GRAVITATION

EXERCISE – I

SINGLE CORRECT

1. $\frac{g}{4} = \frac{GM_e}{(R_e+h)^2}$

$\frac{GM_e^2}{4R^2} = \frac{GM_e}{(R_e+h)^2}$

$R_e + h = 2R_e$

$R_e = h$

2. From E.C.

$$O = -\frac{Gm_1m_2}{d} + \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

from M.C. $m_1v_1 - m_2v_2 = 0$

Now, $\frac{Gm_1m_2}{d} = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2\left(\frac{m_1v_1}{m_2}\right)^2$

$v_1 = \sqrt{\frac{2Gm_2^2}{d\,(m_1+m_2)}}$

$v_2 = \sqrt{\frac{2Gm_1^2}{d\,(m_1+m_2)}}$

Relative velocity of approach = $v_1 + v_2$

$v = \sqrt{\frac{2G\,(m_1+m_2)}{d}}$

3. According to given condition

$g - \omega^2R_e = g\left(1 - \frac{d}{R_e}\right)$

$\frac{\omega^2 R_e^2}{g} = d$

4. $g = \frac{GM_e}{R_e^2} = \frac{GM_e'}{(5R_e)^2}$

$\frac{\frac{4}{3}\pi R_e^3\rho}{R_e^2} = \frac{\frac{4}{3}\pi(5R_e)^3\rho'}{(5R_e)^2}$

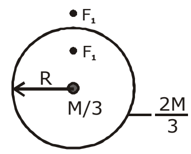
$\rho = 5\rho'$

5. $F_1 = \frac{GMm}{R^2}$

$F_2 = \frac{GMm}{3R^2}$

$\therefore$ Change = $\frac{2}{3}\frac{GMm}{R^2}$

6. $g' = \frac{G(2M_e)}{(2R_e)^2} = \frac{g}{2}$



$T = 2\pi\sqrt{\frac{l}{g}} = 2$

New time period $T' = 2\pi\sqrt{\frac{l}{g/2}} = 2\sqrt{2}$

7. THEORY

8. $G - \omega^2R = g/2$

$\omega^2R = g/2$

$\frac{v^2}{R} = g/2$

$2v^2 = gR$

$v_{es} = \sqrt{2gR}$

$v_{es} = \sqrt{2(2v^2)}$

$= 2v$

9. $g_A = \frac{G\frac{4}{3}\pi R_A^3\rho}{R_A^2}$; $g_B = \frac{G\frac{4}{3}\pi R_B^3\rho}{R_B^2}$

$R_A = 2R_B$

$\Rightarrow$ $g_A = 2g_B$

$V_{es} = \sqrt{2gR}$

$(V_{es})_A = \sqrt{2g_AR_A} = 2\sqrt{2g_BR_B}$

$(V_{es})_B = \sqrt{2g_BR_B}$

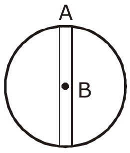
$\frac{v_A}{v_B} = 2$

10. $v_e = \sqrt{2gR} = \sqrt{\frac{2GM}{R}}$

from E.C.

$-\frac{GMm}{R} = \frac{-3GMm}{2R} + \frac{1}{2}mv^2$

$$\frac{GM}{2R} = \frac{1}{2}v^2$$

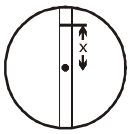


$$v = \frac{v_e}{\sqrt{2}}$$

11. $V_P = -\dfrac{GM}{R}(-ve)$

as $R \downarrow \dfrac{GM}{R} \uparrow$ but due to –ve it decreases.

12. $F = \dfrac{GMmx}{R^3}$



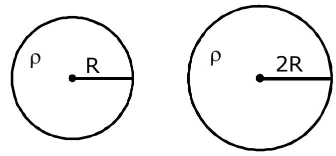
$$T = 2\pi\sqrt{\frac{R^3}{GM}}$$

T = 84.6 min

time to each other end $t = \dfrac{T}{2} = 42.3\text{min}$

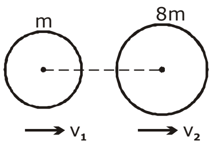
13. $g = \dfrac{GM}{R^2}$

14.



$\rho\,\dfrac{4}{3}\pi R^3 = m$ $\qquad \rho\,\dfrac{4}{3}\,(2R^3) = \mathbf{8}m$

from E.C.



$$O + O = -\frac{Gm8m}{3R}$$

$$+\frac{1}{2}mv_1^2 + \frac{1}{2}8mv_2^2 \qquad ....(1)$$

from M.C.

$mv_1 = 8mv_2$

$v_1 = 8v_2 \qquad ....(2)$

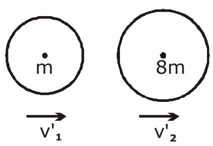
Put value from eq. (2) to eq. (1)

$$\frac{G8m^2}{3R} = \frac{1}{2}m64v_2^2 + \frac{1}{2}8m_2^2$$

$$v_2^2 = \frac{2Gm}{27R}$$

$$\Rightarrow \quad v_1^2 = \frac{64\times 2Gm}{27R}$$

After collision



$u_1 = v_1$

$u_2 = -v_2$

$\therefore$

$$v'_1 = \frac{o + \frac{8m}{2}(-v_2 - v_1)}{9m} = \frac{-4}{9}(v_1 + v_2)$$

$$v'_2 = \frac{v_1 + v_2}{18m}$$

Initial K.E. $= \dfrac{Gm8m}{3R}$

final K.E. $= \dfrac{1}{2}mv_1^2 + \dfrac{1}{2}8mv_2^2$

$$= \frac{1}{2}m\frac{16}{81}(v_1 + v_2)^2 + \frac{1}{2}8m(v_2 + v_1)^2\frac{1}{(18)^2}$$

$$= \frac{m}{g}(v_1 + v_2)^2$$

$$= \frac{2}{3}\frac{Gm^2}{R}$$

15. After collision r is max. separation from M.C.

$8mv'_2 + mv'_1 = 9mv$

$$8m\left[\frac{v_1 + v_2}{18}\right] - m\left[\frac{4}{9}(v_1 + v_2)\right] = 9mv$$

$v = 0$

from E.C.

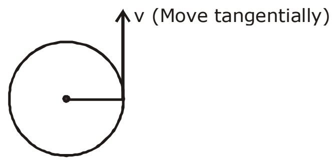
$$\frac{-G8m^2}{r} + \frac{1}{2}8mv^2 + \frac{1}{2}mv^2 = \frac{2}{3}\frac{Gm^2}{R} - \frac{G8m^2}{3R}$$

$\Rightarrow r = 4R$

16. In (a) & (b) $\nearrow \dfrac{2GM^2}{a^2}$

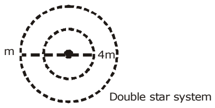
In (c) & (d) $\nearrow \dfrac{4GM^2}{a^2}$

17.



18. $T = \dfrac{2\pi}{\omega_{rel.}} = \dfrac{2\pi}{2\omega} = \dfrac{2\pi\times 24\times hr.}{2\times 2\pi}$

T = 12 hr.

19. 

$$\frac{k_1}{k_2} = \frac{1/2 I_1 \omega^2}{1/2 I_2 \omega^2} = \frac{m_2}{m_1}$$

20. (a) cavity at center, field is zero
(b) Arc of ellipse
(c) for escape T.E. = 0
(d) Notes.

21. $$\frac{-GM_e m}{R} = E_{initial}$$

$$E_{final} = \frac{-GM_e m}{2 \times 2R}$$

$$\therefore \quad \text{difference} = -\frac{GM_e m}{R} + \frac{GM_e m}{4R}$$

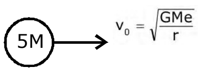
$$= \frac{3}{4} mgR$$

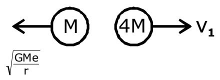
22. $$\text{P.E.} = -\frac{Gm_1 m_2}{r}$$

$$\text{T.E.} = -\frac{Gm_1 m_2}{2r}$$

$$\text{K.E.} = +\frac{Gm_1 m_2}{2r}$$

23. from Kepler's second law arial velocity = const.

24. 



$$5Mv_0 = -Mv_0 + 4Mv_1$$

$$\frac{3v_0}{2} = v_1$$

$$v_1 = \frac{3}{2}\sqrt{\frac{GM_e}{r}}$$

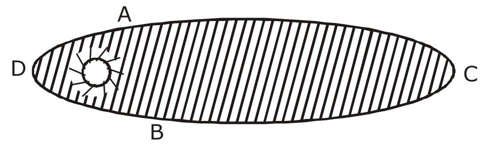
$$\text{T.E.} = -\frac{GM_e 4m}{r} + \frac{1}{2} 4m\left(\frac{9}{4}\frac{GM_e}{r}\right)$$

T.E. > 0

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

26. $$\frac{A}{T} = \frac{L}{2m}$$

$$L = \frac{2mA}{T}$$

27. 

$t_1 > t_2$ between area is ACB is greater than ADB.

28. Both D & C between
Total energy is always –ve

29. $$\frac{dA}{dt} = \frac{m\sqrt{\frac{GMe}{R}} \cdot R}{2m}$$

$$\frac{dA}{dt} \propto \sqrt{R}$$

30. $$\text{P.E.} = -\frac{Gm_1 m_2}{r}$$

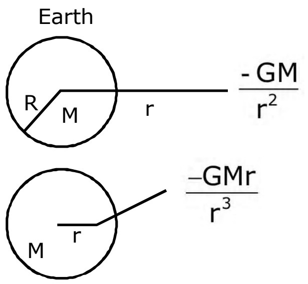
$$\text{T.E.} = -\frac{Gm_1 m_2}{2r}$$

$$\text{K.E.} = +\frac{Gm_1 m_2}{2r}$$

31. $$F = \frac{Gm_1 m_2}{r^2}$$

EXERCISE – II

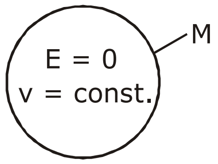
MULTIPLE CHOICE QUESTIONS

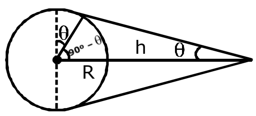
1. 

2. $m_1 \longrightarrow F \qquad F \longleftarrow m_2$

$a_1 = \dfrac{F}{m_1} \quad a_2 = \dfrac{F}{m_2}$

$m_1 < m_2 \Rightarrow a_1 > a_2$

3. 

4. 

$\sin\theta = \dfrac{R}{R+h}$

Area covered = $R^2 2\pi\,(1 - \cos(90 - \theta))$
$= 2\pi R^2\,(1 - \sin\theta)$
Area escaped = $4\pi R^2 - 2\pi R^2\,(1 - \sin\theta)$
$= 2\pi R^2\,(1 + \sin\theta)$

5. Radius decreases $\Rightarrow$ Velocity increases due to which K.E. increases

$m.v.r \Rightarrow m\sqrt{\dfrac{GM}{r}}\,.\,r \Rightarrow \alpha\sqrt{r}$

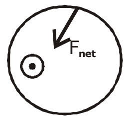
$T^2 \propto r^3$

6. Theory

7. $\dfrac{-GM_e m}{r}$ = P.E.

$v = \sqrt{\dfrac{GM_e}{r}}$

$\omega = \dfrac{2\pi}{T} \qquad r\uparrow\ T\uparrow\ \omega\downarrow$

8. (A) 

(B) Both direction and Magnitude not change
(C) Total Mechanical is constant
(D) Linear momentum changes becoz v change as r changes but rv = constant

9. $v = \sqrt{\dfrac{GM_e}{R}}$ (Max.)

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

T.E. = $\dfrac{-GMm}{2R}$

10. $T = \dfrac{2\pi}{\sqrt{GM_e}} r^{3/2}$

$g = \dfrac{GM_e}{R_e^{\,2}}$ and $T_{min.}$ at $r_{min.} = R$

$\Rightarrow \quad T_{min.} = \dfrac{2\pi R^{3/2}}{\sqrt{gR_e^{\,2}}} = 2\pi\sqrt{\dfrac{R}{g}}$

EXERCISE – III

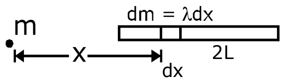
SUBJECTIVE PROBLEMS

1. $TE = -\frac{Gm^2}{a} - \frac{2Gm^2}{a} - \frac{3Gm^2}{a}$

$\Rightarrow$ $T.E. = \frac{-6Gm^2}{a}$

$final = \frac{-6Gm^2}{2a}$

$W.D. = \frac{-6Gm^2}{a} + \frac{6Gm^2}{2a} = \frac{3Gm^2}{a}$

2. 

$\lambda = \frac{m}{2L}$

$dF = \int_{L}^{3L} \frac{Gm\lambda dx}{x^2}$

$F = Gm\lambda \left[\frac{1}{L} - \frac{1}{3L}\right]$

$F = \frac{Gm^2}{3L}$

3. (i) $\frac{-GM_e.m}{R} + \frac{1}{2}mv^2 = \frac{-GM_em}{9R}$

$v = \frac{4}{3}\sqrt{\frac{GM_e}{R}}$

(ii) $\frac{-GM_em}{R} + \frac{1}{2}mv^2 = \frac{-GM_em}{5R} + \frac{1}{2}mv_1^2$

$v_1 = \frac{2}{3}\sqrt{\frac{2}{5}\frac{GM_e}{R}}$

4. When sense of ratation of both earth and satellite is opposite

$T_1 = \frac{2\pi}{\omega_{rel}} = \frac{2\pi}{\frac{2\pi}{24} + \frac{2\pi}{1.5}}$

When sense of ralation of both earth and satellite is same.

$T_2 = \frac{2\pi}{\frac{2\pi}{24} - \frac{2\pi}{1.5}}$

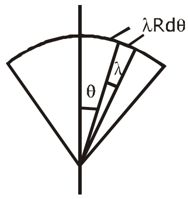
5. $\therefore$ $|\,T.E.\,| = |\,\frac{P.E.}{2}\,|$

$T.E._{final} = -1 \times 10^5 J$

$T.E._{initial} = -2 \times 10^5 J$

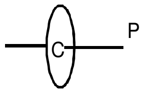
So given energy = 1×10^5 J

6. $E = \frac{G}{R^2}\int_{-\alpha}^{\alpha} \lambda R d\theta \cos\theta$



$E = \frac{G\lambda}{R}[2\sin\alpha]$

Potential = $\frac{Gm}{R} = \frac{GR(2\alpha)\lambda}{R} = -G\lambda 2\alpha$

7. 

$V_P = \frac{-GM}{\sqrt{2}a}$

$V_P = \frac{-GM}{a}$

$\frac{1}{2}mv^2 = \frac{GMm}{a}\left[1 - \frac{1}{\sqrt{2}}\right]$

8. $\frac{g}{\left[1 + \frac{h}{Re}\right]^2} = g\left[1 - \frac{h}{Re}\right]$

9. $-\frac{GM_em}{2r} - \frac{GM_em}{2r} = -\frac{GM_em}{r}$

By M.C. 

final velocity = 0

$\therefore$ $T.E = \frac{-GM_e 2m}{r}$

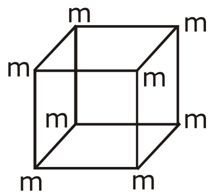
Straight line.

10. $\frac{-GM_em}{R_e} + \frac{1}{2}m(k^2v_e^2) = \frac{-GM_em}{(R_e + h)}$

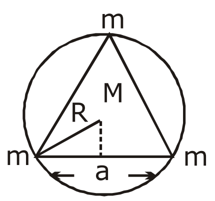
11. $\frac{-GMm}{2r} = T.E._{initial}$

$$\frac{-GMm}{2R_e} = T.E._{final}$$

$$Ct = \frac{GMm}{2}\left(\frac{1}{Re} - \frac{1}{r}\right)$$

12. 

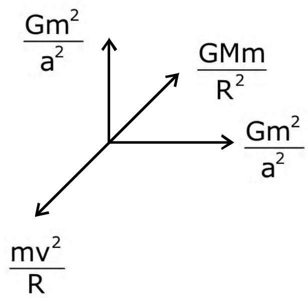
$$U = \frac{-8}{2}\left[\frac{3Gm^2}{\alpha} + \frac{3Gm^2}{\sqrt{2}L} + \frac{Gm^2}{\sqrt{3}\ L}\right]$$

13. (i) 

$$U = 0\ \frac{-Gm^2}{1} - \frac{Gm^2}{a} - \frac{Gm^2}{a} - \frac{3GMm}{R}$$

$2R\cos 30^o = a$

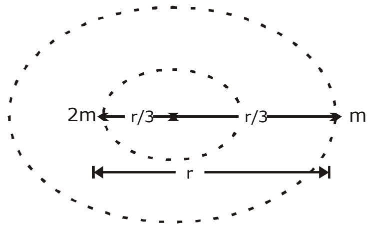
$$= \frac{-3Gm}{R}\left[\frac{m}{\sqrt{3}} + M\right]$$

(ii) 

$$\frac{GMm}{R^2} + \frac{\sqrt{3}Gm^2}{3R^2} = \frac{mv^2}{R}$$

$$\frac{GMm}{R^2} + \frac{\sqrt{3}Gm^2}{3R^2} = \frac{mv^2}{R}$$

$$v = \sqrt{\frac{G}{R}\left(\frac{m}{\sqrt{3}} + M\right)}$$

14. 

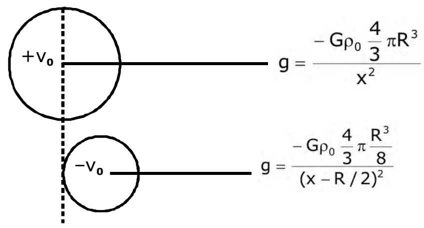
$$\frac{G2m^2}{r^2} = m\omega^2\frac{2}{3}$$

$$\frac{3Gm^2}{r^3} = \omega^2$$

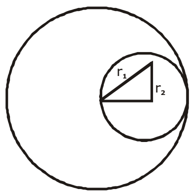
Given $m = \frac{M_s}{3}$

then $\frac{3GM_s}{r^3 3} = \frac{GM_s}{R^3}$

$r = R$

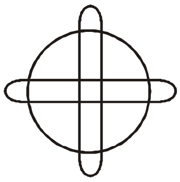
15. 

$$g_{net} = \frac{\pi G\rho_0 R^3}{6}\left[\frac{1}{(x - \frac{R}{2})^2} - \frac{8}{x^2}\right]$$



$$g_{net} = \frac{-G\frac{4}{3}\pi R^3\rho_0 \vec{r_1}}{R^3} + \frac{G\frac{4}{3}\pi\frac{R^3}{8}\rho_0 \vec{r_2}}{R^3}$$

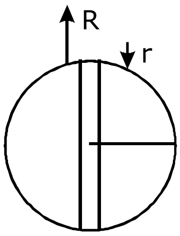
$$= \frac{4G\rho_0\pi}{3}\left[\vec{r_2} - \vec{r_1}\right] = \frac{-2}{3}\pi G\rho_0 R\hat{i}$$

16. 

$v = \sqrt{\frac{GM_e}{r}}$

$\max^m$ distance = $r\sqrt{2}$

$v_{relative} = \sqrt{2}\sqrt{\frac{GMe}{r}}$

17. 

$$\frac{-GMm}{2R} = \frac{-GMm}{R} + \frac{1}{2}mv^2$$

$v = \sqrt{\frac{GM}{R}}$

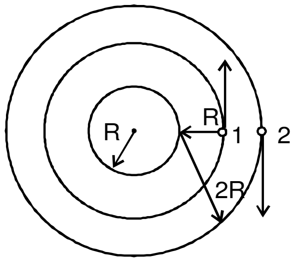
$\therefore$ Time = $\frac{2R}{v}$

$= 2 \times \sqrt{\frac{R^3}{GM}}$

EXERCISE – IV TOUGH SUBJECTIVE PROBLEMS

1 $\omega_1 = \dfrac{\sqrt{GM}}{(2R)^{3/2}}$; $\omega_2 = \dfrac{\sqrt{GM}}{(3R)^{3/2}}$

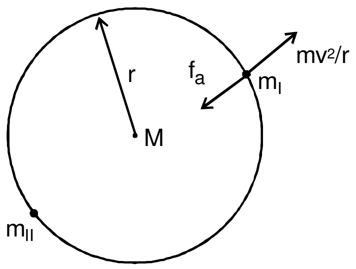
with respect to one time taken



$$t = \frac{2\pi}{\omega_1+\omega_2} \Rightarrow t = \frac{2\pi R^{3/2}(6\sqrt{6})}{\sqrt{GM}(2\sqrt{2}+3\sqrt{3})}$$

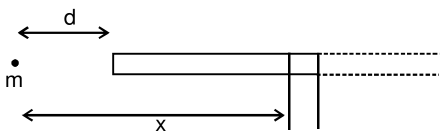
2 Attraction force $F_a = \dfrac{mv^2}{r}$

$$\frac{GMm}{r^2} + \frac{Gm^2}{4r^2} = \frac{mv^2}{r}$$



$$\frac{G}{4r}[4M+m] = v^2 \quad \text{Now} \quad T = \frac{2\pi r}{v} = \frac{4\pi r^{3/2}}{\sqrt{G(4M+m)}}$$

3 $dF = G\left(\dfrac{\lambda}{x}\right)\dfrac{dx.m}{x^2}$



$$F = Gm\lambda \int_{x=d}^{x=\infty} \frac{dx}{x^3} \Rightarrow F = -Gm\lambda\left[\frac{1}{x^2}\right]_d^{\infty} = -\frac{Gm\lambda}{2d^2}$$

4 In a cavity gravitational field

$$a = \frac{\rho r(4\pi r)}{3}$$

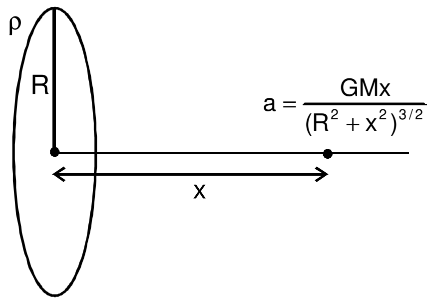
$$r = R/2 \Rightarrow a = \frac{4\pi\rho RG}{6}$$

from $v^2 - u^2 = 2as \Rightarrow v^2 = 2\left(\dfrac{4\pi\rho RG}{6}\right)\dfrac{R}{2} \Rightarrow$

$$v = \sqrt{\frac{2}{3}\pi G\rho R^2}$$

5 $\dfrac{da}{dx} = 0$ for $a_{max} \Rightarrow x = \dfrac{R}{\sqrt{2}}$

$$a = \frac{aMR}{\sqrt{2}\left(\dfrac{3R^2}{2}\right)^{3/2}} = \frac{2GM}{(3)^{3/2}R^2}$$



$$M = (\pi r^2)(2\pi r)\rho \Rightarrow a = \frac{4\pi^2 G r^2 \rho}{(3)^{3/2}R}$$

Now $F = ma$

6 $R_{max} = 4 = \dfrac{u^2}{g} \Rightarrow u = \sqrt{4g}$

According to problem $\sqrt{4g} = \sqrt{2g_p R_p}$

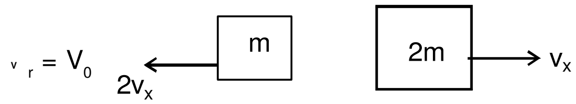
$$4g = 2g_p R_p$$

$$\frac{GM_e}{R_e^2}(2) = \frac{GM_p}{R_p^2}.R_p$$

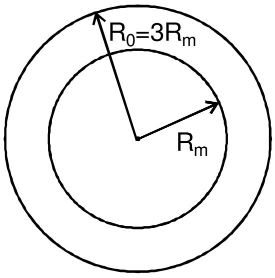
$$\frac{\left(\frac{4}{3}\pi R_e^3\right)\rho(2)}{R_e^2} = \frac{\left(\frac{4}{3}\pi R_p^3\right)(2\rho)Rp}{R_P^2}$$

$R_p = \sqrt{R_e} \Rightarrow R_p = \sqrt{6.4}\,\text{Km}$

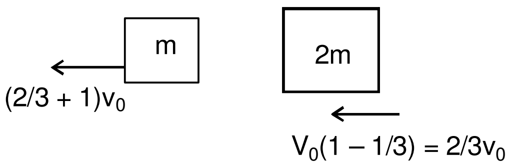
7 w.r toCOM of ship & pad



$3V_x = V_0$



$V_x = V_0/3$



$$K_I + U_i = K_f + U_f$$

$$\frac{1}{2}(2m)\left(\frac{2}{3}v_0\right)^2 + \left[\frac{-GM(2m)}{3R_m}\right] = \frac{1}{2}(2m)v^2 + \left[\frac{-GM(2m)}{R_m}\right]$$

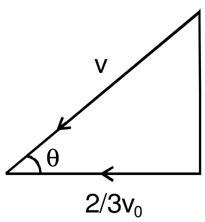
...(1)

$$\frac{GM(m_2)}{R_0^2} = \frac{(2m)v_0^2}{R_0} \Rightarrow v_0 = \sqrt{\frac{GM}{R_0}} = \sqrt{\frac{GM}{3R_m}}$$

...(2)

from (1) & (2)

$$\therefore \quad v = \sqrt{\frac{40}{27}}\sqrt{\frac{GM}{R_m}}$$



$$\cos\theta = \frac{1}{\sqrt{10}} \quad \& \sin\theta = \frac{3}{\sqrt{10}} \quad \text{Ans.}$$

8

$$-\frac{GMm}{R} + \frac{1}{2}mv_0^2 = \frac{-GMm}{R+h} + \frac{1}{2}mv^2 \qquad ...(1)$$

$$v_0 = \sqrt{\frac{3}{2}\frac{Gm}{R}} \qquad ...(2)$$

(given)

conserved about centre of earth

$\therefore$ m R v_0 sin 60° = m(R + h) v ...(3)

Solving these (3) equations

we get $v = \frac{R}{R+h}\frac{\sqrt{3}}{2}v_0$ & $h = R\left(1 + \frac{\sqrt{7}}{2}\right)$

Ans. (i)

$$R_C = \frac{v^2}{a_\perp} = \frac{R^2}{(R+h)^2} \times \frac{3}{4} \times \frac{3}{2}\frac{GM}{R} \times \frac{(R+h)^2}{GM}$$

$$R_C = \frac{9}{8}R$$

$R_C \simeq 1.13R$ Ans.

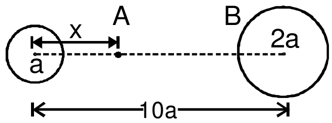
EXERCISE – V   JEE QUESTIONS

1 $T = \dfrac{2\pi}{\sqrt{GMs}} R^{3/2} = 365\,\text{days}$, $T' = \dfrac{2\pi}{\sqrt{GMs}}\left(\dfrac{R}{2}\right)^{3/2}$

after dividing $\dfrac{365}{T'} = (2)^{3/2}$, $T' = 129.4$ days

2 point A where $F_{net} = 0 \Rightarrow \dfrac{GM}{x^2} = \dfrac{16GM}{(10a - x)^2}$

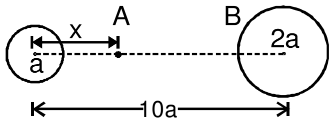
$x = 2a$



So E/C between point A & B

$$-\frac{16GMm}{2a} + \frac{1}{2}mv^2 - \frac{GMm}{8a} = \frac{-GMm}{2a} - \frac{16GMm}{8a}$$

$$\frac{1}{2}mv^2 = \frac{45}{8}\frac{GMm}{a} \Rightarrow v = \frac{3}{2}\sqrt{\frac{5GM}{a}}$$



3 $|\text{P.E.}| = 2\,|\text{T.E.}| = 2E_0$

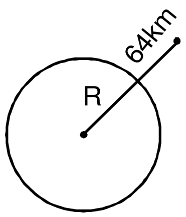
4 $T + mg_{eff} = m\omega^2 (R + 64)$

[REE 98]

$T = m\omega^2 (R + 64) - mg_{eff}$

$$\omega^2 = \frac{GM}{R^3} \Rightarrow T = \frac{mGM}{R^3}(R + 64) - mg\left[1 - \frac{2h}{R}\right]$$

$$T = \frac{GMm}{R^2} + \frac{64\,GMm}{R^3} - mg + \frac{2mg(64)}{R}$$



$$T = \frac{64mg}{R} + \frac{128\,mg}{R}$$

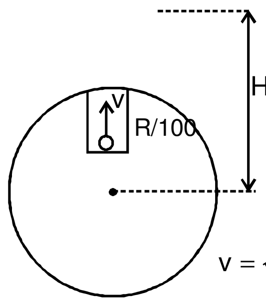
$$T = \frac{192 \times 100 \times 10}{6400 \times 10^3} = 3 \times 10^{-2}\text{N}$$

5 Gravitational force is conservative so work done only depends on position not a path taken

6 from E.C.

$$-\frac{GMm}{2R^3}\left[3R^2 - \left(\frac{99}{100}\right)R^2\right] + \left[\left(\frac{1}{2}\right)m\left(\frac{2GM}{R}\right)\right] = -\frac{GMm}{H}$$

after solving $H \simeq 100.5R$



$v = \sqrt{2GM/R}$

Height from the surface H = H – R

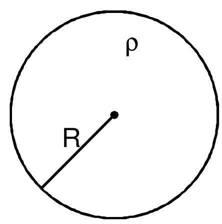
$H' = 99.5$ R

7 In theory $T_A = T_B$

8 for r < R

$$\frac{GMr}{R^3} = \frac{mv^2}{r}$$

$v \propto r$



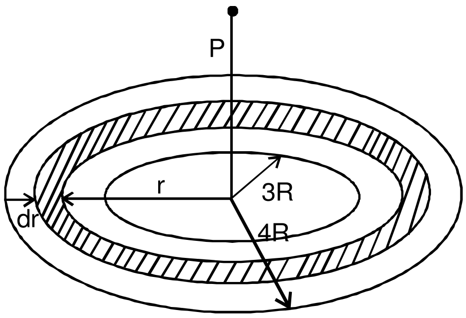
for $r \geq R \Rightarrow \dfrac{GM}{r^2} = \dfrac{mv^2}{r} \Rightarrow v^2 \propto \dfrac{1}{r}$

9 Astronaut feel weight lessness when only gravitational field is act

10 $\sigma = \dfrac{M}{\pi(4R)^2 - \pi(3R)^2} = \dfrac{M}{7\pi R^2}$

$dm = \sigma\, 2\pi r dr$

$$U_p = -\int_{3R}^{4R} \frac{Gdm(1)}{(16R^2 + r^2)^{1/2}} = -\int_{3R}^{4R} \frac{2\pi G\sigma r dr}{(16R^2 + r^2)^{1/2}}$$



after solving $U_p = -\frac{2GM(4\sqrt{2}-5)}{7R}$

work done by external agent $= U_\infty - U_p$

$$= \frac{2GM(4\sqrt{2}-5)}{7R}$$

11 $\frac{L}{L_B} = \frac{m_A v_A r_A + m_B v_B r_B}{m_B v_B r_B} = \frac{m_A v_A r_A}{m_B v_B r_B} + 1 = \frac{m_B}{m_A} + 1 = 6$

12 Given $\frac{GM_P}{R_P^2} = \frac{\sqrt{6}}{11}\frac{GM_e}{R_e^2} \Rightarrow \frac{M_P R_e^2}{M_e R_p^2} = \frac{\sqrt{6}}{11}$ ....(1)

$\rho_p = \frac{2}{3}\rho_e$

$\frac{M_P}{4/3\pi R_p^3} = \frac{2}{3}\frac{Me}{4/3\ \pi R_e^3} \Rightarrow \frac{M_P R_e^3}{M_e R_p^3} = \frac{2}{3}$ ...(2)

$\sqrt{\frac{2GM_e}{R_e}} = 11$; $\sqrt{\frac{2GM_p}{R_p}} = v_{esc} \Rightarrow \frac{11}{V_{esc}} = \sqrt{\frac{R_P Me}{R_e M_p}}$

...(3)

from (1), (2), (3) $V_{sc} = 3$ km/sec

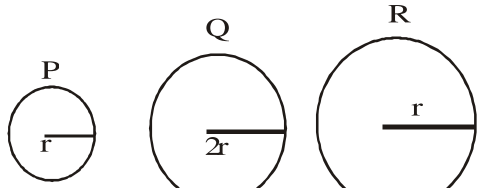
13 $\frac{GM_eM_s}{r^2} = \frac{m_s v^2}{r} \Rightarrow \frac{G.Me}{r} = v^2$

Object escape when its P.E equal to its K.E.

$\Rightarrow$ K.E. $= \frac{G.Mem_0}{r}$

K.E. $= m_0 v^2 = mv^2$

14. B,D



$M_P = M$ $M_Q = 8M$ $M_R = 9M$

Radius of R will be slightly larger than 2r,

$V = \sqrt{2gR} = \sqrt{\frac{2GM}{R}} \propto R$

Hence $V_R > V_Q > V_P$

Also $\frac{V_P}{V_Q} = \frac{1}{2}$.