Applied Mechanics
EG 2102 CE

Year: I **Total: 6 hours /week**
Semester: II **Lecture: 3 hours/week**
Tutorial: 2 hours/week
Practical: hours/week
Lab: 2/2 hours/week

Course Description:
This course focuses on analysis and effect of various types of forces on the particle and rigid body at rest. The course familiarizes with the frictional phenomenon on engineering problems. It includes the evaluation of properties of plane bodies as center of gravity and moment of inertia. The course focuses on the analysis of internal forces/stresses in beams and trusses.

Course Objectives:
After the completion of this course, students will be able to:
1. Understand the basic laws of motion, vector and its laws, concept of particle and rigid body and application of equations of static equilibrium;
2. Describe the different types of forces that may act on the body, resolve the forces; determine resultant of a given force system;
3. Understand the laws of friction forces, be familiar with the frictional force on the body and analysis of typical problems;
4. Be familiar with the distributed forces (Centre of gravity, Centroid, Moment of Inertia) and be able to determine CG and MI for simple plane and solid figures;
5. Be familiar with structures (beam and truss), support systems, loading systems, be able to evaluate the reactions and forces in the truss members;

Course Contents:

Theory

Unit 1: Introduction: Forces Acting on Particle and Rigid Body [6 Hrs.]

1.1 Definition of Mechanics and scope of Applied Mechanics
1.2 Concept of Particle, Rigid Body, Deformable Body
1.3 Review of vectors and its laws;
1.4 Definition of a force, units, representation by a vector and by Bow's notation, Characteristics of a Force and its Effects,
1.5 Classification of Forces Based to Plane and Line of Action: Internal, External, Translational, Rotational, Coplanar, Non-Coplanar, Concurrent, Non-Concurrent, Like Parallel and Unlike Parallel Forces.
1.6 Resolution and Composition of Forces: Methods of resolution, Perpendicular Components and Non-Perpendicular Components,
1.7 Principle of Transmissibility of Forces
1.8 Resolution of a Force in to a Force and a Couple
1.9 Moment of a Force: Definition, Measurement of Moment of a Force, Units, Geometrical Interpretation of Moment, Classification of Moments According to Direction of Rotation, Sign Convention, Law of Moments, Varignon's Theorem of Moment and its Application,
1.10 Couple: Definition, Units, Measurement of a Couple, Properties of Couple, its use.

Unit 2: Equilibrium of Forces: [8 Hrs.]

2.1 Conditions of Equilibrium for a Particle and Rigid Body;
2.2 Analytical and Graphical Conditions of Equilibrium for Concurrent, Non-Concurrent and Parallel Force System;
2.3 Free Body Diagrams, Construction of Free Body Diagrams
2.4 Equations of Static Equilibrium: Two and Three Dimensional analysis of Particle, Two Dimensional analysis of Rigid Body
2.5 State and Prove: Triangle Law of Forces, Parallelogram law of Forces
2.6 Polygon Law of Forces and Lami's Theorem, Application of Lami's Theorem to Solve Various Problems.
2.7 Equivalent Forces: Definition of Equilibrant, Differentiate Resultant and Equilibrant,
Equilibrant of Concurrent and Non-Concurrent force System.
2.8 Resultant and Equilibrium of Moments and Couples

Unit 3: Friction: [5 Hrs.]

3.1 Friction: Definition, Causes, Advantages, Disadvantages, Types, and Force of Friction.
3.2 Laws of Friction: Static and Dynamic Friction and Their Coefficients
3.3 Different status (No Friction, Certain Friction, Impending Motion and Motion)
3.4 Sliding and Tipping Condition of the Body
3.5 Angle of Friction and its Meaning, Angle of Repose, Relation between Angle of Friction Angle of Repose and Coefficient of Friction.
3.6 Equilibrium of Bodies on Level Plane; Equilibrium of Bodies on Inclined Plane:
3.7 External Forces Parallel to the Plane, External Forces in Inclined Plane.

Unit 4: Centre of Gravity (CG) and Centroid: [5 Hrs.]

4.1 Concept of Centre of Gravity, Center of Mass, Centroid (Plane Figures), Axis of Symmetry,
4.2 Centroid of Composite lines (straight line, arc, semicircle and quarter circle)
4.3 Centroid of Composite Figures (Rectangle, Triangle, Circle/Semi-circle/Quarter circle /Circular sector, Parabola/Semi-parabola and Ellipse)
4.4 Centroid of Area under curve by the method of Integration
4.5 Centroid of Built-up Plane Figures
4.6 Center of Gravity of Simple Solids: Cylinder, Sphere, Hemisphere, Cube, Cone and Rectangular Block (Ready to use formulae).

Unit 5: Moment of Inertia (MoI): [7 Hrs.]

5.1 Concept of Moment of Inertia, First Moment and Second Moment of Area
5.2 Axial and Polar Moment of Inertia
5.3 Moment of Inertia of Regular Areas (Rectangle, Triangle, Circle and Ellipse) about their Centroidal axes
5.4 Perpendicular and Parallel axis Theorems for Moment of Inertia
5.5 Moment of Inertia of Composite Area
5.6 Radius of Gyration
5.7 Application of Moment of Inertia in Engineering Problems
5.8 Concept of Principal Moment of Inertia and Application in Engineering Problems.
5.9 MoI of L, T, I- and channel sections. Section modulus

Unit 6: Analysis of Statically Determinate Beams: [3 Hrs.]

6.1 Definition of Structure and Mechanism
6.2 Plane and Space Structures
6.3 Determinacy and Stability (Static and Geometric) of the Structures. Degree of freedom.
6.4 Different types of Load and Support in the Structures
6.5 Definition and Types of Beam
6.6 Calculation of Support Reactions: Examples on Beams, Trusses, Links and Beams with Internal Hinge

Unit 7: Axial Force, Shear Force and Bending Moments [6 Hrs.]

7.1 External and internal forces (Axial Force, Shear Force, and Bending Moment) in the Structural Members: Definition of Axial Force (AF), Shear Force (SF) and Bending Moment (BM), Sign Convention and Calculations and Plotting.
7.2 Concept of Superposition of AF, SF and BM in Beams.
7.3 Relationship between Load, Shear Force and Bending Moment
7.4 Calculations of AF, SF and BM and Draw Corresponding Diagrams for Cantilever, Simply Supported and Overhanging Beams Subjected to Uniformly Distributed Load (UDL), Concentrated and Uniformly Varying Load (UVL).

Unit 8: Analysis of Statically Determinate Plane Truss [5 Hrs.]

8.1 Concept and definition of Trusses, Joints Formation and Load Transfer Mechanisms in the Truss. Classification: Prefect, imperfect, redundant and deficient, relation between members and joints, assumption in the analysis.
8.2 Types of Truss Based on Their Uses
8.3 Calculation of Member Force by the Method of Joints: Examples with Merits and Demerits.
8.4 Calculation of Member Force by the Method of Sections: Examples with Merits and Demerits.

Tutorials: [30 Hrs]

Assist students for conceptual & critical problem solving

1. Problems on vectors addition, subtraction, multiplication, projection of vectors and components
2. Problems on characteristics of force and their effects on rigid bodies
3. Resolution of forces into different components
4. Simple problems on transmissibility of forces
5. Problems on parallel forces, couples and moments
6. Equilibrium of forces: Problems related to triangle law of forces, parallelogram law of forces polygon law of forces and Lami's theorem. Equilibrium of concurrent, non-concurrent and parallel force system. Resultant and equilibrant force. Moments, couples, resultant of parallel forces and moments.
7. Problems related to equilibrium of bodies on level plane; equilibrium of bodies on inclined planes considering frictional forces and external forces parallel to the plane, inclined to the plane.
8. Problems related to CG composite lines: straight line, arc, semicircle and quarter circle. CG of composite figures: Rectangle, triangle, circle/semi-circle/quarter circle/circular sector, parabola/semi-parabola and ellipse. CG of Area under curve by the method of integration.

9. Problems related to MoI of regular areas: Rectangle, triangle, circle/semi-circle/quarter/circle and ellipse. Perpendicular and parallel axis theorems. MoI of simple composite areas.
10. Problems on reactions of beams, trusses, links in beams, beams with internal hinge, portal frame.
11. Problems on calculations of AF, SF, BM and plotting for cantilever, simply supported, overhanging beams subjected to UDL, Concentrated and UVL.
12. Problems related to calculation of member force by the method of joints in simple trusses. Determination of member force by the method of sections for simple trusses.

Practical (Laboratory) [15 Hrs]

1. Verify Triangle law of forces, Parallelogram law of forces and Lami's theorem
2. Verify Principle of Moments
3. Determine Centroid of Plane Figures (Rectangle, Triangles, Circle and Ellipse, L-Section, I-Section)
4. Determine Moment of Inertia by Flywheel
5. Determine Support Reactions of Simply Supported and Cantilever Beam with different types of Loading
6. Determine Support Reactions and Member Force of Simply supported Truss
7. Determine shear force at different sections on a simply supported beam under points loads
8. Determine bending moment at different sections on a simply supported beam under different types of loading.

Textbooks:

1. R. S. Khurmi, "*Applied Mechanics and Strength of Materials"*, Nirja Construction and Development Pvt. Ltd., Ram Nagar, New Delhi
2. F. P. Beer & E. R Johnston Jr, "*Vector Mechanics for Engineers - Statics*", McGraw-Hill
3. I. H. Shames, "*Engineering Mechanics - Statics and Dynamics*", New Delhi, Prentice Hall of India
4. R. C. Hibbeler, "*Engineering Mechanics*", McMilan Publishing Company, New York

References:

1. M. R. Dhital, "*A Course Manual on Applied Mechanics I (Statics)",* IOE, Pulchowk Campus
2. R. Suwal, "*A Text Book of Applied Mechanics"*, R & R Engineering Consultancy Pvt. Ltd

Evaluation Scheme

Unit	Chapters	Hours	Marks
1	Introduction: Forces Acting on Particle and Rigid Body	6	12
2	Equilibrium of Forces	8	16
3	Friction	5	8
4	Centre of Gravity (CG) and Centroid	5	8
5	Moment of Inertia (MoI)	7	12
6	Analysis of Statically Determinate Beams	3	4
7	Axial Force, Shear Force and Bending Moments	6	12
8	Analysis of Statically Determinate Plane Truss	5	8
Total		**45**	**80**