numerical Analysis - II	1) Number Theory 2) Quantitative techniques in operations Research	On job Training/ Field project

M.Sc. (Mathematics)(Online Mode) Part–II (Level-6.5)

Semester	**Mandatory Major** 4 credits	**Mandatory Major** 2 credits	**Mandatory Elective (any one)** 4 credits	**Mandatory RM and OJT/FP**
III	1) Functional Analysis 2) Complex Analysis 3) Classical Mechanics	Advanced Discrete Mathematics	1) Fluid Dynamics 2) Fuzzy Set Theory	Research Project (4 credits)
IV	1) Integral Equations 2) Field Theory 3) Partial Differential Equations	---	1) Computational Fluid Dynamics 2) Fuzzy Relations and Logic	Research Project (6 credits)

M. Sc. Mathematics (Online Mode)
(Part II) (Level-6.5) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2024-25)

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Functional Analysis
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

1. understand the fundamental topics, principles and methods of functional analysis.
2. demonstrate the knowledge of normed spaces, Banach spaces, Hilbert space.
3. define continuous linear transformations between linear spaces, bounded linear functionals.
4. apply finite dimensional spectral theorem.
5. identify normal, self adjoint, unitary, normal operators.

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 Perseval's equation, separable Hilbert spaces, the conjugate of Hilbert space, Riesz's theorem, the adjoint of an operator. **15Lectures**

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. **15Lectures**

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. Convey, A course in Functional Analysis, Springer-Verlag, 1985.
4. G. Bachman and L. Narici, Functional Analysis, Academic Press, 1972.
5. B. V. Limaye, Functioned Analysis, New age international, 1996.

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Complex Analysis
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

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

UNIT– 1: Power series, 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, Rouche's theorem, Schwarz's lemma and its application to characterize conformal maps. **15 Lectures**

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 Bostan, 2006
4. J. Brown, R.Churchill , Complex Variables and Applications, MacGraw 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.

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Classical Mechanics
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. discuss the motion of system of particles using Lagrangian and Hamiltonian approach.
2. solve extremization problems using variational calculus.
3. discuss the motion of rigid body.
4. construct Hamiltonian using Routh process.
5. use infinitesimal and finite rotations to analyze motion of rigid body.

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 Langrange'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. **15Lectures**

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. **15Lectures**

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

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Advanced Discrete Mathematics
Total Credits: 02
Course Outcomes: Upon successful completion of this course, the student will be able to:

1. classify the graphs and apply to real world problems.
2. simplify the graphs using matrix.
3. simplify the Boolean identities and apply to switching circuits.
4. learn applications of discrete mathematics including lattices and Boolean Algebra.

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**

Recommended Book(s):

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

Reference Books:

1. Seymon 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.

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Fluid Dynamics
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1) explain physical properties of fluids.
2) represent general motion of fluid element.
3) test possible fluid flows, classify rotational and irrotational fluid flows .
4) transform stress components from one co-ordinate system to another, establish relation between strain and stress tensor.
5) develop constitutive equations for Newtonian fluids, conservation laws and Navier-Stokes equation.
6) determine the complex potential and images of a two dimensional source, sink and doublet.

UNIT– I: Physical properties of fluids and kinematics of fluids: Concepts of fluids, continuum hypothesis, density, specific weight, specific volume, pressure, viscosity, surface tension, Eulerion & Lagrangian methods of description of fluids, Equivalence in Eulerian and Lagrangian methods, stream lines, path lines, streak lines, stream function, vortex lines, circulation, condition at rigid boundary, general motion of a fluid element. **15 Lectures**

UNIT –II: **Stresses in fluids:** Strain rate tensor, stress tensor, normal stress, shearing stress, symmetry of stress tensor, transformation of stress components from one co-ordinate system to another, principle axes and principle values of stress tensor. Newtonian fluids, constitutive equations for Newtonian fluids. **15 Lectures**

UNIT –III: Conservation laws: Equation of conservation of mass, equation of conservation of momentum, Navier-Stokes equation, equation of moment of momentum, equation of energy, general orthogonal curvilinear co-ordinate system, basic equations in different co-ordinate systems: Cartesian co-ordinate system, Cylindrical co-ordinate system, Spherical co-ordinate system. **15 Lectures**

UNIT – IV: Rotational and irrotational flows: Theorems about rotational and irrotational flows: Kelvins minimum energy theorem, kinetic energy of finite and an infinite fluid, uniqueness of irrotational flows, Bernoullis's equation, Bernoullis equation for irrotational flows, Two dimensional irrotational incompressible flows, circle theorem. Sources and sinks: sources, sinks and doublets in two dimensional flows, methods of images. **15 Lectures**

Recommended Book(s):
1. R. K. Rathy, An introduction to Fluid Dynamics, Oxford & IBH publishing company.
2. F. Chorlton, Text book of Fluid Dynamics, CHS Publishers, Delhi, 1985.
Reference Books:
1. J. K. Goyal and K. P. Gupta, Fluid Dynamics and Advanced Hydrodynamics, Pragati Prakashan, Meerut 1989.
2. L. D. Landay and E. M. Lipschitz, Fluid Mechanics, Pergamon Press London 1985.
3. Kundu and Cohen, Fluid Mechanics, Elsevier pub. 2004.
4. L M Milne-Thomson, Theoretical Hydrodynamics, Macmillan Education Ltd, London 1986.

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Fuzzy Set Theory
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

1. acquire the knowledge of notion of crisp sets and fuzzy sets,
2. understand the basic concepts of crisp set and fuzzy set,
3. develop the skill of operation on fuzzy sets and fuzzy arithmetic,
4. demonstrate the techniques of fuzzy sets and fuzzy numbers.
5. Apply the notion of fuzzy set, fuzzy number in various problems.

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, **r**epresentation of fuzzy sets, decomposition theorems,extensionprinciple,propertiesofdirectandinverseimagesoffuzzysets.
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. 1**5 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

Recommended Books:

1. George J. Klir, BoYuan, 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. Zimmerermann, 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; PHIL earning Private Limited, New Delhi 2011.
5. Bojadev and M. Bojadev, Fuzzy Logic and Application,World Scientific Publication Pvt. Ltd. 2007.

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Research Project

Total Credits: 04

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

M. Sc. Mathematics (Online Mode)
(Part II) (Level-6.5) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2024-25)

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Integral Equations
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

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

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 eigenfunctions. **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 eigenvalues and eigenfunctions for symmetric kernels, expansion in eigenfunctions 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 integrodifferential equations by Adomian decomposition method, Green's function: Definition, Construction of Green's function and its use in solving boundary value problems. **15 Lectures**

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.

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Field Theory
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1) determine the basis and degree of a field over its subfield.
2) construct splitting field for the given polynomial over the given field.
3) find primitive nth roots of unity and nth cyclotomic polynomial.
4) make use of fundamental theorem of Galois theory and fundamental theorem of Algebra to solve problems in Algebra.
5) apply Galois theory to constructions with straight edge and compass.

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: Seperable 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**

Recommended Book(s):
1. Bhattacharya, Jain and Nagpaul, 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.

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Partial Differential Equations
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

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

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 semi infinite 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: Dirichlets 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

Recommended Book(s):

1. T. Amarnath: An 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).

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Computational Fluid Dynamics
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. classify partial differential equations (PDEs) mathematically and physically.
2. apply separation of variables method for solving initial boundary value problems.
3. construct forward, backward and centered difference formulae.
4. test stability, convergence & consistency of finite difference schemes.
5. solve problems in CFD using Scilab software.

UNIT– I: Comparison of experimental, theoretical and numerical approaches, governing equations, continuity equation, momentum equation (inviscid, viscous flows) energy equation, incompressible viscous flow, laminar boundary layer flow. Introduction of Scilab to solve problems in CFD. **15 Lectures**

UNIT –II: Nature of a well posed problems, physical classification and mathematical classification of partial differential equations: hyperbolic, parabolic, elliptic partial differential equations (PDEs). Conversion of PDE to canonical form. Traditional solution method: separation of variables. Transformation relationships, evaluation of transformation parameters. Forward, backward, centered difference formulae, generalized co-ordinates structure of first and second order PDE. **15 Lectures**

UNIT –III: Stability, convergence and consistency of finite difference scheme, Explicit, Implicit and Crank- Nicolson methods for heat equation, Von Neumann analysis, Euler's explicit method, upstream differencing method, Lax method, Euler implicit method for wave equation. Finite difference representation of Laplace equation, five point method. Problem solving by Scilab: codes of explicit methods for heat and wave equations and five point method for Laplace equation. **15Lectures**

UNIT – IV: Finite difference schemes for Burgers equation (inviscid): Lax method, implicit methods. Finite difference schemes for Burgers equation (viscous): FTCS method, Briley – Mc Donald method. Convergence and stability, grid generation, orthogonal gird generation, order of magnitude analysis, reduced Navier-Stokes equations, boundary layer flow. **15Lectures**

Recommended Book(s):
1. Dale A Anderson, John Tannelhill, R. H. Fletcher, Computational Fluid Mechanics and Heat Transfer, Hemisphere publishing corporation, 1984.
2. G D Smith, Numerical Solution of Partial Differential Equations: Finite Difference Methods, Oxford Applied Mathematics and Computing Science Series, Oxford University Press, 1985.
3. C. A.J. Fletcher, Computational Techniques for Fluid Dynamics Vol. I & II, Springer Verlag Berlin Heidelberg, 1988.

Reference Books:
1. T J Chung, Computational Fluid Dynamics, Cambridge University Press, 2002.

M. Sc. Mathematics (Part II) (Level-6.5) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Fuzzy Relations and Logic
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. acquire the concept of fuzzy relations.
2. understand the basic concepts of fuzzy logic.
3. develop the skills of solving fuzzy relation equations.
4. construct approximate solutions of fuzzy relation equations.
5. solve problems in Engineering and medicine.

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**

Unit II: 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. 1**0Lectures**

Recommended Books:

1. George J Klir, BoYuan, 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. Zimmerermann, Fuzzy set: Theory and its Applications, Kluwer,1984.
3. M. Ganesh, Introduction to Fuzzy sets & Fuzzy Logic; PHIL earning Private Limited, New Delhi. 2011.
4. John Mordeson, Fuzzy Mathematics, Springer,2001

M. Sc. Mathematics (Online Mode) (Part II) (Level-6.5) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Research Project
Total Credits: 06

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

9. Scheme of Teaching

1. In a week for each theory course 4 lectures and 1 Seminar/Tutorial/Problem Solving Session shall be conducted.
2. Each theory lecture shall be of 60 minutes.
3. Seminar/Tutorial/Problem Solving Session shall be taken batch wise. Each batch shall be of not more than 15 students.

10. 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

On Job Training/Field Project:

Assessment criteria of OJT/FP shall be based on final report, presentation and oral examination.

1. Student has to submit final report based on the work carried out during OJT/FP.
2. Student has to make a presentation of the work carried out during OJT/FP in front of university appointed panel of one external and one internal examiner.
3. Student has to give midterm presentation of the work carried out during OJT/FP.
4. OJT/FP Evaluation:

Midterm Presentation	20 Marks
Report and Completion certificate of OJT/FP	50 Marks
Presentation and oral examinations	30 Marks
Total	100 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 guide.
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 guide.
3. Research Project Evaluation:

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

Research Methodology:

University examinations shall be of 80 marks and internal examination of 20 marks.

11. 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 7questions 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.

12. Equivalence of courses

There is no need to give equivalence of courses as the course will be started from academic year 2024-25.