25MEMJ205 : Kinematics of Machines

w. e. f. Academic Year:	2026-27
Semester:	3rd (Mechanical Engineering)
Category of the Course:	PCC
Prerequisite:	Engineering Mechanics, Engineering Drawing
Rationale:	This course provides fundamental knowledge and analytical skills for understanding, analyzing, and synthesizing mechanisms, cams, followers, and gears. It enables students to determine motion characteristics and develop efficient mechanisms for practical mechanical engineering applications, with consideration of energy efficiency, wear reduction, and sustainable design.

Course Outcomes:

After Completion of the Course, Student will able to:

	Course Outcome (CO)	RBT Level (Cognitive Domain)
CO1	Explain fundamentals of mechanisms and machines.	Understand
CO2	Analyze velocity and acceleration of mechanisms.	Analyze
CO3	Apply dimensional synthesis for mechanism design.	Apply
CO4	Analyze cam-follower motion and construct cam profiles.	Analyze
CO5	Understand and Analyze kinematics of gears	Understand/Analyze

Teaching and Evaluation Scheme:

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

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

Detailed Syllabus:

Topic		Hrs.	% of Weightage (Approx.)
UNIT: 1	**Introduction to Mechanism & Machines:**	9	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:**	8	18
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:**	9	20
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:**	9	20
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.			
UNIT: 5	**Kinematics of Gear:**	10	22
Introduction, Friction Wheels, Advantages and Disadvantages of Gear Drive, Classification of Toothed Wheels, Terms Used in Gears, Gear Materials, Condition for Constant Velocity Ratio of Toothed Wheels-Law of Gearing, Velocity of Sliding of Teeth, Forms of Teeth, Cycloidal Teeth, Involute Teeth, Effect of Altering the Centre Distance on the Velocity Ratio for Involute Teeth Gears,			

Comparison Between Involute and Cycloidal Gears, Standard Proportions of Gear Systems, Length of Path of Contact, Length of Arc of Contact, Contact Ratio (or Number of Pairs of Teeth in Contact), Interference in Involute Gears, Minimum Number of Teeth on the Pinion in Order to Avoid Interference, Minimum Number of Teeth on the Wheel in Order to Avoid Interference, Minimum Number of Teeth on a Pinion for Involute Rack in Order to Avoid Interference, Helical Gears, Bevel Gear, Spiral Gears.		
	45	**100**

List of Practical:

Sr. No.	Topic	Hrs
1	Identify and analyze kinematic pairs and chains in real mechanical systems using sketches.	2
2	CAD-Based Simulation and Kinematic Analysis of Four-Bar Mechanism.	4
3	CAD-Based Simulation and Kinematic Analysis of Slider crank Mechanism.	4
4	Determine the degree of freedom of planar mechanisms and validate using Gruebler's equation.	2
5	Analyse kinematic inversions of single and double slider–crank mechanisms by constructing link arrangements and identifying applications.	2
6	Analyze quick-return mechanisms and determine quick-return ratio and time efficiency.	2
7	To identify and construct cam terminology for a given cam specification.	2
8	Construct displacement diagrams for different cam–follower motions (uniform velocity, SHM, uniform acceleration).	4
9	Graphical Construction of Cam Profile for different follower.	4
10	Simulation of Cam and Follower Mechanism (Manual/CAD).	2
11	Numerical Analysis of Gear Kinematics: Solve practical problems involving law of gearing, sliding velocity, contact ratio, interference and gear geometry.	2
		30

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

- Lecture-based teaching-learning.
- Group teaching and Learning.
- Peer teaching
- Learning through problem – solving.

Course Outcomes Mapping:

CO	Course Outcome (CO)	POs/ PSOs Mapped	Cognitive Level (RBT)	Knowledge Category	Class Sessions (Lecture)
CO1	Explain fundamentals of mechanisms and machines.	PO1, PO2, PO3, PO5, PO6, PO8, PO9, PO11, PSO1, PSO2	Understand	Conceptual	9
CO2	Analyze velocity and acceleration of mechanisms.	PO1, PO2, PO3, PO4, PO5, PO6, PO8, PO9, PO11, PSO1, PSO2	Analyze	Conceptual/ Procedural	8
CO3	Apply dimensional synthesis for mechanism design.	PO1, PO2, PO3, PO4, PO5, PO6, PO8, PO9, P10, PO11, PSO1, PSO2	Apply	Procedural	9
CO4	Analyze cam-follower motion and construct cam profiles.	PO1, PO2, PO3, PO4, PO5, PO6, PO7 PO8, PO9, P10, PO11, PSO1, PSO2	Analyze	Conceptual/ Procedural	9
CO5	Understand and Analyze kinematics of gears	PO1, PO2, PO3, PO4, PO5, PO6, PO8, PO9, P10, PO11, PSO1, PSO2	Understand/ Analyze	Procedural	10

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	2	-	1	1	-	1	1	3
CO2	3	3	2	1	3	1	-	1	1	-	2	2	3
CO3	3	3	3	1	3	2	-	1	1	1	2	2	3
CO4	3	3	3	1	3	3	1	1	2	1	2	2	3
CO5	3	3	3	1	3	2	-	1	1	1	2	2	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 fundamentals of mechanisms and machines.	SDG 4	Builds engineering fundamentals
CO2	Analyze velocity and acceleration of mechanisms.	SDG 9	Improves machine efficiency
CO3	Apply dimensional synthesis for mechanism design.	SDG 9, SDG 12	Optimized resource usage
CO4	Analyze cam-follower motion and construct cam profiles.	SDG 12	Reduces losses and wear
CO5	Understand and Analyze kinematics of gears	SDG 9, SDG 11, SDG 12	Supports sustainable systems