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 (PG)
ODD SEMESTER
2025 - 2026

Vision

To empower women globally competent with human values and ethics acquiring academic andentrepreneurship 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)

Class : II M.Sc Mathematics
Title of the course : Major Core VII - Complex Analysis
Semester : III
Name of the Course : Complex Analysis
Course code : MP233CC1

Course Code	L	T	P	S	Credits	Inst. Hours	Total Hours	Marks		
								CIA	External	Total
MP233CC1	6	-	-	-	5	6	90	25	75	100

Objectives:

1.To understand the fundamental concepts and theorems of complex analysis, including Cauchy's Integral Formula, Taylor's Theorem, and the Residue Theorem.

2.To develop proficiency in applying complex analysis techniques to solve problems involving harmonic functions, power series expansions, and entire functions.

Course Outcomes

CO	Upon completion of this course the students will be able to	Cognitive Level
CO - 1	demonstrate the ability to compute line integrals over rectifiable arcs and apply Cauchy's Theorem to evaluate integrals in various domains	K2(U), K3 (Ap)
CO - 2	interpret and apply advanced concepts such as Jensen's Formula and Hadamard's Theorem to analyze the behavior of entire functions and infinite products.	K3(Ap), K4(An)
CO - 3	apply the calculus of residues to evaluate definite integrals and utilize harmonic functions to solve boundary value problems using Poisson's Formula and Schwarz's Theorem.	K3(AP), K5(E)
CO - 4	construct power series expansions using Weierstrass's Theorem and apply partial fractions and factorization techniques to manipulate complex functions	K3(Ap), K6(C)
CO - 5	analyze the local properties of analytic functions, including removable singularities, zeros, poles, and the Maximum Principle.	K4 (An)

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	**Complex Integration**								
	1	Line Integrals, Arc Length, Rectifiable Arcs	2	1	K2(U)	Lecture, Brainstorming	In-class Discussion	Referring mathematical concepts through websites like Bijus, GeeksforGeeks	Concept Explanation, CIA I
	2	Line Integrals as Functions of Arcs	2		K3(Ap)	Lecture with illustration	Q &A with Instructor	Google Classroom	Oral Questioning, CIA I
	3	Cauchy's Theorem for a Rectangle and Cauchy's Theorem in a Disk	4	1	K4(An)	Collaborative Learning	Cooperative activities involving small groups	E notes	Class Test, CIA I
	4	Index of a point with respect to a closed curve, Cauchy's Integral Formula	4	1	K3(Ap)	Blended Learning	Concept-based Discussion	You Tube Videos	Slip Test, CIA I
	5	Higher Derivatives, Morera's Theorem, Liouville's Theorem, Cauchy's Estimate	3		K2(U)	Inquiry Based Teaching	Formulating questions and discussing	NPTEL Lectures	Online Quiz, CIA I
II	**Local Properties of Analytic Functions**								

	1	Removable Singularities, Taylor's Theorem,	2	1	K2(U)	Lecture with illustration	Q &A with Instructor	PPT using Gamma	Oral Questioning, CIA I
	2	Zeros and Poles, Isolated Singularity, Meromorphic Function	3		K2(U)	Blended Learning	Explaining concepts, answering questions from peers	You Tube videos	Quiz competition, CIA I
	3	The Local Mapping and the Maximum Principle, Schwarz Lemma	3	1	K3(Ap)	Lecture with Illustration	Q &A with Instructor	Online course materials	Short answer type class test, CIA II
	4	The General Form of Cauchy's Theorem, Chains and Cycles, Simple Connectivity	3		K4(An)	Active Learning	Discussion on the materials referred	Online course materials	MCQ using Google Forms, CIA I
	5	The General Statement of Cauchy's Theorem and Proof of Cauchy's Theorem. .	4	1	K4(An)	Inquiry Based Teaching	Think-Pair-Share	NPTEL Lectures	Conceptual quiz, CIA II
III	**The Calculus of Residues**								
	1	The Residue Theorem	3	1	K3(Ap)	Lecture using videos	In-Class Discussion	Screencast Matic, Ice Cream Video Editor	MCQ, CIA II
	2	The Argument Principle	2		K2(U)	Flipped classroom	Explaining concepts, answering questions from peers	You Tube videos	Oral Questioning, CIA II

	3	Evaluation of Definite Integrals	4	1	K5(E)	Blended learning	Group Discussion	You Tube videos	Assignment, CIA II
	4	Harmonic Functions- Definition and Basic Properties	4	1	K3(Ap)	Lecture with Illustration	Think-Pair-Share	Interactive PPT using Gamma AI	Quiz through Quizizz, CIA II
	5	The Mean-Value Property	2		K4(An)	Active Learning	In-Class Discussion	Interactive PPT using Gamma AI	Oral Test, CIA II
IV	**Power Series Expansions**								
	1	Poisson's Formula	3	1	K3(Ap)	Lecture with Illustration	Group Discussion	You Tube videos	Oral Test, CIA II
	2	Schwarz's Theorem and the Reflection Principle	3		K3(Ap)	Active learning	Peer explanations	NPTEL Lectures	Class test, CIA II
	3	Power Series Expansions- Weierstrass's Theorem	3	1	K4(An)	Blended Learning	Formulating questions and discussing	Online course materials	Evaluation through online quiz, CIA II
	4	The Taylor's Series	3	1	K4(An)	Flipped classroom	Think-Pair-Share	E notes	Short Summary, CIA II
	5	The Laurent Series	3		K2(U)	Peer teaching	Seminar	E notes	Conceptual Questions, CIA II
V	**Partial Fractions and Factorization**								
	1	Partial Fractions	3	1	K2(U)	Peer teaching	Peer explanations	E notes	Peer Review, CIA II

	2	Infinite Products	3		K2(U)	Active learning	Group Discussion	E notes	Oral Questioning, CIA II
	3	Canonical Products	3	1	K3(Ap)	Collaborative Learning	Seminar Presentation	Online course materials	Conceptual Questions, CIA II
	4	Entire Functions-Jensen's Formula	3	1	K4(An)	Peer Tutoring	Formulating questions and discussing	You Tube videos	Concept Explanation, CIA II
	5	Hadamard's Theorem	3		K4(An)	Cooperative Learning	In-Class Discussion	You Tube videos	Oral Questioning, CIA II

Course Focusing on Employability/Entrepreneurship/Skill Development : Skill Development.
Activities (Em/En/SD): Problem solving assignment on evaluation of definite integrals, Quiz Competition on Zeros and Poles, Isolated Singularity, Meromorphic Function
Assignment: Calculation of residues and evaluation of definite integrals (Last date to submit: 19-08-2025)
Seminar Topic: Schwarz's Theorem and the Reflection Principle, the Taylor's Series and the Laurent Series.

Sample questions
Part A (1 mark)

1. Which of the following statements are true? (K2, CO-1)

   a)$\int_{-\gamma} f(z)dz = -\int_{\gamma} f(z)dz$.
   b)An Arc $z = z(t)$ is rectifiable if and only if the real and imaginary parts of $z(t)$ are of bounded variation.
   c)The integral $\int_{\gamma} f(z)dz$, where f is continuous depends only on the end points of γ if and only if f is the derivative of an differentiable function in Ω.
   d)The value of $\int(z-a)^n dz = 0$, for all closed curves γ.
2. Define removable singularities and give an example. (K3, CO-1)
3. The Mean-Value Property for harmonic functions states that the value at a point is _____ (K3,CO-3)

a) The sum of the values at the boundary.
b) The integral of the function over the domain.
c) The average of the values on the boundary of a domain.
d) The value at the centre of the domain.

4. Say true or false: In the reflection principle, the reflection is taken across a real axis. (K3, CO-4)
5. Give an example of a Laurant's Series. (K3, CO-4)

Part B (6 marks)

1. If γ is a piecewise differentiable closed curve that does not pass through the point a, show that the value of the integral $\int_\gamma \frac{dz}{z-a}$ multiple of $2\pi i$. (K2, CO-1)
2. State and prove Liouville's theorem. (K3, CO-2)
3. Prove that the arithmetic mean of a harmonic function u over concentric circles $|z| = r$ is a linear function of $log\ r$. Also discuss the case when u is harmonic in a disk. (K3, CO-3)
4. State and prove Schwarz's theorem. (K3, CO-4)
5. Prove that a necessary and sufficient condition for the absolute convergence of the product $\prod_1^\infty (1 + a_n)$ is the convergence of the series $\sum_1^\infty |a_n|$. (K3, CO-2)

Part: C (12 marks)

1. If an analytic function $f(z)$ lies inside a rectangle R, then show that integral value of $f(z)$ over the boundary is zero. (K2, CO-1)
2. State and prove Residue theorem. (K3, CO-2)
3. Evaluate $\int_0^\pi \frac{d\theta}{a+cos\theta}$, a >1. (K3,CO-3)
4. Suppose that $f_n(z)$ is analytic in the region Ω_n, and that the sequence $\{f_n(z)\}$ converges to a limit function f(z) in a region Ω, uniformly on every compact subset of Ω. Then prove that f(z) is analytic in Ω. Also prove that $f_n'(z)$ converges uniformly to $f\,'(z)$ on every compact subset of Ω.. (K3, CO-4)
5. Prove that the infinite product $\prod_1^\infty (1 + a_n)$ with $1 + a_n \neq 0$ converges simultaneously with the series $\sum^\infty \log (1 + a_n)$ whose terms represent the values of the principal branch of the logarithm. (K3, CO-2)

Department : Mathematics
Class : II M.Sc Mathematics
Title of the Course : Core Course VIII: Topology
Semester : III
Course Code : MP233CC2

Course Code	L	T	P	S	Credits	Inst. Hours	Total Hours	Marks		
								CIA	External	Total
MP233CC2	6	-	-	-	5	6	90	25	75	100

Learning Objectives:

1. To distinguish spaces by means of simple topological invariants.
2. To lay the foundation for higher studies in Geometry and Algebraic Topology

Course Outcomes

On the successful completion of the course, students will be able to:		
1.	recall the definitions of topological space, basis, various topologies, closed sets, limit points, continuity, connectedness, compactness, separation axioms and countability axioms and completeness	**K1**
2.	defends the basic results in topological spaces, continues functions, connectedness, compactness, countability and separation axioms and complete metric spaces	**K2**
3.	solve problems on topological spaces, continuous functions and topological properties.	**K3**
4.	analyse various facts related to continuous functions, connected spaces, compact spaces, countable spaces, separable spaces, normal space and compact spaces.	**K4**
5.	evaluate the comparison between different types of topological spaces	**K5**

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	**TOPOLOGICAL SPACES AND CONTINUOUS FUNCTIONS**								
	1	Topological spaces and examples, Basis for a topology	3	1	K1(R) & K2(U)	Introductory session, **Flipped Classroom**	Think-pair-share, In-class discussions	Open Text books - Introduction to Topology by Bert Mendelson	Questioning, recall steps, concept definitions, CIA I
	2	Order topology, Product topology	3		K2(U) & K5(E)	Collaborative learning, Blended learning	Group activities, Online discussions	Lecture Notes, Video lectures	Evaluation through short test, concept explanations, Group presentation, CIA I
	3	Subspace topology	3	1	K3(Ap)	Peer teaching	Explaining concepts, answering questions from peers	You Tube videos, tutorial notes	Slip Test, concept explanations, CIA I.
	4	Closed sets and limit points	3		K4(An)	Active learning, Flipped classroom	Discussions, Group activities	NPTEL lectures	Quiz using Google Forms, Oral presentation, CIA I.

	5	Continuous function	3	1	K2(U)	Peer teaching, Collaborative learning	Explaining concepts, team-based learning	Digital Libraries & Databases - Google Scholar	Open Book Test, Peer review, CIA I
II	**CONNECTEDNESS AND COMPACTNESS**								
	1	Product topology, Metric topology	3	1	K1(R) & K2(U)	Introductory session, Lecturing	Think-pair-share	Open Text books - Basic Topology by Armstrong	Recall steps, questioning, concept definitions, CIA I
	2	Sequence lemma	2		K3(Ap)	Collaborative learning, Problem-based learning	Group activities, Brainstorming	SWAYAM courses	Group discussion, Quiz using Kahoot, CIA I
	3	Uniform limit theorem	3	1	K2(U)	Demonstration, Inquiry-based learning	Discussions, Formulating questions	Video lectures, Notes	Class test, CIA I
	4	Connected spaces	3		K2(U) & K4(An)	Flipped classroom, Collaborative learning	In-class discussions, Group activities	Video lectures	Multiple-choice questions, CIA I
	5	Components and local connectedness	4	1	K4(An)	Peer Teaching, Active learning	Answering questions from peers, peer instruction	You Tube Videos	Short-answer conceptual questions, Peer review, CIA I
III	**CONNECTEDNESS AND COMPACTNESS**								
	1	Compact spaces	3	1	K2(U)	Active	Discussions,	Video	Multiple

						learning	Brainstorming	Lectures	choice questions, CIA I
	2	Compact subspaces of the real line	3		K4(An)	Inquiry-based learning, Flipped classroom	Formulating questions, In-class discussions	Open Access Learning Platform-Brilliant.org	Quiz using Quizizz, CIA I
	3	Uniform continuity theorem	3	1	K3(Ap)	Blended learning, Problem-based learning	Online discussions, Online problem sets	You Tube Videos	Oral test, CIA II
	4	Limit point compactness	3	1	K4(An)	Lecturing, Blended learning	Think-pair-share, Online problem sets	NPTEL Lectures	Assignment, CIA II
	5	Local compactness	3		K2(U) & K5(E)	Flipped classroom, Collaborative learning	In-class discussions, Group activities	Websites - MIT Open Course Ware	Presentation, Group discussion, CIA II
IV	**COUNTABILITY AND SEPARATION AXIOMS**								
	1	Countability axioms, First and second countable spaces	3	1	K2(U)	Introductory session, Lecturing	Think-pair-share	You Tube videos	Quiz on Countable spaces, Brainstorming, CIA II
	2	Lindeloff and separable spaces	4		K4(An)	Inquiry-Based Learning, Flipped classroom	Formulating questions, Group activities	NPTEL Lectures	Observation note, Presentation, CIA II
	3	Separation axioms	3		K3(Ap)	Lecturing	Think-pair-share	You Tube Videos	Seminar, CIA II

	4	Normal spaces	3	1	K2(U) & K5(E)	Lecturing	Think-pair-share	Lecture notes - Paul's online Math notes	Seminar, CIA II
	5	Urysohn's lemma	2	1	K3(Ap)	Peer teaching, Collaborative learning	Explaining concepts, cooperative activities involving pairs and small groups	NPTEL lectures	Multiple Choice Questions, Surprise test, CIA II
V	**COMPLETE METRIC SPACES AND FUNCTION SPACES**								
	1	Urysohn Metrization theorem	3	1	K3(Ap)	Lecturing	Think-pair-share	Websites – Open Text book Library	Class Test, CIA II
	2	Imbedding theorem	3		K4(An)	Inquiry-Based learning	Formulating questions, discussing research plans	*Video Lectures,* e-books	Brainstorming, Presentation, CIA II
	3	Tietze extension theorem	3	1	K3(Ap)	Blended learning, Differentiated instruction	Online discussions, self-paced learning	NPTEL lectures	Group discussion, Multiple Choice Questions, CIA II
	4	Complete metric spaces	3	1	K3(Ap)	Inquiry-Based Learning, Flipped classroom	Formulating questions, Group activities	Free Text book – Internet Archive	Quiz on Complete metric spaces, CIA II
	5	Compactness in	3		K5(E)	Peer	Explaining	NPTEL	Peer review,

		metric spaces				teaching, Differentiated instruction	concepts, Answering questions from peers	lectures	Oral test, CIA II

Course Focussing on Employability/ Entrepreneurship/ Skill Development: Skill Development
Activities (Em / En /SD): Solve the problems in continuous function
Assignment: Limit point compactness (Last date to submit 21-08-2025)
Seminar Topics: Separation axioms and normal spaces

Sample questions

Part A (1 mark)

1. The indiscrete topology on X consist of _____ **(K1-R, CO 1)**
2. A set U is open in metric topology induced by d iff **(K2-U, CO 2)**
   (a) For each $y \in U$, there is $\delta>0$ such that B(y,d) $\subset U$
   (b) For each $y \in U$, each $\delta>0$ such that B(y,d) $\subset U$
   (c) For some $y \in U$, there is $\delta>0$ such that $B(y, \delta) \subset U$
   (d) For some $y \in U$, each $\delta>0$ such that B(y, δ) $\subset U$
3. Say true or false: **(K2-U, CO 2)**

   Every compact subspace of a Hausdorff space is closed.
4. Every regular space with a _____is normal. **(K2-U, CO 2)**
5. An arbitrary product of compact spaces is compact in the product topology is the statement of **(K2-U, CO 2)**
   (a) Tietze extension theorem (b) Tychonoff theorem
   (c) Imbedding theorem (d) Urysohn Metrization Theorem

Part B (6 marks)

1. Let A be a subset of the topological space X. Then prove that $x \in \bar{A}$ if and only if every Open set U containing intersects A.

(K3-Ap, CO 3)

2. If each space X_α is a Hausdorff space, then show that $\prod$ is a Hausdorff space in both the box and product topologies. **(K3-Ap, CO 3)**
3. State and prove uniform continuity theorem. **(K2-U, CO 2)**
4. Show that every compact Hausdorff space is normal. **(K3-Ap, CO 3)**
5. If A$\subset X$ and $f: A \to Z$ is a continuous map of A into the Hausdorff space Z. Then prove that there is at most one extension of f to a continuous function $g: \bar{A} \to Z$. **(K3-Ap, CO 3)**

Part C (12 marks)

1. If A is a subspace of X and B is subspace of Y, then prove that the product topology on $A \times B$ is same as the topology $A \times B$ inherits as a subspace of $X \times Y$. **(K3-Ap, CO 3)**
2. State and prove the intermediate value theorem. **(K3-Ap, CO 3)**
3. Let X be a metrizable space. Then prove that the following are equivalent: **(K4-An, CO 4)**
   (i) X is compact (ii) X is limit point compact (iii) X is sequentially compact
4. State and prove Urysohn Lemma. **(K3-Ap, CO 3)**
5. State and prove Tietze extension theorem. **(K3-Ap, CO 3)**

Department : Mathematics

Class : II M.Sc. Mathematics

Title of the Course : Traditional Mechanics

Semester : III

Course Code : MP233CC3

Course Code	L	T	P	S	Credits	Inst. Hours	Total Hours	Marks		
								CIA	External	Total
MP233CC3	6	-	-	-	5	6	90	25	75	100

Learning Objectives:

1. To gain deep insight into concepts of Mechanics
2. To do significant contemporary research.

Course Outcomes

COs	Upon completion of this course, the students will be able to:	PSO Addressed	Cognitive Level
CO - 1	grasp concepts like time dilation, relativistic dynamics, and the equivalence principle.	PSO-1	K_4, K_5
CO - 2	understand classical mechanics principles, such as coordinates, constraints, and energy-momentum relationships, to analyse mechanical systems.	PSO-2	K_1, K_2
CO - 3	apply Lagrangian methods to special cases such as impulsive motion and systems with constraints, thereby expanding their problem-solving abilities.	PSO-2	K_3
CO - 4	Integrate classical and relativistic mechanics, enabling them to analyze systems ranging from everyday mechanics to those involving high speeds and gravitational forces.	PSO-4	K_3, K_5
CO - 5	become proficient in using Lagrangian mechanics to solve complex problems and identify integral properties of motion.	PSO-2	K_2, K_3

Total contact hours: 90 (Including instruction hours, assignments, and tests)

Unit	Module	Topic	Teaching Hours	Cognitive level	Pedagogy	Student-Centric Method	E-Resources	Assessment/ Evaluation Methods
I	**The Mechanical System**							
	1	The Mechanical System	3	K1(R), K2 (U)	Recall the basic definitions, Discussions	Discussions, Brainstorming	E-Note	Questioning
	2	Generalized coordinates, Constraints	4	K4(An), K5(E)	Transmissive method with illustration, Team work	Think -Pair- Share, Discussions	PPT, YouTube- Types of constraints	Summarize the concepts
	3	Virtual work and D'Alembert's Principle	4	K2(U), K5(E)	Illustrative Method, Team work	Defining problems, Group discussion	E-Note	Questioning
	4	Energy and Momentum	4	K2(U), K5(E)	Transmissive method	Discussions, Debates	E-Book, You Tube- Generalized Momentum	Assignment
II	**Lagrange's equations**							
	1	Derivation of Lagrange's equations	5	K1(R)	Brainstorming	Problem solving, Think -Pair- Share	PPT	Slip Test
	2	Problems using Lagrange's equation	5	K2(U)	Transmissive method, Discussion	Discussions, Debates	E-Note, You tube- Examples of LE	Collecting MCQ
	3	Integralsof the motion.	5	K2(U)	Think-Pair-Share, Flipped Classroom	Discussions, Brainstorming,	E-Note	Quiz
III	**Special Applications of Lagrange's Equations**							
	1	Special Applications of Lagrange's Equations,	4	K2(U)	Transmissive method, Group	Problem solving, Think -Pair- Share	E-Book, YouTube	Slip Test

		Rayleigh's Dissipation Function			Discussion			
	2	Impulsive Motion, Impulsive, and Momentum	3	K3(Ap), K4(An)	Illustrative Method, Team Work	Discussions, Debates	E-Note	Questioning
	3	Lagrangian method, Ordinary constraints, Impulsive constraints	4	K3(Ap), K4(An)	Problem Solving, Team work	Defining problems, Group discussion,	E-Note, You tube- Impulsive constraints	Collecting MCQ
	4	Energy considerations- Quasi–coordinates. Examples	4	K2(U), K5(E)	Transmissive method	Problem solving, Think -Pair- Share	E-Book	CIA-I, Quiz
IV	**Introduction to Relativity**							
	1	Introduction to Relativity, Introduction, Galilean transformation	2	K1(R), K2(U)	Illustrative Method, Team work	Group Discussions, Think -Pair- Share	E-Book, PPT	Slip Test
	2	Maxwell's equations, The ether theory, The principle of relativity, Relativistic Kinematics	3	K3(Ap)	Illustrative Method, Group Discussion	Defining problems, Group discussion	E-Book, PPT	MCQ
	3	The Lorentz transformation equations, Events and simultaneity, Einstein's train, Time dilation	4	K2(U)	Illustrative Method	Defining problems, Group discussion	E-Book, PPT	Quiz, Collecting MCQ
	4	Longitudinal contraction, the invariant interval, proper time, and proper distance	3	K3(Ap), K4(An)	Transmissive Method, Team work	Presentation, Think-Pair-Share	E-Book, PPT	Questioning
	5	The world line, the twin paradox, the Addition of	3	K2(U), K4(An)	Transmissive	Real -world problems,	E-Book, PPT, You	Slip Test

		velocities, the relativistic Doppler effect			Method, Discussion	Discussions	tube-The relativistic Doppler effect	
V	**Relativistic Dynamics**							
	1	Relativistic Dynamics, Momentum, Energy	4	K2(U)	Transmissive Method, Presentation	Defining problems, Group discussion	E-Book, PPT	Questioning
	2	The momentum, energy four vector, Force, Conservation of energy, Mass and energy, inelastic collision	4	K3(Ap), K4(An)	Illustrative Method,	Presentation, Think-Pair-Share	E-Book, PPT	MCQ, Quiz
	3	The principle of equivalence, Lagrangian and Hamiltonian formulations, Accelerated systems	4	K2(U), K3(Ap)	Illustrative Method, Presentation	Real -world problems, Group Discussion	E-Book, PPT, You tube-Accelerated systems	CIA- II, Quiz
	4	Rocket with constant acceleration, Rocket with constant thrust	3	K2(U)	Transmissive Method, Presentation, Think-Pair-Share	Peer Instruction, Group Discussions	E-Book, PPT	Questioning, Slip Test

Course Focusing on Employability/ Entrepreneurship/ Skill Development: **Skill Development**
Activities (SD): **Problem-solving, Seminar Presentation, Group Discussion**
Course Focussing on Cross-Cutting Issues (Professional Ethics/ Human Values/Environment Sustainability/ Gender Equity): -
Activities related to Cross-Cutting Issues: -
Assignment: **Solving Exercise Problems**
Seminar Topic: The principle of equivalence, Lagrangian and Hamiltonian formulations, Accelerated systems, Rocket with constant acceleration, Rocket with constant thrust**.**
Sample questions

Part A

1. The types of constraints are ----------
2. The generalized coordinates are ---------
3. The derivation of Lagrange's equations for a holonomic system required that the generalized coordinates be ----------

a) Dependent b) independent c) derivable d) both(a), (c)

4. The change in the total linear momentum of a system during a given time interval is equal to the total impulse of the external forces acting over the same interval.

a) True b) False

5. The equivalence of mass and energy also applies to particles such as photons which have a ---- rest mass.

a) unity b) zero c) empty d) reversal force

Part B

1. Write about D'Alembert's principle.
2. A particle of mass m is connected by a massless spring stiffness k and unstressed length r_0 to a point p which is moving along a circular path of radius a at a uniform angle rate ω. Assuming that the particle moves without friction on a horizontal plane, find the differential equation motion.
3. Explain workless constraints with examples.
4. Derive the Lagrange's equation for non-holonomic constraints.
5. Derive the relative Doppler effect.

Part C

1. A rigid bar can rotate freely about a fixed pivot o and has a moment of inertia I about this point. a particle of mass m strikes the bar inelastically at time t_1 and slides along the bar after the impact. Solve for the velocities $\dot{x}, \dot{y}, \dot{\theta}$ after impact, if the initial conditions are

$$x(t_1) = 1m \qquad y(t_1) = 1m \qquad \theta(t_1) = \frac{\pi}{4}$$

$$\dot{x}(t_1-) = 0 \qquad \dot{y}(t_1-) = 1m/\sec \qquad \dot{\theta}(t_1-) = 1rad/\sec$$

Let m=1Kg and I=10Kgm^2

2. Derive Lagrange's equation of motion for a holonomic system.

3. Derive the equation of motion for small oscillation.

4. A double pendulum consists of two particles suspended by massless rods. Find the differential equations of motion assuming that all motion takes place in a vertical plane. Linearize these equations, assuming small motions.

5. Derive Maxwell's Equation.

Department : Mathematics
Class : II M. Sc
Title of the Course : Elective Course V: a) Algorithmic Network Analysis
Semester : III
Course Code : MP233EC1

Course Code	L	T	P	S	Credits	Inst. Hours	Total Hours	Marks		
								CIA	External	Total
MP233EC1	4	-	-	-	3	4	60	25	75	100

Learning Objectives:

1. To master fundamental algorithms and data structures, enabling efficient problem-solving.
2. To develop analytical skills for evaluating and implementing algorithms, addressing real-world challenges in various domains.

Course Outcomes

On the successful completion of the course, students will be able to:		
1.	recall and identify basic concepts and facts related to algorithms, data structures, and graph theory, including definitions, properties, and terminology.	K1
2.	demonstrate a solid understanding of the principles and theories including their applications in problem-solving and computational analysis.	K2
3.	apply algorithmic techniques to solve real-world problems efficiently.	K3
4.	analyze algorithms, data structures, and graph theory concepts to identify optimal solutions for computational problems.	K4
5.	represent graphs in a computer using different data structures.	K5

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

Teaching Plan
Total contact hours: 60 (Including instruction hours, assignments and tests)

Unit	Module	Topic	Teaching Hours	Assessment Hours	Cognitive level	Pedagogy	Student Centric Method	E-Resources	Assessment/ Evaluation Methods
I	**An Introduction to Algorithms**								
	1	Algorithmic Complexity - Tractable Computational Problem – Order of a function	2	1	K1 & K2	Interactive Lecture	Think-pair-share	Interactive PPT	Quiz, CIA I
	2	Search Algorithms - Binary Search Algorithms	1		K3	Active Learning	Brainstorming, Discussions	NPTEL Lectures	Oral Questioning, CIA I
	3	Sorting Algorithms – The Sequential Sort Algorithm – The Bubble sort Algorithm – Merge Sort	2	1	K3	Collaborative Learning	Peer Instruction, Cooperative activities involving small groups	You Tube Videos	Questioning, CIA I
	4	Greedy Algorithms – Knapsack Problem	2	1	K4	Blended Learning	In-class Discussion	You Tube Videos	Class Test, CIA I
	5	Representing Graphs in a Computer – Stack – Adjacency Matrix	2		K5	Blended classroom	In-class Discussion	E notes	Hands-On Task, CIA I
II	**Trees**								
	1	Properties of trees, Forest, Spanning Trees	1	1	K1	Brainstorming	Concept based discussion	PPT using Gamma	Slip Test, CIA I
	2	Depth-First Search – Branch, Low point	2		K2	Blended Learning	Group discussion	You Tube Videos	Short summary, CIA I
	3	Depth-First Search: Finding Blocks using Depth-First	2	1	K3 & K5	Lecture with illustration	Think-pair-share	You Tube Videos	Conceptual Questions,

		Search							CIA I
	4	Breadth-First Search, Breadth-First Search Forest	2	1	K3	Collaborative Learning	Jigsaw Technique	Online course materials	Short answer type class test, CIA I
	5	The Minimum Spanning Tree Problem – Kruskal's Algorithm, Prim's Algorithm.	2		K4	Interactive Lecture	In-class Discussion	You Tube Videos	Assignment, CIA I
III	**Paths and Distance in Graphs**								
	1	Distance in Graphs	1	1	K2	Lecture	Formulating questions and in class discussions to answer the questions	PPT using Gamma	Short test with MCQs, CIA II
	2	Moore's Breadth-First Search Algorithm	2		K3	Collaborative Learning	Cooperative activities involving pairs and small groups	You Tube Videos	Oral Questions, CIA II
	3	Distance in Weighted Graphs	2	1	K3 & K4	Active Learning	Concept based discussion	You Tube Videos	Slip Test, CIA II
	4	Dijkstra's Algorithm	2		K3	Blended Learning	In-class Discussion	NPTEL Lectures	Class Test, CIA II
	5	The Center and Median of a Graph, Radius and Diameter of a Connected graph, Distance of a Vertex	2	1	K3	Lecture with illustration	Group discussion	E notes	Concept explanations, CIA II
IV	**Networks**								
	1	An Introduction to Networks, Neighborhood, Capacity Constraint, Conservation Equation	1	1	K1 & K2	Lecture, Brainstorming	Think-Pair-Share	Google Classroom	Short test with MCQs, CIA II

	2	The Max-Flow Min-Cut Theorem, f-unsaturated, f-augmenting semi path	2		K3	Interactive Lecture	In-class Discussion	You Tube Videos	Differentiate among various ideas, CIA II
	3	A Max-Flow Min-Cut Algorithm	2	1	K3	Integrative teaching	Q&A with instructor	You Tube Videos	Concept Explanation, CIA II
	4	Connectivity and Edge-Connectivity	2	1	K4	Collaborative learning	Peer explanations	Google Forms	Slip Test, CIA II
	5	Menger's Theorem	2		K5	Active Learning	Explaining concepts, answering questions from peers	E notes	Oral Presentation, CIA II
V	**Digraphs**								
	1	Strong Digraphs – Strong Orientation	1	1	K1 & K2	Active Learning	Peer Instruction	Interactive PPT	Class Test with MCQ, CIA II
	2	Depth-First Search in Digraphs	2		K2 & K3	Collaborative Learning	Seminar Presentation	You Tube Videos	Peer Review Writing, CIA II
	3	Depth-First Search Algorithm for Digraphs	2	1	K4 & K5	Cooperative Learning	Seminar Presentation	You Tube Videos	Questioning, CIA II
	4	Strongly Connected Components – Condensation of a Digraph, an algorithm for finding strong components of a Digraph	2	1	K3	Peer Teaching	Explaining concepts, answering questions from peers	Interactive PPT	Recall steps, CIA II
	5	Tournaments	2		K3	Peer Teaching	Seminar Presentation	Interactive PPT	Concept checking through True/False

									Questions, CIA II

Course Focussing on Employability/ Entrepreneurship/ Skill Development: Skill Development
Activities (Em/ En/SD): Class Test on Breadth First Search, Peer Review Writing on Depth-First Search in Digraphs
Assignment: The Minimum Spanning Tree Problem – Kruskal's Algorithm, Prim's Algorithm (Last date to submit – 18-08-2025)
Seminar: Depth-First Search in Digraphs, Depth-First Search Algorithm for Digraphs

Sample questions

Part A (1 mark)

1.What does algorithmic complexity measure? (K1, CO-1)
a) Storage space b) Number of computational steps
c) Input data size d) Running time
2.Which of the following statements is true about the DFS algorithm? (K2, CO-2)
a) DFS always finds the shortest path between two vertices.
b) DFS can be used to detect cycles in a graph.
c) DFS visits vertices in level-order.
d) DFS always visits vertices in decreasing order of their degrees.
3.Which condition must be satisfied for Dijkstra's Algorithm to be applicable? (K4, CO-4)
a) The graph must be a tree.
b) The graph must be connected.
c) All edge weights must be non-negative.
d) The graph must be directed.

4.Which of the following statements is true about the edge-connectivity of the trivial graph? (K4, CO-4)
a) $\lambda(K_1) = 1$ b) $\lambda(K_1) = 0$
c) $\lambda(K_1) = infinity$ b) $\lambda(K_1) = -1$
5.Say true or false: A tournament is transitive if and only if it is cyclic. (K2, CO-2)

Part B (6 marks)

1.Apply the sequential search algorithm to determine whether the word DOOR appears on the list: (K3,CO-3)
W(1) = ARROW W(6) = HAND
W(2) = BALL W(7) = LADDER

W(3) = CAR W(8) = NET
W(4) = DOOR W(9) = PAN
W(5) = FOOT W(10) = TENT

2.Prove that every nontrivial tree contains at least two end-vertices. (K4, CO-4)
3.Prove that every graph is the center of some connected graph. (K4, CO-4)
4.State and prove the Max-Flow Min-Cut Theorem. (K2, CO-2)
5.Prove that every tournament has a Hamiltonian path. (K3, CO-3)

Part C (12 marks)

1.Explain the concept of a greedy algorithm and how it applies to solving the Knapsack problem. (K3, CO-3)
2.Prove that Prim's algorithm produces a minimum spanning tree in a nontrivial connected weighted graph. (K3, CO-3)
3.Explain Dijkstra's Algorithm. (K4, CO-4)
4.Let N be a network with underlying digraph D. Prove that a flow f in N is a maximum flow if and only if there is no f-augmenting semipath in D. (K4, CO-4)
5.Prove that a connected graph G is strongly orientable if and only if G contains no bridges. (K3, CO-3)

Department : Mathematics
Class : II M.Sc Mathematics
Title of the Course : Skill Enhancement Course II: Research Methodology
Semester : III
Course Code : MP233SE1

Course Code	L	T	P	S	Credits	Inst. Hours	Total Hours	Marks		
								CIA	External	Total
MP233SE1	3	-	-	-	2	3	45	25	75	100

Learning Objectives:

3. To write a scientific research manuscript containing important key sections.
4. To realize the importance of Research Ethics and methodologies involved in the research process.

Course Outcomes

On the successful completion of the course, students will be able to:		
1.	understand the objectives and methods of research , standard structure of a scientific paper and avoid plagiarism.	**K2**
2.	analyzing research data and statistical measures such as measures of central tendency, dispersion, and asymmetry.	**K4**
3.	identify the ethics of scientific paper writing and analyze research problems	**K4**
4.	develop research designs for specific research problems and assess the significance of research in various fields.	**K5**
5.	create structured scientific research papers and write project proposals and progress reports for research funding.	**K6**

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

Teaching plan
Total Contact hours: 45 (Including lectures, assignments and tests)

Unit	Module	Topic	Teaching Hours	Assessment Hours	Cognitive level	Pedagogy	Student Centric Method	E-Resources	Assessment/ Evaluation Methods
I	**RESEARCH METHODOLOGY: AN INTRODUCTION**								
	1	Meaning of research, Objectives of research.	1	1	K2(U)	Introductory session, **Flipped Classroom**	Think-pair-share, In-class discussions	*Video Lectures,* e-books	Questioning, recall steps, concept definitions, CIA I
	2	Motivation in research, Types of research, Research approaches, Significance of research	2		K2(U) & K4(An)	Collaborative learning, Blended learning	Group activities, Online discussions	Lecture Notes, assignment and video lectures	Evaluation through short test, concept explanations, Group presentation, CIA I
	3	Research methods versus methodology, Research and scientific method	1	1	K4(An)	Peer teaching	Explaining concepts, answering questions from peers	You Tube videos, tutorial notes	Slip Test, concept explanations, CIA I.
	4	Importance of knowing how research is done, Research process	1		K2(U)	Active learning, Flipped classroom	Discussions, Group activities	NPTEL lectures	Quiz using Google Forms, Oral presentation, CIA I.

	5	Criteria of good research, Problems encountered by researchers in India	1	1	K2(U) & K4(An)	Peer teaching, Collaborative learning	Explaining concepts, team-based learning	Digital Libraries & Databases – Google Scholar	Open Book Test, Peer review, CIA I
II	**DEFINING THE RESEARCH PROBLEM & RESEARCH DESIGN**								
	1	Research problem, Selecting the problem, Necessity of defining the Problem	1	1	K2(U)	Introductory session, Lecturing	Think-pair-share	NPTEL Lectures, YouTube Lectures	Recall steps, questioning, concept definitions, CIA I
	2	Technique involved in defining a problem, An illustration	1		K2(U) & K5(E)	Collaborative learning, Problem-based learning	Group activities, Brainstorming	SWAYAM courses	Group discussion, Quiz using Kahoot, CIA I
	3	Research design, Meaning of research design, Need for research design	2	1	K2(U)	Demonstration, Inquiry-based learning	Discussions, Formulating questions	Video lectures, Notes	Class test, CIA I
	4	Features of a good design, Important concepts relating to research design, Different research designs	1		K4(An)	Flipped classroom, Collaborative learning	In-class discussions, Group activities	Video lectures	Multiple-choice questions, CIA I
	5	Basic principles of experimental designs, Developing a research plan	1	1	K2(U)	Peer Teaching, Active learning	Answering questions from peers, peer instruction	You Tube Videos	Short-answer conceptual questions, Peer review, CIA I

III	**PROCESSING AND ANALYSIS OF DATA**								
	1	Processing operations, Some problems in processing	1	1	K2(U)	Active learning	Discussions, Brainstorming	Video Lectures	Multiple choice questions, CIA I
	2	Elements/ Types of analysis	1		K4(An)	Inquiry-based learning, Flipped classroom	Formulating questions, In-class discussions	Open Access Learning Platform-Saylor Academy	Quiz using Quizizz, CIA I
	3	Statistics in research	1	1	K4(An)	Blended learning, Problem-based learning	Online discussions, Online problem sets	Video lectures - Coursera	Oral test, CIA II
	4	Measures of Central Tendency, Measures of Dispersion	2	1	K4(An)	Lecturing, Blended learning	Think-pair-share, Online problem sets	NPTEL Lectures	Assignment, CIA II
	5	Measures of Asymmetry (Skewness)	1		K4(An)	Flipped classroom, Collaborative learning	In-class discussions, Group activities	Websites – Research Gate	Presentation, Group discussion, CIA II
IV	**UNDERSTANDING THE RESEARCH AND WRITING PROCESS**								
	1	Research Project, Difference between a Dissertation and a Thesis	1	1	K2(U) & K4(An)	Introductory session, Lecturing	Think-pair-share	You Tube videos	Quiz on research project, Brainstorming, CIA II
	2	Basic requirements of a research	1		K2(U)	Inquiry-Based	Formulating questions,	NPTEL	Observation note,

		degree, Deciding on a research topic				Learning, Flipped classroom	Group activities	Lectures	Presentation, CIA II
	3	Writing a proposal, Familiarity with Codes of Practice/ Rules and regulations	2		K2(U)	Peer teaching, Collaborative learning	Explaining concepts, cooperative activities involving pairs and small groups	You Tube Videos	Multiple Choice Questions, Surprise test, CIA II
	4	Ethical considerations, Different components of a research project, Title page, Abstract, Acknowledgement	1	1	K2(U)	Lecturing	Think-pair-share	Tutorials point – Explanations of key methods with formulas	Seminar, CIA II
	5	List of contents, Introduction, Literature review, Methodology, Style of presentation	1	1	K2(U)	Lecturing	Think-pair-share	NPTEL lectures	Seminar, CIA II
V	**PUBLISHING AND PRESENTING YOUR RESEARCH & PUNCTUATION BASICS**								
	1	Publishing and presenting your research and Tool kit	1	1	K2(U)	Introductory session, Lecturing	Think-pair-share	Digital Libraries & Databases - Google Scholar	Quiz on 'Research Paper Publication', CIA II
	2	Journal articles, Book	1		K2(U) & K4(An)	Inquiry-Based	Formulating questions,	Digital Libraries &	Brainstormin g,

						learning	discussing research plans	Databases - JSTOR	Presentation, CIA II
	3	Conference presentation, Final note	2	1	K2(U) & K4(An)	Blended learning, Differentiated instruction	Online discussions, self-paced learning	NPTEL lectures	Group discussion, Multiple Choice Questions, CIA II
	4	Introduction of punctuation, Capital letters, Comma, Semicolon, Colon	1	1	K2(U)	Inquiry-Based Learning, Flipped classroom	Formulating questions, Group activities	Directory of Open Access Journals	Class test, CIA II
	5	Parentheses, Inverted commas, Hyphen, Apostrophe	1		K2(U)	Peer teaching, Differentiated instruction	Explaining concepts, Answering questions from peers	NPTEL lectures	Peer review, Oral test, CIA II

Course Focussing on Employability/ Entrepreneurship/ Skill Development: Employability
Activities (Em / En /SD): Hands on training on 'Formulating the Research problem'
Assignment: Measures of Central Tendency and Measures of Dispersion (Last date to submit 20-08-2025)
Seminar Topics: Ethical considerations and different components of a research project

Sample questions
Part A (2 marks)

1. Write two objectives of research. **(K2-U, CO 1)**
2. State the components of a research problem. **(K2-U, CO 1)**
3. Define canonical analysis. **(K2-U, CO 1)**

4. What is a research project? **(K2-U, CO 1)**
5. What is parenthesis? **(K2-U, CO 1)**

Part B (4 marks)

1. Explain the significance of research in modern times. **(K2-U, CO 1)**
2. Describe the necessity of research design in a research study. **(K4-An, CO 3)**
3. Write short notes on the problem concerning DK responses. **(K2-U, CO 1)**
4. Discuss the process of deciding on a research topic, emphasizing the factors that researchers should consider. Provide practical advice on how researchers can select a suitable research topic within their field of study. **(K4-An, CO 3)**
5. Explain the role of toolkits in research project management. How can researchers customize toolkits to suit their specific research needs? **(K2-U, CO 1)**

Part C (9 marks)

6. Compare and contrast quantitative and qualitative research methods, highlighting their respective strengths and weaknesses. Provide examples of research studies that employ each approach. **(K4-An, CO 3)**
7. Explain the technique involved in defining the problem. **(K2-U, CO 1)**
8. Critically analyze the role of statistics in research, discussing its importance in drawing meaningful conclusions from data analysis. **(K4-An, CO 2)**
9. Examine the role and significance of each component of a research project, including the titlepage, abstract, acknowledgment, list of contents, introduction, literature review, methodology, and style of presentation. **(K4-An, CO 2)**
10. Explore the components of writing a book based on research findings, including the proposal, the review process, going to contract and the publisher's house style. **(K4-An, CO 3)**

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