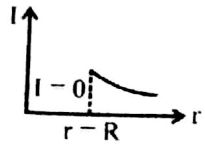
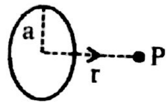


Graph of I against r

(4) 

Intensity due to a uniform circular ring

(i) At a point on the axis $I = \dfrac{GMr}{(a^2 + x^2)^{3/2}}$

(ii) At the centre of the ring I = 0

(b) **Gravitation Potential (V) :** If W is the work done in bringing a body of mass m_0, from infinity to a point P in the gravitational field without acceleration, then the gravitational potential at

$P = V_P = \dfrac{\text{Work}}{\text{mass}} = \dfrac{W}{m_0}$. It is measured in J/kg or m^2/sec^2 and its dimensional formula is

$$[V] = \left[\frac{W}{m_0}\right] = \left[\frac{M^1 L^2 T^{-2}}{M}\right] = [M^0 L^2 T^{-2}].$$

It is a scalar quantity.

- The gravitational potential at a point P at a distance r from the centre of the earth of radius R and mass M, where r > R, is given by $V_P = -\dfrac{GM}{r}$.

Thus V_P is always negative. At the surface of the earth r = R.

$\therefore V_P = -\dfrac{GM}{R}$ and if r = ∞ then $V_P = 0$ at infinity.

This is the maximum value of V.

Gravitational Potential (V)

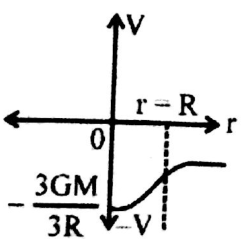
(1) Due to a point mass at a distance r, $V = -\dfrac{GM}{r}$.

(2) V due to a uniform solid sphere.

For $r > R$, $V = -\dfrac{GM}{r}$,

For $r = R$, $V = -\dfrac{GM}{R}$

At the centre, $V = -\dfrac{3}{2}\dfrac{GM}{R}$



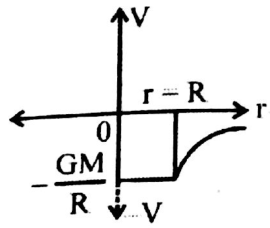
Graph of V against r

(3) V due to a **spherical shell.**

(i) For $r > R$, $V = -\dfrac{GM}{r}$

(ii) For $r = R$, $V = -\dfrac{GM}{R}$

(iii) For $r < R$, $V = -\dfrac{GM}{R}$



(4) **V due to a ring**

(i) At the centre $V_C = -\dfrac{GM}{a}$

(ii) At a point on its axis $V_{axis} = -\dfrac{GM}{\sqrt{a^2 + r^2}}$

(c) **The gravitational P.E.** of a point mass m at a distance r from the centre of the earth (where r > R) is given by the gravitational P.E. = gravitational potential × mass of the body.

$$U = -\frac{GMm}{r} = -V_P \times m$$

U is a scalar. It's unit is joule and dimensional formula is $[U] = [M^1 L^2 T^{-2}]$.

(i) Thus U is –ve and as r is increased, U becomes less negative i.e. it increases and for r = ∞, U = 0. This is the maximum value of U.

(ii) At the surface of the earth, r = R and $U = -\dfrac{GMm}{R}$

(iii) At the centre of the earth, $U = -\dfrac{3}{2}\dfrac{GMm}{R}$. It is minimum but not zero.

Relation between gravitational potential (V) and gravitational field intensity (I).

$I = -\dfrac{dV}{dr}$ (similar to $E = -\dfrac{dV}{dx}$ in electricity).

- **Useful Points :**

(i) Gravitational force is independent of the intervening medium. The ratio of the gravitational force to the electrostatic force between two electrons is of the order of 10^{-43}.

(ii) The escape velocity of a body from the surface of the earth is about 11.2 km/s, while for the moon escape velocity is about 2.38 km/s.