BT-204 Basic Civil Engineering & Engineering Mechanics
Unit–4 Notes Forces and Equilibrium

UNIT–4 TOPICS

- Forces and Equilibrium
- Concurrent and Non-Concurrent Coplanar Forces
- Graphical and Analytical Treatment of Forces
- Free Body Diagram (FBD)
- Force Diagram and Bow's Notation
- Plane Trusses
- Method of Joints
- Method of Sections
- Frictional Force in Equilibrium Problems

1. INTRODUCTION TO FORCE

Force is push or pull acting on body which changes or tends to change state of rest or motion.

Characteristics of Force:
- Magnitude
- Direction
- Point of application
- Line of action

Units of Force:
Newton (N)

2. TYPES OF FORCES

(a) Concurrent Forces
Forces whose lines of action meet at one point.

(b) Non-Concurrent Forces
Forces whose lines of action do not meet at one point.

(c) Coplanar Forces
Forces acting in same plane.

(d) Non-Coplanar Forces
Forces acting in different planes.

3. EQUILIBRIUM OF FORCES

A body is said to be in equilibrium when resultant of all forces acting on it is zero.

Conditions of Equilibrium:

$\sum Fx = 0$
$\sum Fy = 0$
$\sum M = 0$

Where:
Fx = Horizontal forces
Fy = Vertical forces
M = Moment

4. GRAPHICAL TREATMENT OF FORCES

Graphical method uses vector diagrams for force analysis.

Methods:
• Triangle law of forces
• Polygon law of forces
• Parallelogram law of forces

Advantages:
• Simple method
• Useful for approximate solutions

5. ANALYTICAL TREATMENT OF FORCES

Analytical method uses algebraic equations for force analysis.

Steps:
1. Resolve forces into components.
2. Apply equilibrium equations.
3. Solve unknown forces.

6. FREE BODY DIAGRAM (FBD)

Free body diagram is sketch showing all external forces acting on isolated body.

Importance of FBD:
• Simplifies force analysis
• Helps in solving equilibrium problems

7. FORCE DIAGRAM AND BOW'S NOTATION

Force Diagram:
Graphical representation of forces acting on body.

Bow's Notation:
Method of naming spaces between forces using capital letters.

Applications:
• Truss analysis
• Graphical statics

8. PLANE TRUSSES

Truss is structure made of connected members forming triangular units.

Assumptions in Truss Analysis:
• Members are pin jointed.
• Loads act only at joints.
• Members carry axial forces only.

Types of Trusses:
• Simple truss
• Compound truss
• Complex truss

Applications:
• Bridges
• Roof structures
• Towers

9. METHOD OF JOINTS

Method of joints is analytical method used to determine forces in truss members.

Procedure:
1. Find support reactions.
2. Apply equilibrium equations at each joint.
3. Solve member forces.

Advantages:
• Simple method
• Accurate results

10. METHOD OF SECTIONS

Method of sections is used to determine forces in selected truss members directly.

Procedure:
1. Cut truss section.
2. Apply equilibrium equations.
3. Solve unknown member forces.

Advantages:
• Faster than method of joints for selected members.

11. FRICTIONAL FORCE

Friction is resisting force acting between two surfaces in contact.

Types of Friction:
• Static friction
• Kinetic friction

Laws of Friction:
• Friction acts opposite to motion.
• Friction is proportional to normal reaction.

Coefficient of Friction:

$\mu = F / N$

Where:
μ = coefficient of friction
F = friction force
N = normal reaction

Applications of Friction:
• Brakes
• Clutches
• Belt drives

MOST IMPORTANT 14 MARK QUESTIONS

1. Explain concurrent and non-concurrent coplanar forces.

2. Explain graphical treatment of forces with laws of forces.

3. Explain analytical treatment of forces with equilibrium equations.

4. Explain free body diagram with examples.

5. Explain force diagram and Bow’s notation.

6. Explain equilibrium conditions of forces.

7. Explain plane trusses and assumptions used in truss analysis.

8. Explain method of joints with suitable example.

9. Explain method of sections with suitable example.

10. Explain frictional force and laws of friction.

11. Solve equilibrium problems involving frictional forces.

12. Differentiate method of joints and method of sections.

IMPORTANT 7 MARK QUESTIONS

1. Define force and equilibrium.

2. Explain coplanar forces.

3. Explain free body diagram.

4. Explain Bow's notation.

5. Explain simple truss.

6. Explain coefficient of friction.

7. Explain static and kinetic friction.

8. Explain graphical methods of force analysis.

IMPORTANT NUMERICALS

1. Equilibrium numerical problems.

2. Resultant force calculations.

3. Truss analysis by method of joints.

4. Truss analysis by method of sections.

5. Friction numerical problems.

EXAM TIPS

- Practice free body diagrams regularly.
- Learn equilibrium equations properly.
- Practice truss numerical problems daily.
- Revise Bow's notation carefully.
- Focus on friction formulas and applications.