Q1 For the earth, $T_1 = 1$ year ; $r_1 = 1$ AU

For planet venus, $T_2 = ?$; $r_2 = 0.72$ AU.

As $\frac{T_2^2}{T_1^2} = \frac{r_2^3}{r_1^3}$ or $T_2 = T_1\left(\frac{r_2}{r_1}\right)^{3/2} = 1\left(\frac{0.72}{1}\right)^{3/2}$

$= 0.61$ year

$= 0.61 \times 365 =$ **223 days**

Q2 Here, $r_1 = 6R + R = 7R$, $T_1 = 24$ h, $T_2 = 6\sqrt{2}$ h,

$$r_2 = r_1\left(\frac{T_2}{T_1}\right)^{2/3} = 7R\left(\frac{6\sqrt{2}}{24}\right)^{2/3} = 7R\left(\frac{1}{2}\right) = 3.5R$$

∴ Height of satellite from the surface of earth

$= 3.5R - R$

$=$ **2.5 R**

Here, $r_1 = 36000$ km ; $r_2 \approx 6400$ km ;

$T_1 = 24$ h, $T_2 = ?$

$$T_2 = T_1\left(\frac{r_2}{r_1}\right)^{3/2} = 24\left(\frac{6400}{36000}\right)^{3/2} \simeq \mathbf{1.8h}$$

Q3 $$r_2 = r_1\left(\frac{T_2}{T_1}\right)^{2/3} = 7R\left(\frac{6\sqrt{2}}{24}\right)^{2/3} = 7R\left(\frac{1}{2}\right) = 3{\cdot}5R$$

$\therefore$ Height of satellite from the surface of earth

$$= 3{\cdot}5\,R - R$$
$$= \mathbf{2{\cdot}5\ R}$$

Here, $r_1 = 36000$ km ; $r_2 \approx 6400$ km ;
$T_1 = 24$ h, $T_2 = ?$

$$T_2 = T_1\left(\frac{r_2}{r_1}\right)^{3/2} = 24\left(\frac{6400}{36000}\right)^{3/2} \simeq \mathbf{1{\cdot}8\,h}$$

Q4 Here, T_1 is (= 1 year) the present time period of revolution of earth around the sun and R is the present radius of orbital path of earth around sun. When the distance between the earth and sun is $R' = R + 2\,R = 3\,R$, let T_2 be the time period of revolution of earth around the sun. Then

$$\frac{T_2^2}{T_1^2} = \frac{(3\,R)^3}{R^3} = 27$$

or $$T_2 = T_1\sqrt{27} = 1\sqrt{27} = 3\sqrt{3} = 3 \times 1{\cdot}732$$
$$= \mathbf{5{\cdot}196\ years}$$

Q5 (*a*) Radius of earth orbit around sun

$$R = 1{\cdot}496 \times 10^{11}\ \text{m} ;$$

Time period of revolution of earth around sun

$T = 365$ days $= 365 \times 24 \times 60 \times 60$ s

The rate at which the area is swept out by the radius from sun to earth,

Q5

$$\frac{dA}{dt}=\frac{\pi R^2}{T}=\frac{(22/7)\,(1\cdot496\times10^{11})^2}{365\times24\times60\times60}$$

$$= \mathbf{2{\cdot}23 \times 10^{15}\ m^2\ s^{-1}}.$$

(*b*) Radius of moon orbit around earth,

$$R = 3{\cdot}845 \times 10^8 \text{ m}$$

Time period of revolution of moon around earth

$$T = 27\frac{1}{3}\text{ days} = \frac{82}{3}\times24\times60\times60\text{ s}$$

The rate at which the area is swept out by radius from the earth to moon

$$\frac{dA}{dt}=\frac{\pi R^2}{T}=\frac{(22/7)\,(3{\cdot}845\times10^{8})^2}{(82/3)\times24\times60\times60}$$

$$= \mathbf{1{\cdot}97 \times 10^{11}\ m^2\ s^{-1}}$$

Q6

Let x be the distance between rocket and Moon, when the net gravitational force on rocket is zero, *i.e.*, gravitational force on rocket due to Earth = gravitational force on rocket due to Moon.

Then, $$\frac{GM_e\,m}{(r-x)^2}=\frac{GM_m\,m}{x^2}$$

$$\frac{r-x}{x}=\sqrt{\frac{M_e}{M_m}}=\sqrt{\frac{6\times10^{24}}{7{\cdot}4\times10^{22}}}=9{\cdot}0$$

Q6 Let x be the distance between rocket and Moon, when the net gravitational force on rocket is zero, *i.e.*, gravitational force on rocket due to Earth = gravitational force on rocket due to Moon.

Then, $$\frac{GM_e m}{(r-x)^2} = \frac{GM_m m}{x^2}$$

$$\frac{r-x}{x} = \sqrt{\frac{M_e}{M_m}} = \sqrt{\frac{6 \times 10^{24}}{7{\cdot}4 \times 10^{22}}} = 9{\cdot}0$$

Using $r = 3{\cdot}8 \times 10^8$ m and solving the above relation, we get $x = \mathbf{3{\cdot}8 \times 10^7}$ **m**

Q7 $$G\frac{M_s M_e}{r^2} = M_e r \left(\frac{2\pi}{T}\right)^2 \quad \text{or} \quad M_s = \frac{4\pi^2 r^3}{GT^2}$$

where $r = 1{\cdot}49 \times 10^{11}$; $G = 6{\cdot}66 \times 10^{-11}$ N m^2 kg^{-2} and $T = 365 \times 24 \times 60 \times 60$ s

Q8 Here, $m_1 = 20$ kg ; $m_2 = 250$ kg ;

$r = 30$ cm $= 0{\cdot}30$ m,

$F = 0{\cdot}40$ mg wt $= 0{\cdot}40 \times 10^{-6}$ kg wt

$= 0{\cdot}40 \times 10^{-6} \times 9{\cdot}8$ N

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

Q9 or $r_2 = \sqrt{0{\cdot}012}\ r_1 = 0{\cdot}11\ r_1$

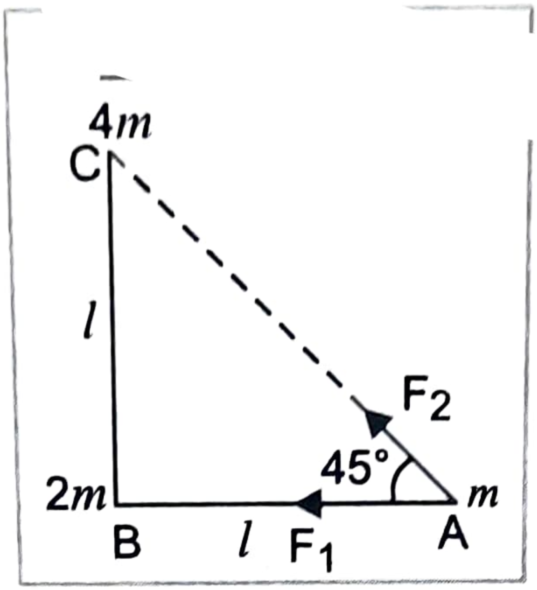
From (i), $r_1 + 0{\cdot}11\ r_1 = 3{\cdot}845 \times 10^8$ m

or $1{\cdot}11\ r_1 = 3{\cdot}845 \times 10^8$ m

or $\mathbf{r_1 = 3{\cdot}464 \times 10^8\ m}$

Q10 **10.** Refer to Fig $AC = (AB^2 + BC^2)^{1/2}$

$$= (l^2 + l^2)^{1/2} = l\sqrt{2}$$



Gravitational pull on body at A due to body at B is

$$F_1 = \frac{Gm \times 2m}{l^2} = \frac{2Gm^2}{l^2} \text{ along } AB.$$

Gravitational pull on body at A due to body at C is

$$F_2 = \frac{Gm \times 4m}{(l\sqrt{2})^2} = \frac{2Gm^2}{l^2} \text{ along } AC$$

As, $AB = AC$ and $\angle ABC = 90°$; so $\angle BAC = 45°$.

i.e., angle θ between $\vec{F_1}$ and $\vec{F_2}$ is 45°

Q10

Using parallelogram law of forces, the resultant gravitational force on body at A is

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1 F_2 \cos 45^\circ}$$

$$= \left[\left(\frac{2Gm^2}{l^2}\right)^2 + \left(\frac{2Gm^2}{l^2}\right)^2 + 2\times\frac{2Gm^2}{l^2}\times\frac{2Gm^2}{l^2}\times\frac{1}{\sqrt{2}}\right]^{1/2}$$

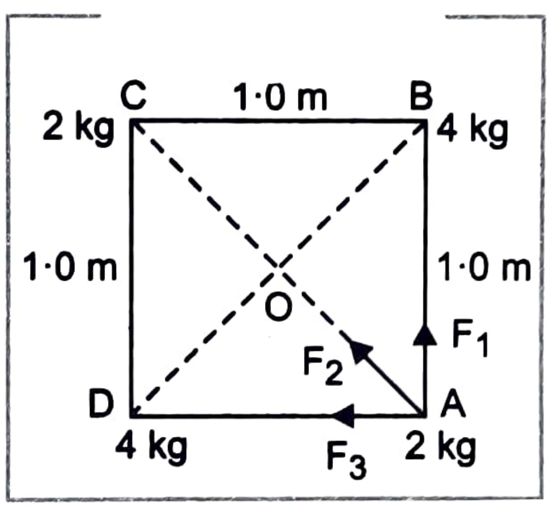
$$= \frac{2Gm^2}{l^2}(1+1+\sqrt{2})^{1/2} = \frac{3{\cdot}696\,Gm^2}{l^2}$$

Here, $AC = \sqrt{AB^2 + BC^2} = \sqrt{1^2 + 1^2} = \sqrt{2}\ \text{m}$

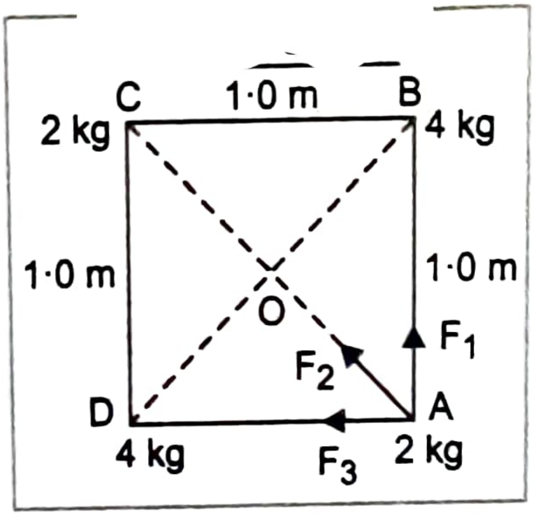
Gravitational force on body A due to body at B is

$$F_1 = G\frac{m_1 m_2}{r^2} = \frac{6{\cdot}6\times10^{-11}\times2\times4}{1^2}$$

$$= 52{\cdot}8\times10^{-11}\ \text{N along } AB$$



Q11



Gravitational force on body at A due to body at C

is $\quad F_2 = \dfrac{G m_1 m_3}{r_1^2} = \dfrac{6{\cdot}6 \times 10^{-11} \times 2 \times 2}{(\sqrt{2})^2}$

$= 13{\cdot}2 \times 10^{-11}$ N along AC

Gravitational force on body at A due to body at D

is $\quad F_3 = \dfrac{G m_1 m_4}{r^2} = \dfrac{6{\cdot}6 \times 10^{-11} \times 2 \times 4}{1^2}$

$= 52{\cdot}8 \times 10^{-11}$ N along AD

As $\vec{F_1}$ and $\vec{F_3}$ are perpendicular to each other and equal in magnitude, their effective gravitational force is

$$F' = \sqrt{F_1^2 + F_3^2} = \sqrt{F_1^2 + F_1^2}$$

$$= F_1\sqrt{2} = (52{\cdot}8 \times 10^{-11})\sqrt{2}\text{ N along } AC$$

Resultant gravitational force on body at A is

$F = F' + F_2 = (5{\cdot}8 \times 10^{-11} \times \sqrt{2}) + 13{\cdot}2 \times 10^{-11}$

$= (74{\cdot}66 + 13{\cdot}2) \times 10^{-11}$

$= \mathbf{87{\cdot}86 \times 10^{-11}}$ **N along AC**

12. $g = \frac{GM}{R^2} = \frac{G}{R^2} \times \frac{4}{3} \pi R^3 \rho = \frac{4}{3} \pi G R \rho$

As per question ; $g = \frac{4}{3} \pi G R \rho = \frac{4}{3} \pi G (2R) \rho'$

or $\rho' = \rho/2$

13. Refer to Solved Example 15.

Q14 The weight of the person on the Earth is 80 kg wt. Hence, his mass m = **80 kg**

Weight of person on the surface of Moon is

$$W' = mg' = \frac{mGM}{R^2}$$

$$= \frac{80 \times (6 \cdot 67 \times 10^{-11}) \times (7 \cdot 34 \times 10^{22})}{(1 \cdot 75 \times 10^6)^2} = \mathbf{128\ N}$$

$$\therefore \quad g' = \frac{W'}{m} = \frac{128}{80} = \mathbf{1 \cdot 6\ m\ s^{-2}}$$

Acceleration due to gravity on the surface of Earth, $g = 9 \cdot 8$ m/s^2 $\therefore$ $g'/g = 1 \cdot 6/9 \cdot 8 \approx 1/6$.

$\therefore$ Person can jump 6 times higher on Moon than that of Earth. Hence, height of jump on Moon

$$= 2 \times 6 \simeq \mathbf{12\ m}$$

Q15 Density of Earth ρ = relative density

$\times$ density of water

$= 11{\cdot}4 \times 10^3$ kg m^{-3}

Acceleration due to gravity on the surface of Earth is

$$g = \frac{GM}{R^2} = \frac{G}{R^2} \times \frac{4}{3} \pi R^3 \rho = \frac{4\pi G R \rho}{3}$$

$$= \frac{4 \times (3{\cdot}14) \times (6{\cdot}67 \times 10^{-11}) \times (6400 \times 10^3) \times (11{\cdot}4 \times 10^3)}{3}$$

$= \mathbf{20{\cdot}38\ ms^{-2}}$