



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch:

Subject Code: BE04000171

Subject Name: Kinematics and Theory of Machines

w.e.f.Academic Year:	2025-26
Semester:	4
Category of the Course:	Professional Core Course

Prerequisite:	Nil
Rationale:	The subject develops the foundation of mechanical design by understanding the basics of linkages and their relationships, and analyzing the motion i.e. kinematics in machine elements. The course blends theory, computational simulation and hands-on labs to provide strong understanding of mechanisms and motion transmissions. This is crucial for further studies in Machine Design, Dynamics of Machinery, Robotics, Mechatronics, Automotive Engineering, and CAD/CAM/CAE.

Course Outcomes:

On successful completion of the course, the student will be able to:

Sr.No.	CO statement	Marks% weightage	RBT Level
CO-1	Classify kinematic pairs, mechanisms and perform mobility analysis of various mechanisms.	22	Remember / Understand
CO-2	Perform velocity and acceleration analysis of planar mechanisms using analytical, graphical, and numerical (software) approaches.	22	Apply / Analyze
CO-3	Synthesize mechanisms for function generation with precision points.	18	Apply / Analyze
CO-4	Develop Cam profiles for different types of followers and related motion characteristics.	10	Analyze
CO-5	Develop the concepts of basic power transmission devices for the given field/industrial application.	28	Understand / Apply / Analyze

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	PBL*	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/CA (I)	PBL (I)	ESE (V)	
45	0	30	45	120	4	70	30	20	30	50	200

* Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.



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Course content:

Sr.No.	Content	Total Hrs
1	Introduction Theory of machines and branches, Concepts of Kinematics, Types of Kinematic Links, classification of Kinematic Pairs, Kinematic Chains, Mobility and constraints, Mechanisms and machines, Kinematic Diagrams, Degrees of Freedom, Kutzbach's criterion, Grubler's criterion and Grashof's Law for mechanisms. Kinematic Inversion of mechanisms, Four-bar mechanisms and inversions, Slider-Crank Chain Mechanisms and inversions, and double-slider mechanisms and inversions. Straight line motion mechanisms. Davis and Ackerman steering gear mechanisms.	10
2	Velocity & Acceleration Analysis of Mechanisms Determination of velocities and accelerations using graphical and analytical techniques Instantaneous centre method, number of instantaneous centres and properties, Graphical and analytical velocity analysis of four bar pin jointed linkages and four-bar slider crank linkages, Acceleration -tangential & normal, Graphical and analytical acceleration analysis of four-bar pin jointed linkages and four-bar slider crank linkages. Graphical velocity and acceleration analysis of Whitworth, Crank-Slotted lever quick return motion mechanisms. Coriolis component of acceleration.	10
3	Dimensional Synthesis of Mechanisms: Analytical methods Introduction to Function, Path and Motion generation, Applications. Two position synthesis, 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.	6
4	Belts and Chains Types of belt drives, Velocity ratio, Slip, Pulley arrangement, Length of belt, Law of belting, Ratio of friction tension, Power transmitted, Centrifugal effects on belts, Maximum power transmitted, Creep in belts. Chains: Chain length, Angular speed ratio, Classification of chains.	6
5	Gears & Gear Trains Fundamental law of gearing, involute and cycloid profiles, interference & undercutting, Simple gear train, Compound gear train and Epicyclic gear train and Compound Epicyclic gear train, Differential gearbox of an automobile.	6
6	Brakes and clutches: Brakes: Classification, analysis of block, band, and internal expanding shoe brakes; braking torque; condition for self-locking and self-energizing; thermal aspects. Clutches: Types – single plate, multiple plate, cone and centrifugal clutches; torque transmission capacity under uniform pressure and uniform wear; efficiency and applications.	7



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7	Cams & Followers Classification of cams and followers, Displacement diagrams – Simple Harmonic Motion, Uniform velocity and uniform acceleration, cycloidal, polynomial, Cam profile design with pressure angle and undercutting constraints.	To be taught in Lab. session
TOTAL		45

Suggested Specification table with Marks (Theory):(For B.E. only)

Distribution of Theory Marks					
RLevel	ULevel	ALevel	NLevel	ELevel	CLevel
25	25	30	10	05	05

Legend:

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

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 vary slightly from above table.

Text Book:

1. S.S. Rattan – *Theory of Machines*, McGraw Hill Education, 5th Edition, 2019.
2. R.S. Khurmi & J.K. Gupta – *Theory of Machines*, S. Chand Publishing, Revised Edition, 2018.
3. J.E. Shigley, J.J. Uicker, G.R. Pennock – *Theory of Machines and Mechanisms*, Oxford University Press, 4th Edition, 2011.
4. Thomas Bevan – *Theory of Machines*, CBS Publishers & Distributors, Reprint Edition, 2010.

Reference Books:

1. Ashok G. Ambekar – *Mechanism and Machine Theory*, PHI Learning Pvt. Ltd., 2007.
2. Ghosh, A. & Mallik, A.K. – *Theory of Mechanisms and Machines*, East-West Press Pvt. Ltd., 3rd Edition, 2009.
3. J.J. Uicker, G.R. Pennock, J.E. Shigley – *Theory of Machines and Mechanisms*, Oxford University Press, 4th Edition, 2011.
4. H. Mabie & C. Reinholtz – *Mechanisms and Dynamics of Machinery*, John Wiley & Sons, 4th Edition, 1987.
5. Robert L. Norton – *Kinematics and Dynamics of Machinery*, McGraw Hill Education, 2nd Edition, 2010.
6. Sadhu Singh – *Theory of Machines*, Pearson Education, 3rd Edition, 2019.
7. A. Erdman, G. N. Sandor, Sridhar Kota – *Mechanism Design: Analysis & Synthesis*, Prentice Hall

List of Experiments:

1. Study & demonstration of different types of mechanisms and their inversions.
2. Velocity and acceleration analysis of a four-bar mechanism using graphical & analytical method.



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3. Velocity and acceleration analysis of slider-crank mechanism using graphical & analytical method.
4. Synthesis of Four Bar Mechanism using C/C++/MATLAB/Python or any other suitable programming language.
5. Synthesis of Slider Crank Mechanism using C/C++/MATLAB/Python or any other suitable programming language.
6. Study and demonstration of Belts, Brakes and Clutches.
7. Determination of Gear train ratios for different types of gear trains.
8. Cam profile generation and follower motion analysis using analytical methods and develop a computer program using C/C++/MATLAB/Python or any other suitable programming language.
9. Mini-project: Design & 3D-print a simple mechanism or 3D CAD modelling and simulation of mechanisms.

Major Equipment:

1. Kinematic Models (four-bar, slider-crank, double-slider, cam-follower, gears, keys, couplings).
2. Gear train demonstration unit.
3. Computer systems with C/C++/MATLAB/Python, SolidWorks Motion, PyDy/Adams Student version or any other open-source software.
4. 3D printer -optional for student projects.

List of Open-Source Software/learning website:

Learning Websites:

MIT Open Course Ware (ocw.mit.edu)

NPTEL (nptel.ac.in) – *Theory of Machines, Dynamics of Machinery* courses

KMODDL (Kinematic Models for Design Digital Library, Cornell Univ.)

YouTube channels: Learn Engineering, IIT/NPTEL channels.

Sr. No.	Link / Portal	Description
1	https://www.youtube.com/watch?v=yDEJxYGAoso&list=PLbRMhDVUMngdCkMipemSKP_dCgZLLfOe8&index=1	SWAYAM NPTEL course : Kinematics of Mechanisms and Machines
2	http://www.mechanalyzer.com/downloads.html	Mech Analyzer is a free software developed to simulate and analyze the mechanisms
3	Link:1 https://www.youtube.com/watch?v=8shK6kbu7Xk Link:2 How a Radial Engine Works - Explained Part 1 Link:3 How a Radial Engine Works - Explained Part 2 - YouTube	Radial engine animation



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4	https://www.youtube.com/watch?v=yHHeicPbEzg	Simple beam engine
5	Straight line motion mechanism Peaucellier Hart Scottrussel Grasshopper Watt Tchiebicheff Robert	Straight Line Motion Mechanisms
6	Types Of Clutches How many types of clutches are there? By AutomotiveEngineHindi	Types of clutches
7	https://www.youtube.com/watch?v=Rib-_ZK8KfE	Cam profile design for inline roller follower using software
8	https://www.vlab.co.in/broad-area-mechanical-engineering	Virtual Laboratory: Ministry of Education, Govt. of India Under the National Mission on Education through ICT

Software / Tools

- MATLAB/Python or similar programming tools (kinematic equations, numeric synthesis)
- SolidWorks Motion / MSC ADAMS / OpenModelica / PyDy (for multi-body simulation) or any other open source software.
- CAD (Any open source Solid modelling software) for Cam/Gear visualization.

- **List of suggested activities for Problem Based Learning:**

1. Solve advanced mechanism problems using software tools.
2. Prepare motion simulation videos of mechanisms using CAD tool/s.
3. Develop a mini-project (a small group work) with prototype or simulation.
4. Research papers, literature review on modern applications: robotic mechanisms, compliant mechanisms, MEMS, biomechanical linkages or any other similar mechanisms.
5. Seminar/presentation on global innovations in mechanism design.
6. Online MOOCs (SWAYAM NPTEL/Coursera/edX etc.) on robotics/mechanical design as add-on.
7. Industry-aligned mini projects - Students may use 3D printing where possible for prototypes.
8. Regular computational labs: students must submit scripts (MATLAB/Python/Mathematica or any other programming tools may be used) that reproduce analytic results.
9. Hands-on experience with mechanism simulation tools (MATLAB/Python/Mathematica or any other programming language + SolidWorks Motion / Adams Lite / open-source alternatives) and performing laboratory tests.
10. For further activities, refer additional list as attached herewith.

Sr. No	Name of the Activity	No. of Hours	Evaluation Criteria
1	Visit of various relevant industries	Visit: 5h, Report preparation: 5h Total: 10h	Based on the report submitted. Report should contain observations and calculations based on Industry/ lab data.
2	Technical Video based learning related to the	Duration of video: 5h Report preparation: 5h Total: 10h	Report /presentation based on the video learning outcomes.



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3	Assignment writing Numerical based assignment is preferable.	5 assignments of 4h each. Total:20h	Based on the assignment submitted.
4	Problem solving/Coding using c, c++, Pyhon, SCILAB, MATLAB, MS- EXCEL or any other relevant software	5 small coding based assignments of 2h each. Total: 10h	Based on the coding solution submitted.
5	Self-learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment at the end of course. Based on the certificate produced.
6	Complex problem solving	Maximum 2 problems. Study of the problem and solution finding. Total: 10h/ problem	Based on the depth of the solution submitted.
7	Videos on Industrial safety/Disaster Management aspects based on subject	Duration of video: 5h Report preparation: 5h Total: 10h	Based on quiz report submitted
8	Discussion on research paper based on relevant subject	5 research papers: 20h	Summarize research paper and evaluation critical parameters
9	Poster/chart/PowerPoint preparation on technical topics	Duration:6 h	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working: 12h Non-working: 8 h	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society /environment/health/other issue	Duration: 15 h for industrial exposure Problem identification and tentative solution: 10h Total:25 h	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration: t h each	Based on performance in group discussion, technical depth, knowledge etc.
13	Real world case studies- based learning	Duration of data collection/study: 5h Report preparation: 5h Total: 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
14	Application Software development	Duration: 10 h	Depending on the complexity of the Application/Software



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15	Depending on the complexity of the Application/Software	Duration 2 hrs. For attending the lecture/session - 2 hrs. and for report writing 2 h.	Based on the proof of attendance and report submitted
16	Blog or Technical Article Writing	10h (Research - 6h, Writing - 4h)	Based on originality, technical content, references cited, and clarity of communication.
17	Annotated Video Explanation of Concept / Problem	10h (Preparation * Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
18	Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10h	Based on quiz scores and reflection report after each quiz.
19	Tech Blog/YouTube Channel Curation	10h (Content curation * Analysis)	Summary report on curated content and learning outcomes.
20	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.
21	Maintenance or Troubleshooting Logbook	10h (For example: lab instruments, computer hardware)	Based on documented cases, approach, and resolution.

Activity Note:

- All activities should be related to the subject.
- The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, the total number of hours is fixed.
- For a course, min 3 activities must be carried out as per the availability of faculties and students. There is no limit to the maximum number of activities.
- Rubrics for the evaluation can be prepared by the respective faculty members.
- Subject teachers can add the relevant activities from the above list other than those mentioned in the syllabus, with the consent of the head of the department and DQAC.

Subject coordinator shall identify activities from the above list as per the subject needs, they will also declare a list of activities wise hours, evaluation scheme and rubrics to students at the beginning of the semester.
