25MEMJ205 : Kinematics of Machines

w. e. f. Academic Year:	2025-26
Semester:	3rd
Category of the Course:	Core Course
Prerequisite:	Engineering Mechanics, Engineering Drawing
Rationale:	Mechanical Mechanism is a fundamental subject in Mechanical Engineering that deals with the study of relative motion between machine components without considering forces. The course provides essential knowledge for understanding mechanisms used in machines and forms the foundation for advanced subjects such as Dynamics of Machines, Machine Design, Robotics, and Automation.

Course Outcomes:

After Completion of the Course, Student will able to:

	Course Outcome (CO)	RBT Level (Cognitive Domain)	Marks % Weightage (approx.)
CO1	Explain fundamental concepts of mechanisms, kinematic pairs, and machine elements.	Understand	15
CO2	Analyze velocity and acceleration of mechanisms using analytical methods.	Analyze	30
CO3	Apply dimensional synthesis techniques for mechanism design.	Apply	20
CO4	Evaluate motion characteristics and design of cam and follower systems.	Evaluate	20
CO5	Design and analyze mechanisms such as four-bar, slider-crank, and steering systems considering sustainability and efficiency.	Analyze	15

Teaching and Evaluation Scheme:

Teaching Scheme					Examination Scheme				
L	**T**	**P**	**C**	**Hrs/Week**	**IE**	**EE**	**CIA**	**Practical/ Viva**	**Total Marks**
3	0	2	4	5	40	60	30	20	150

IE: Internal Exam
EE: External Exam (End Semester)
CIA: Continuous Internal Assessment
Practical: Practical Exam (End Semester)

Detailed Syllabus:

Topic		Hrs.	% of Weightage
UNIT: 1	**Introduction to Mechanism & Machines:**	10	20
Terminology and Definitions, Mechanism & Machines, rigid and resistance body, link, Kinematic pair, Types of motion, degrees of freedom, classification of Kinematic pairs, Kinematic Chain, Linkage, Mechanics, Kinematic Inversion of Single and double slider crank Chain, Four bar Chain Mechanism with lower pairs, Straight line mechanism and approximate straight line mechanism such as Peaucellier, Hart's mechanism, Watt, Modified Scott-Russel, Grasshopper, Robert's mechanism, Hooke's Joint its analysis, condition for equal speed of driven and driver shafts, Double Hooks Joint, Quick return mechanisms, Steering gear mechanisms such as Davis and Ackermann Steering gear. Study of mechanisms used in transportation and infrastructure systems contributing to sustainable mobility.			
UNIT: 2	**Velocity, Acceleration Analysis:**	10	30
Velocity and Acceleration analysis of mechanisms using analytical methods. Velocity and Acceleration of a point on a rotating link. Relative velocity and Acceleration method. Velocity and Acceleration analysis of slider–crank and four-bar mechanisms. Analysis aimed at improving energy efficiency and reducing mechanical losses in machines.			
UNIT: 3	**Dimensional Synthesis of Mechanisms:**	12	25
Introduction to dimensional synthesis of mechanisms using analytical approaches. Concepts of function, path and motion generation with applications. Two-position and three-position synthesis. Freudenstein's equation for three-position function generation. Chebyshev's spacing for precision points. Angle relationships. Analytical synthesis of four-bar and slider–crank mechanisms. Design of optimized mechanisms to minimize material usage and enhance sustainable production.			
UNIT: 4	**Kinematics of Cam and Follower Systems:**	13	25
Introduction, Definitions of cam and followers, their uses, Types of Cams, Types of Followers and their motion, Cam Terminology, Displacement Diagrams, Motion of the Followers, Analysis of motion of followers: Roller follower, circular cam with straight, concave and convex flanks, Graphical Construction of the Profile. Design considerations for reducing wear, energy loss, and improving lifecycle sustainability.			
		45	**100**

List of Practical:

	Hrs
Identify and analyze kinematic pairs and chains in real mechanical systems using	2

sketches.	
CAD-Based Simulation and Kinematic Analysis of Four-Bar Mechanism.	4
CAD-Based Simulation and Kinematic Analysis of Slider crank Mechanism.	4
Determine the degree of freedom of planar mechanisms and validate using Gruebler's equation.	2
Analyse kinematic inversions of single and double slider–crank mechanisms by constructing link arrangements and identifying applications.	2
Analyze quick-return mechanisms and determine quick-return ratio and time efficiency.	2
To identify and construct cam terminology for a given cam specification.	2
Construct displacement diagrams for different cam–follower motions (uniform velocity, SHM, uniform acceleration).	4
Graphical Construction of Cam Profile for different follower.	4
Simulation of Cam and Follower Mechanism (Manual/CAD).	4
	30

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks in Percentage					
Remember	Understand	Apply	Analyze	Evaluate	Create
7	8	20	30	20	15

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may very slightly from above table.

Reference Books:

1. **Shigley, J.E. and Uicker, J.J.**: *Theory of Machines and Mechanisms*, Oxford University Press.
2. **Rattan, S.S.**: *Theory of Machines*, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
3. **Rao, J.S. and Dukkipati, R.V.**: *Mechanisms and Theory of Machines*, Wiley Eastern Ltd.
4. **Wilson**: *Kinematics and Dynamics of Machinery*, 3rd Edition, Pearson Education.

Teaching Learning Method

- Interactive Classroom Teaching.
- Problem-Based Learning.
- Demonstration Using Physical Models.
- Graphical Method Practice.
- Incorporation of SDG-oriented case studies and sustainable design practices.

Course Outcomes Mapping:

CO	Course Outcome (CO)	POs/ PSOs Mapped	Cognitive Level (RBT)	Knowledge Category	Class Session (Lecture)
CO1	Explain fundamental concepts of mechanisms,	PO1, PO2, PO3, PO11,	Understand	Conceptual	7

	kinematic pairs, and machine elements.	PSO1, PSO2			
CO2	Analyze velocity and acceleration of mechanisms using analytical methods.	PO1, PO2, PO3, PO4, PO5, PO11, PSO1, PSO2	Analyze	Conceptual/ Procedural	14
CO3	Apply dimensional synthesis techniques for mechanism design.	PO1, PO2, PO3, PO4, PO5, PO10, PO11, PSO1, PSO2	Apply	Procedural	9
CO4	Evaluate motion characteristics and design of cam and follower systems.	PO1, PO2, PO3, PO4, PO5, PO10, PO11, PSO1, PSO2	Evaluate	Conceptual/ Procedural	9
CO5	Design and analyze mechanisms such as four-bar, slider-crank, and steering systems.	PO1, PO2, PO3, PO4, PO5, PO6, PO8, PO9, P10, PO11, PSO1, PSO2	Analyze	Procedural	6

Mapping of COs with POs & PSOs:

CO	PO											PSO	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3	2	1	-	-	-	-	-	-	-	1	3	1
CO2	3	3	1	2	2	-	-	-	-	1	1	3	2
CO3	3	2	3	2	2	-	-	-	-	-	1	3	2
CO4	3	2	3	2	2	-	-	-	-	-	1	3	2
CO5	3	3	3	2	3	1	-	1	1	1	1	3	3

3: High, 2: Medium, 1: Low

Sustainable Development Goals (SDG) Integration

This course integrates principles of sustainable engineering by emphasizing efficient mechanism design, reduced material consumption, and applications in sustainable infrastructure and transportation systems aligned with SDG 4 (Quality Education), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Responsible Consumption and Production).

SDG Mapping with Course Outcomes

CO	Course Outcome	Relevant SDGs	Justification
CO1	Explain fundamental concepts of mechanisms, kinematic pairs, and machine elements.	SDG 4	Develops strong engineering fundamentals for understanding mechanical systems
CO2	Analyze velocity and acceleration of mechanisms using analytical methods.	SDG 9	Enhances efficiency and performance of mechanical systems
CO3	Apply dimensional synthesis techniques for mechanism design.	SDG 9, SDG 12	Promotes optimized design and efficient use of materials
CO4	Evaluate motion characteristics and design of cam and follower systems.	SDG 12	Reduces wear, energy losses, and improves system sustainability
CO5	Design and analyze mechanisms such as four-bar, slider-crank, and steering systems.	SDG 9, SDG 11, SDG 12	Supports sustainable system design, efficient operation, and infrastructure development