Chapter 3: Laws of Motion

Force and Its Types

What is Force?

- A physical cause that can change (or tends to change) the size, shape, or the state of rest/motion of a body.

Types of Forces

1. Contact Forces

- **Frictional Force**: Opposes motion between two surfaces in contact.
- **Normal Reaction Force**: Upward force exerted by a surface to support the weight of an object.
- **Tension Force**: Force transmitted through a stretched string or rope.
- **Restoring Force**: Spring's tendency to return to its original shape.
- **Collision Force**: Equal and opposite forces during impact between bodies.

2. Non-Contact Forces

- **Gravitational Force**: Attractive force between any two masses.
- **Electrostatic Force**: Force between charged particles.
- **Magnetic Force**: Force between magnetic poles.

General Nature of Non-Contact Forces:

1. Gravitational force is always attractive.
2. Electrostatic and magnetic forces can be attractive or repulsive.
3. Magnitude $\propto 1 / (\text{distance})^2$.

Newton's Laws of Motion

First Law (Law of Inertia)

- A body remains at rest or in uniform motion unless acted upon by an external force.
- **Inertia**: Resistance to change in state.
- **Mass is a measure of inertia.**

Types of Inertia:

- **Inertia of Rest**: Tendency to stay at rest.
- **Inertia of Motion**: Tendency to stay in motion.

Second Law

- Force ∝ mass × acceleration → **F = ma**
- **Momentum (p)** = mass × velocity → **p = mv**
- **Force** = Rate of change of momentum → **F = Δp/Δt**
- **SI Unit of Force**: Newton (N)
  1 N = 1 kg × 1 m/s²

Examples: Catching a ball, landing on sand, glass falling on carpet vs floor.

Third Law

- For every action, there is an equal and opposite reaction.
- **Action and reaction** act on **different bodies**.

Examples: Book on a table, pushing a wall, firing a bullet.

Universal Law of Gravitation

- Every object attracts every other object:

$$\mathbf{F} = \frac{GMm}{r^2}$$

- **G** = 6.67 × 10^{-11} Nm²/kg² (Universal Gravitational Constant)
- **G** is independent of the medium, mass, or distance.

Force and Acceleration Due to Gravity

Force due to Gravity:

- For mass **m**:
- $$F = \frac{GMm}{r^2} = mg$$

  → Earth attracts 1 kg with **9.8 N**.

Acceleration due to Gravity (g):

$$g = \frac{GM}{R^2} = 9.8\ m/s^2$$

- Same for all bodies.
- Vector quantity directed downward.

Free Fall and Motion Under Gravity

If u = 0 (freely falling body):

- $v = gt$
- $s = \frac{1}{2} gt^2$
- $v^2 = 2gs$

If thrown upward:

- $v = u - gt$
- $s = ut - \frac{1}{2} gt^2$
- $v^2 = u^2 - 2gs$

Mass vs Weight

Mass	Weight
Amount of matter in a body	Force with which Earth attracts it
SI unit: kg	SI unit: Newton (N)
Scalar	Vector
Constant everywhere	Varies with location (due to g)

Gravitational Units of Force

- **1 kilogram-force (kgf)** = 9.8 N
- **1 gram-force (gf)** = 980 dyne
