THEORY OF MACHINES AND MECHANISMS

ENME 256

Lecture : 3 **Year : II**
Tutorial : 2 **Part : II**
Practical : 0

Course Objectives:
The objective of this course is to provide theoretical knowledge on various mechanisms used in machines and devices and to conduct comprehensive analyses of machines and mechanisms, including linkages, gears, gear trains, cams, and followers, along with their dynamic and vibratory responses.

1 Introduction (6 hours)

1.1 Basic definitions and descriptions
1.2 Kinematic links, kinematic pairs and kinematic chain
1.3 Mobility/degree of freedom: Grubler and Kutzbach criterion
1.4 Mechanism types and inversions
1.5 Position analysis of the four-bar mechanism: Grashoff's law and loop closure equations
1.6 Synthesis concepts

2 Kinematic Analysis of Mechanisms (6 hours)

2.1 Absolute and relative motion velocity analysis: Velocity polygons, graphical or vector algebra solutions
2.2 Instantaneous centers of velocity and Aronhold-Kennedy theorem
2.3 Velocities by instantaneous centers
2.4 Relative motion acceleration analysis; Acceleration polygons; Graphical or vector algebra solutions; Coriolis acceleration applications
2.5 Kinematic analysis by complex number method

3 Kinetic Analysis of Mechanisms (6 hours)

3.1 Introduction to methods of force analysis of mechanisms
3.2 Superposition force analysis methods of mechanisms: Graphical or analytical method
3.3 Linkage force analysis by matrix methods, virtual work method, complex number method
3.4 Analytical and graphical method for velocity and acceleration of the piston and the connecting rod in an engine

4 Cams and Followers (5 hours)

4.1 Classification of cams and nomenclature and graphical cam layout
4.2 Disc cam with knife edge, roller and flat-faced follower
4.3 Disc cam with radial or offset follower and oscillating follower
4.4 Standardized follower displacement, velocity and acceleration diagram for uniform, accelerated and retarded, simple harmonic and cycloidal motion
4.5 Analytical design of disc cam
4.6 Force analysis on cams and followers

5 Gear and Gear Train (8 hours)

5.1 Introduction to spur, bevel, helical, spiral and worm gear
5.2 Geometry and characteristics of gear tooth: Involute and cycloidal tooth
5.3 Interference, undercutting and backlash of involute gear
5.4 Non-standard spur gears representing extended center distance system
5.5 Introduction and classification of gear train
5.6 Planetary gear and differential gear
5.7 Formula and tabular method for speed ratio for spur and bevel gears
5.8 Forces on spur gear teeth

6 Gyroscopic Effect, Flywheel and Governors (4 hours)

6.1 Gyroscopic couples and its application
6.2 Stability of a two wheel and four wheel vehicles
6.3 Turning moment diagram and flywheel sizing
6.4 Governors: Types, functions and characteristics

7 Dynamic Balancing (4 hours)

7.1 Balancing of rotating mass
7.2 Balancing of reciprocating mass
7.3 Balancing of multi-cylinder engine, in-line, v-type, opposed and radial configuration and balancing of four bar linkage
7.4 Types of balancing machine

8 Mechanical Vibration (6 hours)

8.1 Free and forced vibrations
8.2 Element of vibrating systems and vibration absorbers
8.3 Vibration of single degree of freedom: Undammed, damped and forced
8.4 Vibration of two degree of freedom: Undammed, damped and forced
8.5 Vibration of continuous system: Lateral vibration in beam and string, longitudinal vibration in road, torsional oscillation in circular shaft

Tutorial (30 hours)

1. Mobility of kinematic chain/mechanisms, Grashof's law
2. Velocity and acceleration of linkages in planar mechanisms

3. Inertia force and torque in planar mechanisms
4. Displacement diagram and cam profile generation
5. Interference, contact ratio and center distance for spur gears and speed ratio and torque in epicyclic gear trains
6. Gyroscopic couple, turning moment on flywheel and speed in governors
7. Balancing of Rotating mass, Reciprocating mass and engines
8. Natural frequency, damping ratio, mode shapes, and response amplitude in un-damped and damped vibration under free and forced condition

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	6	6
2	6	9
3	6	9
4	5	9
5	8	9
6	4	3
7	4	6
8	6	9
Total	**45**	**60**

* There may be minor deviation in marks distribution.

Reference

1. Shigley, J.E., Uicker, J.J., Jr. (2023). Theory of machines and mechanisms. McGraw Hill.
2. Rao, J.S., Dukkipati, R.V. (2007). Mechanisms and machine theory. John Wiley & Sons.
3. Mabie, H.H., Reinholtz, C.F. (1987). Mechanism and dynamics of machinery. Wiley.
4. Khurmi, R.S. (2005). Theory of machines. S. Chand & Co. Ltd.
5. Singh, V.P. (2017). Theory of machines. Dhanpat Rai & Co. (P) Ltd.
6. Paul, B. (1979). Kinematics and dynamics of planar machinery. Prentice Hall.
7. Wilson, C.E., Sadler, J.P., Michels, W.J. (1960). Kinematics and dynamics of machinery. Harper Row.
8. Luintel, M.C. (2024). Textbook of Mechanical Vibrations (1st ed.). Springer Singapore.
9. Thomson, W.T., Dahleh, M.D. (1997). Theory of Vibration with Applications (5th ed.). Prentice Hall.
10. Rao, S.S. (1990). Mechanical Vibrations (2nd ed.). Addison-Wesley.