Chapter - 8
Gravitation

Q.1 What do you mean by gravitation?
Q.2. What do you mean by gravity?
Q.3. Write the law of Newton's Universal law of gravitation.
Q.4 What do you mean by acceleration due to gravity.
Q.5. Derive relation b/w G and g.

Ans.1) ~~wt a body apply an attraction force~~ two bodies are attracted on the side of ~~masses~~ each other due to gravitational force, this phenomena is known as gravitation.

Ans.2) The gravitational force b/w a Planet and any body, this phenomena is known as gravity.

Ans.3) The FOA is directly proportional to Product of masses and inversaly proportional to square of distance.

$$\Rightarrow \boxed{F = \frac{G m_1 m_2}{r^2}}$$

$$\Rightarrow \boxed{G = \frac{F r^2}{m_1 m_2}}$$

→ unit of G :- $N\ m^2/kg^2$

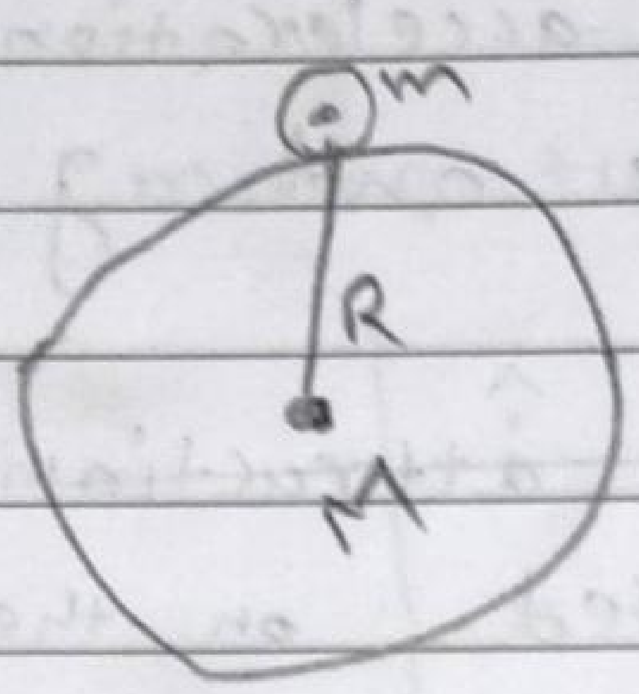
and G = universal gravitational constant.

$G = 6.67 \times 10^{-11}\ N\ m^2/kg^2$.

The

Ans. 4) The acceleration which we are getting due to gravitational force.

Ans. 5) Relation b/w G and g,



$$\Rightarrow \quad F = \frac{G m_1 m_2}{r^2}$$

$$\Rightarrow \quad F = \frac{G M m}{R^2}$$

$$\Rightarrow \quad mg = \frac{G M m}{R^2}$$ [$\because$ $F = mg$, g is acceleration due to gravity]

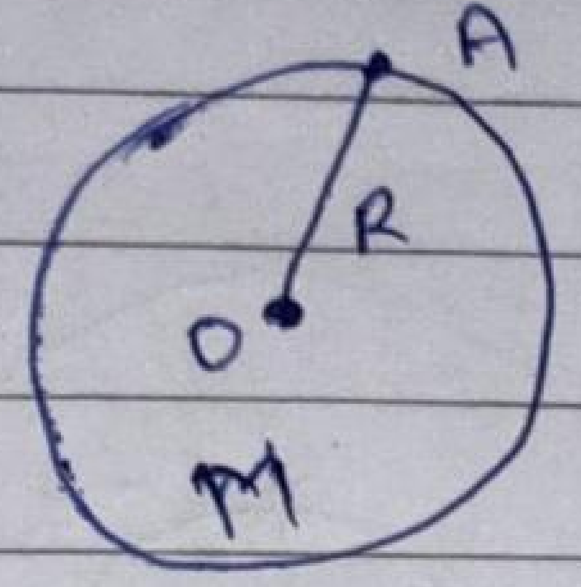
$$\Rightarrow \quad \boxed{g = \frac{GM}{R^2}}$$

Q.6 Write diff. b/w G and g.

G	g
1) Universal Gravitational Constant	1) acceleration due to gravity
2) Scalar	2) Vector
3) Nm^2/kg^2	3) m/s^2
4) constant	4) change
5) 6.67×10^{-11} Nm^2/kg^2	5) 9.81 m/s^2

Q7. derive expression for change in the value of g due to height 'h' from earth surface.

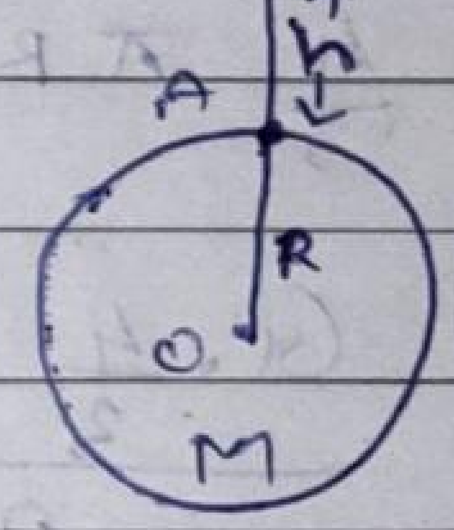
Sol.



$$g = \frac{GM}{R^2} \longrightarrow ①$$

At point B,

$$g' = \frac{GM}{(R+h)^2} \longrightarrow ②$$



eq^n ② ÷ eq^n ①

$$\Rightarrow \frac{g'}{g} = \frac{\frac{GM}{(R+h)^2}}{\frac{GM}{R^2}}$$

$$\Rightarrow \frac{g'}{g} = \frac{R^2}{(R+h)^2}$$

$$\Rightarrow \frac{g'}{g} = \frac{\cancel{R^2}}{\cancel{R^2}\left(1+\frac{h}{R}\right)^2}$$

$$\Rightarrow \frac{g'}{g} = \left(1+\frac{h}{R}\right)^{-2}$$

$$\because \left(1+\frac{h}{R}\right)^{-2}$$

$$(1+x)^n = 1 + nx + \frac{n(n-1)}{1\cdot 2}x^2 + \frac{n(n-1)(n-2)}{1\cdot 2\cdot 3}x^3 + \dots$$

$$1 + (-2)\frac{h}{R} + \dots$$

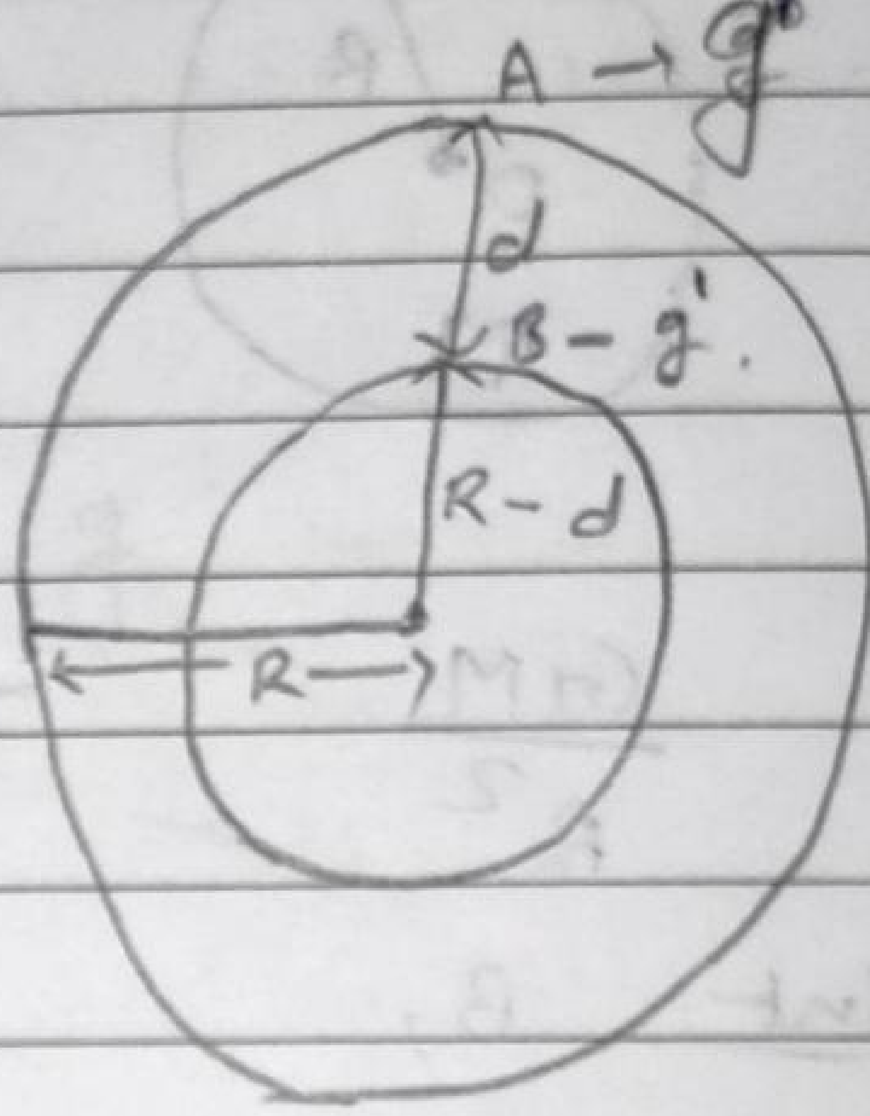
$$1 - \frac{2h}{R}$$

$$\Rightarrow \frac{g'}{g} = \left(1 - \frac{2h}{R}\right) \quad [\because \text{by bynomial theorem}]$$

$(1+x)^n$ ~~$1+nx$~~

$$\Rightarrow \boxed{g' = g\left(1 - \frac{2h}{R}\right)}$$

Q.8. derive expression for change in the value of g with the depth below surface of the earth.



⇒ At Point A,

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

⇒ mass = volume × density

$$\Rightarrow M = \frac{4}{3}\pi R^3 D$$

$$\Rightarrow g = \frac{G \cdot \frac{4}{3}\pi R^3 D}{R^2}$$

$$\Rightarrow g = \frac{4}{3}\pi G R D \longrightarrow (1)$$

At point B,

$$\Rightarrow g' = \frac{GM'}{(R-d)^2}$$

$$\Rightarrow M' = \frac{4}{3}\pi (R-d)^3 D$$

$$\Rightarrow g' = \frac{G \cdot \frac{4}{3}\pi (R-d)^3 \cdot D}{(R-d)^2}$$

$$\Rightarrow g' = \frac{4}{3}\pi G (R-d) D \longrightarrow (2)$$

⇒ eq^n (2) ÷ eq^n (1),

$$\Rightarrow \frac{g'}{g} = \frac{\frac{4}{3}\pi G(R-d)D}{\frac{4}{3}\pi G R D}$$

$$\Rightarrow \frac{g'}{g} = \frac{R-d}{R}$$

$$\Rightarrow \frac{g'}{g} = 1 - \frac{d}{R}.$$

$$\Rightarrow \boxed{g' = g\left(1 - \frac{d}{R}\right)}$$

$$\boxed{g' < g}$$

→ Special condition →

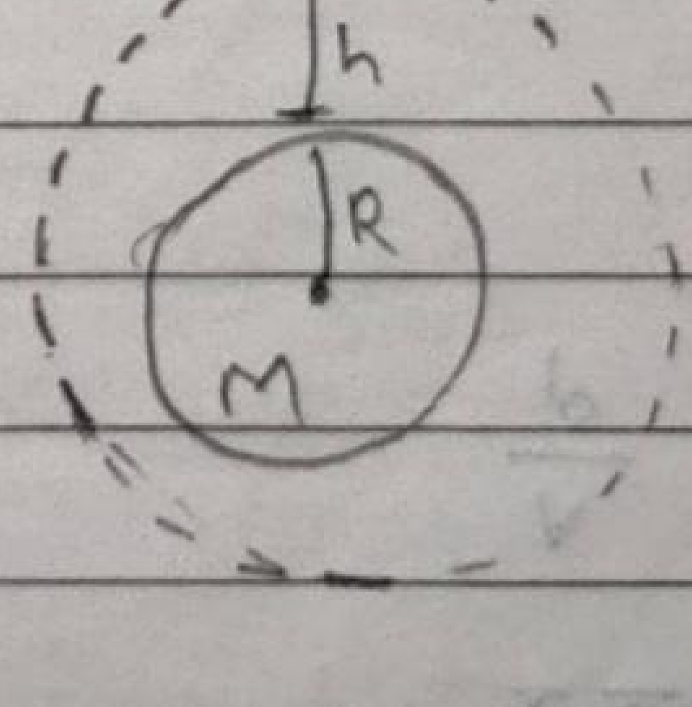
when $d = R$

then, $\Rightarrow g' = g\left(1 - \frac{R}{R}\right)$

$\Rightarrow \boxed{g' = 0}$ at centre of earth.

Q.9. derive the expression for orbital speed of a satellite.

Ans. Orbital speed :- speed required to stablish the satellite in a orbit.



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

$$\Rightarrow F = \frac{GMm}{(R+h)^2 = r^2}$$

centripetal force $= \frac{mv^2}{r}$ — (2)

$$\Rightarrow \frac{GMm}{r^2} = \frac{mv^2}{r}$$

$$\Rightarrow \frac{GM}{r} = v^2$$

$$\Rightarrow v = \sqrt{\frac{GM}{r}}$$

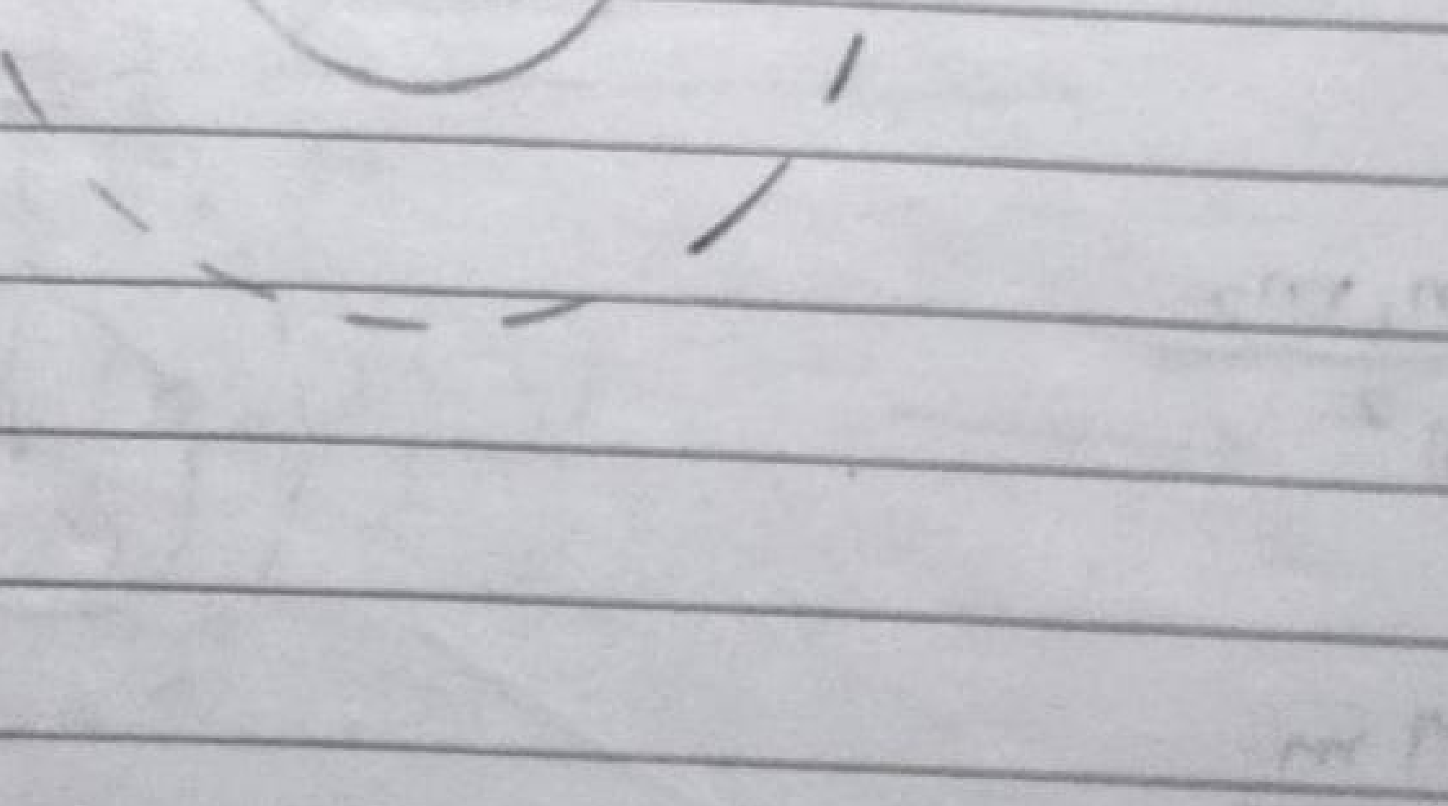
$$\because g = \frac{GM}{R^2} \Rightarrow gR^2 = GM.$$

$$\Rightarrow v = \sqrt{\frac{gR^2}{r}}$$

$$\Rightarrow v = R\sqrt{\frac{g}{R+h}}$$

<u>period of revolution</u> :-

Time Taken by satellite to complete one revolution around earth is known as period of revolution.



$$\Rightarrow T = \frac{d}{v}$$

$$\Rightarrow T = \frac{2\pi r}{v}$$

$$\Rightarrow \quad T = \frac{2\pi (R+h)}{R\sqrt{\frac{g}{R+h}}}$$

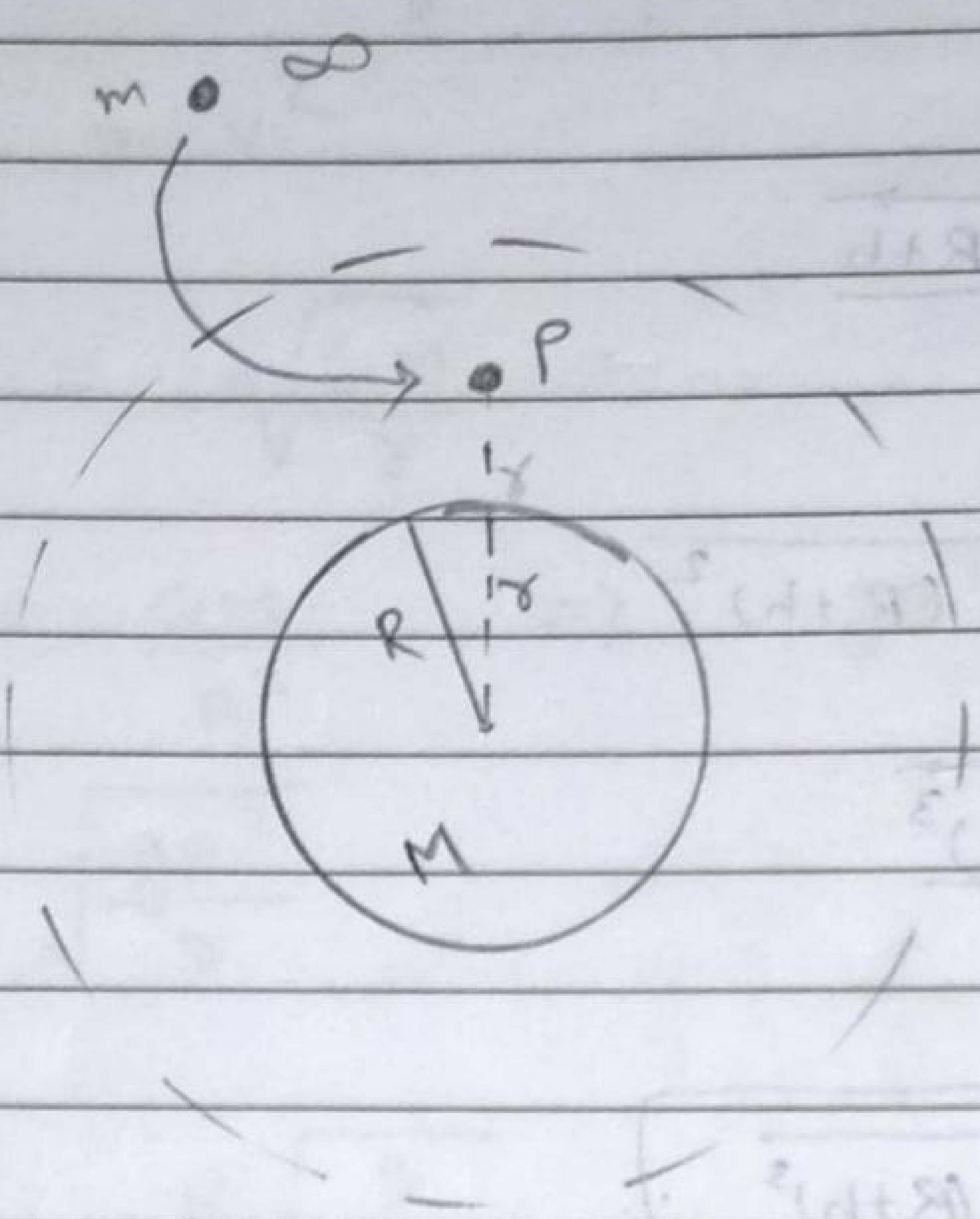
$$\Rightarrow \quad T = \frac{2\pi (R+h)\sqrt{R+h}}{R\sqrt{g}}$$

$$\Rightarrow \quad T = 2\pi \sqrt{(R+h)(R+h)^2}$$

$$\Rightarrow \quad T = \frac{2\pi \sqrt{(R+h)^3}}{R\sqrt{g}}$$

$$\Rightarrow \quad \boxed{T = \frac{2\pi}{R}\sqrt{\frac{(R+h)^3}{g}}}$$

Gravitational Potential Energy :-



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

$$\Rightarrow \cancel{W} = dW = F \cdot dr$$

$$\Rightarrow \int_0^W dW = \int_\infty^r F \cdot dr.$$

$$\Rightarrow [W]_0^W = \int_\infty^r \frac{GMm}{r^2} dr$$

$$\Rightarrow [W - 0] = GMm \int_\infty^r \frac{1}{r^2} dr.$$

$$\Rightarrow W = GMm \left[\frac{r^{-2+1}}{-2+1} \right]_\infty^r$$

$$\Rightarrow W = GMm \left[\frac{r^{-1}}{-1} \right]_\infty^r$$

$$\Rightarrow W = -GMm \left[\frac{1}{r} \right]_\infty^r$$

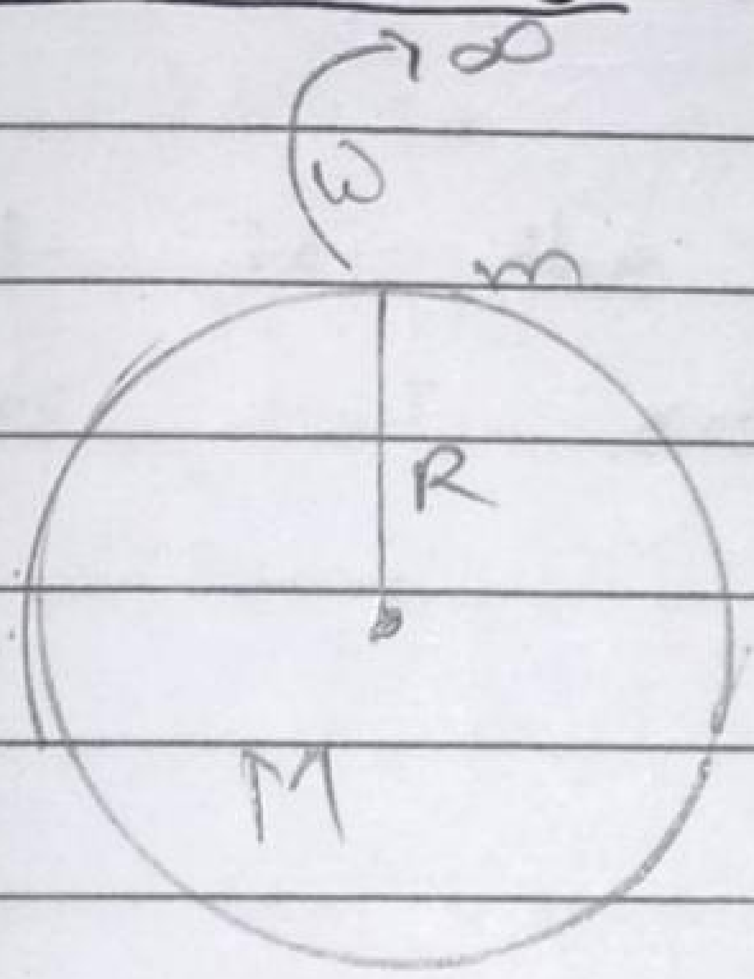
$$\Rightarrow W = -GMm\left[\frac{1}{r} - \frac{1}{\infty}\right]$$

$$\Rightarrow W = -GMm\left[\frac{1}{r} - 0\right]$$

$$\Rightarrow \boxed{W = -\frac{GMm}{r}} \quad \text{or} \quad \boxed{U = -\frac{GMm}{r}}$$

where, U = gravitational P.E.

Escape Velocity :- Minimum velocity at which object crosses the gravitational field.



$$\Rightarrow F = \frac{GMm}{R^2}$$

$$\Rightarrow dW = F \cdot dx$$

$$\Rightarrow dW = \frac{GMm}{x^2} \cdot dx$$

$$\Rightarrow \int_0^W dW = \int_R^\infty \frac{GMm}{\cancel{R^2}\, x^2} \cdot dx$$

$$\Rightarrow [W]_0^W = GMm \int_R^\infty \frac{1}{x^2} dx$$

$$\Rightarrow W = GMm \int_R \cancel{x}^{-2} dx$$

$$\Rightarrow W = GMm\left[\frac{x^{-2+1}}{-2+1}\right]_R^\infty$$

$$\Rightarrow W = GMm\left[\frac{x^{-1}}{-1}\right]_R^\infty$$

$$\Rightarrow W = -GMm\left[x^{-1}\right]_R^\infty$$

$\Rightarrow \; W = -GMm\left[x^{-1}\right]_R^{\infty}$

$\Rightarrow \; W = -GMm\left[\frac{1}{\infty} - \frac{1}{R}\right]$

$\Rightarrow \; W = -GMm\left[0 - \frac{1}{R}\right]$

$\Rightarrow \; W = \frac{GMm}{R}$

$\Rightarrow \because W = KE$

$\therefore \; \frac{GMm}{R} = \frac{1}{2}mv^2$

$\Rightarrow \; \frac{2GM}{R} = \cancel{\frac{1}{2}m}\, v^2$

$\Rightarrow \; v = \sqrt{\frac{2GM}{R}}$

$\because \; g = \frac{GM}{R^2}$

$\Rightarrow \; gR^2 = GM$

$\Rightarrow \; v = \sqrt{\frac{2gR^2}{R}} \quad \left[\because gR^2 = GM\right]$

$v = \sqrt{2gR}$

$\Rightarrow$ Earth

$v = \sqrt{2 \times 9.8 \times 6.36 \times 10^6}$

$\Rightarrow \boxed{v = 11.2 \text{ Km/sec}}$

If we throw at speed of 11.2 Km/sec then object reach out of gravitational field.

$\boxed{\text{Moon} = 2.4 \text{ Km/sec}}$

Q- What do you mean by Satelite? Explain the types of Satelite.

Ans. The body revolving around the planets is known as Sattelite.

There are two types of Satellite.

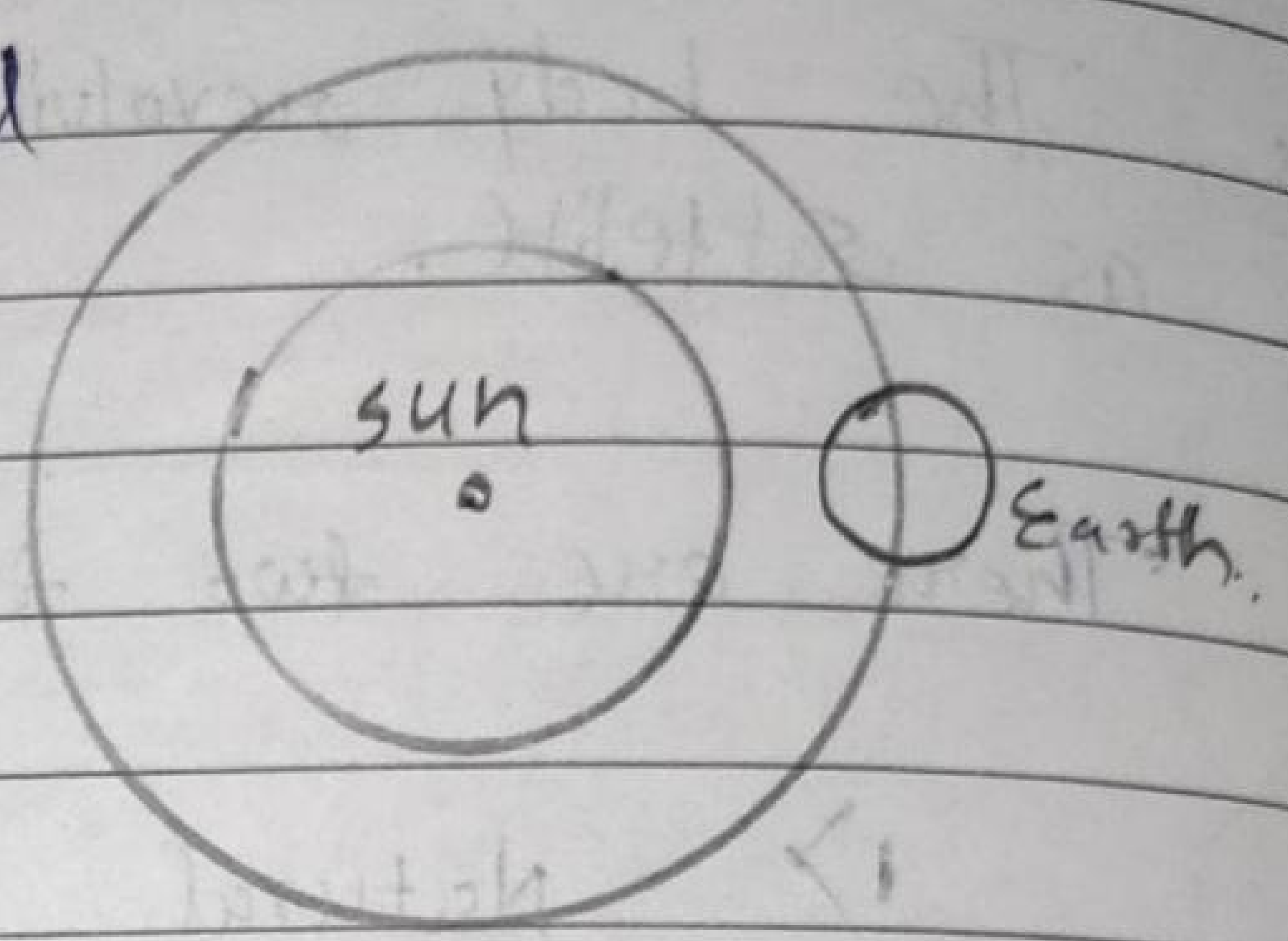
1) Natural Satellite
2) Artificial Satellite.

Q. what is the uses of Satelite?

Ans. uses of Satellite -

Kepler's law of planetary motion :-

→ Earth rotates in elliptical Path.



1) Kepler's first law

or

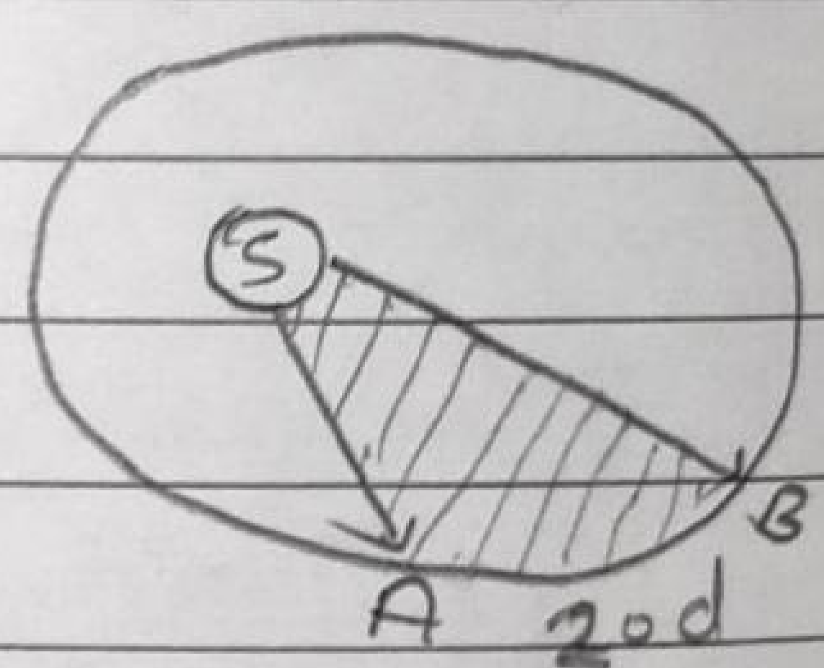
law of orbit :-

The shape or path of the orbit is elliptic.

2) second law or law of area :-

Example :-

Area of ASB is 20d.



For same interval of time,
Area of ASB = CSD.

3) Third law :-

According to this law, if time is different then area are not same mean time should be same for same area.

$\Rightarrow \quad T^2 \propto r^3$

$\Rightarrow \quad \boxed{T^2 = Kr^3}$