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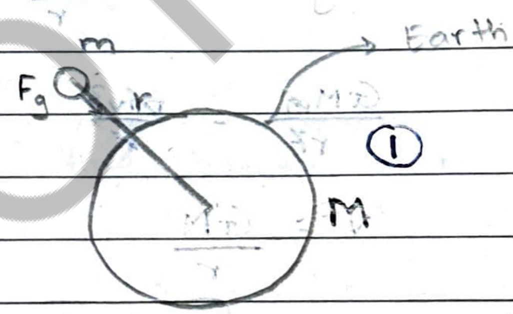
Gravitation

Newton's law of gravitation → Any 2 bodies attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distances between them.

Example. $F \propto \frac{M_1 M_2}{r^2}$ $F = \frac{GMm}{r^2}$

$G \rightarrow$ gravitational constant $= 6.67 \times 10^{-11}\ Nm^2 kg^{-2}$

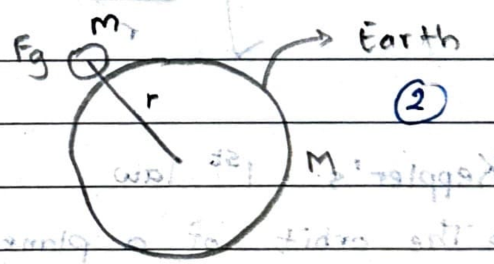
⇒ Gravitational field strength



$F_{net_m} = F_g$

$F_{net_m} = \frac{-GMm}{r^2}$

$ma = \frac{-GMm}{r^2}$



$a = \frac{\frac{-GM\cancel{m}}{r^2}}{\cancel{m}}$

$a = \frac{-GM}{r^2}$

acceleration is nothing but gravity so $a = g$

$g = \frac{-GM}{r^2}$, look at figure 2. The r = radius of earth.

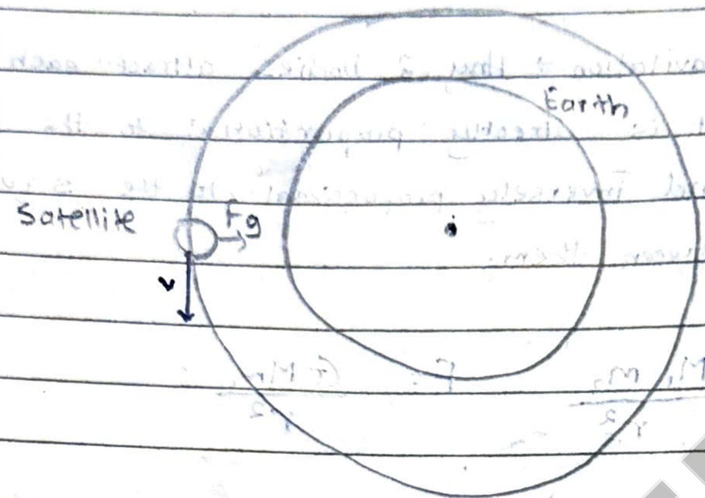
Mass of earth $= 5.972 \times 10^{24}$ kg

radius of earth $= 6.371 \times 10^{6}$ m

let's plug in these values.

$$g = \frac{-6.6 \times 10^{-11} \times 5.972 \times 10^{24}}{[6.371 \times 10^{6}]^2} = \boxed{9.81\ ms^{-2}}$$

Speed of object moving around Earth



here the F_g is basically centripital force

$$F_g = F_c = \frac{mv^2}{r}$$

$$\frac{GM\cancel{m}}{r^{\cancel{2}}} = \frac{\cancel{m}v^2}{\cancel{r}}$$

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

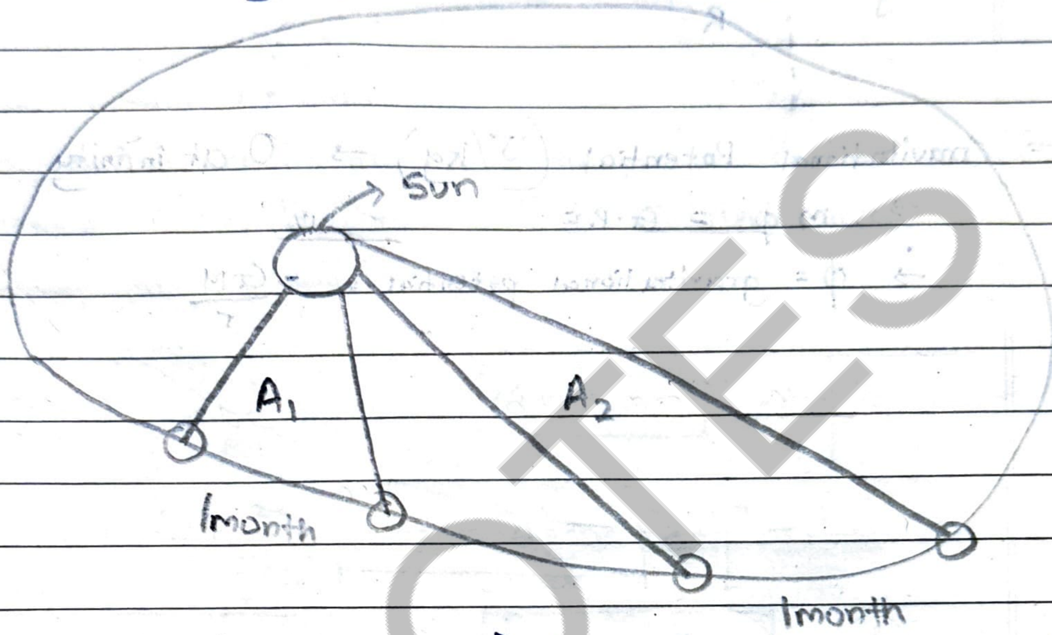
$$v = \sqrt{\frac{GM}{r}}$$ formula to find speed.

Keppler's 1st law

→ The orbit of a planet is an ellipse with the sun at one of the two foci.

⇒ Kepler's 2^{nd} law

→ A line segment ~~joing~~ joining a planet and the sun sweeps out equal areas during equal time intervals.



kepler's second law says that if time interval is same then $A_1 = A_2$. This law suggests that the planet will be moving faster when it's closer to the sun due to the gravitational force of the sun.

⇒ Kepler's 3^{rd} law

→ The square of the orbital time period of a planet is proportional to the cube of it's orbital distance.

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

$$\boxed{T^2 = \left[\frac{4\pi^2}{GM}\right] r^3}$$

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⇒ Gravitational Potential Energy at a point → 0 at infinity
→ The work done in bringing a mass from infinity to ~~the~~ a point.

$$E_g = \frac{-GMm}{R}$$

⇒ Gravitational Potential (J/kg) → 0 at infinity
→ $m\phi$ = G.P.E
→ ϕ = gravitational potential = $-\frac{GM}{r}$