

THEORY OF MACHINES AND MECHANISMS

ENME 303

Lecture : 3
Tutorial : 2
Practical : 0

Year : III
Part : I

Course Objectives:

The objective of this course is to provide students with a comprehensive understanding of the concepts of kinematics and dynamics of machine, enabling them to analyze and solve problems related to motion and forces within mechanisms.

- 1 Basic Concept of Mechanism (4 hours)**
 - 1.1 Kinematic links, kinematic pairs, and kinematic chains
 - 1.2 Mechanism: Introduction and classification
 - 1.3 Inversions of mechanism
 - 1.4 Mobility
 - 1.5 Grübler's criterion, Kutzbach criterion (Including higher pair)
 - 1.6 Grashoff's law

- 2 Velocity and Acceleration in Mechanisms (6 hours)**
 - 2.1 Graphical methods
 - 2.2 Velocity analysis of planar linkages using velocity polygons
 - 2.3 Instantaneous centers of velocity
 - 2.4 Kennedy's theorem of three centers
 - 2.5 Velocity analysis of planar linkages using instantaneous centers
 - 2.6 Coriolis acceleration
 - 2.7 Acceleration analysis of planar linkages using acceleration polygons
 - 2.8 Rubbing velocity

- 3 Kinematic Synthesis of Mechanisms (6 hours)**
 - 3.1 Function, path, and motion generation
 - 3.2 Freudenstein's equation
 - 3.3 Chebyshev spacing of precision points
 - 3.4 Limit position, dead center position, and transmission angle
 - 3.5 Dimensional synthesis of planar mechanisms

- 4 Cams (4 hours)**
 - 4.1 Classification of cams and followers
 - 4.2 Terminology and definitions

- 4.3 Graphical cam layout
 - 4.3.1 Disk cam with flat-faced follower
 - 4.3.2 Disk cam with knife edge, roller - radial or offset follower
 - 4.3.3 Standardized follower displacement or lift curves (Uniform velocity, uniform acceleration and deceleration, SHM, cycloidal)

5 Spur Gears (4 hours)

- 5.1 Classification of gears
- 5.2 Terminology and definitions
- 5.3 Gear tooth profiles
- 5.4 Meshing of gear teeth
- 5.5 Interference and undercutting
- 5.6 Contact ratio
- 5.7 Center distance

6 Helical Gears, Bevel Gears, and Worm and Worm Gears (5 hours)

- 6.1 Terminology and definitions of helical gear
- 6.2 Velocity ratio and center distance of helical gears
- 6.3 Helical gear forces and efficiency
- 6.4 Terminology and definitions of bevel gears
- 6.5 Velocity ratio and pitch cones of bevel gears
- 6.6 Terminology and definitions of worm and worm gear
- 6.7 Velocity ratio and center distance of worm and worm gear
- 6.8 Efficiency of worm gears

7 Gear Trains (4 hours)

- 7.1 Classification of gear trains
- 7.2 Speed ratio of gear trains
- 7.3 Analysis of epicyclic gear trains: Formula and tabular methods
- 7.4 Torques in epicyclic gear trains
- 7.5 All-wheel drive train

8 Graphical Method of Force Analysis (4 hours)

- 8.1 Inertia force and inertia couple
- 8.2 Line of action of inertia force in a link
- 8.3 Superposition methods for force analysis
- 8.4 Force analysis of a four-bar mechanism
- 8.5 Force analysis of slider-crank mechanism

9 Balancing (4 hours)

- 9.1 Static and dynamic balancing

- 9.2 Balancing of several masses revolving in the same plane
- 9.3 Balancing of several masses revolving in different planes
- 9.4 Balancing of reciprocating mass

10 Gyroscopic Couples, Flywheel, and Governors (4 hours)

- 10.1 Gyroscopic couples: Effect and application
- 10.2 Flywheel: Application, turning moment, and energy storage
- 10.3 Governors: Terms, types, characteristics

Tutorial (30 hours)

1. Mobility of kinematic chain/mechanisms, Grashoff's law, determining all inversions of kinematic chain/mechanisms
2. Velocity and acceleration diagrams of linkages in planar mechanisms; four-bar mechanisms, slider-crank mechanisms, and a combination of four-bar and slider-crank mechanisms
3. Dimensional synthesis of planar mechanisms; Four-bar mechanisms and slider-crank mechanisms
4. Cam profiles for standard motions (Harmonic motion, uniform velocity, uniform acceleration and retardation, and cycloidal) of radial/offset followers with knife-edge/roller/flat contact points
5. Various gear terms, interference, contact ratio, and center distance for spur gear meshing
6. Speed ratio, number of teeth, and torque in epicyclic gear trains
7. Inertia force and torque in four-bar linkages and reciprocating engine parts
8. Balancing multiple masses rotating in the same or different planes and reciprocating masses

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	4	6
2	6	8
3	6	8
4	4	6
5	4	6
6	5	4
7	4	6
8	4	6
9	4	6
10	4	4
Total	45	60

* There may be minor deviation in marks distribution.

References

1. Uicker, J. J., Pennock, G. R., Shigley, J. E. (2016). Theory of machines and mechanisms (5th ed.). Oxford University Press.
2. Ghosh, A., Mallik, A. K. (2020). Theory of mechanisms and machines (3rd ed.). East West Press Pvt. Ltd.
3. Bevan, T. (2009). Theory of machines. Pearson Education India.
4. Wilson, C. E., Sadler, J. P. (2013). Kinematics and dynamics of machinery. Pearson Education Limited.
5. Khurmi, R. S., Gupta, J. K. (2015). Theory of machines. S. Chand Publishing.
6. Paul, B. (1979). Kinematics and dynamics of planar machinery (Latest Edition). Prentice Hall.
7. Wilson, C. E., Sadler, J. P., Michels, W. J. (1983). Kinematics and dynamics of machinery (Latest Edition). Harper & Row.
8. Mabie, H. H., Reinholtz, C. F. (1991). Mechanisms and dynamics of machinery (Latest Edition). Wiley.
9. Shigley, J. E., Uicker, J. J. (2003). Theory of machines and mechanisms. McGraw-Hill.
10. Rao, J. S., Dukkupati, R. V. (2008). Mechanism and machine theory. Wiley Eastern Ltd.
11. Rattan, S. S. (2015). Theory of machines. Tata McGraw-Hill Education Pvt. Ltd.