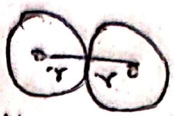
WS-14. Gravitation 8th foundation of

Thagk

(1) Given when two bodies are kept in contact

$F_g = F$. ie



$d_1 = 2r$.

d_1 = distance between their centres

In 2nd case radius of sphere $r' = 2r$.

d_2 = distance between their centres = $4r$

F' be the force between them

According to Newton's law of gravitation

$$F \propto \frac{1}{d^2} \Rightarrow \frac{F}{F'} = \left(\frac{d_2}{d_1}\right)^2$$

$$\Rightarrow \frac{F}{F'} = \left[\frac{\cancel{4r}^{\,2}}{\cancel{2r}}\right]^2 = 2^2 \Rightarrow 4$$

$$\Rightarrow F' = \frac{F}{4} \rightarrow A$$

(2)

$g_{surface} = 10\ m/s^2$ $\quad M_p = \frac{1}{5} M_e$; $r_p = \frac{1}{2} r_e$.

we know $g = \frac{GM}{R^2}$

$$\frac{g_p}{g_e} = \frac{M_p}{M_e}\left[\frac{R_e}{R_p}\right]^2$$

$$\Rightarrow \frac{g_p}{10} = \frac{\cancel{M_e}}{5\cancel{M_e}}\left[\frac{R}{\frac{1}{2}R}\right]^2$$

$$\Rightarrow \frac{g_p}{\cancel{10}_2} = \frac{1}{\cancel{5}} \times 2^2$$

$$\Rightarrow \frac{g_p}{2} = 4 \Rightarrow g_p = 8\ m/s^2 \rightarrow C$$

(3)

Given $r_e' = \frac{1}{2}R$: $M_e' = \frac{1}{8}M$

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

$$\Rightarrow \frac{g'}{g} = \frac{M'}{M}\left[\frac{R}{R'}\right]^2$$

$$\Rightarrow \frac{g'}{g} = \frac{1}{8}\frac{\cancel{M}}{\cancel{M}}\left[\frac{2R}{R}\right]^2$$

$$\Rightarrow \frac{g'}{g} = \frac{1}{8} \times 2^2$$

$$\Rightarrow g' = \frac{4}{8}g = \frac{1}{2}g \rightarrow B$$

(4)

Given $r_m = \frac{1}{2}r_e = \frac{1}{2}R$

we know $g = \frac{GM}{R^2}$ (or) $g = \frac{4\pi}{3}\rho G R$

$$g \propto R$$

$$\frac{g_m}{g} = \frac{R_m}{R} \Rightarrow g_m = \frac{1}{2}\frac{R}{R} \times g = \frac{g}{2} \rightarrow B$$

(5)

we know $g = \frac{4\pi}{3}\rho G R$ (or) $\frac{4\pi}{3} d G R$

Given $r_2 = 2r_1$; $d_2 = 4d_1$

$$\frac{g_2}{g_1} = \frac{r_2}{r_1}\frac{d_2}{d_1}$$

$$\Rightarrow \frac{g_2}{g_1} = \frac{2\cancel{r_1}}{\cancel{r_1}}\frac{4\cancel{d_1}}{\cancel{d_1}} = \frac{8}{1}$$

$$\Rightarrow \frac{g_1}{g_2} = \frac{1}{8} \rightarrow A$$

(6) Given $h = R$

variation of g with height: $g_h = \frac{g}{(1+\frac{h}{R})^2}$

weight on the surface of earth $w = mg = 200$

$$\Rightarrow g_h = \frac{g}{(1+\frac{R}{R})^2} = \frac{g}{2^2} = \frac{g}{4}$$

weight at a height $w' = mg_h = \frac{mg}{4}$

$$= \frac{200}{4} = 50 \text{ kg wt}$$

$\rightarrow C$

(7)

we know For $h << R$

g at a height $h \Rightarrow g_h = g(1 - \frac{2h}{R})$

For $x << R$ g at a depth $= g_d = g(1 - \frac{d}{R})$

Given $g_h = g_d$

$$\Rightarrow 1 - \frac{2h}{R} = 1 - \frac{x}{R}$$

$$\Rightarrow \frac{2h}{R} = \frac{x}{R} \Rightarrow x = 2h$$

$\rightarrow B$

(8)

Given $R_1 = 2R$; $R_2 = 3R$; $w_1 = 2.5N$

Acc to law of Gravitation $F = \frac{GM_1M_2}{R^2}$

$$F \propto w \propto \frac{1}{R^2}$$

$$\frac{w_1}{w_2} = \left[\frac{R_2}{R_1}\right]^2$$

$$\Rightarrow \frac{2.5}{w_2} = \left(\frac{3R}{2R}\right)^2 \Rightarrow \frac{2.5}{w_2} = \frac{9}{4}$$

$$w_2 = \frac{4}{9} \times 2.5 = 1.1N$$

$\rightarrow A$

(9)

Given $M_m = \frac{1}{9} M_e$, $R_m = \frac{1}{2} R_e$

$W_{earth} = mg = 90$ kgwt where m → mass of the body.

we know $g = \frac{GM}{R^2}$

$$\frac{g_M}{g_e} = \frac{M_m}{m_e} \left[\frac{R_e}{R_m}\right]^2$$

$$\Rightarrow \frac{g_M}{g} = \frac{\frac{1}{9}\cancel{M_e}}{\cancel{M_e}} \left(\frac{\cancel{R_e}}{\frac{1}{2}\cancel{R_e}}\right)^2$$

$$\Rightarrow \frac{g_M}{g} = \frac{1}{9} \times 2^2 = \frac{4}{9}$$

$$g_M = \frac{4}{9} g$$

weight on mars $= W_m = m g_m = \frac{4mg}{9}$

$$= \frac{4}{9} \times 90 = 40 \text{ kgwt}$$

(10)

Given at certain height h

W_h = 36% less than weight on Earth

= ie 64% W_e

$$\cancel{m} g_h = \frac{64}{100} \cancel{m} g$$

$$\Rightarrow \frac{\cancel{g}}{(1+\frac{h}{R})^2} = \frac{64}{100} \cancel{g}$$

$$\Rightarrow \frac{1}{(1+\frac{h}{R})^2} = \frac{\cancel{64}^{16}}{\cancel{100}_{25}} = \frac{16}{25}$$

$$\Rightarrow (1+\frac{h}{R})^2 = \frac{25}{16} \Rightarrow 1+\frac{h}{R} = \frac{5}{4}$$

$$\Rightarrow \frac{h}{R} = \frac{5}{4} - 1 = \frac{1}{4}$$

$$\Rightarrow R = 4h$$

$$\Rightarrow h = R/4 \rightarrow D$$

(11) Given $g_m = \frac{1}{6} g_e$

We know $g \propto \frac{1}{R^2}$. If density = constant

$g = \frac{4\pi}{3} G \rho R$

$g \propto R$.

For ρ = constant $g_{\cancel{1}}$ $\frac{R_m}{R_e} = \frac{g_m}{g_e} = \frac{1}{6}$.

For mass = constant $g \propto \frac{1}{R^2} \Rightarrow \left(\frac{R_m}{R_e}\right)^2 = \frac{g_e}{g_m}$

$\Rightarrow \frac{R_m}{R_e} = \sqrt{\frac{g_e}{g_m}} = \sqrt{6}$.

If $\frac{\rho_e}{\rho_m} = \frac{5}{3}$ $g \propto R\rho$

$\Rightarrow \frac{R_m}{R_e} = \frac{g_m}{g_e} \times \frac{\rho_e}{\rho_m}$

$= \frac{1}{6} \times \frac{5}{3} = \frac{5}{18}$.

If $\frac{\rho_m}{\rho_e} = \frac{9}{5} \Rightarrow \frac{R_m}{R_e} = \frac{g_m}{g_e} \times \frac{\rho_e}{\rho_m} = \frac{1}{6} \times \frac{9}{5} = \frac{3}{10}$

only a, b are correct → A

(12)

we know $g = \frac{GM}{R^2} \Rightarrow \frac{\Delta g}{g} = \frac{\Delta m}{m} + 2\frac{\Delta R}{R}$

If No change in radius $\frac{\Delta g}{g} = \frac{\Delta m}{m}$.

Given $\frac{\Delta m}{m} = 1\%$ $\Rightarrow \frac{\Delta g}{g}$ = increases by 1%

$B \cdot E = mc^2 \Rightarrow B \cdot E \propto m \Rightarrow$ B·E increases by 1%

density $\propto m \Rightarrow$ density increases by 1%

→ A

(15)

Given $R' = \frac{R}{2}$ we know $g \propto \frac{1}{R^2}$

$$\frac{g'}{g} = \left(\frac{R}{R'}\right)^2 \Rightarrow \frac{g'}{g} = \left[\frac{R}{\frac{R}{2}}\right]^2 \Rightarrow g' = 4g \rightarrow C$$

(16)

at $h = R$.

$$g_h = \frac{g}{(1+\frac{h}{R})^2} = \frac{g}{(1+\frac{R}{R})^2} = \frac{g}{(1+1)^2} = \frac{g}{4} \rightarrow B$$

(17)

At depth $d = \frac{R}{4}$.

$$g_d = g(1-\frac{d}{R}) = g(1-\frac{R}{4R}) = \frac{3g}{4} \rightarrow A$$

L Task

Jee mains level

(11)

we know Gravitational force $F \propto \frac{1}{d^2}$

As the distance doubled $d' = 2d$

then $\frac{F'}{F} = \left(\frac{d}{d'}\right)^2 = \left(\frac{d}{2d}\right)^2 = \frac{1}{4}$

$$F' = \frac{F}{4} \rightarrow D$$

(12) Here the body is a Freely falling body.

time of descent $t = \sqrt{\frac{2h}{g}}$

(ie) $t \propto \frac{1}{\sqrt{g}}$.

we know $g_{moon} = \frac{g_e}{6}$

$\frac{t_m}{t_e} = \sqrt{\frac{g_m}{g_e}} \Rightarrow \frac{t_m}{t} = \sqrt{\frac{\frac{g_e}{6}}{g_e}} = \frac{1}{\sqrt{6}}$

$\Rightarrow t_m = \frac{t}{\sqrt{6}}$ s.

(13)

Given $g_p = \frac{g}{5}$, Max height $H = \frac{v^2}{2g}$

$H \propto \frac{1}{g} \Rightarrow \frac{H_p}{H_e} = \frac{g_e}{g_p}$

$\Rightarrow \frac{H_p}{H} = \frac{g}{\frac{g}{5}} = 5$

$\Rightarrow H_p = 5H \rightarrow C$

(14)

Here the body is a FFB [Freely falling body]

$S = \frac{1}{2} g t^2$ $S \propto g$

$\frac{S_p}{S_e} = \frac{g_p}{g_e}$

$\Rightarrow \frac{4h}{h} = \frac{g_p}{g}$

$g_p = 4g \rightarrow B$

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(15)

$\frac{r_1}{r_2} = \frac{2}{1}$ when the material is same

density = same

then From $g = G \frac{4\pi}{3} \rho R$

$g \propto R$

$\frac{g_1}{g_2} = \frac{R_1}{R_2} = \frac{2}{1} \rightarrow A$

(16)

weight on surface $w = mg$

at a height $h = R$ $g_h = \frac{g}{(1+\frac{h}{R})^2} = \frac{g}{(1+\frac{R}{R})^2}$

$\Rightarrow g_h = \frac{g}{4}$

weight at a height $w_h = mg_h$

$= \frac{mg}{4}$

$= \frac{w}{4} \rightarrow C$

(17)

Given $g_h = \frac{g}{2}$

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

$\Rightarrow 1 + \frac{h}{R} = \sqrt{2}$

$\Rightarrow \frac{h}{R} = (\sqrt{2}-1)$

$h = R(\sqrt{2}-1)$

$\rightarrow D$

(18)

$g_p = \frac{1}{6} g_e$; $R_p = \frac{1}{3} R$

we know $g = \frac{GM}{R^2}$ $\Rightarrow \frac{g_p}{g_e} = \frac{M_p}{M_e} \left[\frac{R_e}{R_p}\right]^2$

$\Rightarrow \frac{1}{6} = \frac{M_p}{M_e} \left[\frac{R}{\frac{1}{3}R}\right]^2$

$\Rightarrow \frac{M_p}{M_e} = \frac{1}{54} \rightarrow D$

(19)

Given $g_{depth} = 20\% \, g$

$$(1-\frac{d}{R})\cancel{g} = \frac{20}{100} g$$

$$\Rightarrow 1-\frac{d}{R} = \frac{1}{5} \Rightarrow \frac{d}{R} = 1-\frac{1}{5} = \frac{4}{5}$$

$$\Rightarrow d = \frac{4}{5} \times R$$

$$= \frac{4}{\cancel{5}} \times \cancel{6400}^{1280}$$

$$= 5120 \text{ km} \rightarrow B$$

(20)

Given $\omega_{depth} = \frac{3}{4} \omega_{surface}$

$$\Rightarrow \cancel{m} g_d = \frac{3}{4} \cancel{m} g$$

$$\Rightarrow g(1-\frac{d}{R}) = \frac{3}{4} \cancel{g}$$

$$\Rightarrow \frac{d}{R} = 1-\frac{3}{4} = \frac{1}{4}$$

$$d = \frac{R}{4} \rightarrow A$$

(21)

we know $g_h = \frac{g}{(1+\frac{h}{R})^2}$ if $r > R$

As we move away from centre of earth $(r > R)$ g decreases

~~As we~~ if $r < R$ $g_d = g(1-\frac{d}{R}) \rightarrow g_d$ ~~decreases~~ increases

at centre $g = 0$.

(B) The centrifugal force due to rotation slightly reduces the effective value of g. If the earth were stop rotating, this centrifugal force would disappear, and $g \rightarrow$ would increase.

$\rightarrow C$

(22)

Time period of Rotation of earth $T = 2\pi\sqrt{\frac{r^2}{GM}}$

$T \propto \sqrt{\frac{I}{G}}$

If $G \downarrow$, T increase, this means that the length of the year will also increases

$$F = \frac{GM_1M_2}{R^2} \rightarrow \cancel{G \propto R^2}$$

If G decreases, F decreases, as a result R increase $\rightarrow$ Radius of orbit.

$$K.E = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\sqrt{\frac{GM}{R}}\right)^2 = \frac{1}{2}m\frac{GM}{R}$$

$$K.E \propto G.$$

G decreases K.E will also decrease.

$\rightarrow B$

(24)

we know $g = \frac{GM}{R^2} \Rightarrow g \propto \frac{1}{R^2}.$

$R_{poles} < R_{equator}$

So $g_{poles} > g_{equator}$. $\rightarrow$ B

(25)

Given $R' = \frac{R}{3}$

we know $g \propto \frac{1}{R^2} \Rightarrow \frac{g'}{g} = \left[\frac{R'}{R}\right]^2 = \left[\frac{\frac{R}{3}}{R}\right]^2$

$\Rightarrow \frac{g'}{g} = \frac{1}{9} \Rightarrow g' = \frac{g}{9} \rightarrow A$

(26)

Given $h = 3R$

$g_h = \frac{g}{(1+\frac{h}{R})^2} = \frac{g}{(1+\frac{3R}{R})^2}$

$g_h = \frac{g}{4^2} = \frac{g}{16} \rightarrow B$

(27)

Given $d = \frac{R}{3}$

$g_d = g(1-\frac{d}{R}) = g(1-\frac{R}{3R}) = \frac{2g}{3} \rightarrow C$

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