25UMET403	THEORY OF MECHANISMS	Category	L	T	P	R	Credit	Year of Introduction
		PBL	3	1	0	0	4	2025

Preamble: Theory of Mechanisms forms the foundation for understanding how machines work. It deals with the study of motion, forces, and the interrelationship between different parts of a mechanical system. By analyzing links, joints, and mechanisms, this subject helps engineers design machines that perform desired tasks efficiently and safely.

Prerequisite: Engineering Mechanics

Course Outcomes: After the completion of the course, the student will be able to:

CO	Course Outcomes	Knowledge Level
CO1	Apply the concept of degrees of freedom to determine the mobility of planar mechanisms and identify their kinematic inversions.	K3 Apply
CO2	Analyze the velocity and acceleration characteristics of planar mechanisms using appropriate analytical methods.	K4 Analyse
CO3	Apply kinematic synthesis and cam–follower principles to design planar mechanisms and cam profiles.	K3 Apply
CO4	Apply cam and gear drive principles to solve engineering problems and select suitable configurations based on functional requirements.	K3 Apply

Mapping of course outcomes with program outcomes and program specific outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	2	1	–	–	–	2	2	–	2	3
CO2	3	3	1	3	2	–	–	–	2	2	–	2	3
CO3	3	3	3	2	2	–	–	–	2	2	–	2	3
CO4	3	3	2	2	1	–	–	–	2	2	–	2	3
Avg	**3**	**2.75**	**1.75**	**2.25**	**1.5**	**–**	**–**	**–**	**2**	**2**	**–**	**2**	**3**

Mapping of course outcomes with Knowledge and Attitude Profile (WK)

	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CO1	*	*	*	*	*	_	_	_	_
CO2	*	*	*	*	*	*	_	_	_
CO3	*	*	*	*	*	*	_	_	_
CO4	*	*	*	*	*	*	_	_	_

WKs Mapped with the course

WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
*	*	*	*	*	*	_	_	_

Mark Distribution:

Total Marks	CIE Marks	ESE Marks	ESE Duration
100	**60**	**40**	**2.5 hrs**

Continuous Internal Evaluation Pattern:

Attendance : 5 marks
Continuous Assessment Test : 20 marks
Continuous Assessment Assignment : 15 marks

SYLLABUS

Module 1 (12 hrs)

Classification of mechanisms – Basic kinematic concepts and definitions – Degree of freedom, Mobility – Kutzbach criterion, Gruebler's criterion – Grashof's Law –Kinematic inversions of four-bar chain, slider crank chains and double slider crank chains – Limit positions –Mechanical advantage – Transmission Angle -Coupler curves – Description of some common Mechanisms – Quick return mechanisms, Straight line generators, Dwell Mechanisms, Ratchets and Escapements, Universal Joint, steering mechanisms

Module 2 (12 hrs)

Displacement, velocity and acceleration analysis of simple mechanisms – Graphical method – Velocity and acceleration polygons – Velocity analysis using instantaneous centers – Kennedy's theorem, kinematic analysis by complex algebra methods – Vector approach – Computer applications in the kinematic analysis of simple mechanisms – Coincident points – Coriolis component of Acceleration.

Module 3 (12 hrs)

Kinematic synthesis (Planar Mechanisms) - Tasks of kinematic synthesis – Type, Number and dimensional synthesis – Precision points - Graphical synthesis for four link mechanism Function generator – 2 position and 3 position synthesis

Cams and Followers: - types-follower motion-SHM-uniform velocity and acceleration. Cycloidal -

displacement, velocity and acceleration curves-Cam profile-Reciprocating and oscillating followers

Module 4 (12 hrs)

Law of toothed gearing – Involutes and cycloidal tooth profiles –Spur Gear terminology and definitions –Gear tooth action – contact ratio – Interference and undercutting – Non-standard gear teeth – Helical, Bevel, Worm, Rack and Pinion gears [Basics only] Gear trains – Speed ratio, train value – Parallel axis gear trains– Epicyclic Gear Trains – Differentials

Text Books:

1. Ballaney, P. L., Theory of machines and mechanisms. Khanna Publishers, 2005.
2. Rattan, S. S., Theory of machines. Tata McGraw Hill, 2009.
3. Ghosh, A., Theory of mechanisms and machines. East West, 2008.

Reference Books:

1. Wilson, C. E., & Sadler, P., Kinematics and dynamics of machinery. Pearson Education, 2005.
2. Shigley, J. E., & Uicker, J. J., Theory of machines and mechanisms. McGraw Hill, 2010.
3. Myszka, D. H., Machines and mechanisms: Applied kinematic analysis. Pearson Education, 2013.
4. Norton, R. L., Kinematics and dynamics of machinery. Tata McGraw Hill, 2009.

Project / Experiential Evaluation (30 Marks)

1. Mechanism Identification & Motion Study (10 Marks)

Field + Analytical Activity (Team of 3–4)

Task:

Students must identify a real-life mechanical system such as:

- Bicycle pedal-crank mechanism
- Car steering mechanism
- Wiper mechanism
- Sewing machine mechanism
- Quick return mechanism in shaping machine
- Door closer mechanism
- Mechanical jack
- Folding chair linkage

Students must:

Identify:

- Type of mechanism
- Kinematic chain
- Degree of freedom
- Inversion (if applicable)

Analyze:

- Motion type (rotary/reciprocating/oscillating)
- Velocity direction at key points
- Practical limitations or inefficiencies

Deliverables:

- Kinematic diagram
- DOF calculation
- 3-minute demonstration video
- Short technical report

Evaluation Rubric (10 Marks)

Criteria	Marks
Correct mechanism identification	3

DOF & inversion analysis	3
Motion interpretation	2
Presentation quality	2

2. Velocity & Acceleration Analysis Challenge (10 Marks)

Task:

Each team selects one planar mechanism (max 6 links):

- Four-bar mechanism
- Slider crank
- Whitworth quick return
- Crank and slotted lever

Students must:

- Perform velocity analysis (relative velocity / instantaneous centre)
- Perform acceleration analysis (include Coriolis acceleration if applicable)
- Interpret mechanical significance

Deliverables:

- Analytical solution (hand calculation or MATLAB/Excel)
- Vector diagrams
- Engineering interpretation note

Evaluation Rubric (10 Marks)

Criteria	**Marks**
Correct velocity analysis	3
Correct acceleration analysis	3
Interpretation of results	2
Technical clarity	2

3. Mechanism Design & Gear Application Mini Project (10 Marks)

Option A: Mechanism Synthesis Challenge

Design a mechanism that achieves:

- Specific output motion
- Quick return ratio
- Required stroke length
- Straight line motion

OR

Option B: Gear Train Application Study

Select a real industrial component (e.g., gearbox, bicycle gear, planetary gearbox in automatic transmission) and:

- Identify gear type
- Determine gear ratio
- Explain interference / backlash issues
- Tabulate gear train

Deliverables:

- Design justification
- Calculations
- Sketch/model (manual or CAD)
- 2-minute explanation video

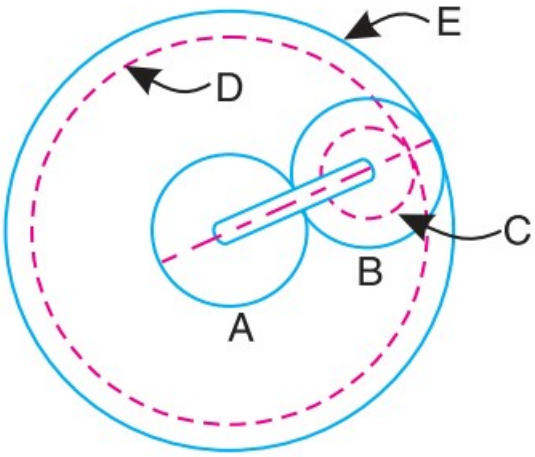
Evaluation Rubric (10 Marks)

Criteria	Marks
Design logic / gear analysis	3
Calculation accuracy	3
Application relevance	2
Innovation & clarity	2

END SEMESTER EXAMINATION – MODEL QUESTION PAPER

Course Code	**25UMET403**
Course Name	**THEORY OF MECHANISMS**
Max. Marks: 40	**Duration: 2.5 Hours**

Part A (Answer all questions. Each question carries 2 marks)				
Qn No.	**Question**	**Marks**	**CO**	**BL**
1	Use Kutzbach criterion to determine the mobility of a given planar mechanism.	2	CO 1	L3
2	Illustrate any one kinematic inversion of a slider-crank chain.	2	CO 1	L3
3	Analyze the velocity of a link in a simple mechanism using the instantaneous centre method.	2	CO 2	L4
4	Determine the Coriolis component of acceleration in a mechanism having sliding motion.	2	CO 2	L4
5	Use two-position synthesis to construct a simple four-bar mechanism for a given motion requirement.	2	CO 3	L3
6	Illustrate follower displacement for a cam operating with simple harmonic motion.	2	CO 3	L3
7	Use the law of gearing to identify proper gear tooth action in a gear pair.	2	CO 4	L3
8	Solve the train value of a simple gear train from the given gear teeth data.	2	CO 4	L3
Part B (Answer any one full question from each Module. Each carries 6 marks)				
Module I				
Qn No.	**Question**	**Marks**	**CO**	**BL**
9	Use Kutzbach criterion to determine the degree of freedom of a quick-return mechanism and identify its kinematic chain and inversion.	6	CO 1	L3
OR				
10	Use Grashof's law to classify a four-bar mechanism with link lengths 40 mm, 70 mm, 90 mm and 110 mm, and illustrate its possible motion.	6	CO 1	L3
Module II				
Qn No.	**Question**	**Marks**	**CO**	**BL**
11	Analyze the velocity and acceleration of a four-bar mechanism using velocity and acceleration polygons for a given crank position.	6	CO 2	L4
OR				

12	Analyze a slider-crank mechanism using the instantaneous centre method and determine the velocity relationship between the crank and slider.	6	CO 2	L4
Module III				
Qn No.	**Question**	**Marks**	**CO**	**BL**
13	Use graphical synthesis to develop a four-link mechanism for two specified positions of the input and output links.	6	CO 3	L3
OR				
14	Develop the cam profile of preferable dimensions for a knife-edge follower with simple harmonic motion during rise and return, using suitable displacement diagrams.	6	CO 3	L3
Module IV				
Qn No.	**Question**	**Marks**	**CO**	**BL**
15	Use the law of toothed gearing to illustrate involute gear tooth action and determine the condition for avoiding interference.	6	CO 4	L3
OR				
16	Fig. shows an epicyclic gear train. Pinion A has 15 teeth and is rigidly fixed to the motor shaft. The wheel B has 20 teeth and gears with A and also with the annular fixed wheel E. Pinion C has 15 teeth and is integral with B (B, C being a compound gear wheel). Gear C meshes with annular wheel D, which is keyed to the machine shaft. The arm rotates about the same shaft on which A is fixed and carries the compound wheel B, C. If the motor runs at 1000 r.p.m., find the speed of the machine shaft. Solve the torque exerted on the machine shaft, if the motor develops a torque of 100 N-m. 	6		L3