11. Gravitation

Gravity: The gravitational force due to earth is called gravity.

Newton's law of gravitation: In this universe all things attract each other. The force of attraction acting between two bodes of masses m_1 and m_2 separated by a distance r is directly proportional to product of their masses and inversely proportional to square of the separation between them.

i.e. $F \propto \dfrac{m_1 m_2}{r^2}$

$$F = \dfrac{G m_1 m_2}{r^2}$$

Here G is proportionality constant is called Gravitation constant i.e. $G = 6.67 \times 10^{-11}$ $Nm^2 \times kg^{-2}$

Relation between g (Acceleration due to gravity) and G (gravitation constant)

$$F = \dfrac{GMm}{r^2} \qquad (i)$$

(From Newton's law of gravitation)

$$F = mg \qquad (ii)$$

(From Newton's second law)

From (i) and (ii)

$$mg = \dfrac{GMm}{r^2}$$

$$g = \dfrac{GM}{r^2}$$

The value of g near the surface of the earth is taken as 9.8 ms^{-2}

Motion of object under gravity:

When a body is falling down then a is replaced by g

(i) $v = u + gt$ (ii) $s = ut + \dfrac{1}{2} gt^2$ (iii) $v^2 = u^2 + 2gs$

when a body is thrown up then a is replaed by ($-$g)

(i) $v = u - gt$ (ii) $s = ut - \dfrac{1}{2} gt^2$ (iii) $v^2 = u^2 - 2gs$

Buoyancy: Whenever a body is immersed in a fluid, an upward force is exerted by the fluid on the body, called force of buoyancy or buoyant force. This is also known as upthrust.

Archimedes Principle

When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to weight of the fluid displaced by it.

Build Your Understanding

- A weighing machine measures the reaction R which is equal to the weight of the body.
- Astronaut in space experiences weightlessness because normal reaciton R is zero. Therefore astronaut appears to be floating weightlessly.

Mass	*Weight*
(i) Matter contained by a body is called mass of the body.	(i) The gravitational force acting on a body is called weight.
(ii) It is represented by m.	(ii) It is represented by W.
(iii) It is measured by physical balance.	(iii) It is measured by spring balance.
(iv) It is scalar quantity.	(iv) It is a vector quantity.
(v) The unit of mass is kg.	(v) The unit of weight is Newton.
(vi) Mass of a body remains constant	(vi) Weight of body may change from place to place in accordance wtih *g*.

✔ Maximise Your Marks

- The value of acceleration due to gravity (g) is maximum at poles and minimum at equator.
- The gravitational force is always attractive in nature.
- The magnitude of the buoyant force acting on a body at a given place depends on the density of the liquid and volume of the body immersed in the fluid.
- A body inside a freely fallig laboratory under gravity is weightless.
- Gravitational forces are very weak forces.
- Acceleration produced due to force of attraction by the earth is known as acceleration due to gravity.
- Acceleration due to gravity of the moon is 1/6 of the acceleration due to gravity of the earth.

★ Stretch Yourself

1. Why do two objects of different masses fall at same rate, when dropped from the same height?

2. Why do two students sitting close to each other not feel force of gravitational force of attraction between them?

3. Does the buoyant force act on a body when it is kept in vacuum?

4. Does a body experience same bouyant force when it is immersed in different liquids separately?

? Test Yourself

1. A ball is thrown upwards and rises to a height of 19.6 m. Calculate –

   (a)   The velocity with which the ball was thrown.

   (b)   The time taken by the ball to reach the highest point.

2. State two factors on which weight of an object depends.

3. A body weights 3.5 N in air and 2 N in water. How much buoyant force acts on the body?

4. What is the mass of the object whose weight is 90 N? (given $g = 9.8$ ms^{-2})

5. Why does a caped empty bottle released under water bounces back to the surface of water?