Chapter 02: Generalities and Basic Definitions

1. Introduction

A good understanding of the forces acting on a mechanical system is essential for solving problems in statics, kinematics, and dynamics. This chapter covers the definition, representation, composition, and classification of forces.

2. Definition and Representation of a Force

A force represents the interaction between two bodies (contact or long-range). It is represented by a vector with:
- Direction
- Sense
- Magnitude (in Newtons)
- Point of application

Example: The weight of a body is a vertical force directed downward with magnitude $P = m \times g$.
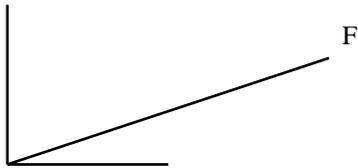
3. Composition and Decomposition of a Force

→ Composition: Several forces F1, F2, …, Fn acting on a body can be replaced by a single resultant force:
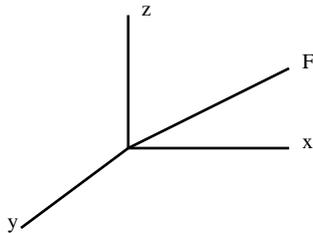$F = F1 + F2 + … + Fn$.

→ Decomposition: A force F can be resolved into components F1 and F2 such that $F = F1 + F2$.

Example: In a 3D Cartesian system: $F = F_x\, i + F_y\, j + F_z\, k$, with $F_x = F \sin\theta \cos\phi$, $F_y = F \sin\theta \sin\phi$, $F_z = F \cos\theta$.
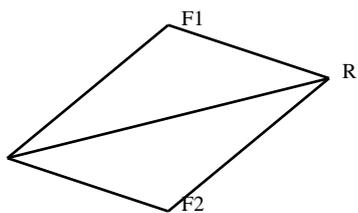
4. Direction Cosines of a Force

The force F makes angles α, β, γ with the axes x, y, z. Direction cosines are defined as:
$\cos\alpha = F_x / |F|$, $\cos\beta = F_y / |F|$, $\cos\gamma = F_z / |F|$, with $\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$.

5. Systems of Forces in Space

Systems of forces are categorized as:
- Concurrent: all lines of action intersect at a single point.
- Parallel: all lines of action are parallel.
- Non-concurrent and non-parallel: forces neither meet at a point nor are parallel.
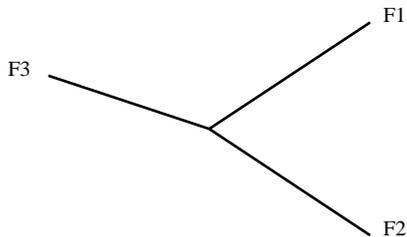
6. Classification of Forces According to Their Origin

Forces can be internal or external.

$\rightarrow$ Internal forces: act between different parts of a structure (tension, compression, torsion, shear).
$\rightarrow$ External forces: act from outside (e.g., gravity, always directed downward).

Depending on their nature, forces can also be point, line, surface, or volume forces.