

Gravitation

Introduction

Gravitation is the force of attraction between any two objects in the universe. It is responsible for keeping planets in their orbits, causing objects to fall towards the Earth, and holding the atmosphere around our planet. In this chapter, we study Newton's Law of Gravitation, gravity, mass, weight, thrust, pressure, buoyancy, and Archimedes' Principle.

Universal Law of Gravitation

Newton's Law of Gravitation

Sir Isaac Newton stated that every object in the universe attracts every other object with a force called **gravitational force**.

The gravitational force:

- Is directly proportional to the product of the masses of the two objects.
- Is inversely proportional to the square of the distance between them.

Formula:

$$F = G (m_1 m_2 / r^2)$$

Where:

- **F** = Gravitational force
 - **G** = Universal gravitational constant
 - **m₁, m₂** = Masses of the objects
 - **r** = Distance between their centres
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Gravity

Force of Attraction by the Earth

Gravity is the force with which the Earth attracts objects towards its centre.

The acceleration produced due to gravity is represented by **g**.

Value of $g = 9.8 \text{ m/s}^2$

Gravity keeps us on the Earth's surface and causes objects to fall when dropped.

Mass and Weight

Difference Between Mass and Weight

Mass is the amount of matter present in an object.

- SI Unit: **Kilogram (kg)**
- Mass remains constant everywhere.

Weight is the force with which the Earth attracts an object.

Formula:

$$\text{Weight} = \text{Mass} \times g$$

$$W = mg$$

- SI Unit: **Newton (N)**
 - Weight changes from place to place depending on gravity.
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Free Fall

Meaning

When an object falls towards the Earth under the influence of gravity alone, it is said to be in **free fall**.

During free fall:

- The object accelerates at **9.8 m/s^2** .
 - Air resistance is neglected.
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Thrust and Pressure

Definitions

Thrust is the force acting **perpendicular** to a surface.

Pressure is the thrust acting on **unit area**.

Formula:

Pressure = Force / Area

SI Unit: Pascal (Pa)

Pressure increases when the area decreases and vice versa.

Buoyancy

Upward Force

When an object is placed in a liquid or gas, it experiences an **upward force** called **buoyant force** or **upthrust**.

Buoyancy depends on:

- Density of the fluid.
- Volume of the displaced fluid.

This is why some objects float while others sink.

Archimedes' Principle

Principle

Archimedes' Principle states:

"A body immersed partially or completely in a fluid experiences an upward force equal to the weight of the fluid displaced by it."

Applications:

- Ships and boats float on water.
- Submarines move underwater.

- Hydrometers measure the density of liquids.
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Relative Density

Definition

Relative density is the ratio of the density of a substance to the density of water at 4°C.

It has **no unit** because it is a ratio.

Key Points

- Gravitation is the force of attraction between two masses.
 - Gravity is the Earth's pull on objects.
 - Mass remains constant, but weight depends on gravity.
 - **$g = 9.8 \text{ m/s}^2$** on Earth.
 - Pressure = Force $\div$ Area.
 - Buoyant force acts upward in fluids.
 - Archimedes' Principle explains floating and sinking.
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Chapter Summary

Gravitation is a universal force that governs the motion of celestial bodies and objects on Earth. This chapter explains Newton's Law of Gravitation, gravity, mass, weight, free fall, pressure, buoyancy, and Archimedes' Principle. These concepts help us understand many natural phenomena and their applications in everyday life.