# Holy Cross College (Autonomous), Nagercoil – 629004
## Kanyakumari District, Tamil Nadu
## Nationally Accredited with A$^{++}$ by NAAC V cycle – CGPA 3.53

*Affiliated to*
**Manonmaniam Sundaranar University, Tirunelveli**

## DEPARTMENT OF MATHEMATICS (SF)

# TEACHING PLAN
## EVEN SEMESTER 2025 - 2026

**Vision**

To empower women globally competent with human values and ethics acquiring academic and entrepreneurship skills through holistic education.

**Mission**

1. To create opportunities which will ensure academic excellence in critical thinking, humanistic and scientific inquiry.
2. To develop application-oriented courses with the necessary input of values.
3. To create a possible environment for innovation, team spirit and entrepreneurial leadership.
4. To form young women of competence, commitment and compassion.

**Graduate Attributes**

Graduates of our College develop the following attributes during the course of their studies.

- **Creative thinking:**

  Equipping students with hands-on-training through skill based courses and promote startup.

- **Personality development:**

  Coping with increasing pace and change of modern life through value education, awareness on human rights, gender issues and giving counselling for the needful.

- **Environmental consciousness and social understanding:**

  Reflecting upon green initiatives and understanding the responsibility to contribute to the society; promoting social and cultural diversity through student training and service-learning programmes.

- **Communicative competence:**

  Offering effective communication skills in both professional and social contexts through bridge courses and activities of clubs and committees.

- **Aesthetic skills:**

  Engaging mind, body and emotions for transformation through fine arts, meditation and exercise; enriching skills through certificate courses offered by Holy Cross Academy.

- **Research and knowledge enrichment:**

  Getting in-depth knowledge in the specific area of study through relevant core papers; ability to create new

understanding through the process of critical analysis and problem solving.

- **Professional ethics:**

  Valuing honesty, fairness, respect, compassion and professional ethics among students. The students of social work adhere to the *National Association of Social Workers Code of Ethics*

- **Student engagement in the learning process:**

  Obtaining extensive and varied opportunities to utilize and build upon the theoretical and empirical knowledge gained through workshops, seminars, conferences, industrial visits and summer internship programmes.

- **Employability:**

  Enhancing students in their professional life through Entrepreneur development, Placement & Career guidance Cell.

- **Women empowerment and leadership:**

  Developing the capacity of self-management, team work, leadership and decision making through gender sensitization programmes

**Programme Educational Objectives (PEOs)**

| **POs** | **Upon completion of M. Sc. Degree Programme, the graduates will be able to:** | **Mapping with Mission** |
|---|---|---|
| **PEO1** | apply scientific and computational technology to solve social and ecological issues and pursue research. | **M1, M2** |
| **PEO2** | continue to learn and advance their career in industry both in private and public sectors. | **M4 & M5** |
| **PEO3** | develop leadership, teamwork, and professional abilities to become a more cultured and civilized person and to tackle the challenges in serving the country. | **M2, M5 & M6** |

## Programme Outcomes (POs)

| POs | Upon completion of M.Sc. Degree Programme, the graduates will be able to: | Mapping with PEOs |
|---|---|---|
| **PO1** | apply their knowledge, analyze complex problems, think independently, formulate and perform quality research. | **PEO1 & PEO2** |
| **PO2** | carry out internship programmes and research projects to develop scientific and innovative ideas through effective communication. | **PEO1, PEO2 & PEO3** |
| **PO3** | develop a multidisciplinary perspective and contribute to the knowledge capital of the globe. | **PEO2** |
| **PO4** | develop innovative initiatives to sustain ecofriendly environment | **PEO1, PEO2** |
| **PO5** | through active career, team work and using managerial skills guide people to the right destination in a smooth and efficient way. | **PEO2** |
| **PO6** | employ appropriate analysis tools and ICT in a range of learning scenarios, demonstrating the capacity to find, assess, and apply relevant information sources. | **PEO1, PEO2 & PEO3** |
| **PO7** | learn independently for lifelong executing professional, social and ethical responsibilities leading to sustainable development. | **PEO3** |

## Programme Specific Outcomes (PSOs)

| PSO | Upon completion of M.Sc. Degree Programme, the graduates of Mathematics will be able to: | PO Addressed |
|---|---|---|
| **PSO–1** | acquire good knowledge and understanding, to solve specific theoretical & applied problems in different area of mathematics & statistics | **PO1 & PO2** |
| **PSO–2** | understand, formulate, develop mathematical arguments, logically and use quantitative models to address issues arising in social sciences, business and other context /fields. | **PO3 & PO5** |
| **PSO–3** | prepare the students who will demonstrate respectful engagement with other's ideas, behaviors, beliefs and apply diverse frames of references to decisions and actions | **PO6** |
| **PSO–4** | pursue scientific research and develop new findings with global Impact using latest technologies. | **PO4 & PO7** |
| **PSO–5** | possess leadership, teamwork and professional skills, enabling them to become cultured and civilized individuals capable of effectively overcoming challenges in both private and public sectors. | **PO5 & PO7** |

## Mapping of PO'S and PSO'S

| POs | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 |
|---|---|---|---|---|---|
| **PO 1** | **S** | M | S | S | S |
| **PO 2** | S | S | S | S | M |
| **PO 3** | S | S | M | S | S |
| **PO4** | S | M | S | S | M |
| **PO5** | M | S | M | S | S |
| **PO6** | S | S | S | M | S |
| **PO7** | S | S | S | S | S |

Strong -S (3), Medium – M (2), Low – L (1)

**Department : Mathematics**
**Class : II M. Sc Mathematics**
**Title of the Course : CORE COURSE X: FUNCTIONALANALYSIS**
**Semester : IV**
**Course Code : MP234CC1**

| Course Code | L | T | P | S | Credits | Inst. Hours | Total Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CIA | External | Total |
| MP234CC1 | 6 | - | - | - | 5 | 6 | 90 | 25 | 75 | 100 |

**Learning Objectives:**

1. To provide students with a strong foundation in functional analysis, focusing onspaces, operators and fundamental theorems.
2. To develop student's skills and confidence in mathematical analysis and prooftechniques.

**Course Outcomes**

| On the successful completion of the course, students will be able to: | | |
|---|---|---|
| 1 | able to demonstrate comprehension of the definitions and basic properties of Banach and Hilbert spaces | **K1** |
| 2 | able to apply the Hahn Banach theorem to extend continuous linear functionals on subspaces to the whole space | **K3** |
| 3 | describe the concept of adjoint operators in Hilbert spaces and recognize properties of self-adjoint, normal, and unitary operators | **K2** |
| 4 | analyze the concepts of determinants, spectrum, and the spectral theorem for operators in finite-dimensional spaces | **K4** |
| 5 | evaluate the structure of commutative Banach algebras, including understanding the Gelfand Mapping and applications of spectral radius formula | **K5** |

**Teaching plan**

**Total Contact hours*: 90 (Including lectures, assignments and tests)**

| Unit | Module | Topic | Teaching Hours | Assignment Hours | Cognitive level | Pedagogy | Student Centric Method | E-Resources | Assessment/ Evaluation Methods |
|---|---|---|---|---|---|---|---|---|---|
| **I** | **Banach spaces** | | | | | | | | |
| | 1 | Definition and some examples | 2 | 1 | K1(R) | Lecture, Worked examples with detailed steps, Counter examples for clarity | Group Discussion, Think–Pair–Share on examples of Banach spaces | PPT, Online Notes | Quiz, Short tests on definitions, CIA I |
| | 2 | Some important inequalities | 3 | | K2(U) | Lecture, Concept explanation with diagrams | Peer Teaching, Group activity: Identify Banach vs non-Banach spaces | PPTs, Video Lectures, Interactive Apps | Quiz, Worksheet, Oral Presentation, CIA I |
| | 3 | Operators | 3 | 1 | K4(An) | Collaborative Group Work, Inquiry-Based Learning | cooperative activities involving pairs and small groups, Group | PPT, Video Lectures, Online Notes | Simple definitions, MCQ, Recall steps, Concept definitions, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Presentations | | |
| | 4 | Continuous linear transformations | 4 | | K4(An) | Collaborative Learning, Chalk-and-talk, Socratic Questioning | Think-Pair-Share, Peer Learning | PPT Presentation | Evaluation through short test, Viva on continuous linear transformations, CIA I |
| | 5 | The Hahn Banach theorem | 3 | 1 | K3(Ap) | Lecture, Proof-based teaching | Peer teaching: Students explaining simple proofs , Think-Pair-Share, Discussion | Video Lectures | Quizziz, Assignment on Hahn–Banach applications, CIA I |
| **II** | **Banach spaces** | | | | | | | | |
| | 1. | Natural Embedding of N into N** | 2 | 1 | K1(R) | Lecture, Illustration of dual and double-dual spaces | Think-Pair-Share, Peer Teaching, Group Discussion, Concept mapping between N, N* and N** | PPT, Video Lectures, Online Notes | Quiz, Written Assignment, Oral Presentation, CIA I |
| | 2. | Reflexive Spaces | 3 | | K2(U) | Inquiry-Based Learning, Jigsaw Method | Formulating questions, Reflective learning sheets , Concept Mapping | PPT Presentation | Quiz, Worksheet, Group Presentation, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3. | Open Mapping Theorem | 3 | 1 | K2(U) | Lecture with Illustration, Flipped Classroom, Theorem–Proof strategy | In-class discussions, group activities, Q&A with instructor, Student-led proof presentation | Video Lectures, Online Notes | Evaluation through quiz test using quizziz, MCQ, Group presentation of Open Mapping Theorem, CIA I |
| | 4. | Closed Graph Theorem | 3 | 1 | K3(Ap) | Lecture, Visual Aids, Step-by-step mapping diagrams | Think-Pair-Share, Peer Teaching, Student-led proof presentation | PPT, Video Lectures, Online Notes | Quiz, Written Assignment, Oral Presentation, CIA I |
| | 5. | Conjugate of an Operator | 4 | | K4(An) | Lecture, Socratic Questioning, Worked-out proofs | Peer Teaching, Think-Pair-Share, Discussion, Peer teaching: Students explaining simple proofs | Video Lectures | Quiz test, Written assignment on operator conjugate, CIA I |
| **III** | **Hilbert spaces** | | | | | | | | |
| | 1. | Definition and Basic Properties of Hilbert Spaces | 3 | 1 | K1(R) | Lecture, Socratic Questioning, Concept Mapping | Think-Pair-Share, Peer discussions on Hilbert space properties, Group Discussion | PPT, Video Lectures, Online Notes | Quiz, Written Assignment, Oral Presentation, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2. | Orthogonal Complements | 3 | | K2(U) | Lecture, Visual Aids, geometric interpretation of inner products | Peer Teaching, Jigsaw Method, Quiz: Identify orthonormal sets | PPTs, Video Lectures | Quiz, Worksheet, Oral viva on orthogonality concepts, CIA I |
| | 3. | Orthonormal Sets & Gram–Schmidt Process | 3 | 1 | K2(U) | Demonstration of Gram–Schmidt Process, Collaborative Group Work, Inquiry-Based Learning | Pair activity: Perform Gram–Schmidt on sample sets, Learning-by-doing (inner product computations) | PPT, Online simulators for orthogonalization, Online Notes | Gram–Schmidt assignment, Recall steps, Concept definitions, CIA II |
| | 4. | Bessel's Inequality & Parseval's Identity | 3 | 1 | K4(An) | Lecture, Activity-based learning, Concept Mapping | Think-Pair-Share, Peer Learning, brainstorming | PPT Presentation | Evaluation through short test, CIA II |
| | 5. | Conjugate Space H* | 3 | | K3(Ap) | Blended Learning, Use of function space examples | Worksheets for H*, Group Presentations | Video Lectures | Quizz test, CIA II |
| **IV** | **Hilbert spaces** | | | | | | | | |
| | 1. | Adjoint of an Operator | 3 | 1 | K1(R) | Lecture, Problem Solving, Blended Learning, | Online problem sets, Students create | PPT, Video Lectures, Online Notes | Assignment: Compute adjoints, Oral |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Operator visualisation using matrices | comparison tables of operators, Peer Teaching, Group Discussion | | Presentation, CIA II |
| | 2. | Self-Adjoint Operators | 3 | | K2(U) | Lecture with Visual Aids, Comparison charts of operator types, Inquiry-Based Learning | Think-Pair-Share, Formulating questions, Adjoint operator computation | PPT Presentation | Quiz, Worksheet, Group Presentation, CIA II |
| | 3. | Normal and Unitary Operators | 3 | 1 | K4(An) | Lecture with Illustration, Flipped Class, Concept Mapping | In-class discussions, group activities, Q&A with instructor | Video Lectures, Online Notes | Evaluation through quiz test using quizziz, Seminar, MCQ, Recall steps, CIA II |
| | 4. | Projections in Hilbert Spaces | 3 | 1 | K4(An) | Lecture, Problem-Based Learning, Proof-oriented approach | Think-Pair-Share, Peer Teaching | PPT, Video Lectures, Online Notes | Quiz, Written Assignment, Oral Presentation, CIA II |
| | 5. | Finite Dimensional Spectral Theorem | 3 | | K3(Ap) | Lecture, Socratic Questioning, Concept Mapping | Peer Teaching, Think-Pair-Share, Discussion | Video Lectures | Slip Test, CIA II |
| **V** | **General Preliminaries on Banach Algebras** | | | | | | | | |
| | 1. | Definition & Examples of Banach Algebras | 3 | 1 | K1(R) | Lecture, Socratic Questioning, Chalk & talk for | Think-Pair-Share, Group assignment on | PPT, Video Lectures, Online Notes | Quiz, Written Assignment, Oral |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | algebraic structures | Banach algebra examples, Group Discussion, Seminar presentations by students | | Presentation, CIA II |
| | 2. | Regular & Singular Elements | 3 | | K2(U) | Lecture, Visual Aids, Example-based teaching | Peer Teaching, Jigsaw Method, Seminar presentations by students | PPTs, Video Lectures, Interactive Apps | Quiz, Worksheet, Oral Presentation, CIA II |
| | 3. | Topological Divisors of Zero | 3 | 1 | K4(An) | Collaborative Group Work, Inquiry-Based Learning, Flowcharts for operator properties | Debates, Group Presentations, Seminar presentations by students | PPT, Video Lectures, Online Notes | Simple definitions, MCQ, Recall steps, Concept definitions, CIA II |
| | 4. | The Spectrum of an Element | 3 | 1 | K4(An) | Lecture with Illustration, Flipped Classroom | Think-Pair-Share, Peer Learning, Seminar presentations by students , Problem-based learning: Compute spectrum | PPT Presentation | Evaluation through short test, CIA II |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5. | Spectral Radius Formula | 3 | | K3(Ap) | Lecture with Illustration , Group Discussion, | Peer Teaching, Think-Pair-Share, Discussion, Seminar presentations by students | Video Lectures, PPT | Slip Test using Quizziz, CIA II |

Course Focussing on Employability/ Entrepreneurship/ Skill Development: **Skill Development**

Activities (Em/ En/SD): Pair activity: Perform Gram–Schmidt on sample sets

Assignment : Gram–Schmidt assignment (Last date to submit – 19-02-2026)

Seminar Topic: General Preliminaries on Banach Algebras

**Sample questions**

**Part A (1 mark)**

1. A **Banach space** is a normed linear space that is _____ **CO-1, K1**
   a) Finite-dimensional
   b) Complete with respect to the norm
   c) Compact
   d) Bounded
2. The conjugate or dual space of a Banach space X consists of _____ **CO-1, K1**
   a) All bounded linear functionals on X
   b) All continuous mappings from X to itself
   c) All unbounded linear functionals on X
   d) All compact operators on X

3. An inner product space is a vector space equipped with _____ **CO-1, K1**
   a) A rule that assigns a real or complex number to each pair of vectors satisfying certain conditions
   b) A rule that assigns a number only to single vectors
   c) A metric that measures only distance
   d) A set of orthogonal vectors only
4. The adjoint of an operator T on a Hilbert space H is _____ **CO-3, K2**
   a) The operator T star such that the inner product of T x with y equals the inner product of x with T star y for all x, y in H
   b) The transpose of T
   c) The inverse of T
   d) The identity operator
5. A Banach algebra is _____ **CO-5, K5**
   a) A Banach space which is also an algebra and in which multiplication is continuous
   b) A vector space with an inner product
   c) A Hilbert space with a norm
   d) A metric space with bounded operators

## Part B (6 marks)

1. Prove that $\|\|x\| - \|y\|\| \leq \|x - y\|$. **CO-2, K3**
2. State and prove the Uniform Boundedness theorem. **CO-2, K3**
3. State and prove the Schwartz inequality. **CO-2, K3**
4. Prove that an operator T on a Hilbert space H is unitary if and only if it is an isometric isomorphism of H onto itself. **CO-3, K2**
5. Define spectrum of an operator T on a Hilbert space H and prove that if T is non singular, then $\lambda \in \sigma(T)$ iff and only if $\lambda^{-1} \in \sigma(T^{-1})$. **CO-5, K5**

## Part C (12 marks)

1. Let M be a closed linear subspace of a normed linear space N. If the norm of a coset x+M in the quotient space N/M is defined by $\|x + M\| = inf\{\|x + m\| : m \varepsilon M\}$ Prove that N/M is a normed linear space. Further, if N is a Banach space, then so is N/M. **CO-2, K3**

2. State and prove the closed graph theorem. **CO-2, K3**

3. If $\{e_i\}$ is an orthonormal set in a Hilbert space H, and if x is an arbitrary vector in H, prove that $x - \sum < x, e_i > e_i \perp e_j$ for each j. **CO-3, K2**

4. If T is an operator on H prove that the following conditions are all equivalent to one another.

(i) T* T = I (ii) <Tx,Ty> = <x,y> for all x and y

(iii) $\|Tx\| = \|x\|$ for all x. **CO-3, K2**

5. State and prove the spectral theorem. **CO-5, K5**

**Head of the Department**

**Dr. J. Anne Mary Leema**

**Course Instructors**

**Dr. J. Anne Mary Leema & Dr. C. Jenila**

## Teaching Plan

**Department : Mathematics**
**Class : II M.Sc Mathematics**
**Title of the Course : Core Course XI: Probability Theory**
**Semester : IV**
**Course Code : MP234CC2**

| Course Code | L | T | P | S | Credits | Inst. Hours | Total Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CIA | External | Total |
| MP234CC2 | 6 | - | - | - | 5 | 6 | 90 | 25 | 75 | 100 |

**Learning Objectives:**

1. To upgrade the knowledge of Probability theory.
2. To solve NET /SET related Probability theory problems.

### Course Outcomes

| On the successful completion of the course, students will be able to: | | |
|---|---|---|
| 1. | recall the basic probability axioms, conditional probability, random variables, and related concepts | **K1** |
| 2. | define Special Mathematical Expectations, The Binomial Distribution, and The Poisson Distribution. | **K2** |
| 3. | Define the Exponential, Gamma, and Chi-square Distributions, The Normal Distribution. | **K2** |
| 4. | study Bivariate Distributions of discrete, and continuous types, The correlation coefficient, Conditional Distribution, and The Bivariate Normal Distribution. | **K5** |
| 5. | discuss Functions of one random variable, Transformations of two random variables, The central limit Theorem, Chebyshve's inequality, and convergence in probability, Limiting moment-generating functions. | **K3, K4** |

**K1** - Remember; **K2** - Understand; **K3**- Apply; **K4** - Analyse; **K5**- Evaluate

**Teaching plan**

**Total Contact hours: 90 (Including lectures, assignments and tests)**

| Unit | Module | Topic | Teaching Hours | Assessment Hours | Cognitive level | Pedagogy | Student Centric Method | E-Resources | Assessment/ Evaluation Methods |
|---|---|---|---|---|---|---|---|---|---|
| **I** | **PROBABILITY** | | | | | | | | |
| | 1 | Properties of probability – Examples | 3 | 1 | K1 (R) | Introductory session, Lecturing | Think-pair-share | Open Text books - Introduction to Probability Theory | Questioning, recall steps, concept definitions, CIA I |
| | 2 | Methods of enumeration - Examples | 3 | | K1 (R) | Collaborative learning | Cooperative activities involving pairs and small groups | Lecture Notes | Evaluation through short test, concept explanations, CIA I |
| | 3 | Conditional probability - Examples | 3 | 1 | K2 (U) | Peer teaching | Answering questions from peers | You Tube videos | Peer review, CIA I |
| | 4 | Independence events - Examples | 3 | | K1 (R) | Active learning | Group discussions | NPTEL lectures | Quiz using Google Forms, CIA I |
| | 5 | Baye's theorem - Examples | 3 | 1 | K2(U) | Flipped classroom | In-class discussions | Digital Libraries & Databases - | Open Book Test, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Google Scholar | |
| **II** | **DISCRETE DISTRIBUTIONS** | | | | | | | | |
| | 1 | Random variables of the discrete type - Examples | 3 | 1 | K1(R) | Introductory session, Lecturing | Think-pair-share | Open Text books Library - Introduction to Probability Theory | Recall steps, questioning, concept definitions, CIA I |
| | 2 | Mathematical Expectation - Examples | 2 | | K3(Ap) | Problem-based learning | Brainstorming | SWAYAM courses | Quiz using Kahoot, CIA I |
| | 3 | Special Mathematical Expectation - Examples | 3 | 1 | K3(Ap) & K4(An) | Inquiry-based learning | Formulating questions | Course material - MIT OCW | Class test, CIA I |
| | 4 | Binomial Distribution - Examples | 3 | | K2(U) & K3(Ap) | Collaborative learning | Group activities | Video lectures | Multiple-choice questions, CIA I |
| | 5 | Poisson Distribution - Examples | 4 | 1 | K5(E) | Peer Teaching | Answering questions from peers | You Tube Videos | Short-answer conceptual questions, CIA I |
| **III** | **CONTINUOUS DISTRIBUTIONS** | | | | | | | | |
| | 1 | Random variables of continuous type - Examples | 3 | 1 | K2(U) | Active learning | Peer instruction | Video Lectures | Multiple choice questions, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | Exponential distributions - Examples | 3 | | K3(Ap) | Inquiry-based learning | Formulating questions | Open Access Learning Platform - Brilliant.org | Quiz using Quizizz, CIA I |
| | 3 | Gamma distributions - Examples | 3 | 1 | K5(E) | Problem-based learning | Solving problems | You Tube Videos | Oral test, CIA II |
| | 4 | Chi-square distributions - Examples | 3 | 1 | K3(Ap) & K4(An) | Blended learning | Online problem sets | NPTEL Lectures | Assignment, CIA II |
| | 5 | Normal Distribution - Examples | 3 | | K2(U) & K3(Ap) | Flipped classroom | Group activities | Websites - MIT Open Course Ware - Theory of Probability | Presentation, Group discussion, CIA II |
| **IV** | **BIVARIATE DISTRIBUTIONS** | | | | | | | | |
| | 1 | Bivariate Distributions of discrete type - Examples | 3 | 1 | K2(U) | Introductory session, Lecturing | Think-pair-share | You Tube videos | Quiz on Bivariate distribution, CIA II |
| | 2 | Correlation coefficient - Examples | 4 | | K5(E) | Inquiry-Based Learning | Formulating questions | NPTEL Lectures | Observation note, CIA II |
| | 3 | Conditional distribution - Examples | 3 | | K2(U) & K3(Ap) | Blended learning | Online problem sets | You Tube Videos | Seminar, CIA II |
| | 4 | Bivariate distributions of continuous type - Examples | 3 | 1 | K3(Ap) | Flipped classroom | Collaborative problem-solving sessions | Lecture notes - Paul's online Math notes | Seminar, CIA II |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | Bivariate normal distribution - Examples | 2 | 1 | K3(Ap) & K4(An) | Collaborative learning | Problem solving tasks | NPTEL lectures | Multiple Choice Questions, Surprise test, CIA II |
| **V** | **DISTRIBUTIONS OF FUNCTIONS OF RANDOM VARIABLES** | | | | | | | | |
| | 1 | Functions of one random variable - Examples | 3 | 1 | K3(Ap) | Introductory session, Lecturing | Think-pair-share | Websites – Open Text book Library | Class Test, CIA II |
| | 2 | Transformations of two random variable - Several random variables | 3 | | K5(E) | Inquiry-Based learning | Formulating questions | Video Lectures | Quiz on Several random variables, CIA II |
| | 3 | Central limit theorem - Examples | 3 | 1 | K2(U) | Blended learning | Collaborative problem solving tools | NPTEL lectures | Multiple Choice Questions, CIA II |
| | 4 | Chebyshve's inequality and convergence in probability - Examples | 3 | 1 | K3(Ap) & K4(An) | Collaborative learning | Problem solving tasks | Free Text book - Internet Archive | Brainstorming, CIA II |
| | 5 | Limiting moment generating functions - Examples | 3 | | K2(U) & K3(Ap) | Peer teaching | Answering questions from peers | SWAYAM courses | Peer review, Oral test, CIA II |

Course Focussing on Employability/ Entrepreneurship/ Skill Development: Skill Development

Activities (Em / En /SD): Solve the problems in correlation coefficient

Assignment: Chi-square distributions (Last date to submit 16-02-2026)

Seminar Topics: Conditional distribution and Bivariate distributions of continuous type

**Sample questions**

**Part A (1 mark)**

1. Events A and B are _____ if and only if $P(A \cap B) = P(A)P(B)$. **(K1 – R, CO 1)**

   (a) dependent (b) independent (c) enumeration (d) permutation

2. State True or False: A Bernoulli experiment is a random experiment, the outcome of which can be classified in one of two mutually exclusive and exhaustive ways. **(K1 – R, CO 1)**

3. Complete: The gamma function is defined by _____. **(K2 – U, CO 2)**

4. State True or False: $0 \leq f(x, y) \leq 1$. **(K2 – U, CO 2)**

5. Complete: The mathematical expectation (or expected value) of $u(X_1, X_2, \ldots, X_n)$ is given by _____. **(K2 – U, CO 2)**

**Part B (6 mark)**

1. If $A$, $B$, and $C$ are any three events, then prove that $P(A \cup B \cup C) = P(A) + P(B) + P(C) - P(A \cap B)$ **(K2 – U, CO 2)**

2. Let $X$ have a Poisson distribution with a mean of $\lambda = 5$. Evaluate $P(X \leq 6)$, $P(X > 5)$ and $P(X = 6)$. **(K5 – E, CO 5)**

3. Derive the moment generating function of exponential distribution. **(K4-An, CO 4)**

4. Let the joint pmf of $X$ and $Y$ be defined by $f(x, y) = \frac{xy^2}{13}, (x, y) = (1,1), (1,2), (2,2)$. Evaluate the pmf of X and Y. **(K5 – E, CO 5)**

5. Say $X_1, X_2, \ldots, X_n$ are independent random variables and $Y = u_1(X_1)\, u_2(X_2) \ldots u_n(X_n)$. If $E[u_i(X_i)]$, $i = 1, 2, \ldots, n$, exist, then prove that $E(Y) = E[u_1(X_1)\, u_2(X_2) \ldots u_n(X_n)] = E[u_1(X_1)]E[u_2(X_2)] \ldots E[u_n(X_n)]$. **(K2 – U, CO 2)**

## Part C (12 mark)

1. Prove that (a) $P(A|B) \geq 0$;

   (b) $P(B|B) = 1$;

   (c) If $A_1, A_2, A_3, \ldots$ are mutually exclusive events, then $P(A_1 \cup A_2 \cup \cdots \cup A_k\,|B) = P(A_1\,|B) + P(A_2\,|B) + \cdots + P(A_k\,|B)$, for each positive integer $k$, and $P(A1 \cup A2 \cup \cdots\,|B) = P(A1\,|B) + P(A2\,|B) + \cdots$, for an infinite, but countable, number of events. **(K2 – U, CO 2)**

2. (a) If $c$ is a constant, then prove that $E(c) = c$.

   (b) If $c$ is a constant and $u$ is a function, then prove that $E[cu(X)] = cE[u(X)]$.

   (c) If $c_1$ and $c_2$ are constants and $u_1$ and $u_2$ are functions, then prove that $E[c_1u_1(X) + c_2u_2(X)] = c_1E[u_1(X)] + c_2E[u_2(X)]$. **(K3 – Ap, CO 3)**

3. If the random variable $X$ is $N(\mu, \sigma^2)$, $\sigma^2 > 0$, then prove that the random variable $V = \frac{(x-\mu)^2}{\sigma^2} = Z^2$ is $\chi^2(1)$. **(K3 – Ap, CO 3)**

4. If $X$ and $Y$ have a bivariate normal distribution with correlation coefficient $\rho$, then $X$ and $Y$ are independent if and only if $\rho = 0$.

   **(K3 – Ap, CO 3)**

5. State and prove Central limit theorem. **(K2 – U, CO 2)**

**Head of the Department** **Course Instructor**

**Dr. J. Anne Mary Leema** **Dr. C. Jenila**

## Teaching Plan

**Department : Mathematics (SF)**
**Class : II M.Sc Mathematics**
**Title of the Course : Core Course XII: Numerical Analysis**
**Semester : IV**
**Course Code : MP234CC3**

| Course Code | L | T | P | S | Credits | Inst. Hours | Total Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CIA | External | Total |
| MP234CC3 | 5 | - | - | - | 5 | 6 | 90 | 25 | 75 | 100 |

**Learning Objectives:**

1. Understand fundamental numerical analysis techniques and their applications.
2. Develop proficiency in implementing numerical algorithms using computational tools.

## Course Outcome

| CO | Upon completion of this course the students will be able to: | PSO addressed | CL |
|---|---|---|---|
| CO - 1 | recall and list basic numerical methods covered in the course, including root-finding algorithms and interpolation techniques. | PSO - 1 | K1(R) |
| CO - 2 | understand the principles behind key numerical algorithms such as Newton's method, Gaussian elimination, and Runge-Kutta methods. | PSO - 2 | $K_2$(U) |
| CO - 3 | apply numerical methods to solve algebraic equations, interpolate data points, fit curves to data sets, and solve systems of linear equations. | PSO - 3 | $K_3$(Ap) |
| CO - 4 | analyse the accuracy, convergence, and stability of numerical solutions obtained using different techniques. | PSO - 3 | $K_4$(An) |
| CO - 5 | evaluate the suitability and effectiveness of various numerical methods for specific mathematical problems based on computational efficiency and solution quality. | PSO - 2 | $K_5$(E) |

**K1** - Remember; **K2** - Understand; **K3**- Apply; **K4** - Analyse; **K5**- Evaluate

**Teaching plan**
**Total Contact hours: 90 (Including lectures, assignments and tests)**

| Unit | Module | Topic | Teaching Hours | Assessment Hours | Cognitive level | Pedagogy | Student Centric Method | E-Resources | Assessment/ Evaluation Methods |
|---|---|---|---|---|---|---|---|---|---|
| **I** | **Solution of Algebraic and Transcendental Equations** | | | | | | | | |
| | 1. | Solution of Algebraic and Transcendental Equations - Introduction - Iteration Method | 4 | 1 | K1(R) | Introductory session, Blended Learning | Think-pair-share, In-class discussions | E-notes | Home Work - Iteration Method – Exercise problems, CIA I |
| | 2. | Newton-Raphson Method | 3 | 1 | K3(Ap) | Group Discussion. | Group activities, In-class discussions | Video lectures | Evaluation through short test, CIA I |
| | 3. | Ramanujan's Method | 3 | | K3(Ap) | Blended Learning | Explaining concepts, answering questions from peers | You Tube videos | Class test, CIA I. |
| | 4 | Secant Method | 3 | 1 | K3(Ap) | Interactive Method | Discussions, Group, problem solving in groups | NPTEL lectures | Assignment, CIA I. |
| | 5 | Muller's Method | 2 | | K3(Ap) | Collaborative learning | Explaining concepts, problem solving | Websites | Open Book Test, Peer review, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **II** | **Differences of a polynomial** | | | | | | | | |
| | 1. | Differences of a polynomial - Newton's formulae for Interpolation - | 3 | 1 | K2(U) | Introductory session, Peer Teaching | Think-pair-share | E-notes | Recall formulae, CIA I |
| | 2. | Central Difference Interpolation formulae | 2 | | K3(Ap) | Collaborative learning, Problem-based learning | Group activities, Brainstorming | YouTube videos | Group discussion, Quiz using Quizizz, CIA I |
| | 3. | Gauss's central difference formulae - Stirling's formula - Bessel's formula | 4 | 1 | K3(Ap) | Demonstration, Inquiry-based learning | Discussions, Formulating questions | Video lectures, Notes | Class test, CIA I |
| | 4 | Everett's formula - Relation between Bessel's and Everett's formulae -. | 3 | | K3(Ap) | Flipped classroom, Collaborative learning | In-class discussions, Group activities | Video lectures | Homework, CIA I |
| | 5 | Practical Interpolation | 3 | 1 | K3(Ap) | Peer Teaching, Active learning | Answering questions from peers, peer instruction | You Tube Videos | Assignment, CIA I |
| **III** | **Least squares and Fourier Transforms** | | | | | | | | |
| | 1. | Least squares and Fourier Transforms - Introduction - Least squares Curve Fitting Procedure | 3 | 1 | $K_2$(U) | Active learning | Discussions, Brainstorming | E-notes | Multiple choice questions, CIA I |
| | 2. | Fitting a straight line - | 3 | 1 | $K_2$(U) | Peer Instruction | Formulating questions, In-class | Video Lectures | Quiz using Quizizz, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | discussions | | |
| | 3. | Multiple Linear Least squares | 3 | | K3(Ap) | Problem-based learning | Problem solving method | You Tube Videos | Questioning, CIA II |
| | 4 | Linearization of Nonlinear laws | 3 | 1 | K3(Ap) | Blended learning | Think-pair-share | You Tube Videos | Assignment, CIA II |
| | 5 | Curve fitting by Polynomials | 3 | | K3(Ap) | Collaborative learning | In-class discussions, Group activities | E notes | Group discussion, CIA II |
| **IV** | **Numerical Linear Algebra** | | | | | | | | |
| | 1 | Numerical Linear Algebra - Introduction - Triangular Matrices - LU Decomposition of a matrix - | 3 | 1 | K2(U) | Introductory session, Lecturing | Think-pair-share | You Tube videos | Questioning, CIA II |
| | 2 | Solution of Linear systems – Direct Methods - Gauss elimination | 4 | | K2(U) | Flipped classroom | Group activities | NPTEL Lectures | Home work, CIA II |
| | 3 | Necessity for Pivoting - Gauss - Jordan method - Modification of the Gauss method to compute the inverse | 3 | | K3(Ap) | Problem-based learning | Problem solving in groups | You Tube Videos | Assignment, CIA II |
| | 4 | LU Decomposition | 2 | 1 | K3(Ap) | Blended | In class | Lecture notes | Quiz, CIA II |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | method - | | | | Learning | discussions | | |
| | 5 | Solution of Linear systems - Iterative methods. | 3 | 1 | K3(Ap) | Collaborative learning | Explaining concepts, cooperative activities involving pairs and small groups | NPTEL lectures | Multiple Choice Questions, Surprise test, CIA II |
| **V** | **Numerical Solution of Ordinary Differential Equations** | | | | | | | | |
| | 1 | Numerical Solution of Ordinary Differential Equations - Solution by Taylor's series | 3 | 1 | K2(U) | Lecturing | Think-pair-share | Websites | Class Test, CIA II |
| | 2 | Euler's method - | 3 | | K3(Ap) | Problem based method | Problem solving in groups | Video Lectures, | Home work, CIA II |
| | 3 | Runge - Kutta methods - II order and IV order | 3 | 1 | K3(Ap) | Blended learning | Online discussions, self-paced learning | NPTEL lectures | Group discussion, CIA II |
| | 4 | Numerical Integration – Trapezoidal Rule | 3 | 1 | K3(Ap) | Flipped classroom | Formulating questions, Group activities | Free Text book – Internet Archive | Short test, CIA II |
| | 5 | Simpson's 1/3– Rule - Simpson's 3/8– Rule. | 3 | | K3(Ap) | Collaborative learning | Explaining concepts, Answering questions from peers | You tube videos | Peer review, Oral test, CIA II |

Course Focussing on Employability/ Entrepreneurship/ Skill Development: Skill Development
Activities (Em / En /SD): Solving problems using Gauss elimination, Gauss - Jordan method
Assignment: Solving problems using Interpolation formulae, Problems on Least squares and Fourier Transforms (Last date to submit 04-02-2026)
Seminar Topics: Differences of a polynomial, Least squares and Fourier Transforms

**Sample questions:**

**Part A**

**1.** Say True or False: 'Every Polynomial equation of the $n^{th}$ degree has n and only n roots'. (K1, CO-1)

**2.** Everett's formula will be easier to apply, since it uses only the ------order differences. (K2, CO-2)

3. Say True or False:" The given data may not always follow a linear relationship" (K2, CO-2)

4. Define the norm of a vector. (K2, CO-2)

5. The Second order Runge – Kutta formula is ------- (K2, CO-2)

**Part B**

**1.** Find a real root of equation $x^3 = 1- x^2$ on the interval [0, 1] with an accuracy of $10^{-4}$. (K3, CO-3)

**2.** Derive the relation between Bessel's formula and Everett's formula. (K3, CO-3)

**3.** Fit the second-degree parabola $y = a + bx + cx^2$ to the data $(x_i, y_i)$ ; (1,0.63), (3, 2.05), (4, 4.08), (6, 10.78) (K3, CO-3)

**4.** Factorize the matrix $\begin{pmatrix} -1 & 2 & 3 \\ 3 & 1 & 0 \\ 0 & 5 & 3 \end{pmatrix}$ in to LU form. (K3, CO-3)

**5.** Derive Trapezoidal rule. (K3, CO-3)

**Part: C**

**1.** Use the Iterative method to find the real root of the equation $sin\ x\ =\ 10(x-1)$ correct to three decimal places. (K3, CO-3)
**2.** Derive Bessel's formula. (K3, CO-3)
**3.** Explain Linearization of Nonlinear laws with example. (K3, CO-3)

**4.** Derive a LU decomposition of a matrix. (K3, CO-3)
**5.** Derive Simpson's $3/8\ th$ rule. (K3, CO-3)

**Head of the Department** **Course Instructor**

**Dr. J. Anne Mary Leema** **Dr. J. Anne Mary Leema**

# Teaching Plan

**Department : Mathematics (SF)**
**Class : II M. Sc Mathematics (SF)**
**Title of the Course : ELECTIVE COURSE VI: b) FOUNDATIONS OF COMPUTER NETWORKING**
**Semester : IV**
**Course Code : MP234EC2**

| Course Code | L | T | P | S | Credits | Inst. Hours | Total Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CIA | External | Total |
| MP234EC2 | 4 | - | - | - | 3 | 4 | 60 | 25 | 75 | 100 |

**Objectives:**

1.To understand the fundamental principles and components of network hardware, reference models, and protocols.

2.To analyse and apply various networking concepts such as data link layer design, routing algorithms, congestion control, and transport layer protocols.

**Course Outcomes**

| **On the successful completion of the course, students will be able to:** | | |
|---|---|---|
| 1 | demonstrate a thorough understanding of network hardware, reference models (such as OSI and TCP/IP), and the architecture of the Public Switched Telephone Network (PSTN). | **K2** |
| 2 | describe the architecture and services of the application layer, analyze protocols such as HTTP for web communication, and understand the principles of streaming media and real-time conferencing over networks. | **K2, K4** |
| 3 | design data link layer protocols, analyze error detection and correction techniques, and implement routing algorithms for efficient data transmission. | **K3, K4** |
| 4 | develop skills in identifying congestion control issues, apply appropriate congestion control algorithms, and implement traffic-aware routing strategies to optimize network performance. | **K3, K4** |
| 5 | demonstrate proficiency in analyzing and implementing transport layer protocols, particularly TCP, including connection establishment, data transfer, and connection release mechanisms. | **K4** |

**K2** - Understand; **K3** – Apply; **K4** - Analyse;

**Teaching plan**

**Total Contact Hours: 60 (Including lectures, assignments and tests)**

| Unit | Module | Topic | Teaching Hours | Assessment Hours | Cognitive level | Pedagogy | Student Centric Method | E-Resources | Assessment/ Evaluation Methods |
|---|---|---|---|---|---|---|---|---|---|
| **I** | **Introduction – Network Hardware** | | | | | | | | |
| | 1 | Introduction: Local Area Networks – Wide Area Networks. | 2 | 1 | K2 | Interactive Diagrams | Think-Pair-Share | Interactive PPT, Notes | Oral test, CIA I |
| | 2 | Reference Models: The OSI Reference Model – The TCP/IP Reference Model | 2 | | K2 | Collaborative method | In-class discussions | Interactive PPT, Notes | Concept Map Evaluation, CIA I |
| | 3 | The Physical Layer – Guided Transmission Media | 2 | 1 | K2 | Illustrative Method | Formulating questions and in class discussions to answer the questions | You tube videos | Diagram Labelling Tests, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | Magnetic Media – Twister Pairs – Coaxial Cable | 2 | 1 | K2 | Active Learning | Concept based discussion | Online course materials | Case Study Reports, CIA I |
| | 5 | Power Lines – Fiber Optics. | 1 | | K2 | Blended Learning | Explaining concepts, answering questions from peers | NPTEL Lectures | Short test, CIA I |
| **II** | **The Public Switched Telephone Network** | | | | | | | | |
| | 1 | Structure of the Telephone System – The Local Loop: Modems, ADSL and Fiber – Switching. | 2 | 1 | K3 | Blended Learning | Co-operative activities involving pairs and small groups | Online course materials | Peer Assessments, CIA I |
| | 2 | The Data Link Layer: Data Link Layer Design Issues: Framing | 1 | 1 | K4 | Demonstration Method | Think pair share | Learning through websites like Cisco Networking Academy, Online platforms like freeCodeCamp | Slip test, CIA I |
| | 3 | Error Detection and Correction: Error-Correcting Codes – | 2 | | K3 | Problem-Based Learning | Co-operative activities involving pairs and small groups | E notes | Assignment, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Error-Detecting Codes | | | | | | | |
| | 4 | Sliding Window Protocols: A One-Bit Sliding Window Protocol | 2 | 1 | K3 | Inductive Learning | In class discussions | PPT using Gamma | Questioning, CIA I |
| | 5 | A Protocol using Go-Back – A Protocol using Selective Repeat | 2 | | K3 | Active Learning | Small group activities | NPTEL Lectures | Quiz, CIA I |
| **III** | **The Network Layer – Network Layer Design Issues** | | | | | | | | |
| | 1 | Store-and-Forward Packet Switching | 2 | 1 | K4 | Collaborative Learning | Concept based discussion | PPT using Gamma | Evaluation through short test, CIA I |
| | 2 | Routing Algorithms: Shortest Path Algorithm – Distance Vector Routing | 2 | | K4 | Inquiry-based learning | Explaining concepts, answering questions from peers | Video Lectures | Quiz, CIA I |
| | 3 | Congestion Control Algorithms: | 2 | 1 | K3 | Interactive Lectures | Formulating questions and in class discussions to answer the questions | Learning through websites like Cisco Networking Academy, Online platforms like | Slip Test, CIA II |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | freeCodeCamp | |
| | 4 | Approaches to Congestion Control | 2 | 1 | K3 | Interactive method | Co-operative activities involving pairs and small groups | E notes | Quiz Competition, CIA II |
| | 5 | Traffic-Aware Routing. | 1 | | K3 | Blended Learning | Small group activities | Online course materials | Class test, CIA II |
| **IV** | **The Transport Layer – Congestion Control** | | | | | | | | |
| | 1 | Desirable Bandwidth Allocation – Regulating the Sending Rate – Wireless Issues. | 3 | 1 | K4 | Interactive Method | In class discussions | NPTEL Lectures | Peer Discussion with questions, CIA II |
| | 2 | The Internet Transport Protocols: | 1 | 1 | K4 | Blended Learning | Co-operative activities involving pairs and small groups | YouTube videos | Questioning, CIA II |
| | 3 | Introduction to TCP – The TCP Protocol | 1 | | K4 | Active Learning | Small group activities | Online course materials | Evaluation through short, test, CIA II |
| | 4 | The TCP Segment Header – TCP Connection | 2 | 1 | K4 | Flipped Classroom | Peer instruction | Learning through websites like Cisco | Quiz, CIA II |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Networking Academy, Online platforms like freeCodeCamp | |
| | 5 | Establishment – TCP Connection Release. | 2 | | K4 | Collaborative Learning | Formulating questions and in class discussions to answer the questions | E notes | Evaluation through MCQs, CIA II |
| **V** | **The Application Layer – Electronic Mail** | | | | | | | | |
| | 1 | Architecture and Services – The User Agent – Message Formats – Message Transfer – Final Delivery | 2 | 1 | K2 | Collaborative Learning | Formulating questions and in class discussions to answer the questions | Online course materials | Peer Review Writing, CIA II |
| | 2 | The World Wide Web: Architectural Overview – Static Web Pages – Dynamic Web Pages and Web Applications | 2 | | K2 | Interactive Learning | Small group activities | You tube videos | Seminar, CIA II |
| | 3 | HTTP-The Hyper Text Transfer Protocol – The Mobile Web – Web Search | 2 | 1 | K2 | Blended Learning | Co-operative activities involving pairs and small groups | Video lectures | Slip Test, CIA II |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | 4 | Streaming Audio and Video: Digital Audio – Digital Video | 1 | | K4 | Flipped Classroom | Concept based discussion | Learning through websites like Cisco Networking Academy, freeCodeCamp | Presentations, CIA II |
| | 5 | Streaming Stored Media – Streaming Live Media – Real-Time Conferencing | 2 | 1 | K4 | Active Learning | In class discussions | NPTEL Lectures | Practical Tests, Presentations, CIA II |

Course Focussing on Skill Development.

Activities (Em/ En/SD): Quiz, Presentation

Assignment: Exploring Networking Technologies: From LANs to the Web and Streaming Media.

Seminar Topic: The Application Layer – Electronic Mail

**Sample questions**

**Part A**

1. Which layer in the OSI model is responsible for error control and flow control? (K2, CO-1)

   a) Physical Layer b) Data Link Layer c) Network Layer d) Application Layer

2. Which component of the telephone system is known as the "last mile"? (K3, CO-3)

   a) Modem b) Local loop c) Toll office d) DSLAM

3. Say true or false: The shortest path algorithm always chooses the path with the fewest hops between nodes. (K4, CO-4)

4. What is the function of the TCP three-way handshake?(K4, CO-5)

   a) To terminate a connection securely. b) To establish a reliable connection between sender and receiver.

   c)To ensure all packets are sent in the correct order d) To check network bandwidth before transmission.

5. What is the main purpose of MIME in email? (K2, CO-2)

   a) To provide a standard format for text-only messages

   b) To allow multimedia content like images and audio to be sent in emails

   c) To enable the encryption of email messages

   d) To allow users to access their email on mobile devices

**Part B**

1. Explain the characteristics of Local Area Networks (LANs) and discuss their typical uses. (K2, CO-1)
2. Explain the difference between circuit switching and packet switching in the telephone network. (K4, CO-3)
3. What is the distance vector routing algorithm, and how does it operate? (K3, CO-4)
4. Describe the AIMD control law used in TCP for congestion control. (K4, CO-5)
5. Describe the architecture of the World Wide Web. (K2, CO-2)

**Part C**

1. Discuss guided transmission media used in computer networks, including twisted pair, coaxial cable, and Fiber optics. Describe their characteristics, advantages, and disadvantages. (K2, CO-1)
2. Explain ADSL technology and its advantages over traditional dial-up modems. (K4, CO-3)
3. Explain Dijkstra's shortest path algorithm and discuss its application in routing. (K3, CO-4)
4. Describe TCP connection establishment and termination using the three-way handshake and four-way handshake. (K4, CO-5)
5. Describe the process of message transfer in an email system using SMTP. Explain how IMAP and POP3 differ from SMTP. (K4, CO-2)

**Head of the Department**
Dr. J. Anne Mary Leema

**Course Instructor**
Dr. J. Anne Mary Leema

## Teaching Plan

**Department : Mathematics**
**Class : II M.Sc Mathematics**
**Title of the Course : Elective Course VII: c) Stochastic Process**
**Semester : IV**
**Course Code : MP234EC6**

| Course Code | L | T | P | S | Credits | Inst. Hours | Total Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CIA | External | Total |
| MP234EC6 | 3 | 1 | - | - | 3 | 4 | 60 | 25 | 75 | 100 |

**Learning Objectives:**

1. To understand the stochastic models.
2. To relate the models studied to real life probabilistic situations.

### Course Outcomes

| On the successful completion of the course, students will be able to: | | |
|---|---|---|
| 1. | Recall the basic results of Markov Chains as Graphs- Higher Transition Probabilities | **K1** |
| 2. | Understand Stability of a Markov System | **K2** |
| 3. | Apply Generalisations of Poison Process-Poison Process in Higher Dimensions | **K3** |
| 4. | Determine Discrete Stat Space-Introduction-Chapman-Kolmogorov Equations | **K4** |
| 5. | Calculate the possible partitions of a given number and draw Ferrer's graph | **K5** |

**K1** - Remember; **K2** - Understand; **K3**- Apply; **K4** - Analyse; **K5-** Evaluate

**Teaching plan**

**Total Contact hours: 60 (Including lectures, assignments and tests)**

| Unit | Module | Topic | Teaching Hours | Assessment Hours | Cognitive level | Pedagogy | Student Centric Method | E-Resources | Assessment/ Evaluation Methods |
|---|---|---|---|---|---|---|---|---|---|
| **I** | **RANDOM VARIABLES AND STOCHASTIC PROCESSES** | | | | | | | | |
| | 1 | Stochastic Processes: An Introduction - Specification of Stochastic Processes | 1 | 1 | K1 (R) | Introductory session, Lecturing | Think-pair-share | Open Text books - Introduction to Stochastic Processes | Questioning, recall steps, concept definitions, CIA I |
| | 2 | Definition and Examples - Transition Matrix (or Matrix of Transition Probabilities) - Order of a Markov Chain - Markov Chains as Graphs | 2 | | K2 (U) & K3 (Ap) | Collaborative learning | Cooperative activities involving pairs and small groups | Lecture Notes | Evaluation through short test, CIA I |
| | 3 | Higher Transition Probabilities | 2 | 1 | K2 (U) | Peer teaching | Answering questions from peers | You Tube videos | Peer review, CIA I |
| | 4 | Generalisation of Independent Bernoulli Trials: Sequence of Chain- | 2 | | K5 (E) | Active learning | Group discussions | NPTEL lectures | Quiz using Google Forms, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Dependent Trials - Markov-Bernoulli Chain - Correlated Random Walk | | | | | | | |
| | 5 | Classification of States and Chains - Communication Relations - Class Property - Classification of Chains - Classification of States: Transient and Persistent (Recurrent) States | 2 | 1 | K3 (Ap) & K4 (An) | Flipped classroom | In-class discussions | Digital Libraries & Databases - Google Scholar | Open Book Test, CIA I |
| **II** | **MARKOV CHAINS** | | | | | | | | |
| | 1 | Determination of Higher Transition Probabilities - Aperiodic Chain: Limiting Behaviour | 1 | 1 | K2 (U) | Introductory session, Lecturing | Think-pair-share | Open Text books Library - Stochastic Processes | Recall steps, questioning, concept definitions, CIA I |
| | 2 | Stability of a Markov System - Computation of the Equilibrium Probabilities | 2 | | K3(Ap) | Problem-based learning | Brainstorming | SWAYAM courses | Quiz using Kahoot, CIA I |
| | 3 | Graph Theoretic Approach | 2 | 1 | K2(U) | Inquiry-based learning | Formulating questions | Course material - MIT OCW | Class test, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | Markov Chain with Denumerable Number of States | 2 | | K4(An) | Collaborative learning | Group activities | Video lectures | Multiple choice questions, CIA I |
| | 5 | Reducible Chains - Finite Reducible Chains with a Single Closed Class - Chain with One Single Class of Persistent Non-null Aperiodic States - Absorbing Markov Chains - Extension: Reducible Chain with one Closed class of Persistent Aperiodic States- Further Extension: Reducible Chains with more than one Closed Class | 2 | 1 | K5 (E) | Peer Teaching | Answering questions from peers | You Tube Videos | Short-answer conceptual questions, CIA I |
| **III** | **MARKOV PROCESS WITH DISCRETE STATE SPACE** | | | | | | | | |
| | 1 | Poisson Process - Introduction | 1 | 1 | K2(U) | Active learning | Peer instruction | Video Lectures | Multiple choice questions, CIA I |
| | 2 | Postulates for Poisson Process - Properties of Poisson Process | 2 | | K2 (U) & K3 (Ap) | Inquiry-based learning | Formulating questions | Open Access Learning Platform - Brilliant.org | Quiz using Quizizz, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | Poisson Process and Related Distributions - Interarrival Time -Further Interesting Properties of Poison Process | 2 | 1 | K4(An) | Problem-based learning | Solving problems | You Tube Videos | Oral test, CIA II |
| | 4 | Generalisations of Poison Process - Poison Process in Higher Dimensions | 2 | 1 | K3(Ap) | Blended learning | Online problem sets | NPTEL Lectures | Assignment, CIA II |
| | 5 | Poisson Cluster Proscess (Compound or Cumulative Poisson Process) | 2 | | K5 (E) | Flipped classroom | Group activities | Websites - MIT Open Course Ware – Stochastic Processes | Group discussion, CIA II |
| **IV** | **MARKOV PROCESS WITH DISCRETE STATE SPACE** | | | | | | | | |
| | 1 | Birth and Death Process | 2 | 1 | K2(U) | Introductory session, Lecturing | Think-pair-share | You Tube videos | Quiz on Birth and Death process, CIA II |
| | 2 | Particular Cases | 1 | | K4(An) | Inquiry-Based Learning | Formulating questions | NPTEL Lectures | Observation note, CIA II |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | Markov Processes with Discrete Stat Space -Introduction | 2 | | K5(E) | Blended learning | Online problem sets | You Tube Videos | Seminar, CIA II |
| | 4 | Chapman-Kolmogorov Equations - Limiting Distribution (Ergodicity of Homogeneous Markov Process) | 2 | 1 | K3(Ap) | Flipped classroom | Collaborative problem-solving sessions | Lecture notes - Paul's online Math notes | Seminar, CIA II |
| | 5 | Stationary Processes - Second order processes - Stationarity - Gaussian Processes | 2 | 1 | K5(E) | Collaborative learning | Problem solving tasks | NPTEL lectures | Surprise test, CIA II |
| **V** | **TIME SERIES** | | | | | | | | |
| | 1 | Time Series: Introduction | 1 | 1 | K2(U) | Introductory session, Lecturing | Think-pair-share | Websites - Open Text book Library | Class Test, CIA II |
| | 2 | Purely Random Process - First Order Markov Process | 2 | | K3(Ap) | Inquiry-Based learning | Formulating questions | Video Lectures | Quiz on Purely random process, CIA II |
| | 3 | Moving Average (MA) Process - Autoregressive Process (AR Process) - Autoregressive | 2 | 1 | K4(An) | Blended learning | Collaborative problem solving tools | NPTEL lectures | Multiple Choice Questions, CIA II |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Process of Order Two (Yule Process) - Autoregressive Moving Average Process (ARMA Process) | | | | | | | |
| | 4 | Time and Frequency Domain: Power Spectrum - Properties of Covariance and Correlation Functions - Continuous Parameter Processes | 2 | 1 | K3(Ap) | Collaborative learning | Problem solving tasks | Free Text book - Internet Archive | Brainstorming, CIA II |
| | 5 | Statistical Analysis of Time Series: Some Observations | 2 | | K2(U) | Peer teaching | Answering questions from peers | SWAYAM courses | Peer review, Oral test, CIA II |

Course Focussing on Employability/ Entrepreneurship/ Skill Development: Skill Development

Activities (Em / En /SD): Solve the problems in Markov Chain

Assignment: Poison Process (Last date to submit 18-02-2026)

Seminar Topics: Markov Processes with Discrete Stat Space

**Sample questions**

**Part A (1 mark)**

1. State true or false
   Recurrent is a state called if it is eventually revisited **(K1 – R, CO 1)**
2. The probability vector $V'$ is itself an eigenvector of $P$ corresponding to the eigenvalue of $P$. **(K1 – R, CO 1)**

   a )0 b )2 c) 1 d) Infinity

**3.** The number $N(t)$ of clusters in time $t$, *i.e.* the points at which clusters occur constitute a Poisson process with mean rate **(K2 – U, CO 2)**

   a)$\alpha$ b)$\beta$ $c)\gamma$ $d)\mu$

4. Immigration-emigration process is the process associated with the simple queueing model **(K2 – U, CO 2)**
5. Complete: _____ is a slowly varying function of time due to growth and other such permanent effects. **(K2 – U, CO 2)**

**Part B (6 marks)**

1. Suppose that the probability of a dry day following a rainy day is 1/3 and that the probability of a rainy day following a dry day is ½. Given May 1 is a dry day, evaluate the probability that (i) May 3 is also a dry day (ii) May 5 is also a dry day. **(K5 – E, CO 5)**

2. Determine the higher transition probabilities. Let $a_{ik}$ denote the probability that the chain starting with a transient state $i$ eventually gets absorbed in an absorbing state $k$. **(K2 – U, CO 2)**
3. A machine goes out of order whenever a component part fails. The failure of this part is in accordance with a Poisson process with mean rate of 1 per week. Then the probability that two weeks have elapsed since the last failure is $e^{-2} = 0.135$ being the probability that in

time $t = 2$ weeks, the number of occurrences (or failures) is 0. Suppose that there are 5 spare parts of the component in an inventory and that the next supply is not due in 10 weeks. Find the probability that the machine will not be out of order in the next 10 weeks **(K3 – Ap, CO 3)**

4. Analyze Birth and Death rates. **(K4-An, CO 4)**
5. Explain first order Markov Process. **(K2-U, CO 2)**

**Part C (12 marks)**

1. (i) Consider a communication system which transmits the two digits 0 and 1 through several stages. Let $X_n$, $n \geq 1$ be the digit leaving the $n^{th}$ stage of system and $X_0$ be the digit entering the first stage (leaving the $0^{th}$ stage). At each stage there is a constant probability $q$ that the digit which enters will be transmitted unchanged (*i.e.* the digit will remain unchanged when it leaves), and probability $p$ otherwise (*i.e.* the digit changes when it leaves), $p + q = 1$. Find the probability that the digit entering the first stage is 0 given that the digit leaving the $m^{th}$ stage is 0 by Bayes' rule. **(K3 – Ap, CO 3)**
2. Explain Gambler's ruin problem. **(K2-U, CO 2)**
3. Describe the properties of poisson distribution. **(K5 – E, CO 5)**
   (i) Additive property
   (ii) Differerence of 2 independent poisson process
   (iii) Poisson process and binomial distribution.
4. Analyze Forward and Backward Kolmogorov equations. **(K4-An, CO 4)**
5. Explain autoregressive process of order two. **(K2-U, CO 2)**

**Head of the Department** **Course Instructor**

**Dr. J. Anne Mary Leema** **Dr. C. Jenila**

## Teaching Plan

**Department : Mathematics**
**Class : II M.Sc Mathematics**
**Title of the Course : Skill Enhancement Course III: Training for competitive examinations**
**Semester : IV**
**Course Code : MP234SE1**

| Course Code | L | T | P | S | Credits | Inst. Hours | Total Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CIA | External | Total |
| MP234SE1 | 4 | - | - | - | 2 | 4 | 60 | 25 | 75 | 100 |

**Learning Objectives:**

1. To solve problems needed for various competitive examinations.
2. To develop a comprehensive understanding of algebraic principles enabling proficient problem- solving in various Mathematical contexts.

### Course Outcomes

| On the successful completion of the course, students will be able to: | | |
|---|---|---|
| 1. | describe the concepts of topological properties of metric spaces. | **K1** |
| 2. | associate the concept of continuity and connectedness | **K2** |
| 3. | apply Cauchy's integral formula and Maximum modulus principle to evaluate integral | **K3** |
| 4. | outline Liouville's theorem and open mapping theorem | **K4** |
| 5. | built the mental ability to face GATE, CSIR and SET examinations | **K5** |

**K1** - Remember; **K2** - Understand; **K3**- Apply; **K4** - Analyse; **K5**- Evaluate

**Teaching plan**

**Total Contact hours: 60 (Including lectures, assignments and tests)**

| Unit | Module | Topic | Teaching Hours | Assessment Hours | Cognitive level | Pedagogy | Student Centric Method | E-Resources | Assessment/ Evaluation Methods |
|---|---|---|---|---|---|---|---|---|---|
| **I** | **REAL ANALYSIS** | | | | | | | | |
| | 1 | Problems in metric spaces | 1 | 1 | K1 (R) | Introductory session, Lecturing | Think-pair-share | Open Text books - Introduction to Real Analysis | Questioning, recall steps, concept definitions, CIA I |
| | 2 | Problems in distance function | 2 | | K3 (Ap) | Collaborative learning | Cooperative activities involving pairs and small groups | Lecture Notes | Evaluation through short test, CIA I |
| | 3 | Problems in convergence of sequences in metric spaces | 2 | 1 | K2 (U) & K3 (Ap) | Peer teaching | Answering questions from peers | You Tube videos | Peer review, CIA I |
| | 4 | Problems in Cauchy sequences | 2 | | K5 (E) | Active learning | Group discussions | NPTEL lectures | Quiz using Google Forms, CIA I |
| | 5 | Problems in complete metric spaces | 2 | 1 | K3 (Ap) & K4 (An) | Flipped classroom | In-class discussions | Digital Libraries & Databases - | Open Book Test, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Google Scholar | |
| **II** | **REAL ANALYSIS** | | | | | | | | |
| | 1 | Problems in connected sets | 1 | 1 | K2(U) & K3 (Ap) | Introductory session, Lecturing | Think-pair-share | Open Text books Library - Real Analysis | Recall steps, questioning, concept definitions, CIA I |
| | 2 | Problems in Continuous functions on metric spaces, Intermediate value property | 2 | | K3(Ap) | Problem-based learning | Brainstorming | SWAYAM courses | Quiz using Kahoot, CIA I |
| | 3 | Problems in Heine-Borel theorem | 2 | 1 | K2(U) & K3 (Ap) | Inquiry-based learning | Formulating questions | Course material - MIT OCW | Class test, CIA I |
| | 4 | Problems in Compact subsets in metric spaces | 2 | | K3(Ap) & K4(An) | Collaborative learning | Group activities | Video lectures | Multiple choice questions, CIA I |
| | 5 | Problems in totally bounded metric spaces | 2 | 1 | K5 (E) | Peer Teaching | Answering questions from peers | You Tube Videos | Short-answer conceptual questions, CIA I |
| **III** | **COMPLEX ANALYSIS** | | | | | | | | |
| | 1 | Problems in algebra of complex | 1 | 1 | K2(U) & K3 (Ap) | Active learning | Peer instruction | Video Lectures | Multiple choice questions, CIA I |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | numbers, polar form | | | | | | | |
| | 2 | Problems in the complex plane - Geometric representation, Modulus- argument form | 2 | | K2 (U) & K3 (Ap) | Inquiry-based learning | Formulating questions | Open Access Learning Platform - Brilliant.org | Quiz using Quizizz, CIA I |
| | 3 | Problems in roots of polynomials and power series | 2 | 1 | K3(Ap) & K4(An) | Problem-based learning | Solving problems | You Tube Videos | Oral test, CIA II |
| | 4 | Problems in radius of convergence | 2 | 1 | K3(Ap) | Blended learning | Online problem sets | NPTEL Lectures | Assignment, CIA II |
| | 5 | Problems in exponential, trigonometric, and hyperbolic functions in complex plane | 2 | | K5 (E) | Flipped classroom | Group activities | Websites - MIT Open Course Ware – Problems in Real Analysis | Group discussion, CIA II |
| **IV** | **COMPLEX ANALYSIS** | | | | | | | | |
| | 1 | Problems in contour integral | 2 | 1 | K2(U) & K3 (Ap) | Introductory session, Lecturing | Think-pair-share | You Tube videos | Quiz on contour integral, CIA II |
| | 2 | Problems in Cauchy theorem, Cauchy's | 1 | | K3(Ap) & K4(An) | Inquiry-Based Learning | Formulating questions | NPTEL Lectures | Observation note, CIA II |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | integral formula | | | | | | | |
| | 3 | Problems in Liouville's theorem | 2 | | K5(E) | Blended learning | Online problem sets | You Tube Videos | Seminar, CIA II |
| | 4 | Problems in Maximum modulus principle, Schwarz lemma | 2 | 1 | K3(Ap) | Flipped classroom | Collaborative problem-solving sessions | Lecture notes - Paul's online Math notes | Seminar, CIA II |
| | 5 | Problems in open mapping theorem | 2 | 1 | K5(E) | Collaborative learning | Problem solving tasks | NPTEL lectures | Surprise test, CIA II |
| **V** | **COMPLEX ANALYSIS** | | | | | | | | |
| | 1 | Problems in Taylors series | 1 | 1 | K2(U) & K3 (Ap) | Introductory session, Lecturing | Think-pair-share | Websites - Open Text book Library | Class Test, CIA II |
| | 2 | Problems in Laurents series | 2 | | K3(Ap) | Inquiry-Based learning | Formulating questions | Video Lectures | Quiz on Laurents series, CIA II |
| | 3 | Problems in calculus of residues | 2 | 1 | K3(Ap) & K4(An) | Blended learning | Collaborative problem-solving tools | NPTEL lectures | Multiple Choice Questions, CIA II |
| | 4 | Problems in conformal mappings | 2 | 1 | K3(Ap) | Collaborative learning | Problem solving tasks | Free Text book - Internet Archive | Brainstorming, CIA II |
| | 5 | Mobius transformations | 2 | | K2(U) & K3 (Ap) | Peer teaching | Answering questions from peers | SWAYAM courses | Peer review, Oral test, CIA II |

Course Focussing on Employability/ Entrepreneurship/ Skill Development: Skill Development

Activities (Em / En /SD): Solve the problems in Metric spaces.

Assignment: Problems in radius of convergence (Last date to submit 20-02-2026)

Seminar Topics: Liouville's theorem and Schwarz lemma

**Sample questions**

**Part A (1 mark)**

1. Say true or false: In any metric space every convergent sequence is a Cauchy sequence. **(K-U, CO 2)**
2. A metric space is said to be totally bounded if _____**(K-U, CO 2)**

a) Every Cauchy sequence converges.

b) For every $\epsilon > 0$, the space can be covered by finitely many $\epsilon$ -balls.

c) It is compact.

d) It contains no infinite subset.

3. If $z = 3 + 4i$, then $|z|^2$ is _____**(K-Ap, CO 3)**

a) 7

b) 25

c) 10

d) 5

4. What does Liouville's Theorem state about bounded entire functions? **(K-U, CO 2)**
5. The radius of convergence for the Taylor series of $ln(1 + z)$ at $z = 0$ is _____**(K-Ap, CO 3)**

a) 1

b) $\infty$

c) Valid for $|z| < 1$

d) Not valid at $z = 1$

## Part B (6 marks)

1. Let $\{x_n\}$ be a sequence in R defined by $x_{n+1}=\frac{x_n}{2}$. If $x_1 = 2$, then discuss about the convergence of the sequence. **(K-An, CO 4)**
2. Check whether the following sets are connected in R under the standard metric? **(K-Ap, CO 3)**
   a) $[0,1] \cup [2,3]$ b) $(0,1)$ c) $[0,1)$
3. Test the convergence of the series $\sum_{n=0}^{\infty} \frac{z^n}{n!}$ **(K-An, CO 4)**
4. Using Schwarz's Lemma, show that a holomorphic self-map of the unit disk that fixes the origin has modulus less than or equal to 1. **(K-U, CO 2)**
5. For which type of singularity does the Taylor series converge? **(K-U, CO 2)**

## Part C (12 marks)

1. Check whether each of the following metric space is complete and bounded? **(K-Ap, CO 3)**
   a) R under $d(x,y) = |x - y|$
   b) Q under $d(x,y) = |x - y|$
   c) [0,1] under $d(x,y) = |x - y|$
   d) C under $d(x,y) = |x - y|$
2. Let $X = \{(x,y) \in R^2 : x^2 + y^2 \leq 1\}$ with the Euclidean metric. Check the validity of each of the following statements: **(K-Ap, CO 3)**
   a) X is connected.
   b) X is compact.
   c) X is not totally bounded.
   d) X is complete.

3. Check the validity of each statement:

The Cauchy-Riemann equations guarantee: **(K-Ap, CO 3)**

a) Differentiability in the complex sense.

b) Analyticity of a function.

c) Continuity of $u(x, y)$ and $v(x, y)$

d) Laplace's equation is satisfied.

4. Prove Liouville's Theorem and deduce that every bounded analytic function on the entire complex plane is constant.

5.Check the validity of each of the following statements: **(K-Ap, CO 3)**

For $f(z) = e^z + sin(z)$, the Taylor expansion:

a) Contains both odd and even powers of $z$.

b) Converges for all $z$ in $\mathbb{C}$.

c) Includes coefficients involving $1/n!$

d) Has no radius of convergence restriction.

**Head of the Department**

**Dr. J. Anne Mary Leema**

**Course Instructor**

**Dr. J. Anne Mary Leema & Dr. C. Jenila**