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

SHIVAJI UNIVERSITY, KOLHAPUR - 416004, MAHARASHTRA

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

शिवाजी विद्यापीठ, कोल्हापूर -४१६००४,महाराष्ट्र

दूरध्वनी-ईपीएबीएक्स -२६०९०००, अभ्याससमंडळे 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 with Computer Applications)

Part II (Level-6.5) (Semester III and IV)
under
Faculty of Science and Technology

(To Be Implemented From Academic Year 2023-24)

INDEX

Sr. No.	Contents	Page No
1	Preamble	3
2	Duration	3
3	Eligibility for Admission	3
4	Medium of Instruction	3
5	Programme Structure	4
6	Programme Outcomes (POs)	8
7	Course Codes	9
8	Syllabus	11
9	Scheme of Teaching	36
10	Examination Pattern	36
11	Nature of Question Paper and Scheme of Marking	38
12	Equivalence of courses	38

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.

IT industry is growing exponentially. Mathematics is a backbone in the development of computer softwares. Mathematics candidates with computer background are on demand. Therefore, the Department has started a new program M.Sc. (Mathematics with Computer Applications) of 2 years duration having combination of both mathematics and computer science courses from academic year 2023-24.

2. Duration

The M.Sc. (Mathematics with Computer Applications) will be 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 with Computer Applications) Part – I (Level-6.0)

	Course Code	Teaching Scheme			Examination Scheme					
		Theory and Practical			University Assessment (UA)			Internal Assessment (IA)		
		Lectures + Tutorial/ (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	--	4	80	32	3	20	8	1
	MMT -102	2	--	2	40	16	2	10	4	1/2
	MMPR -102	--	4	2	40	16	2	10	4	1/2
	MMT-103	2	--	2	40	16	2	10	4	1/2
	MMPR -103	--	4	2	40	16	2	10	4	1/2
	MMT-104	2	--	2	40	16	2	10	4	1/2
Major Elective	MET-105	4	--	4	80	32	3	20	8	1
Research Methodology	RM-106	4	--	4	80	32	3	20	8	1
Total				22	440			110		
Semester-II										
Major Mandatory	MMT-201	4	--	4	80	32	3	20	8	1
	MMT -202	4	--	4	80	32	3	20	8	1
	MMT -203	4	--	4	80	32	3	20	8	1
	MMPR -204	--	4	2	40	16	2	10	4	1/2
Major Elective	MET-205	4	--	4	80	32	3	20	8	1
OJT/FP	OJT/FP-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	• Total Marks for M.Sc.-I : **1100** • Total Credits for M.Sc.-I (Semester I & II) : 44 • ***Separate passing is mandatory for University and Internal Examinations***

*Evaluation scheme for OJT/FP shall be decided by concerned BOS

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

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

OR

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

OR

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

- **Requirement for Exit after Level 6.0:**
  Students can exit after completion of Level 6.0 with Post Graduate Diploma in Mathematics with Computer Applications.

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

	Course Code	Teaching Scheme			Examination Scheme					
		Theory and Practical			University Assessment (UA)			Internal Assessment (IA)		
		Lectures + Tutorial (Per week)	Hours (Per week)	Credit	Maximum Marks	Minimum Marks	Exam. Hours	Maximum Marks	Minimum Marks	Exam. Hours
Semester-III										
Major Mandatory	MMT-301	4	--	4	80	32	3	20	8	1
	MMT -302	4	--	4	80	32	3	20	8	1
	MMT-303	2	2	4	40	16	2	10	4	1/2
	MMPR -303	--	4	2	40	16	2	10	4	1/2
	MMT-304	2	--	2	40	16	2	10	4	1/2
Major Elective	MET-305	4	--	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	--	4	80	32	3	20	8	1
	MMT -402	4	--	4	80	32	3	20	8	1
	MMT-403	2	--	2	40	16	2	10	4	1/2
	MMPR -403	--	4	2	40	16	2	10	4	1/2
Major Elective	MET-405	4	--	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	• Total Marks for M.Sc.-II : **1100** • Total Credits for M.Sc.-II (Semester III & IV) : 44 • ***Separate passing is mandatory for University and Internal Examinations***
Evaluation scheme for Research Project: 80% weightage for University assessment and 20% for Internal Assessment.	

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

1. Any candidate who has successfully completed Post Graduate Diploma (Level 6.0) in Mathematics with Computer Applications 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 with Computer Applications.

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

6. Programme Outcomes (POs)

- Demonstrate basic knowledge in fundamentals of programming, algorithms and programming technologies and fundamentals of Computer Science.
- Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.
- Create, select and apply appropriate techniques, resources and modern engineering and IT tools, including prediction and modelling to complex engineering activities, with an understanding of the limitations.
- Develop the ability to design creative solutions to real life problems faced by the industry.
- Improve the capability for self-learning.
- Map their qualities of learning to demonstrate latest technology.

7. Course Codes

M. Sc. (Mathematics with Computer Applications) Part I (Semester I and II)

Semester No.	Department Course Code	Course Code	Title of New Course
I	MMT-101	MSU0325MML828G1	Linear Algebra
I	MMT -102	MSU0325MML828G2	Object Oriented Programming
I	MMPR -102	MSU0325MMP828G2	
I	MMT-103	MSU0325MML828G3	Database Management System
I	MMPR -103	MSU0325MMP828G3	
I	MMT -104	MSU0325MML828G4	Numerical Analysis
I	MET-105	MSU0325MEL828G1	Combinatorics
		MSU0325MEL828G2	Differential Geometry
		MSU0325MEL828G3	Integral Transforms
		MSU0325MEL828G4	Theory of computations
		MSU0325MEL828G5	Graph Theory- I
		MSU0325MEL828G6	Lattice Theory-I
		MSU0325MEL828G7	Linear programming and its applications
		MSU0325MEL828G8	Dynamical Systems-I
		MSU0325MEL828G9	Basics of Python
		MSU0325MEL828G10	Web Technology
I	RM-106	MSU0325RML828G	Research Methodology
II	MMT-201	MSU0325MML828H1	Algebra
II	MMT -202	MSU0325MML828H2	Advanced Calculus
II	MMT -203	MSU0325MML828H3	Java Programming
II	MMPR -204	MSU0325MMP828H4	Java Programming Practical
II	MET-205	MSU0325MEL828H1	Number Theory
		MSU0325MEL828H2	Advanced Algebra
		MSU0325MEL828H3	Difference Equations
		MSU0325MEL828H4	Algebraic Automata Theory
		MSU0325MEL828H5	Graph Theory II
		MSU0325MEL828H6	Lattice Theory- II
		MSU0325MEL828H7	Quantitative techniques in operations Research
		MSU0325MEL828H8	Dynamical Systems-II
		MSU0325MEL828H9	Data Science with Python
		MSU0325MEL828H10	PHP with MySQL
II	OJT-206/ FP-206	MSU0325OJP828H / MSU0325FPP828H	On job Training / Field project

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

Semester No.	Department Course Code	Course Code	Title of New Course
III	MMT-301	MSU0325MML928I1	Ordinary Differential Equations
III	MMT -302	MSU0325MML928I2	Real Analysis
III	MMT -303	MSU0325MML928I3	Front end Development
III	MMPR-303	MSU0325MMP928I3	
III	MMT-304	MSU0325MML928I4	Complex Analysis
III	MET-305	MSU0325MEL928I1	Algebraic Number Theory
		MSU0325MEL928I2	Advanced Discrete Mathematics
		MSU0325MEL928I3	Coding Theory
		MSU0325MEL928I4	Introduction to Cryptography
		MSU0325MEL928I5	Automata, Languages And computations
		MSU0325MEL928I6	Software Engineering and Project Management
		MSU0325MEL928I7	Android Development with Kotlin
		MSU0325MEL928I8	Cyber Security
III	RP-306	MSU0325RPP928I	Research Project
IV	MMT-401	MSU0325MML928J1	Field Theory
IV	MMT -402	MSU0325MML928J2	Functional Analysis
IV	MMT -403	MSU0325MML928J3	Back end Development
IV	MMPR -403	MSU0325MMP928J3	
IV	MET-404	MSU0325MEL928J1	Fuzzy Mathematics
		MSU0325MEL928J2	Wavelet Transform
		MSU0325MEL928J3	Probability and Stochastic Processes
		MSU0325MEL928J4	AI and Machine Learning
		MSU0325MEL928J5	Internet of Things (IoT)
		MSU0325MEL928J6	Cloud Computing
IV	RP-405	MSU0325RPP928J	Research Project

8. Syllabus

M.Sc. (Mathematics with Computer Applications) 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		TH	PR	Numerical Analysis	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
	1) Linear Algebra	4	-			
	2) Object Oriented Programming	2	2			
	3) Database Management System	2	2			
II	1) Algebra 2) Advanced Calculus 3) Java Programming			Java Programming Practical	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 with Computer Applications) 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		TH	PR	Field Theory	1) Algebraic Number Theory 2) Advanced Discrete Mathematics 3) Coding Theory 4) Introduction to Cryptography 5) Automata, Languages And computations 6) Software Engineering and Project Management 7) Android Development with Kotlin 8) Cyber Security	Research Project (4 credits)
	1) Ordinary Differential Equations	4	--			
	2) Real Analysis	4	--			
	3) Front end Development	2	2			
IV		TH	PR	---	1) Fuzzy Mathematics 2) Wavelet Transform 3) Probability and Stochastic Processes 4) AI and Machine Learning 5) Internet of Things (IoT) 6) Cloud Computing	Research Project (6 credits)
	1) Complex Analysis	4	-			
	2) Functional Analysis	4	-			
	3) Back end Development	2	2			

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

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

Title of Course: Ordinary Differential Equations

Total Credits: 04

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

1. study basic notions in Differential Equations and use the results in developing advanced mathematics.
2. solve problems modeled by linear differential equations.
3. use power series methods to solve differential equations about ordinary points and regular singular points.
4. construct approximate solutions using method of successive approximation.
5. establish uniqueness of solutions.

UNIT– I: Linear differential equations with constant coefficients: The second order homogeneous equation, initial value problems for second order equations, linear dependence and independence, formula for the Wronskian, the non-homogeneous equations of order two.

15 Lectures

UNIT –II: The homogeneous equations of order n, initial value problems for the nth order equations, the non-homogeneous equation of nth order. Linear equations with variable coefficients: Initial value problems for the homogeneous equations. Solutions of the homogeneous equations, the Wronskian and linear independence. **15 Lectures**

UNIT –III: Reduction of the order of a homogeneous equation, the non-homogenous equations, homogeneous equations with analytic coefficients, the Legendre equations. Linear equations with regular singular points: The Euler equations, second order equations with regular singular points.

15 Lectures

UNIT – IV: The Bessel equation, regular singular points at infinity. Existence and uniqueness of solutions: The method of successive approximations, the Lipschitz condition, convergence of the successive approximation. **15 Lectures**

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

Recommended Book(s):

1. E. A. Coddington: An introduction to ordinary differential equations. (2012) Prentice Hall of India Pvt.Ltd. New Delhi.

Reference Books:

1. G. Birkoff and G.G.Rota, Ordinary differential equations, John Willey and Sons.
2. G.F. Simmons, Differential Equations with Applications and Historical note, McGraw-Hill, Inc. New York. (1972).
3. E.A. Coddington and Levinson, Theory of ordinary differential equations, McGraw-Hill, New York(1955).
4. E.D. Rainvills, Elementary differential equations, The Macmillan company, New York. (1964).

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

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

1. generalize the concept of length of interval.
2. analyze the properties of Lebesgue measurable sets.
3. demonstrate the measurable functions and their properties.
4. understand the concept of Lebesgue integration of measurable functions.
5. characterize Riemann and Lebesgue integrability.
6. prove completeness of L^P Spaces.

UNIT– I : σ-algebra and Borel Sets of Real numbers, Lebesgue Outer Measure, The sigma algebra of Lebesgue measurable sets, Outer and Inner approximation of Lebesgue Measurable Sets, Countable Additivity, Continuity and Borel-Cantelli Lemma. **15 Lectures**

UNIT –II: Nonmeasurable Sets, Lebesgue Measurable Functions: Sums, Product and Composition of Measurable Functions, Sequential Pointwise Limits and Simple Approximation, Littlewood's Three Principles (Statement and importance of Egoroff's Theorem and Lusin's Theorem)
15 Lectures

UNIT –III: Lebesgue Integral of a Bounded Measurable Function over a Set of Finite Measure, Lebesgue integral of a Measurable Non-negative Function, The General Lebesgue Integral, Characterizations of Riemann and Lebesgue Integrability. **15 Lectures**

UNIT – IV: Lebesgue's Theorem (Statement Only), Functions of Bounded Variations, Jordan's theorem, Absolutely Continuous Functions, Integrating Derivatives: Differentiating Indefinite Integrals, The L^P Spaces: Normed Linear Spaces, The Inequalities of Young, Hölder and Minkowski, The Riesz-Fischer Theorem. **15 Lectures**

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, McMillan, New York, 1965.
4. P. K. Jain, V. P. Gupta, Lebesgue measure and Integration, Wiley Easter Limited, 1986.
5. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill Book Co, 1964.
6. P. K. Halmos, Measure Theory, Van Nostrand, 1950.

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

Title of Course: Front End Development

Total Credits: 04(2Theory+ 2 Practical)

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

1. Understand the basics of web development.
2. Understand the fundamentals of JavaScript.
3. Understand React Components.
4. Develop Basic Front-End Applications.

Unit-I: Introduction to web design principles, overview of web development technologies and tools, understanding the role of HTML, CSS, and JavaScript, HTML basics, HTML elements, Attributes, heading, paragraphs, Styles, Formatting, Quotations, colors, links, images, table, list tags, Iframe, File paths, HTML layouts, Introduction to CSS syntax and selectors, applying styles to HTML elements, managing layouts using CSS**.** **15 Lectures**

Unit-II: JavaScript: Overview, Data types, variables, scope of variables, casting, data type conversion rules, conditions, Looping structure, Expressions and operators. Arrays. Built-in functions, and Built-in objects- String, Date, Math, Types of dialog boxes-alert, prompt, confirm. Custom Functions. Event and event handling. **15 Lectures**

Unit-III: Introduction to React: Overview of React.js and its role in web development, Role of NodeJs and NPM in React, setting up a development environment using Create React App, Understanding JSX (JavaScript XML). React Components, React Props and State. Handling Events and Forms, React Bootstrap. **15 Lectures**

Unit-IV: React Hooks: Exploring various hooks (useEffect, useContext, useRef, etc.). Introduction to React Router for navigation. **Introduction to Redux**: Redux Architecture, Redux Installation, Core concepts. **Introduction to Flux:** Dispatcher, Stores, Views and Advantage of Flux.

15 Lectures

References:

1. Head First HTML and CSS by Elizabeth Robson and Eric Freeman
2. HTML, CSS, and JavaScript All in One by Meloni and Kyrin's
3. HTML5andCSS3 All-in-One For Dummies –by Andy Harris
4. The Road to React: The React.js with Hooks in JavaScript by Robin Wieruch,
5. Learn React Hooks by Daniel Bugl, Packt Publishing

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

Title of Course: Field Theory-I
Total Credits: 02
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 and Separable extensions:** Splitting fields, Normal extensions, Multiple roots, Finite fields, Separable extensions. **15 Lectures**

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 with Computer Applications) (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. **15 Lectures**

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. **15 Lectures**

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. **15 Lectures**

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. **15 Lectures**

N.B. - 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).
6. Harry Pollard, The Theory of Algebraic Numbers, The Mathematical Association of America.

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

Title of Course: Advanced Discrete Mathematics
Total Credits: 04
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. study Binomial theorem and use to solve various combinatorial problems.
4. simplify the Boolean identities and apply to switching circuits.
5. locate and use information on discrete mathematics and its applications.

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.

15 Lectures

Unit II: Fusion, definition and simple properties of a tree, bridges, spanning trees, cut vertices, Euler tours and Hamiltonian cycles, Fleury's Algorithm, Hamiltonian graphs, plane and planar graphs.

15 Lectures

Unit III: Principle of inclusion and exclusion, Pigeonhole principle, permutations and combinations, Binomial theorem, discrete numeric functions, manipulation of numeric functions, generating functions, linear recurrence relations with constant coefficients, particular solutions of linear recurrence relations, total solutions, solution by the method of generating function.

15 Lectures

Unit IV: 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

N.B. - Seminars, Tutorials, Problem solving session and group discussions on above units.

Recommended books:

2. John Clark and Derek Holton, A first look at Graph Theory, Allied Publishers Ltd., 1991.
3. C.L. Liu, D. P. Mohapatra, Elements of Discrete Mathematics, Tata McGraw Hill Pvt Ltd, 1985.
4. G. Gratzer, General Lattice Theory, Birkhauser, 2002.
5. J. Eldon Whitesitt, Boolean Algebra and Its Applications, Addison-Wesley PublishingCompany, Inc.,1961.

Reference books:

5. Seymon Lipschutz and Mark Lipson, Discrete Mathematics (second edition) Tata Mc Graw Hill Publishing Company Ltd. New Delhi.
6. Richard A. Brualdi, Introductory Combinatorics, Pearson, 2004.
7. Garrett Birkhoff: Lattice Theory, American mathematical society, 1940.

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

Title of Course: 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.

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 Z_4 Quaternary codes Binary codes derive from codes over Z_4, Galuis rings over Z_4 cyclic codes over, Z_4.
15 Lectures

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

Recommended Book(s):

1. J. H. Van Lint : Introduction to coding theory, springer verlag 1998

Reference Books:

7. Berle Kamp E.R.: Algebraic coding Theory, New york McGraw Hill,1968

M. Sc.(Mathematics with Computer Applications)(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**

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 with Computer Applications) (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**

N.B. - 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 with Computer Applications) (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

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

Title of Course: Android Development with Kotlin

Total Credits: 04

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

1. Understand Android Studio Environment and application structure.
2. Demonstrate different layouts, views, activities and intents
3. Design good user interface for the application.
4. Able to store, retrieve and load data
5. Demonstrate programming skills using Kotlin

Unit-I : Introduction to Kotlin: Kotlin basics: Introduction to Kotlin, Benefits of using Kotlin, Use Kotlin REPL to practice basic expressions, Control flow statements in Kotlin, Null safety with Kotlin. Functions: Creating and calling functions with default and named arguments, Writing concise and compact functions, Passing functions as arguments to other functions, Writing simple lambdas. Classes and Objects: Introduction to object-oriented programming in Kotlin, Classes and objects in Kotlin, Constructors, Visibility modifiers, Subclasses and inheritance, Interfaces, Data classes, Singleton class enums, Pairs, triples and collections in Kotlin, Extensions in Kotlin **15 Lectures**

Unit-II: Introduction to Android Build in first Android app: Installing Android Studio, Creating an Android app project, Deploying theapp to an emulator or a device, Building an Android app that contains images and a click handler, Modifying views within the layout of an app, Adding libraries to module gradle file. Layouts: Creating layouts in Android Studio using XML and the Layout Editor, Adding interactivity to your app, Working with ConstraintLayout, Data binding basics. App Navigation: Creating Fragments, Defining NavHostFragment, navigation graphs, navigational paths, Functionality of Back and Up buttons, Defining the options menu, Creating a navigational drawer, Using the Safe Args plugin and passing of arguments, Starting an external Activity.

15 Lectures

Unit-III: Android Application Architecture Activity and Fragment Lifecycles: Understanding Activity and Fragment Lifecycles, Exploring logging options in your app, Using the Android Lifecycle library, Exploring configuration changes. App Architecture (UI Layer): Using the recommended Android App Architecture, Using the Life Cycle, ViewModel, and ViewModelFactory classes, Adding LiveData and LiveData, observers, Adding Data Binding with ViewModel and LiveData, Adding LiveData, transformations App Architecture (Persistence): Overview of Room Persistence Library, Introduction to coroutines, Advanced RecyclerView use cases: Introduction to RecyclerView Fundamentals, Implementing data binding with RecyclerView, Using GridLayout with RecyclerView, Interacting with RecyclerView items, Adding headers in RecyclerView **15 Lectures**

Unit-IV: Connect to the Internet and App Design Connect to the Internet: Connecting to a web service with the Retrofit library, Parsing a JSON response with the Moshi library, Using coroutines with Retrofit, Loading and displaying images from the Internet, Filtering data from the Internet. Repository pattern and WorkManager: Adding an offline cache and repository, Implementing Work Manager, Working with background workers and periodic WorkerRequest App UI Design: Introduction to basic app design, Understanding Styles and Themes, Implementing Material Design, Designing for everyone. **15 Lectures**

References:

1. Kotlin for Android Developers: Learn Kotlin the Easy Way While Developing an Android Appby , Antonio Leiva (Free ebook)
2. Learn Android Studio 3 with Kotlin: Efficient Android App Development by, Ted Hagos, A press publisher.
3. https://developer.android.com/kotlin
4. Android Development with Kotlin by Marcin Moskala, Packt Publishing; Standard Edition

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

Title of Course: **Cyber Security**

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

1. Realize the need for Cyber Security
2. Understand the need for Security in day to day communications
3. Understand the vulnerabilities in the Network and Computer System
4. Understand the cyber law and Cyber Forensics

Unit-I **15 Lectures**

Introduction to Cyber Security: Overview of Cyber Security, Internet Governance – Challenges and Constraints, Cyber Threats:- Cyber Warfare-Cyber Crime-Cyber terrorism-Cyber Espionage, Need for a Comprehensive Cyber Security Policy, Cyber Security Vulnerabilities-Overview, Cyber Security Safeguards- Overview, Access control, Biometrics, Denial of Service Filters, Ethical Hacking, Response, Scanning, Security policy, Threat Management.

Unit-II **15 Lectures**

Cryptography and Network Security: Introduction to Cryptography, Symmetric key Cryptography, Asymmetric key Cryptography, RSA, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls- Types of Firewalls, User Management, VPN Security Protocols:- security at the Application Layer- PGP and S/MIME

Unit –III **15 Lectures**

Securing Web Application, Services and Servers: Introduction, Basic security for HTTP Applications and Services, Basic Security for SOAP Services, Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges. Intrusion Detection and Prevention: Intrusion, Unauthorized Access by Outsider, Malware infection, Intrusion detection and Prevention Techniques, Anti-Malware software, Network based Intrusion detection Systems, Network based Intrusion Prevention Systems, Host based Intrusion prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation.

Unit –IV **15 Lectures**

Cyberspace and the Law: Introduction, Cyber Security Regulations, Roles of International Law, the state and Private Sector in Cyberspace, Cyber Security Standards. The INDIAN Cyberspace, National Cyber Security Policy 2013.Cyber Forensics: Introduction to Cyber Forensics, Handling Preliminary Investigations, Controlling an Investigation, Conducting disk-based analysis, Investigating Information-hiding, Scrutinizing E-mail, Validating E-mail header information, Tracing Internet access, Tracing memory in real-time.

References:

1. Preston Gralla, How Personal and Internet Security Work, Que Publications
2. Alfred Basta and Wolf Halton, Computer Security Concepts, Issues and Implementation, Cengage Learning
3. Digital Defense: A Cybersecurity Primer by Joseph Pelton , Indu B. Singh
4. Cryptography and Network Security: Principles and Practice by William Stallings

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

M. Sc. (Mathematics with Computer Applications) (Part II) (Level-6.5) (Semester IV)
(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

Seminars, Tutorials, Problem solving session and group discussions on above four 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 with Computer Applications)(Part II) (Level-6.5) (Semester IV)
(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**

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

Title of Course: Back End Development

Total Credits: 04(2Theory+ 2 Practical)

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

1. develop application using MVC
2. understand Entity Framework and core Framework
3. understand Web API
4. .Understand the fundamentals of Node.js.

Unit-I: Introduction to MVC, Benefits of using ASP.NET MVC, Role of Model, View, and Controller,ASP.NET MVC Works, Naming conventions, Creating views, Defining controllers, Defining a data model, Creating strongly-typed views, Razor View Engine: Razor Basics, Razor design goals, Implementation of Razorview, Razor syntax**.** **15 Lectures**

Unit-II: Using Entity Framework: Crud Operations, Crud Operation Using BO Class, Crud Operations Using Generic BO Class, Authentication techniques. Working with URLs and Routing: Understanding the Routing Mechanism, Adding a Route Entry, Using Parameters, Using Defaults, Using Constraints. Introduction to ASP.NET Core: Overview ASP.NET Core, Features of ASP.NET Core, Architecture of ASP.NET Core, benefits ASP.NET Core. **15 Lectures**

Unit-III: Introduction to MongoDB (No-sql), Difference between NoSQL and RDBMS, Benefits of NoSQL, Objectives, Design Goals, The Mongo Shell, JSON Introduction, JSON Structure, Collections in MongoDb, Documents In mongoDb, Inserting data into database, Filter queries in Mongodb Database, Schema Validation in MongoDb database, Indexing In collections, Aggregation in MongoDb, Embedded Document in MongoDb. **15 Lectures**

Unit-IV: Introduction to Node.js: Overview of Node.js and its architecture, Installing Node.js and npm. Node.js global objects and modules. **File System**: read File, Writing a File, Writing a file asynchronously, Opening a file, Deleting a file, Other IO Operations. **Node.js Events**: Event Emitters, Binding Functions to Events, Event Requests, Event Listening. Mongodb with Nodejs, Design the Schema in Nodejs, Design the Rest API's, GET, POST, PUT, and DELETE methods. **15 Lectures**

References:

1. Professional ASP.NETMVC5,byJon Galloway, Brad Wilson,K.Scott Allen,David Matson
2. ASP.NETMVC4 and the WebAPI: Building a REST Service from Start to Finish by Jamie Kurtz
3. Node.js web development by David Herron
4. Beginning Node.js, Express & MongoDB Development by Greg Lim
5. Node.js Design Patterns by Mario Casciaro and Luciano Mammino

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

Title of Course: Fuzzy Mathematics
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

N.B. - 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 with Computer Applications (Part II) (Level-6.5) (Semester IV)
(NEP-2020)
(Introduced from Academic Year 2024-25)

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

1. Calculate wavelet transforms of functions
2. Calculate eigen values and eigen functions of Fourier transform
3. Solve ODE and PDE by using Fourier transforms
4. Use Parseval's formula and inversion theorem of wavelet transforms
5. Calculate wavelet transforms using different wavelets

UNIT– I : 15 Lectures
Fourier transforms : Fourier transforms in L1(R), Basic properties of Fourier transforms, Riemann Lebesgue lemma, Convolution theorem, Approximate identity theorem, uniqueness, general modulation

UNIT –II:. **15 Lectures**
Fourier transforms in L2(R): Parseval's relation, inverse Fourier transform, General Parsevals relation, Plancherels theorem, Duality, Eigenvalues and eigen functions of the Fourier transform, Poisson summation formula, Shannon Sampling theorem, Heisenberg uncertainty principle

UNIT –III: 15Lectures
Applications of Fourier transforms to ordinary differential equations, Bernoulli-Euler Beam equation, solutions of integral equations, solutions of partial differential equations, Dirichlet problem in the half plane, Neumann's problems in the half plane, the Cauchy problem for the diffusion equation, Green's function.

UNIT – IV:. **15Lectures**
Wavelet Transform: Mother wavelet , Continuous wavelet transforms, Haar wavelet, convolution,the Mexican hat wavelet, Morlet wavelet, Basic properties of Wavelet transforms, Parseval's formula for wavelet transforms, inversion formula, Discrete wavelet transforms, Frame operator, orthonormal wavelets

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

Recommended Book(s):
1. Lokenath Debnath: Wavelet Transforms and Applications, Birkhauser 2002

Reference Books:
1. Christian Blatter ,Wavelets a primer ,Universities press 1998
2. Mark A. Pinsky : Introduction To Fourier Analysis and Wavelets.
3. Gerald Kaiser : A Friendly Guide to Wavelets , Springer 1994.
4. George Bachman , Lawrwnce Narici, Edward Beckenstein: Fourier and Wavelet Analysis, Springer, 2005.

M. Sc.(Mathematics with Computer Applications)(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**

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:

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

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

Title of Course: Cloud Computing

Course Outcomes: Upon successful completion of this course, the student will be able to:
1. Acquire knowledge of cloud computing and its usage.
2. Understand components and operations of cloud computing system.
3. Understand the concept of Virtualization and design of cloud Services
4. Enhance the skills for data management, storage and operations in cloud computing system.
5. Study recent trends in cloud computing.

Unit I: **15 Lectures**

Fundamentals of cloud computing Evolution of cloud computing, characteristics of cloud computing, need of cloud computing, Components of cloud computing, cloud computing architecture, client server architecture, grid computing environment, Cloud computing vs. Cluster computing, types of cloud, major players in cloud computing, advantages and challenges of cloud computing.

Unit II: **15 Lectures**

Virtualization Virtualization architecture and its needs, benefits and challenges, types of virtualization, Levels of Virtualization Implementation, virtualization of CPU, Memory and I/O devices, server virtualization, virtualization design requirements, virtualization structure, open source virtualization technology, Pros and cons of virtualization. Hypervisor, Virtual Machine Types, load balancing, Examples of cloud services- Microsoft azure, Google cloud, VMware, Amazon EC2.

Unit III: **15 Lectures**

Cloud computing services & security Cloud services-IaaS, SaaS, PaaS, DaaS, MaaS, CaaS, DBaas, Implementation and Architecture of Eucalyptus, Nimbus &OpenNebula, cloud development techniques, cloud based storage, cloud backup, Cloud security - Cloud Security Challenges and Risks, disaster recovery, data integration, data transformation, data migration, challenges with data security

Unit IV: **15 Lectures**

Recent trends in cloud computing Cloud standards, service oriented architecture (SOA) for cloud application, mobile cloud computing its application, architecture and working. MongoDB, MapReduce implementations for the Cloud.Multicloud approach, Role of AI in Cloud Computing, Hybrid and on- premise cloud.IoT cloud platforms.

References Books:

1. Kai Hwang, Geoffrey C Fox, Jack G Dongarra, "Distributed and Cloud Computing, From Parallel Processing to the Internet of Things", 2012, 1st Edition, Morgan Kaufmann Publishers.
2. Kailash Jauaswal, JagannathKallakurchi, Donald J. Houde, Dr. Deven Shah, "Cloud Computing", Black Book, Dreamtech , 2014
3. Barrie Sosinsky, "Cloud Computing Bible, " Wiley India Pvt. Ltd. 2012
4. Anthony T. Velte, Toby J. Velte, Robert Elsenpeter, Cloud Computing "A Practical Approach"

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

Title of Course: AI and Machine Learning
Total Credits: 04

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

5. Gaining knowledge and expertise in AI and ML
6. Understand basic concepts of Supervised Learning and unsupervised Learning
7. Design solutions to real life problems by applying ML algorithms.
8. Understand Recommender Systems

Unit-I : Introduction to Artificial Intelligence and Machine learning, Essential concepts in Artificial Intelligence and Machine learning. Machine learning basics: Key terminology, Key tasks of machine learning, choosing the right algorithm, Steps in developing a machine learning application.

15 Lectures

Unit-II: Supervised Learning The k-Nearest Neighbors classification algorithm, Parsing and importing data from a text file, creating scatter plots with Matplotlib, Normalizing numeric values. **Decision tree**, Tree construction, plotting trees in Python, Testing and storing the classifier.

15 Lectures

Unit-III: Naïve Bayesian decision theory, Conditional probability, classifying with conditional probabilities, Document classification with naïve Bayes, classifying text with python, Case study: classifying spam email with naïve Bayes.
Unsupervised learning: Clustering, Grouping unlabeled data using K-Means clustering, K-means algorithm. **15 Lectures**

Unit-IV: Recommender System: Introduction, Understanding Recommendation Systems, Content Based Filtering, User Based Collaborative Filtering, Item Based Collaborative Filtering, Methods and tricks of the trade, Issues in Recommendation Systems, Recommender System in Python.

15 Lectures

References:

1. Machine Learning and Artificial Intelligence, Ameet V. Joshi, Springer, Cham
2. Machine Learning in Action,Peter Harrington, April 2012 , Manning publications. https://livebook.manning.com/book/machine-learning-in-action/about-this-book/
3. Artificial Intelligence and Machine Learning Fundamentals by Zsolt Nagy
4. Data Mining Concepts and Techniques, Jiawei Han and Micheline Kamber, Else

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

Title of Course: Internet of Things (IoT)
Total Credits: 04

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

9. Understand of the basic concepts, principles, and components of the Internet of Things.
10. Apply IoT to different applications
11. Analysis and evaluate protocols used in IoT
12. Design smart city in IoT.
13. 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**

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

9. Scheme of Teaching

1. Each theory lecture shall be of 60 minutes.
2. Each practical shall be of 120 minutes.
3. In a week for each theory course 4 lectures shall be conducted.
4. One Practical Batch should be of 20 students.
5. Practical evaluation shall be conducted before the commencement of University examination

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

Practical:

Practical evaluation shall be through university appointed panel of one external and one internal examiner.

On Job Training:

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 carrying16 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. QuestionNo.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.

Practical Evaluation:
Nature of the Practical examination for courses of 2 credits:

1. There shall be 3 questions each carrying 20 marks.
2. Students have to attempt any two questions.
3. Duration of university practical examination of 50 marks shall be of 2 hours.
4. There shall be 10 marks for practical viva and assignments.
5. The practical examination will be conducted semester wise.

There shall be university appointed 1 internal examiner and 1 external examiner to conduct practical examination.

12. Equivalence of courses

M. Sc. (Mathematics with Computer Applications) is a new program started from the academic year 2023-24.