# Theory of Machines

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**Course Objectives:**

- Introduce various basic mechanisms and their applications.
- Explain importance of degree of freedom.
- Familiarize velocity and acceleration in mechanisms.
- Describe the cams and follower motions.
- Explain the importance of gyroscopic couples.
- Introduce the equation of motion for single degree of freedom system.

**UNIT I:** **10 Hours**

**Simple Mechanisms:**

Classification of mechanisms – Basic kinematic concepts and definitions – Degree of freedom, mobility – Grashof's law, kinematic inversions of four bar chain and slider crank chains- Limit positions – Mechanical advantage- Transmission angle- Description of some common mechanisms- Quick return mechanism, straight line mechanisms – UniversalJoint – Rocker mechanisms.

**Learning outcomes:**

After completion of this unit, students will be able to

- Contrast the difference between machine and structure. (L2)
- Identify different types of kinematic pairs, kinematic chains. (L3)
- Find degrees of freedom for different mechanisms. (L1)
- Identify the inversions of four bar mechanism. (L3)
- Explain the difference between Davis and Ackerman steering gear mechanisms. (L2)

**UNIT II:** **12 Hours**

**Plane and motion analysis:**

Displacement, velocity and acceleration analysis of simple mechanisms, graphical velocity analysis using instantaneous centers, velocity and acceleration analysis using loop closure equations – kinematicanalysis of simple mechanisms – slidercrank mechanism dynamics – Coincidentpoints – Corioliscomponent of acceleration.

**Learning outcomes:**

After completion of this unit, students will be able to

- Calculate the velocities and acceleration of various links in a mechanism. (L4)
- Determine instantaneous centers for a given mechanism. (L4)

**UNIT III:** **10 Hours**

**Gyroscope:**

Principle of gyroscope, gyroscopic effect in an aeroplane, ship, car and two wheeler, simple problems

**Gear Profile:**

Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference/undercutting – helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics.

**Learning outcomes:**

After completion of this unit, students will be able to

- Explain the concept of gyroscopic couple. (L2)
- Analyze the effects of gyroscopic couple on an aeroplane, ship and road vehicles. (L4)
- Explain the different gear profiles and parameters. (L2)
- Identifydifferent types of gears and application. (L3)

**UNIT IV:** **12 Hours**

**Balancing of Rotating masses:**

Need for balancing, balancing of single mass and several masses in different planes, using analytical and graphical methods.

**Cams:**

Classification of cams and followers- Terminology and definitions – Displacementdiagrams – Uniformvelocity, parabolic, simple harmonic and cycloidal motions – derivativesof follower motions- specified contour cams- circular and tangent cams –pressureangle and undercutting.

**Learning outcomes:**

After completion of this unit, students will be able to

- Explain the importance of balancing. (L2)
- Analyze balancing problems in rotating engines. (L4)
- Explain the working of cams and followers. (L2)
- Analyze the different motions in cam and followers. (L4)

**UNIT V:** **12 Hours**

**Vibrations:**

Introduction, degree of freedom, types of vibrations, free natural vibrations, Newton method and energy method for single degree of freedom. Damped vibrations- under damped, critically damped; and over

damped systems, forced vibrations with and without damping in single degree of freedom; Vibration isolation and transmissibility.

**Turning Moment Diagrams and Flywheels:** Turning moment diagrams for steam engine, I.C engine and Multi Cylinder Engine. Crank effort – coefficient of fluctuation of energy, coefficient of fluctuation of speed – Fly Wheel and their design, fly wheels for punching press.

**Learning outcomes:**

After completion of this unit, students will be able to

- Formulate equations of motion and solve for single degree of freedom system with damping. (L6)
- Estimate natural frequency of vibratory systems. (L5)
- Explain concept of vibration isolation and transmissibility. (L2)

**Text Book(s)**

1. S.S.Rattan, Theory of Machines, 4/e, Tata Mc-Graw Hill, 2014.
2. P.L.Ballaney, Theory of Machines & Mechanisms, 25/e, Khanna Publishers, Delhi, 2003.

**References**

1. F. Haidery, Dynamics of Machines, 5/e, NiraliPrakashan, Pune, 2003.
2. J.E.Shigley, Theory of Machines and Mechanisms, 4/e, Oxford, 2014.
3. G.K.Groover, Mechanical Vibrations, 8/e, Nemchand Bros, 2009.
4. Norton, R.L., Design of Machinery – An Introduction to Synthesis and Analysis of Mechanisms and Machines, 2/e, McGraw Hill, New York, 2000.
5. William T. Thomson, Theory of vibration with applications, 4/e, Englewood Cliffs, N.J.: Prentice Hall, 1993.

**Course Outcomes:**

At the end of the course the students will be able to

- Understand different mechanisms and their inversions. (L2)
- Calculate velocity and acceleration of different links in a mechanism. (L4)
- Apply the effects of gyroscopic couple in ships, aero planes and road vehicles. (L3)
- Evaluate unbalance mass in rotating machines. (L5)
- Analyze free and forced vibrations of single degree freedom systems. (L4)