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

SHIVAJI UNIVERSITY, KOLHAPUR - 416004, MAHARASHTRA
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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)
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) Part – I (Level-6.0)

	Course Code	Teaching Scheme			Examination Scheme					
		Theory and Practical			University Assessment (UA)			Internal Assessment (IA)		
		Lectures + S/T/PSS (Hours / week)	Practical (Hours / week)	Credit	Maximum Marks	Minimum Marks	Exam. Hours	Maximum Marks	Minimum Marks	Exam. Hours
Semester-I										
Major Mandatory	MMT-101	4+1	--	4	80	32	3	20	8	1
	MMT -102	4+1	--	4	80	32	3	20	8	1
	MMT-103	4+1	--	4	80	32	3	20	8	1
	MMT -104	2+1	--	2	40	16	2	10	4	1/2
Major Elective	MET-105	4+1	--	4	80	32	3	20	8	1
Research Methodology	RM-106	4+1	--	4	80	32	3	20	8	1
Total				22	440			110		
Semester-II										
Major Mandatory	MMT-201	4+1	--	4	80	32	3	20	8	1
	MMT -202	4+1	--	4	80	32	3	20	8	1
	MMT -203	4+1	--	4	80	32	3	20	8	1
	MMT -204	2+1	--	2	40	16	2	10	4	1/2
Major Elective	MET-205	4+1	--	4	80	32	3	20	8	1
OJT/FP	OJT-206	--	8	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 • S/T/PSS – Seminar/Tutorial/Problem Solving Session	• 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*** • **Seminar/Tutorial/Problem Solving Session shall be taken batch wise. Each batch shall be of not more than 15 students.**
*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) Part – II (Level-6.5)

	Course Code	Teaching Scheme			Examination Scheme					
		Theory and Practical			University Assessment (UA)			Internal Assessment (IA)		
		Lectures + S/T/PSS (Hours / week)	Practical (Hours / week)	Credit	Maximum Marks	Minimum Marks	Exam. Hours	Maximum Marks	Minimum Marks	Exam. Hours
Semester-III										
Major Mandatory	MMT-301	4+1	--	4	80	32	3	20	8	1
	MMT -302	4+1	--	4	80	32	3	20	8	1
	MMT -303	4+1	--	4	80	32	3	20	8	1
	MMT-304	2+1	--	2	40	16	2	10	4	1/2
Major Elective	MET-305	4+1	--	4	80	32	3	20	8	1
Research Project	RP-307	--	8	4	80	32	3	20	8	1
Total				22	440			110		
Semester-IV										
Major Mandatory	MMT-401	4+1	--	4	80	32	3	20	8	1
	MMT -402	4+1	--	4	80	32	3	20	8	1
	MMT -403	4+1	--	4	80	32	3	20	8	1
Major Elective	MET -405	4+1	--	4	80	32	3	20	8	1
Research Project	RP -407	--	12	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 • S/T/PSS – Seminar/Tutorial/Problem Solving Session	• 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*** • **Seminar/Tutorial/Problem Solving Session shall be taken batch wise. Each batch shall be of not more than 15 students.**

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) Part I (Semester I and II)

Semester	Code	Course Code	Title of New Course
I	MMT-101	MSU0325MML825G1	Linear Algebra
I	MMT-102	MSU0325MML825G2	Real Analysis
I	MMT-103	MSU0325MML825G3	Ordinary Differential Equations
I	MMT-104	MSU0325MML825G4	Numerical Analysis-I
I	MET-105	MSU0325MEL825G1	Combinatorics
		MSU0325MEL825G2	Differential Geometry
		MSU0325MEL825G3	Integral Transforms
		MSU0325MEL825G4	Theory of computations
		MSU0325MEL825G5	Graph Theory- I
		MSU0325MEL825G6	Lattice Theory-I
		MSU0325MEL825G7	Linear programming and its applications
		MSU0325MEL825G8	Dynamical Systems-I
		MSU0325MEL825G9	Basics of Python
		MSU0325MEL825G10	Web Technology
I	RM-106	MSU0325RML825G	Research Methodology
II	MMT-201	MSU0325MML825H1	Algebra
II	MMT-202	MSU0325MML825H2	Topology
II	MMT-203	MSU0325MML825H3	Advanced Calculus
II	MMT-204	MSU0325MML825H4	Numerical Analysis - II
II	MET-205	MSU0325MEL825H1	Number Theory
		MSU0325MEL825H2	Advanced Algebra
		MSU0325MEL825H3	Difference Equations
		MSU0325MEL825H4	Algebraic Automata Theory
		MSU0325MEL825H5	Graph Theory II
		MSU0325MEL825H6	Lattice Theory- II
		MSU0325MEL825H7	Quantitative techniques in operations Research
		MSU0325MEL825H8	Dynamical Systems-II
		MSU0325MEL825H9	Data Science with Python
		MSU0325MEL825H10	PHP with MySQL
II	OJT-206 / FP-206	MSU0325OJP825H / MSU0325FPP825H	On job Training / Field project

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

Semester	Code	Course Code	Title of New Course
III	MMT-301	MSU0325MML925I1	Functional Analysis
III	MMT-302	MSU0325MML925I2	Complex Analysis
III	MMT-303	MSU0325MML925I3	Classical Mechanics
III	MMT-304	MSU0325MML925I4	Advanced Discrete Mathematics
III	MET-305	MSU0325MEL925I1	Algebraic Number Theory
		MSU0325MEL925I2	Fluid Dynamics
		MSU0325MEL925I3	Dynamic Equations on Time Scales
		MSU0325MEL925I4	Coding Theory
		MSU0325MEL925I5	Fixed Point Theory and Applications
		MSU0325MEL925I6	Measure and Integration
		MSU0325MEL925I7	Introduction to Cryptography
		MSU0325MEL925I8	Automata, Languages And computations
		MSU0325MEL925I9	Fuzzy Set Theory
		MSU0325MEL925I10	Theory of Ideals
		MSU0325MEL925I11	Software Engineering and Project Management
III	RP-306	MSU0325RPP925I	Research Project
IV	MMT-401	MSU0325MML925J1	Integral Equations
IV	MMT-402	MSU0325MML925J2	Field Theory
IV	MMT-403	MSU0325MML925J3	Partial Differential Equations
IV	MET-404	MSU0325MEL925J1	Space Dynamics
		MSU0325MEL925J2	Computational Fluid Dynamics
		MSU0325MEL925J3	Fractional Calculus
		MSU0325MEL925J4	Approximation Theory
		MSU0325MEL925J5	Wavelet Analysis
		MSU0325MEL925J6	Boundary Value Problem
		MSU0325MEL925J7	Probability and Stochastic Processes
		MSU0325MEL925J8	Theory of Distribution
		MSU0325MEL925J9	Fuzzy Relations and Logic
		MSU0325MEL925J10	Module Theory
		MSU0325MEL925J11	Internet of Things
IV	RP-405	MSU0325RPP925J	Research Project

M.Sc. (Mathematics) 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) Differential Geometry 3) Integral Transforms 4) Theory of computations 5) Graph Theory- I 6) Lattice Theory-I 7) Linear programming and its applications 8) Dynamical Systems-I 9) Basics of Python 10)Web Technology	Research Methodology
II	1) Algebra 2) Topology 3) Advanced Calculus	Numerical Analysis - II	1) Number Theory 2) Advanced Algebra 3) Difference Equations 4) Algebraic Automata Theory 5) Graph Theory II 6) Lattice Theory- II 7) Quantitative techniques in operations Research 8) Dynamical Systems-II 9) Data Science with Python 10)PHP with MySQL	On job Training/ Field project

M.Sc. (Mathematics) 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) Algebraic Number Theory 2) Fluid Dynamics 3) Dynamic Equations on Time Scales 4) Coding Theory 5) Fixed Point Theory 6) Measure and Integration 7) Introduction to Cryptography 8) Automata, Languages And computations 9) Fuzzy Set Theory 10) Theory of Ideals 11) Software Engineering and Project Management	Research Project (4 credits)
IV	1) Integral Equations 2) Field Theory 3) Partial Differential Equations	---	1) Space Dynamics 2) Computational Fluid Dynamics 3) Fractional Calculus 4) Approximation Theory 5) Wavelet Analysis 6) Boundary Value Problem 7) Probability and Stochastic Processes 8) Theory of Distribution 9) Fuzzy Relations and Logic 10) Module Theory 11) Internet of Things	Research Project (6 credits)

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

M. Sc. Mathematics (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**

S/T/PSS: 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. 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 (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**

S/T/PSS: 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 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 (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**

S/T/PSS: 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

M. Sc. Mathematics (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**

S/T/PSS: 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. 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 (Part II) (Level-6.5) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2024-25)

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

1. deal with algebraic numbers, algebraic integers and its applications,
2. concept of lattices and geometric representation of algebraic numbers.
3. understand the concept of fractional ideals.
4. relate finitely generated abelian groups and modules
5. derive Minkowski's theorem.
6. compute class groups and class numbers.

Unit I: Revision of ring and fields, factorization of polynomials and field extensions. Symmetric polynomials, modules, free abelian groups, algebraic numbers, conjugates and discriminates. **15Lectures**

Unit II: Integral bases, norms and traces, rings of integers. Quadratic and cyclotomic fields. Trivial factorization, factorization into irreducibles, examples of non-unique factorization into irreducibles, prime factorization, Euclidean domains, Euclidean quadratic fields. **15Lectures**

Unit III: Prime factorization of ideals, the norm of an ideal, non-unique factorization in cyclotomic fields. Lattices, the quotient torus, Minkowski's theorem, the two-square theorem, the four-square theorem. **15Lectures**

Unit IV: Geometric Representation of algebraic numbers. The class group, Existence theorem, finiteness of the class group. Factorization of a rational prime, Minkowski's constants, some class number calculations, tables. **15Lectures**

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

Recommended Books:

1. I. N. Stewartand D. O. Tall, Algebraic Number Theory and Fermat's Last Theorem, 2015, CRC press.

Reference Books:

1. Algebraic Number Theory: Mathematical Pamphlet, TIFR, Bombay.
2. N. Jacobson, Basic Algebra-I, Hindustan Publishing Corporation(India),Delhi(Unit-I)
3. Paulo Ribenboim, Classical Theory of Algebraic Numbers, Springer, New York(2001).
4. N. S. Gopalkrishnan, University Algebra, New Age International (P) Ltd. Publishers.
5. Ian Stewart, Galoi Theory, CRC press(2015).

Harry Pollard, The Theory of Algebraic Numbers, The Mathematical Association of America.

M. Sc. Mathematics (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**

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

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 (Part II) (Level-6.5) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Dynamic Equations on Time Scales
Total Credits: 04
Course Outcomes: Upon successful completion of this course, students will be able to:

1. demonstrate the concepts of time scales calculus and dynamic equations on time scales.
2. develop sophisticated skill in understanding unification of continuous and discrete theory.
3. analyze the qualitative and quantitative aspects of solutions of dynamic equations.
4. develop various techniques and apply them to solve certain dynamic equations.
5. unify and extend the traditional study of differential equations and difference equations

UNIT– I Definition of time scale, examples of time scale, forward and backward jump operators and their properties, classification of points, graininess function, Hilger derivative and its properties, Leibniz formula, regulated and rd-continuous functions, pre-differentiable functions and its existence, mean value theorems, intermediate value theorem. **15 Lectures**

UNIT –II Antiderivative and its existence, indefinite delta integral, Cauchy integral, properties of delta integrals, chain rules, change of variables, Taylor's formula, Hilger's complex plane and its properties, basic operations on Hilger's complex plane (circle plus addition, circle minus subtraction, circle dot multiplication, generalized square), regressive functions, generalized exponential function on time scales. Examples of generalized exponential functions **15 Lectures**

UNIT –III First order linear dynamic equations, initial value problems on time scales, adjoint operators, Lagrange identity, variation of constants, second order linear dynamic equations, existence and uniqueness theorem, Wronskians, Abel's theorem. **15 Lectures**

UNIT – IV Hyperbolic and trigonometric functions on time scales, Solution of second order linear equation: by Reduction of order, by method of factoring, equations with non-constant coefficients, Hyperbolic and Trigonometric Functions-II , Euler-Cauchy dynamic Equations, Variation of Parameters, Annihilator Method. **15 Lectures**

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

Recommended Book(s):

1. Martin Bohner, Allan Peterson, *Dynamic equations on time scales : An introduction with applications*, Birkhauser, Boston, 2001.

Reference Book(s):

1. Martin Bohner, Allan C. Peterson, *Advances in dynamic equations on time scales*, Birkhauser, Boston, 2003

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

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

1. design various codes.
2. decodes codes.
3. apply codes for secrete massages.
4. apply ring theory in cyclic codes

Unit – I Introduction to Coding Theory : Linear Codes : Block codes, linear codes, Humming codes, Majority logic decoding weight enumerates, the Lee Metric. Some good codes : Hadamard codes and generalizations, The Binary Golary codes, the Ternery Golary codes, constructing codes from other codes, reed Muller codes, Kerdock codes. **15 Lectures**

Unit – II Bounds on codes : The Gilbert bound, Upper bounds, the linear programming bound, Cyclic codes : Definitions Generator matrix and check polynomial, zeros of a cyclic code, The idempotent of a cyclic code, other representations of cyclic codes, BCH-codes Decoding BCH codes, Read soloman codes, Quadratic. **15 Lectures**

Unit – III Residue codes, Binary cyclic codes of length 2n (nodd) Generalised Reed muller codes.Perfect codes and uniformly packed codes Lioyds theorem, The characteristic polynomial of a code uniformly packed codes. **15 Lectures**

Unit – IV Examples of uniformly packed codes, Non existence theorems. Codes over Z4 Quaternary codes Binary codes derive from codes over Z4, Galuis rings over Z4 cyclic codes over, Z4. **15 Lectures**

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

Recommended Books:
1. J. H. Van Lint : Introduction to coding theory, springer verlag 1998
References Books:-
1. Berle Kamp E.R.: Algebraic coding Theory, New york McGraw Hill,1968

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

Title of Course: Fixed Point Theory and Applications
Total Credits: 04
Learning outcome: Upon successful completion of this course, students will be able to:

1. demonstrate the various generalizations for Banach's contraction principle, nonexpansive mappings.
2. apply a fixed point theory for compact (non-self) maps
3. to examine existence of multiple solutions of a nonlinear Fredholm integral equation
4. use the methods of successive approximations to obtain the fixed points
5. demonstrate fixed points for self-mappings using successive approximations and for monotone non-expansive mappings

Unit 1 Contractions- : Liupschitzian map, uniqueness of fixed point in compact metric space, Banach's contraction principle, Edelstein Theorem, Non expansive Maps- Fixed points of nonexpansive maps, Browder fixed point theorem, Gohde fixed point theorem and Kirk's fixed point theorem

15 Lectures

Unit 2 Continuation Methods- Continuation Methods for Contractive and Non expansive Mappings, The Theorems of Brouwer, Schauder and Monch

15 Lectures

Unit 3 Continuation Principles for Condensing Maps- compact maps, homotopy for compact maps,Fixed Point Theorems in Conical Shells-Krasnoselskii's compression, expansion of a cone theorem, some generalisations

15 Lectures

Unit 4 Successive Approximations- The Method of Successive Approximations, The Iteration Process for Continuous Functions, TheMann Iterative Process, The Sequence of Iterates of Non-expansive Mappings, Convergence Criteria in Convex Metric Spaces, Iterative Methods for Variational Inequalities.

15 Lectures

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

Recommended Book(s):

1. R.P. Agarwal, M. Mechan and D. Oregan, Fixed Point Theory and Applications, Cambridge University press.
2. Sankatha Singh, Bruce Watson and Pramila Srivastava, Fixed Point Theory and Best Approximation:The KKM-map Principle, Springer Science Business Media Dordrecht (1997), Originally published by Kluwer Academic Publishers in 1997.

Reference Book(s):

1. Mohamed A. Khamsi and William A. Kirk, An Introduction to Metric Spaces and Fixed Point Theory, Hohn Wiley and Sons, Inc, New York (2001).
2. V. Berinde, Iterative Approximation of Fixed Points, Lecture Notes in Mathematics, No. 1912, Springer, 2007.

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

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

1. generalize the concept of measure.
2. appreciate the properties of Lebesgue measurable sets.
3. demonstrate the measurable functions and their properties.
4. understand the concept of Lebesgue integration of general measurable functions.
5. apply Fubini and Tonelli theorem to interchange order of the integration.

UNIT– I : Measures and measurable sets, signed measures: The Hahn and Jordan Decompositions, The Caratheodory measure induced by an outer measure, the construction of outer measures, The Caratheodory-Hahn Theorem, The Extension of a premeasure to a measure.
15 Lectures

UNIT –II: Integration over general measure spaces, measurable functions, integration of nonnegative measurable functions, integration of general measurable functions , The Radon-Nikodym Theorem. **15 Lectures**

UNIT –III: General L^p Spaces: The completeness of L^p (X, μ), $1 \leq p \leq \infty$, Holder's Inequality, The Cauchy-Schwarz Inequality, The Riesz-Fischer Theorem, Rapidly Cauchy Sequence, The Riesz Representation Theorem for the Dual of L^p (X, μ), The Kantorovitch Representation Theorem for the Dual of $L\infty(X, \mu)$. **15Lectures**

UNIT – IV: Product Measures: The theorems of Fubini and Tonelli, Lebesgue measure on Euclidean space R^n, Caratheodory outer measures and Hausdorff measures on a metric space.
15Lectures

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

Recommended Book(s):
1. H. L. Royden, P.M. Fitzpatrick, Real Analysis, Fourth Edition, PHI Learning Pvt. Ltd., New Delhi, 2010.

Reference Books:
1. G. de Barra, Measure Theory and Integration, New Age International (P) Ltd., 1981.
2. I. K. Rana, An Introduction to Measure and Integration, Narosa Book Company, 1997.
3. S. K. Berberian, Measure and Integration, Chelsea Publications Co., 1965.
4. P. K. Jain, V. P. Gupta, Lebesgue Measure and Integration, Wiley Easter Limited, 1986.
5. P. K. Halmos, Measure Theory, Van Nostrand, 1950.

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

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

1. Apply specialized knowledge in cryptography to solve network security problems.
2. Gain an advanced and integrated understanding of the fundamental of and interrelationship between mathematics and cryptography.
3. Gain a comprehensive introduction to the history of cryptography, known attacks on cryptosystems.

UNIT– I : Classical cryptography and Shannon's Theory: Introduction to Caeser Cipher, modular arithmetic, the Shift Cipher, Affine Cipher, Vigenere Cipher, Perfect secrecy, Applications of Shift Cipher. **15 Lectures**

UNIT –II: Block Cipher: Product Cipher, Block Cipher, Modes of Operation for Block Cipher, Substitution Permtation Network, Fiestel Cipher, S-Box Theory, Cryptanalysis and its Variants, Linear Attack. **15 Lectures**

UNIT –III: Public key Cryptology: RSA Cryptosystem, Complexity analysis of Euclidean Algorithm ad RSA Cryptosystem, square and multiply algorithm, Primality testing-Miller-Rabin Algorithm, Legendre Symbol and Jacobi Symbol, Solovay-Stassen Algorithm. **15 Lectures**

UNIT – IV: Cryptographic Hash Function: Introduction, Random Oracle Model, Security of hash functions, Randomized Algorithm and its application on Preimage resistance and collision resistance, Iterated Hash Functions. **15 Lectures**

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

Recommended Book(s):

1. Stinson D., Cryptography Theory and Practice, 3rd edition, Chapman Hall/CRC

Reference Books:

1. Das A. and Venimadhavan C.E., "Public-key Cryptography-Theory and Practice", Pearson Education Inc.
2. Koblitz N.,"a Course in Number Theory and Cryptography", 2nd Edition, Springer (Indian Reprint)
3. D.Boneh and V. Shoup: A Graduate Course in Applied Cryptography (free)

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

Title of Course: Automata, Languages and Computations
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Model, compare and analyse different computational models using combinatorial methods.
2. Apply rigorously formal mathematical methods to prove properties of languages, grammars and automata.
3. Construct algorithms for different problems and argue formally about correctness on different restricted machine models of computation
4. Identify limitations of some computational models and possible methods of proving them.

Unit I: Finite automata, regular languages, regular expressions, equivalence of deterministic and non-deterministic finite automata, minimization of finite automata, closure properties, Kleene's theorem. **15 Lectures**

Unit II: pumping lemma and its application, Myhill-Nerode theorem and its uses; Context-free grammars, context-free languages, Chomsky normal form, closure properties. **15 Lectures**

Unit III: pumping lemma for CFL, pushdown automata, Computable functions, primitive and recursive functions, universality, halting problem, recursive and recursively enumerable sets. **15 Lectures**

Unit IV: parameter theorem, diagonalisation, reducibility, Rice's Theorem and its applications. Turing machines and variants; Equivalence of different models of computation. **15 Lectures**

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

Recommended Book:

1. M. Sipser: Introduction to The Theory of Computation, PWS Pub. Co., New York, 1999.

Reference Books

1. N. J. Cutland: Computability: An Introduction to Recursive Function Theory, Cambridge University Press, London, 1980.
2. M. D. Davis, R. Sigaland E. J. Weyuker: Complexity, Computability and Languages, Academic Press, New York, 1994.
3. J. E. Hopcroft and J. D. Ullman: Introduction to Automata Theory, Languages and Computation, Addison-Wesley, California, 1979.

M. Sc. Mathematics (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

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

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 (Part II) (Level-6.5) (Semester III)
(NEP-2020)
(Introduced from Academic Year 2024-25)

Title of Course: Theory of Ideals

Total Credits: 04

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

1. classify the ideals to solve the related problems.
2. understand various radicals.
3. understand Boolean rings and Regular rings.
4. know Hilbert basis theorem and apply it to other development.
5. derive Wedderburn Theorem.

Unit–I : Examples and properties of minimal, prime and primary ideals, the nil radical of an ideal and its properties, semiprime ideals, the associated prime ideal of a primary ideal, problems. **15 Lectures**

Unit – II: Minimal prime ideals of a ring, certain radicals of a ring : Jacobson radical, the definition of the idempotents of R/I can be raised or lifted into R and its properties, primary rings, Quasiregular element and its properties, problems. **15 Lectures**

Unit–III: Prime radicals, modular ideals, J-radial of a ring, Boolean rings, regular rings, Stone representation theorem, direct sum of rings, Birkhoff theorem , problems. **15 Lectures**

Unit–IV: Rings with Chain conditions: Equivalence of three conditions of a ring with ACC, Hilbert basis theorem, Levitsky theorem, Wedderburn theorem, any semi-simple Artinion ring R is the direct sum of a finite number of fields, problems. **15 Lectures**

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

Recommended Book:

1) Barton David M. : A first course in Rings and Ideals, Addison-Wesley Educational Publishers Inc 1970.

Reference Books:

1. Oscar Zoriski and P. Samuel: Commutative Algebra, Vol. I, Springer.
2. M. Atiyah and I. C. McDonald: Introduction to Commutative Algebra, Addison-Wesley Publishing Company (Series in Mathematics) .
3. Hideyuki Matsumura: Commutative Algebra, Revised and modernized edition by TEXromancers.
4. C. Musili: Rings and Modules, Narosa Publishing House.

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

Title of Course: Software Engineering and Project Management
Course Outcome: Upon successful completion of this course, the student will be able to --
1. Understand various models of Software Development.
2. Understand requirement gathering and requirement modelling.
3. Explore concepts and models in software design.
4. To understand the testing and debugging methods for software.

Unit I : 15 Lectures
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.

Unit II : 15 Lectures
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.

Unit III: 15 Lectures
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.

Unit IV : 15 Lectures
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

S/T/PSS: 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

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

M. Sc. Mathematics (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

S/T/PSS: 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.

M. Sc. Mathematics (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**

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

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 (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

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

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

Title of Course: Space Dynamics
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. formulate trajectory equations and classify trajectories
2. determine state vector from orbital elements
3. determine orbit from position vectors and from one ground based observation
4. Calculate time of flight and orbit propagation
5. use perturbation methods

UNIT– I : **15 Lectures**
Two Body Orbital Mechanics: Introduction, Two Body Problem, Constants of Motion, Conservation of Angular Momentum, Conservation of Energy, Conic Sections, Trajectory Equation, Eccentricity Vector, Energy and Semi major Axis, Elliptical Orbit, Ellipse Geometry, Flight Path Angle and Velocity Components, Period of an Elliptical Orbit, Circular Orbit, Parabolic Trajectory, Hyperbolic Trajectory.

UNIT –II:. **15 Lectures**
Orbit Determination: Introduction, Coordinate Systems, Classical Orbital Elements, Transforming Cartesian Coordinates to Orbital Elements, Transforming Orbital Elements to Cartesian Coordinates, Coordinate Transformations, Orbit Determination from One Ground-Based Observation,

UNIT –III: **15Lectures**
Time of Flight: Introduction, Kepler's Equation, Time of Flight Using Geometric Methods, Time of Flight Using Analytical Methods, Relating Eccentric and True Anomalies, Parabolic and Hyperbolic Time of Flight, Kepler's Problem.

UNIT – IV:. **15Lectures**
Non Keplerian Motion: Introduction, Special Perturbation Methods, Non Spherical Central Body, General Perturbation Methods, Perturbation Accelerations for Earth Satellites, Non Spherical Earth, Atmospheric Drag, Solar Radiation Pressure.

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

Recommended Book(s):
1. Craig Kluever , Space Flight Dynamics, Wiley 2018.

Reference Books:
1. William Tyrrell Thomson, Introduction to Space Dynamics, Dover publication , New York.
2. Gerhard, Methods of Celestial Mechanics, Vol. II, Springer.
3. George W. Collins, The Foundations of Celestial Mechanics, Pachart Foundation dba Pachart Publishing House.

M. Sc. Mathematics (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**

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

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: Fractional Calculus
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

1. analyse the properties of Grünwald-Letnikov, Riemann-Liouville, and Caputo fractional derivative.
2. evaluate fractional derivatives and fractional integrals
3. analyse the behaviour of fractional derivatives near and far from the lower terminal
4. evaluate Laplace and Fourier transforms of fractional derivatives and integrals.
5. solve fractional differential equations using Laplace and Fourier transforms.

Unit I: Brief review of Special Functions of the Fractional Calculus: Gamma Function, Mittag-Leffler Function, Fractional Derivative and Integrals: Grünwald-Letnikov (GL) Fractional Derivatives-Unification of integer order derivatives and integrals, GL Derivatives of arbitrary order, GL fractional derivative of $(t-a)^{\beta}$, Composition of GL derivative with integer order derivatives, Composition of two GL derivatives of different orders. **15 Lectures**

Unit II: Riemann-Liouville (RL) fractional derivatives- Unification of integer order derivatives and integrals, Integrals of arbitrary order, RL derivatives of arbitrary order, RL fractional derivative of $(t-a)^{\beta}$, Composition of RL derivative with integer order derivatives and fractional derivatives, Link of RL derivative to Grünwald-Letnikov approach **15 Lectures**

Unit III: Caputo's fractional derivative, Properties of fractional derivatives: Linearity, The Leibnitz rule for fractional derivatives, Fractional derivative for composite function Riemann-Liouville fractional differentiation of an integral depending on a parameter, Behaviour near the lower terminal, Behaviour far from the lower terminal. **15 Lectures**

Unit IV: Laplace transform of the Riemann-Liouville fractional derivative, Caputo derivative and Grünwald-Letnikov fractional derivative. Fourier transforms of fractional integrals and derivatives. Methods of solving FDE's: Using Laplace transform and Fourier transforms-Ordinary fractional differential equations, Partial fractional differential equations, Power series method: One term equation, Equation with non-constant coefficients, Two-term nonlinear equation. **15 Lectures**

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

Recommended Book(s):

1. Igor Podlubny, Fractional Differential Equations. San Diego: Academic Press; 1999.
2. L. Debnath, D. Bhatta, Integral Transforms and Their Applications, CRC Press, 2010.

Reference Books:

1. A. Kilbas, H.M. Srivastava, J.J. Trujillo, Theory and Applications of Fractional Differential Equations, Elsevier, Amsterdam, 2006.
2. Kai Diethelm, The Analysis of Fractional Differential Equations, Springer, 2010.
3. K. S. Miller, B. Ross AnIntroduction to the Fractional Calculus and Differential Equations, Wiley, New York, 1993.
4. S. G. Samko, A. A. Kilbas, O. I. Marichev, Fractional Integrals and Derivatives,Theory and Applications, Gordon and Breach, New York, 1993.

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

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

1. Construct approximate polynomial for periodic function using Bernstein polynomials
2. Interpolate given function using finite interpolation.
3. determine error bounds in polynomial approximations and establish uniqueness of approximating polynomials.
4. prove convergence of Fourier series of a function of bounded variation.
5. establish orthogonality of Jacobi polynomials and predict zeros of orthogonal polynomials.
6. formulate recurrence relations of orthogonal polynomials

UNIT– I : 15 Lectures
Approximation of periodic functions, Fejers theorem, Dirichlet Kernel, Lebesgue constant, approximation by algebraic polynomials, Weierstrass theorem, Bernstein polynomials, convergence of Bernstein polynomials Approximation in normed linear spaces, existence ,uniqueness, alternation theorem

UNIT –II:. **15 Lectures**
Interpolation: Algebraic Formulation of Finite Interpolation problem , Gram determinant, well posed problems, Lagrange interpolation, Taylor interpolation, Hermite interpolation; Lagrange Form, fundamental Lagrange polynomials, Cauchy relations, biorthonormal relations, error in Lagrange interpolation; Convergence of sequence of Lagrange interpolating polynomials, Extended Haar Subspaces and Hermite Interpolation, generalized Gram determinant; Hermite - Fejer Interpolation

UNIT –III: 15Lectures
Fourier Series: Introduction, Fourier Sine and Cosine series, Piecewise continuity and smoothness, bounded variation, Riemann- Lebesgue lemma, Localization principle, Dirichlet and Fourier Kernels, Discrete Fourier Kernel, Criterion for pointwise convergence, Dini test, Lipschitz's test,Pointwise convergence of Fourier series, Dirichlet's pointwise convergence theorem.

UNIT – IV:. **15Lectures**
Orthogonal Polynomials: Introduction, Chebyshev polynomials, properties of Chebyshev polynomials, recurrence relation of Chebyshev polynomials, Chebyshev polynomials of second kind , Jacobi Polynomials: Elementary Properties, Legendre polynomials, ultraspherical polynomials, Asymptotic Properties.

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

Recommended Book(s):

1. Hrushikesh N. Mhaskar and DevidasV.Pai : Fundamentals of Approximation Theory, Narosa Publishing House.
2. George Bachman , Lawrwnce Narici, Edward Beckenstein: Fourier and Wavelet Analysis, Springer 2005.

Reference Books:

1. Theodore J. Rivlin : An Introduction to the Approximation of Functions, Dover Publications, Inc. New York.

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

Title of Course: Wavelet Analysis
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. calculate Fourier transforms and wavelet transforms of functions.
2. carry out synthesis and analysis of time signal.
3. construct mother wavelets.
4. construct inverse of Gram operator in infinite dimensional space.
5. use orthogonal wavelets.

UNIT– I : **15 Lectures**
Fourier analysis: Fourier series, Riemann Lebesgue lemma, Parseval's formula, variation of function, functions of bounded variation, Fourier transform on R, translational and scaling properties of Fourier transforms, convolution, convolution theorem, Parseval Plancherel formula, inverse Fourier transform, Fourier transforms of derivatives, derivatives of Fourier transforms, examples on Fourier transforms, the Heisenberg uncertainty principle, The Shannon sampling theorem.

UNIT –II:. **15 Lectures**
The continuous wavelet transform: Wavelet transform, definitions and examples, A Plancherel formula on H, A Plancherel formula on H', bilinearity of Plancherel formula, analysis and synthesis of time signals, inversion formulas, Regularization lemma, reconstruction formula for time signal, the kernel function, inverse wavelet transform, reproducing kernel, decay of the wavelet transform ,asymptotic properties of wavelet transform ,Hoelder continuity, moment of wavelet , r-click, decay estimates.

UNIT –III: **15Lectures**
Inverse wavelet transform, reproducing kernel, decay of the wavelet transform ,asymptotic properties of wavelet transform ,Hoelder continuity, moment of wavelet , r-click, decay estimates.

Frames: Geometrical considerations, the general notion of a frame, adjointoperator , Gram operator, frame constants, tight frame ,examples of frames, orthogonal projections, dual frame, general notion of a frame, Riesz basis, inverse of Gram operator defined on infinite dimensional space, mother wavelet, general notion of tight frame.

UNIT – IV:. **15Lectures**
General notion of a frame, Riesz basis, inverse of Gram operator defined on infinite dimensional space, mother wavelet, general notion of tight frame.
Multiresolution analysis: Axiomatic description, pair wise orthogonal spaces, orthogonal components, orthonormal wavelet basis, orthonormal wavelets with compact support.

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

Recommended Book(s):
1. Christian Blatter ,Wavelets a primer ,Universities press 1998

Reference Books:
1. Mark A. Pinsky : Introduction To Fourier Analysis and Wavelets.
2. Gerald Kaiser : A Friendly Guide to Wavelets , Springer 1994.
3. George Bachman , Lawrwnce Narici, Edward Beckenstein: Fourier and Wavelet Analysis, Springer, 2005.

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

Title of Course: Boundary Value Problems
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. Represent the given function in Fourier series.
2. Examine the convergence of Fourier Series.
3. Solve boundary value problems arising in physics and engineering.
4. Apply Fourier method for solving boundary value problems.
5. Able to write Fourier integral representation of given functions
6. Solve Sturm-Liouville problems and their solutions.

Unit I: Fourier Series: Piecewise Continuous Functions, Fourier Cosine Series, Fourier Sine Series, Fourier series, adaptations to other intervals. Convergence of Fourier Series: One-Sided Derivatives, A Property of Fourier Coefficients, Two lemmas, A Fourier Theorem, Discussion of the theorem and its corollary, convergence on other intervals, A Lemma, Absolute and Uniform Convergence of Fourier Series, Differentiation of Fourier Series, Integration of Fourier Series.
15 Lectures

Unit II: Partial Differential Equations of Physics: Linear Boundary Value Problems, One-dimensional Heat Equation, Laplacian in cylindrical and spherical coordinates, derivations, Boundary conditions, A vibrating string, vibrations of bars and membranes, general solution of the wave equation, types of equations and boundary conditions. **15 Lectures**

Unit III: The Fourier Method: Linear Operators, Principle of Superposition, a temperature problem, a vibrating string problem. Boundary Value Problems: A slab with faces at prescribed temperatures, a slab with internally generated heat, steady temperatures in a rectangular plate, cylindrical coordinates, a string with prescribed initial conditions, resonance, an elastic bar.
15 Lectures

Unit IV: Fourier Integrals and applications: The Fourier Integral Formula, Dirichlet's integral, Two lemmas, A Fourier integral theorem, The Cosine and Sine integrals, more on superposition of solutions. Sturm-Liouville Problems and applications: Regular Sturm-Liouville Problems, modifications, orthogonality of eigen functions, real valued eigen functions and non-negative eigen values, methods of solution.
15 Lectures

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

Recommended Books:

1. R.V. Churchill and J. Brown.: "Fourier Series and Boundary Value Problems" (7th edition)(Publisher: McGraw-Hill Book Company)

Reference Books:

1. W. E. Boyce and R. C. DiPrima, "Elementary Differential Equations and Boundary Value Problems", John Wiley and Sons.(7th Edition)
2. D.G.Zell and Cullen, "Differential Equations with Boundary Value Problems", Cengage Learning Publishers.

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

Title of Course: Probability and Stochastic Processes
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Apply the specialized knowledge in probability theory and random processes to solve practical problems.
2. Gain advanced and integrated understanding of the fundamentals of and interrelationship between discrete and continuous random variables and between deterministic and stochastic processes.
3. Create mathematical models for practical design problems and determine theoretical solutions to the created models.

UNIT– I : Probability, conditional probability and independence; Random variables and their distributions (discrete and continuous). **15 Lectures**

UNIT –II: Bivariate and multivariate distributions; Laws of large numbers, central limit theorem (statement and use only). **15 Lectures**

UNIT –III: Definition and examples of stochastic processes, weak and strong stationarity; Markov chains with finite and countable state spaces -classification of states. **15 Lectures**

UNIT – IV: Markov processes, Poisson processes, birth and death processes, branching processes, queuing processes. **15 Lectures**

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

Recommended Book(s):

1. Dimitri Bertsekas, John N. Tsitsiklis : Introduction To Probability, Athena Scientific; 2nd edition

Reference Books:

1. W. Feller: An Introduction to Probability Theory and its Applications (Volume I and II), 3rd ed. John Wiley, New York, 1973.
2. P. G. Hoel, S. C. Port and C. J. Stone: Introduction to Probability Theory, University Book Stall/ HoughtonMifflin, New Delhi/New York, 199811971. 15
3. K. L. Chung: Elementary Probability Theory and Stochastic Processes, Springer-Verlag, New York, 1974.
4. S. M. Ross: Stochastic Processes, John Wiley, New York, 1983.
5. H. M. Taylor: First Course in Stochastic Processes, 2nd ed. Academic Press, Boston, 1975.
6. H. M. Taylor: Second Course in Stochastic Processes, Academic Press, Boston, 1981.

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

Title of Course: Theory of Distributions
Total Credits: 04
Course Outcomes: Upon successful completion of this course, the student will be able to:
1. construct test functions, approximate identity, distributions.
2. differentiate a generalized function.
3. calculate limit of sequence of generalized functions.
4. analyze properties of support of generalized functions.
5. define directional derivatives of generalized functions.

UNIT– I : 15 Lectures
Locally convex spaces, topological vector spaces, seminorms, locally convex spaces, examples of locally convex spaces, generalized functions, test functions, distributions

UNIT –II:. **15 Lectures**
Test functions and distributions: space of test functions, Frechet space, balanced sets, distribution in Ω , linear mapping of distributions, functions and measures as distributions, differentiation of distributions, distribution derivatives of functions, examples

UNIT –III: 15Lectures
Multiplication by smooth functions ,sequences of distributions, convergence of distributions, local properties of distributions, local equality, locally finite partition of unity distributions of finite order, distributions defined by powers of x.

UNIT – IV:. **15Lectures**
Support of distribution, distribution with compact support, distributions as derivatives, convolutions, translation, reflexion, approximate identity, differential of convolutions, properties of convolutions, regularization of distributions

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

Recommended Book(s):
1. M.A. AlGawaiz, Marcel Dekkar, Theory of Distributions, Inc New York 1992.

Reference Books:
1. Walter Rudin, Functional Analysis, Tata McGraw Hill publishing company, 1986.
2. A.H. Zemanian, Distribution Theory and Transform Analysis, Dover publication , 1987.

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**

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

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

Title of Course: Module Theory

Total Credits: 04

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

1. understand Artirian and Noetherion modules.
2. study the Krull-Schmidt theorem.
3. know projective modules for further development in modules.
4. study tensor product of modules.
5. derive prime decomposition theorem.

Unit I: Operations on submodules, direct summand, Free modules, Exact sequence and short exact sequence of modules isomorphism theorem for modules, Artirian and Noetherion modules.
15Lectures

Unit II: Schreier refinement theorem, Jordan-Holder Theorem, Composition series for modules, The Krull-Schmidt theorem, Fittings lemma, completely reducible modules, Schur's lemma,.
15Lectures

Unit III: Abstract dependence relations, tensor product of modules, Bimodules, Algebras and Coalgebras, Projective modules,. **15Lectures**

Unit IV: Injective modules, Morita Contexts, Generators and Progenerators, Uniqueness Theorem for primary decomposition of modules. **15Lectures**

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

Recommended Book:

1. N. Jacobson: Basic Algebra– II, Hindustan publishing corporation(India).

Reference Books:

1. C. Musili: Rings and Modules, Narosa Publishing House
2. M. D. Larsen and P. J. McCarthy: Multiplicative Theory of Ideals, Academicpress,1971.
3. D. G. Northcot, Ideal Theory, Cambridge University, press,1953.

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

Title of Course: Internet of Things
Total Credits: 04

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

1. Understand of the basic concepts, principles, and components of the Internet of Things.
2. Apply IoT to different applications
3. Analysis and evaluate protocols used in IoT
4. Design smart city in IoT.
5. Analysis data received through sensors in IoT

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: Seminars, Tutorials, Problem solving session and group discussions on above units.

References:

1. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age ofIntelligence”, 1st Edition, Academic Press, 2014
2. Vijay Madisetti and ArshdeepBahga, “Internet of Things (A Hands-onApproach)”, 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

M. Sc. Mathematics (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

M. Sc. Part II (Semester III and IV)

Old Course				Equivalent Course		
Sem No.	Course Code	Title of Old Course	Credit	Course Code	Title of New Course	Credit
III	CC-301	Functional Analysis	4	MSU0325MML925I1	Functional Analysis	4
III	DSE-302	Advanced Discrete Mathematics	4	MSU0325MML925I4	Advanced Discrete Mathematics	2*
III	CCS-303, CCS-304, CCS-305, CCS-306	Non - Linear Optimization Techniques	4	MSU0325MEL825G7	Linear programming and its applications	4
		Fuzzy Mathematics –I	4	MSU0325MEL925I9	Fuzzy Set Theory	4
		Fluid Dynamics	4	MSU0325MEL925I2	Fluid Dynamics	4
		Fractional Calculus	4	MSU0325MEL925J3	Fractional Calculus	4
		Lattice Theory–I	4	MSU0325MEL825G6	Lattice Theory–I	4
		Approximation Theory	4	MSU0325MEL925J4	Approximation Theory	4
		Dynamical Systems– I	4	MSU0325MEL825G8	Dynamical Systems– I	4
		Graph Theory-I	4	MSU0325MEL825G5	Graph Theory-I	4
		Differential Geometry	4	MSU0325MEL825G2	Differential Geometry	4
		Combinatorics	4	MSU0325MEL825G1	Combinatorics	4
		Commutative Algebra-I	4	MSU0325MEL925I10	Theory of Ideals	4
		Space Dynamics-I	4	MSU0325MEL925J1	Space Dynamics	4
		Theory of Computation	4	MSU0325MEL825G4	Theory of Computation	4
		Probability and Stochastic Processes	4	MSU0325MEL925J7	Probability and Stochastic Processes	4
		Coding Theory	4	MSU0325MEL925I4	Coding Theory	4
IV	CC-401	Field Theory	4	MSU0325MML925J2	Field Theory	4
IV	DSE-402	Integral Equations	4	MSU0325MML925J1	Integral Equations	4
		Measure and Integration		MSU0325MEL925I6	Measure and Integration	
IV	CCS-403, CCS-404, CCS-405, CCS-406	Quantitative Techniques In Operations Research	4	MSU0325MEL825H7	Quantitative Techniques In Operations Research	4
		Fuzzy Mathematics –II	4	MSU0325MEL925J9	Fuzzy Relations and Logic	4
		Computational Fluid Dynamics	4	MSU0325MEL925J2	Computational Fluid Dynamics	4
		Lattice Theory–	4	MSU0325MEL825H6	Lattice	4

		II			Theory–II	
		Wavelet Analysis	4	MSU0325MEL925J5	Wavelet Analysis	4
		Dynamical Systems– II	4	MSU0325MEL825H8	Dynamical Systems– II	4
		Graph Theory-II	4	MSU0325MEL825H5	Graph Theory-II	4
		Theory of Distributions	4	MSU0325MEL925J8	Theory of Distributions	4
		Commutative Algebra- II	4	MSU0325MEL925J10	Module Theory	4
		Algebraic Automata Theory	4	MSU0325MEL825H4	Algebraic Automata Theory	4
		Dynamic Equations on Time Scales	4	MSU0325MEL925I3	Dynamic Equations on Time Scales	4
		Automata, Languages and Computation	4	MSU0325MEL925I8	Automata, Languages and Computation	4
		Algebraic Number Theory	4	MSU0325MEL925I1	Algebraic Number Theory	4

***Marks obtained out of 40 shall be converted to out of 80 marks.**