Gravitation

- The Phenomenon of attraction between any two objects in the Universe is called gravitation.
- Gravity — attractive force which is exerted by earth or any body.

Universal law of Gravitation.

Everybody in the universe attracts every other body with a force which is directly proportional to the product of their masses & inversely proportional to the square of the distance between them.

$F \propto m_1 m_2$

$F \propto \frac{1}{r^2}$

$F = G \times \frac{m_1 m_2}{r^2}$ → Universal gravitational constant

SI unit of G

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

$G = \frac{N \times m^2}{kg^2}$

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

Universal gravitational Constant

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

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

$G = \frac{F \times (1m)^2}{1kg \times 1kg}$

$G = F$

Universal gravitational constant is numerically equal to the gravitational force of attraction between two bodies each of mass 1kg kept at unit distance from each other.

Why gravitational constant (G) is known as Universal gravitational constant?

→ The value of G doesn't depend on mass of two bodies, distance b/w two bodies, nature, medium, shape, size.

Conditions

i) when two objects each of 1kg and 1m apart

$F = \frac{G m_1 m_2}{r^2} = \frac{6.67 \times 10^{-11} \times 1 \times 1}{1} = 6.67 \times 10^{-11} N$

$= 0.000\ldots\ldots 67 N$

ii)

Force of Ball to Train $= \frac{G m_1 m_2}{r^2} = \frac{G \times 2 \times 5000}{1^2}$

$F = 10006 N$

Force of Train to Ball $= \frac{G m_2 m_1}{r^2} = \frac{G \times 5000 \times 2}{1^2} = 10006 N$

iii)

earth mass $= 6 \times 10^{24}$ kg

Radius of earth $= 6400$ km $= 6400 \times 1000$ m $= 6.4 \times 10^6$ m

$F_{BE} = \frac{6.67 \times 10^{-11} \times 1 \times 6 \times 10^{24}}{(6.4 \times 10^6)^2} = 9.8 N$

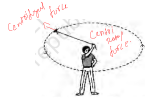
$F_{EB} = 9.8 N$

Newton's 2nd law of motion

$F = ma$

$a_B = \frac{F_{EB}}{m} = \frac{9.8}{1} = 9.8 m s^{-2}$

$a_{BE} = \frac{F}{m} = \frac{9.8}{6 \times 10^{24} kg} = 1.63 \times 10^{-24} m s^{-2}$



Before the thread is released, the stone moves in a circular path with a certain speed and changes direction at every point. The change in direction involves change in velocity or acceleration. The force that causes this accelerations and keeps the body moving along the circular path is acting towards the centre. This force is called the centripetal (meaning 'centre-seeking') force. In the absence of this

The motion of the moon around the earth is due to the centripetal force. The centripetal force is provided by the force of attraction of the earth. If there were no such force, the moon would pursue a uniform straight line motion.

$F_1 = \frac{G m_1 m_2}{r^2}$

$F_{12} = \frac{G 3m_1 \frac{1}{2}m_2}{(\frac{r}{2})^2} = \frac{G \frac{3}{2} m_1 m_2}{\frac{r^2}{4}} = \frac{6}{2} \frac{G m_1 m_2}{r^2}$

$F_{12} = 3 F_1$

m_1 3 times, m_2 $\frac{1}{2}$ times, r $\frac{1}{2}$ times

1) Two particles A and B of mass m_1 and m_2 respectively are placed on some distance. If the mass of each of the two particles is doubled, keeping the distance b/w them unchanged, the gravitational force b/w them will be.

i) m_1 m_2 r $F_1 = \frac{G m_1 m_2}{r^2}$

ii) $2m_1$ $2m_2$ r $F_2 = \frac{G 2m_1 2m_2}{r^2}$

$F_2 = 4 \frac{G m_1 m_2}{r^2}$

$F_2 = 4 F_1$

$F_2 = \frac{F_1}{\frac{1}{3}}$

$F_2 = \frac{\frac{G m_1 m_2}{r^2}}{\frac{r^2}{4}}$

$F_2 = \frac{G m_1 m_2}{\frac{r^2}{4}}$

2) mass of sun is 2×10^{30} kg & mass of earth is 6×10^{24} kg. If the avg distance b/w the sun and the earth is 1.5×10^{8} Km, Calculate the gravitational force b/w them.

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

3) The gravitational force b/w two objects is F. If masses of both objects are halved w/o changing distnce b/w them, gravitational force would become.

$F_1 = \frac{G m_1 m_2}{d^2}$

$F_2 = \frac{G (m_1/2)(m_2/2)}{d^2} = \frac{G m_1 m_2}{d^2} \cdot \frac{1}{4} = \frac{F_1}{4}$

$F_2 = F_1/4$

4) Gravitational force b/w two objects weighing 20kg and 15kg is 150×10^{-10} N. Find distance b/w two objects.