Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	Cam Terminology, Motion Diagram and Profile Generation	10	
2	Analysis of Pressure Angle and Radius of Curvature	10	
3	Design and Construction of Cam Profile for a Prescribed Motion (ALA-3)		10
	Total	20	10

Examination Style:

Cam Terminology, Motion Diagram and Profile Generation – 10 Marks

Students will construct the displacement diagram for a prescribed follower motion and generate the corresponding cam profile for a roller or flat-faced follower. The activity may involve simple harmonic motion or cycloidal motion as specified in the problem. The assessment will consider the accuracy of cam terminology, displacement diagram, construction of the cam profile, follower motion interpretation, and overall technical accuracy.

Analysis of Pressure Angle and Radius of Curvature – 10 Marks

Students will analyze the pressure angle and radius of curvature of a given cam profile and explain their influence on follower motion and smooth operation of the mechanism. Students will compare the characteristics of different follower-motion programs wherever applicable. The assessment will consider the accuracy of pressure-angle and radius-of-curvature analysis, understanding of follower motion, interpretation of results, and engineering justification.

Design and Construction of Cam Profile for a Prescribed Motion – 10 Marks

Students will construct a cam profile for a specified follower displacement and motion requirement using graphical construction methods. Students will select an appropriate motion law such as simple harmonic motion or cycloidal motion, prepare the displacement diagram, construct the corresponding cam profile, and determine the follower position at different cam angles. Students will compare the characteristics of the selected motion law with another suitable motion program. The assessment will consider the selection of appropriate motion law,

	components, accuracy of observations and calculations, interpretation of governor characteristics, and understanding of speed regulation. **Flywheel and Gyroscopic Motion Analysis – 10 Marks** Students will analyze the function of a flywheel using a turning-moment diagram and determine the fluctuation of energy associated with a cyclically varying torque. Students will also demonstrate or analyze gyroscopic motion and determine the effect of gyroscopic couple for a specified rotating system The assessment will consider the understanding of flywheel operation, interpretation of turning-moment diagrams, accuracy of energy-fluctuation analysis, understanding of gyroscopic effect, and technical interpretation **Performance Analysis of Governor and Flywheel – 10 Marks** Students will analyze the performance of a governor or flywheel using experimental or simulated data. For a governor, students will study characteristics such as speed, governor height, sleeve displacement, stability, and sensitiveness. For a flywheel, students will analyze the turning-moment diagram and fluctuation of energy. Students will organize the data, prepare suitable graphs or diagrams, interpret the obtained results, and draw appropriate engineering conclusions. The assessment will consider understanding of governor and flywheel principles, accuracy of data analysis and calculations, quality of graphical representation, interpretation of performance characteristics, engineering conclusions, and technical presentation.		

Suggested Specification table with Marks:

Distribution of Theory Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage %	5%	19%	35%	25%	15%	10%

Gear Profile & Technical Interpretation	Identifies the gear profile and explains the significance of the determined parameters in gear operation.	5
Total		10

Gear Train Assembly and Speed Ratio Analysis (10 Marks)		
Criteria	Description	Marks
Gear Train Analysis	Correctly identifies the gear-train arrangement and determines the speed ratio.	5
Direction & Application Analysis	Correctly determines the direction of rotation and relates the gear train to its practical application.	5
Total		10

Module 5: Flywheels, Governors and Gyroscopic Motion

Governor Characteristics and Performance Analysis (10 Marks)		
Criteria	Description	Marks
Governor Analysis	Correctly identifies governor components and determines/analyses the required governor characteristics.	5
Performance Interpretation	Correctly interprets stability, sensitiveness, speed regulation and the effect of operating conditions.	5
Total		10

Flywheel and Gyroscopic Motion Analysis (10 Marks)		
Criteria	Description	Marks
Flywheel & Energy Analysis	Correctly interprets the turning-moment diagram and determines fluctuation of energy or related flywheel parameters.	5
Gyroscopic Analysis & Application	Correctly explains/analyses gyroscopic effect and relates gyroscopic couple to practical engineering applications.	5
Total		10

	Examination Style: **Gear Identification, Terminology and Parameter Measurement – 10 Marks** Students will identify the given gear type and determine important gear parameters such as number of teeth, module, pitch diameter, outside diameter, and pressure angle using suitable gear models or drawings. Students will also identify the involute or cycloidal nature of the gear profile and discuss its application. The assessment will consider the accuracy of gear identification, parameter measurement or calculation, understanding of gear terminology, and technical interpretation. **Gear Train Assembly and Speed Ratio Analysis – 10 Marks** Students will assemble or analyze a given simple, compound, reverted, or epicyclic gear train and determine its speed ratio and direction of rotation. Students will relate the calculated gear ratio to practical power-transmission applications. The assessment will consider correct gear-train identification, accuracy of speed-ratio calculation, direction-of-rotation analysis, and interpretation of the practical application. **Gear Train Selection and Design Activity – 10 Marks** Students will select and design a suitable gear-train arrangement for a specified input and output speed requirement using gear models, drawings, and analytical calculations. Students will identify the appropriate simple, compound, reverted, or epicyclic gear arrangement, determine the required gear ratio, select suitable numbers of teeth, and prepare a schematic representation of the selected gear train. Students will justify the selected arrangement based on the required transmission ratio and practical application. The assessment will consider the selection of appropriate gear-train configuration, accuracy of gear-ratio calculations, selection of suitable gear combinations, schematic representation, engineering justification, and technical presentation.		
5	**Flywheels, Governors and Gyroscopic Motion** Theory of Flywheels, Turning moment diagram, Types of governors, Watt governor, Porter, Proell, and Hartnell governors, Stability and sensitiveness of governors, Gyroscopic couple and effect, Applications in automobiles, ships and aircrafts.	18	20%

	calculation of acceleration components, identification of Coriolis acceleration, accuracy of results, and technical interpretation of mechanism motion **Case Study on Slider-Crank Mechanism in an IC Engine – 10 Marks** Students will study the slider-crank mechanism used in a reciprocating IC engine and analyze the conversion of rotary motion of the crank into reciprocating motion of the piston. Students will investigate piston velocity and acceleration at selected crank positions using graphical, analytical, or simulation-based methods and relate the results to actual engine operation. The assessment will consider the application of velocity and acceleration principles, accuracy of analysis, interpretation of results, engineering relevance, and quality of the case study.		
3	**Cams and Followers** Types of cams and followers, Cam terminology, Motion curves, Displacement, velocity and acceleration diagrams, Cam profile generation with roller and flat-faced followers, Pressure angle, Radius of curvature. **Practical:** 21) Study and identification of various types of cams and followers used in machines. 22) Study of cam terminology, including base circle, pitch curve, prime circle, pressure angle, lift and trace point. 23) Construction of displacement diagram for uniform velocity motion of a follower. 24) Construction of displacement, velocity and acceleration diagrams for SHM motion. 25) Construction of displacement, velocity and acceleration diagrams for cycloidal motion. 26) Construction of cam profile for a radial cam with roller follower using SHM motion. 27) Construction of cam profile for a radial cam with roller follower using cycloidal motion. 28) Construction of cam profile for a flat-faced follower for a prescribed follower motion. 29) Determination and analysis of pressure angle at different positions of a cam and follower. 30) Determination and comparison of radius of curvature of a cam profile and discussion of its effect on smooth follower motion	18	20%

Course Outcome:

After learning the course, the students should be able to:	
CO1	Identify and classify mechanisms, kinematic pairs, and determine the mobility of mechanical systems.
CO2	Analyze velocity and acceleration characteristics of mechanisms.
CO3	Design and evaluate cam-follower mechanisms for prescribed motion requirements.
CO4	Analyze the gears and gear train systems used in power transmission applications.
CO5	Analyze governors, flywheels, and gyroscopic systems used for speed regulation, energy storage, and stability control in engineering applications.

Instructional Method:

The course delivery method will depend upon the requirement of content and the needs of students. The teacher, in addition to conventional teaching methods by black board, may also use any tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

From the content 10% topics are suggested for flipped mode instruction.

Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e-courses, Virtual Laboratory

The internal evaluation will be done on the basis of Active Learning Assignment.

Reference Books:

[1] Theory of Machines, S S Rattan, Tata McGraw-Hill.
[2] Theory of Machines and Mechanisms, J J Uicker, G R Pennock, J E Shigley, Oxford University Press.
[3] Theory of Machines, R S Khurmi, J K Gupta, S. Chand Publication.
[4] Kinematics and Dynamics of Machinery, C E Wilson, J P Sadler, Pearson Education.

Practical:

41) Study and demonstration of Porter, Proell and Hartnell governor models.
42) Experimental determination of governor characteristics by measuring speed and sleeve displacement.
43) Plotting of governor characteristics and determination of governor height/speed relationships.
44) Analysis of stability of governors using experimental or simulated governor characteristics.
45) Determination of sensitiveness of governors and comparison of different governor types.
46) Study of flywheel applications in IC engines, punching machines and presses.
47) Analysis of the turning-moment diagram of an IC engine and identification of energy fluctuations.
48) Determination of fluctuation of energy and required flywheel size from a turning-moment diagram.
49) Demonstration and analysis of gyroscopic effect using a rotating disc setup and determination of gyroscopic couple.
50) Case study of gyroscopic applications in automobiles, ships and aircraft, including vehicle stability, ship stabilization and aircraft attitude/control applications.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	Governor Characteristics and Performance Analysis	10	
2	Flywheel and Gyroscopic Motion Analysis	10	
3	Performance Analysis of Governor and Flywheel (ALA-5)		10
	Total	20	10

Examination Style:

Governor Characteristics and Performance Analysis – 10 Marks

Students will study a given governor model or simulated governor system and determine its operating characteristics for different speeds. Students will analyze governor height, sleeve displacement, stability, and sensitiveness and compare the behaviour of different governor types. The assessment will consider the correct identification of governor

14) Construction of velocity polygons for a slider-crank mechanism and determination of slider velocity.
15) Determination of instantaneous centres of a four-bar mechanism using the graphical method.
16) Determination of instantaneous centres of a slider-crank mechanism and verification of velocity relationships.
17) Verification and application of Kennedy's theorem for locating instantaneous centres.
18) Construction of acceleration polygons for four-bar mechanisms and determination of acceleration of selected points.
19) Demonstration and analysis of Coriolis acceleration in mechanisms containing sliding and rotating links.
20) Velocity and acceleration analysis of a slider-crank mechanism using Klein's construction and comparison with graphical/analytical results.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	Velocity Analysis of Mechanisms	10	
2	Acceleration Analysis and Coriolis Component	10	
3	Case Study on Slider-Crank Mechanism in an IC Engine (ALA-2)		10
	Total	20	10

Examination Style:

Velocity Analysis of Mechanisms – 10 Marks

Students will perform velocity analysis of a given four-bar or slider-crank mechanism using the relative velocity method and construct the corresponding velocity polygon. The velocity of specified links or points will be determined for a given input condition. The assessment will consider the correct identification of velocity vectors, construction of the velocity polygon, accuracy of calculations, and interpretation of the resulting mechanism motion.

Acceleration Analysis and Coriolis Component – 10 Marks

Students will perform acceleration analysis of a given mechanism using graphical or analytical methods and determine the relevant radial, tangential, and Coriolis components of acceleration wherever applicable. Students will interpret the effect of acceleration on the motion of the mechanism. The assessment will consider the correct construction or

Practical:

1) Identification and classification of various kinematic pairs and mechanisms.
2) Study and identification of different types of links and joints used in mechanical mechanisms.
3) Demonstration of inversions of a four-bar chain and identification of their practical applications.
4) Study of inversions of a single slider-crank chain such as reciprocating engine mechanism, oscillating-cylinder mechanism and other standard inversions.
5) Study of inversions of a double slider-crank chain and identification of practical applications.
6) Determination of degree of freedom of different planar mechanisms using the Gruebler/Kutzbach criterion and verification using a mechanism model or CAD model.
7) Analysis of a four-bar mechanism for input-output motion relationship and identification of crank, rocker and coupler.
8) Determination and interpretation of transmission angle for a four-bar mechanism at different configurations.
9) Determination of mechanical advantage of a four-bar mechanism for different positions of the input link.
10) Demonstration and analysis of a quick-return mechanism, including identification of its applications in shaper and slotter machines.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	Kinematic Pair, Mechanism Identification and Classification	10	
2	Degree of Freedom and Mechanism Analysis	10	
3	Design and Modelling of a Four-Bar Mechanism (ALA-1)		10
	Total	20	10

Examination Style:

Kinematic Pair, Mechanism Identification and Classification – 10 Marks

Students will be provided with physical models, mechanism diagrams, CAD models, or suitable mechanism animations and will identify and classify the given kinematic pairs, links, joints, kinematic chains, and

	mechanisms. Students will determine the type of constrained motion and explain the working principle and practical application of the identified mechanism, The assessment will consider the accuracy of identification, classification of kinematic pairs and mechanisms, understanding of mechanism configuration, and technical explanation. **Degree of Freedom and Mechanism Analysis – 10 Marks** Students will determine the degree of freedom of a given planar mechanism using the appropriate mobility criterion and verify the result using a mechanism model or simulation. Students will also analyze the motion of four-bar, slider-crank, or quick-return mechanisms and identify the input and output links. The assessment will consider the correctness of degree-of-freedom calculation, mechanism analysis, interpretation of motion, and ability to relate the mechanism to its practical application. **Design and Modelling of a Four-Bar Mechanism – 10 Marks** Students will design a four-bar mechanism for a specified input-output motion using a physical mechanism model or graphical construction. Students will identify the links, joints, kinematic pairs, input and output links, and determine the degree of freedom of the mechanism. They will prepare the kinematic diagram, demonstrate the mechanism motion using a physical model, and explain its practical application. The assessment will consider the identification and classification of mechanism components, correctness of degree-of-freedom determination, quality of kinematic diagram, understanding of mechanism motion, and technical presentation.		
2	**Velocity and Acceleration Analysis of Mechanisms** Relative velocity method, Velocity polygon, Instantaneous centre method, Kennedy's theorem, Acceleration analysis, Coriolis component of acceleration, Klein's construction, Motion analysis of slider crank and four-bar mechanisms. **Practical:** 11) Velocity analysis of a four-bar mechanism using the relative velocity method. 12) Velocity analysis of a slider-crank mechanism using the relative velocity method. 13) Construction of velocity polygons for a four-bar mechanism and determination of velocity of different links.	18	20%

Gyanmanjari Innovative University

Syllabus
Gyanmanjari Institute of Technology
Semester- 3 (B.Tech.)

Subject: Kinetics of Machinery -BET2ME13306

Type of course: Professional Core

Prerequisite: Engineering Mechanics, Engineering Graphics, and Engineering Mathematics.

Rationale: The subject of Kinematics of Machines provides a practical understanding of motion transmission and mechanism behavior used in mechanical systems. The course focuses on mechanism analysis, motion simulation, graphical methods, experimental learning, and industrial applications. Students will develop skills related to mechanism identification, velocity and acceleration analysis, gear train operation, cam profile development, and governor analysis through practical and activity-based learning methods. The course supports applications in machine design, robotics, automation, automobiles, and manufacturing industries.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks		Total Marks
CI	T	P	C	SEE	CCE	
2	0	4	4	100	50	150

Legends: CI-Class Room Instructions; T – Tutorial; P - Practical; C – Credit; SEE - Semester End Evaluation; CCE-Continuous and Comprehensive Evaluation

Course Content:

Sr. No	Course content	Hrs.	% Weigh tage
1	**Fundamentals of Mechanisms and Kinematic Pairs** Introduction to Theory of Machines, Mechanism and machine, Types of constrained motion, Rigid and resistant bodies, Link, Types of joints, Kinematic pair and its classification, Kinematic chains, Degrees of freedom, Structure and Mechanism, Four bar mechanism, Single and Double slider crank mechanisms, Inversions of Four bar chain, Single slider crank chain and Double slider crank chain, Mechanical advantage, Transmission angle, Quick return mechanism.	18	20%

GYANMANJARI INNOVATIVE UNIVERSITY BHAVNAGAR