CHAPTER - 9 GRAVITATION

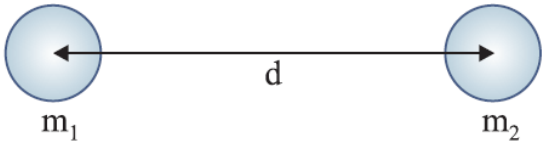
Gravitation

It is defined as the force of attraction between any two bodies in the universe. The earth attracts (or pulls) all objects lying on or near its surface towards its Centre.

The force with which the earth pulls the objects towards its center is called the gravitational force of the earth or gravity of the earth.

Newton's Universal Law of Gravitation

Every mass in this universe attracts every other mass with a force which is directly proportional to the product of two masses and inversely proportional to the square of the distance between them.



Let masses (m_1) and (m_2) of two objects are distance (d) apart, then force of attraction (F) between them

$$F \propto m_1 \times m_2 \qquad \ldots\ldots\ldots\ldots(1)$$

$$F \propto \frac{1}{d^2} \qquad \ldots\ldots\ldots\ldots(2)$$

$from\ qua.\ (1) and (2)$

$$F \propto \frac{m_1 \times m_2}{d^2}$$

$$\boxed{F = \frac{Gm_1m_2}{d^2}}$$

Where G is a constant and is known as universal Gravitational constant.

Value of G = 6.67×10^{-11} Nm^2/kg^2

- If unit of F is in Newton, m is in kg, d is in meter, then unit of G can be calculated as

$$G = \frac{F \times d^2}{m_1 \times m_2}$$

$$= \frac{Nm^2}{kg^2}$$

Importance of universal law of gravitation

a) The force that binds us to the earth.

b) The motion of moon around the earth.
c) The motion of earth around the sun.
d) The occurrence tides are due to the gravitational force of attraction of moon.

Free fall

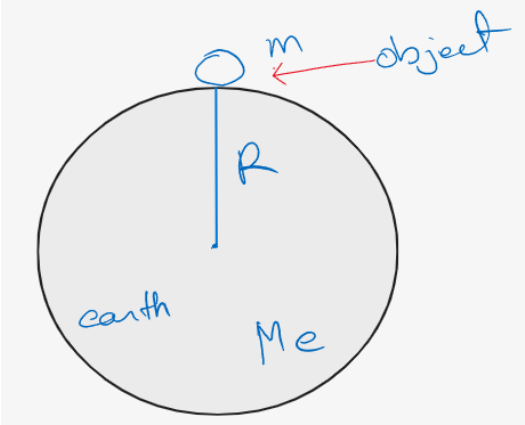
When objects fall towards the earth under the influence of earth's gravitational force alone, then these are called freely falling objects and such a motion is called free fall.

Gravitational Acceleration

The uniform acceleration produced in a freely falling object due to the gravitational force of earth, is called acceleration due to gravity. It is represented by 'g' and it always acts towards the center of the earth.

Value of 'g' on the surface of earth

The force acting on an object is



$$F = \frac{GM_e\, m}{R^2} \qquad \ldots(i)$$

$Where \qquad M_e = Mass\ of\ earth$

$m = Mass\ of\ an\ object$

$R = Radius\ of\ earth$

$and\ if\ acceleration\ due\ to\ gravity\ is\ 'g'\ due\ to\ force\ F\ then,$

$$F = m \times g \qquad \ldots(ii)$$

$$Equating\ (i)\ and\ (ii),\ we\ get \qquad m \times g = \frac{GM_e m}{R^2}$$

$$Or \qquad g = \frac{GM_e}{R^2}$$

$$If \quad G = 6.673 \times 10^{-11}\frac{Nm^2}{kg^2},$$

$$M_e = 6 \times 10^{24}\, kg,$$

$$R^2 = (6.37 \times 10^6)^2$$

$$Then, \quad g = \frac{6.6734 \times 10^{-11} \times 6 \times 10^{24}}{(6.37 \times 10^6)^2}$$

$$\boxed{g = 9.8\, m/s^2}$$

Relationship between G and g

$$G = Gravitational\ constant$$

$$g = Acceleration\ due\ to\ gravity$$

$$\boxed{g = \frac{GM}{R^2}}$$

Difference between G (Gravitational constant) and g (Acceleration due to gravity)

Gravitation Constant (G)	Gravitational acceleration (g)
1. Its value is 6.6734×10^{-11} Nm^2/kg^2. 2. Its value remains constant always and everywhere. 3. Its unit is Nm^2/kg^2. 4. It is a scalar quantity.	1. Its value is 9.8 m/s^2. 2. Its value varies at various places. 3. Its unit is m/s^2. 4. It is a vector quantity.