Exercise Level - 01

1. The force of ~~attraction~~ gravition is ~~attract~~ conservative.

2. $F = \dfrac{Gm_1m_2}{r^2}$ if r becomes $2r$.

$$F' = \frac{Gm_1m_2}{4r^2} = \frac{F}{4}$$

3. $$F = \frac{G\,m(M-m)}{d^2}$$

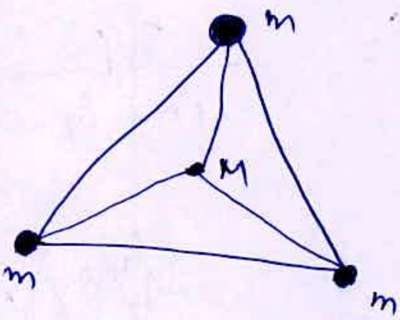
$$\frac{dF}{dm} = \frac{G}{d^2}\left[M - 2m\right]$$

Putting $\dfrac{dF}{dm} = 0$

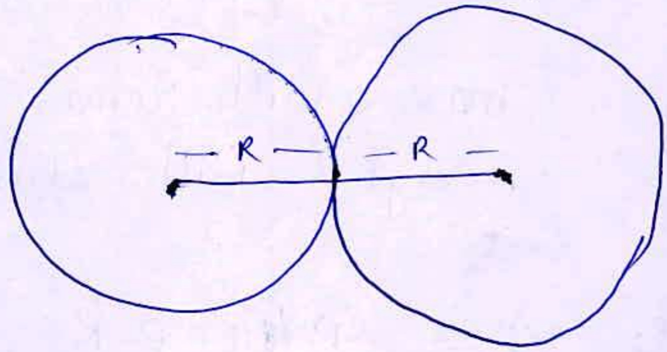
$$M = 2m$$

$$\therefore \frac{m}{M} = \frac{1}{2}$$

4. Because each force has same magnitude and acts symmetrically hence resultant force is zero.



5. ~~Ptop~~ $F = \dfrac{GMM}{(2R)^2} = \dfrac{GM^2}{4R^2}$



~~to~~ 4 $M = dV$

$$M = d\,\frac{4}{3}\pi R^3$$

$$M = d\,\frac{4}{3}\pi R^3$$

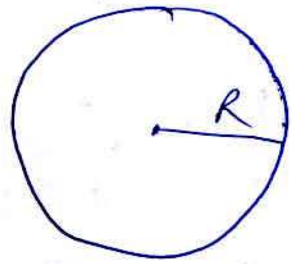
$$\therefore\ F = \frac{G\, d^2 \times \frac{16\pi^2}{9} \times R^6}{4R^2}$$

$$F = \frac{G d^2 \times 16\pi^2}{4 \times 9}\ R^4$$

$$\therefore\ F \propto R^4$$

6. ~~If~~ c

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



$$\& \quad M = d\left(\frac{4}{3}\pi R^3\right)$$

$$g = \frac{G}{\cancel{R^2}}\left(\frac{d \times 4\pi R^{\cancel{3}}}{3}\right)$$

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

7. ~~A~~ $\cancel{g' = G\left(\frac{M_e}{2}\right)}$

mass will remain unchanged whereas weight will change.

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

$$\therefore \frac{g_1}{g_2} = \frac{\rho_1 R_1}{\rho_2 R_2} = \frac{1}{2} \times \frac{4}{1} = \frac{2}{1}$$

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

$$\therefore \frac{g_{moon}}{g_{earth}} = \frac{1}{6} = \frac{\cancel{\rho_{moon}}}{\cancel{\rho_{earth}}} \frac{R_{moon}}{R_{earth}}$$ [$\rho_{moon} = \rho_{earth}$ as given in ques].

$$\frac{R_{moon}}{R_{earth}} = \frac{1}{6}$$

10. $mg = \frac{GMm}{R^2}$

$$mg' = \frac{GMm}{\left(R+\frac{R}{2}\right)^2} = \frac{GMm}{\left(\frac{3}{2}R\right)^2} = 4\frac{GMm}{9R^2} = \frac{4}{9}W$$

11. $g' = g\left(1-\frac{2h}{R}\right)$ [for small h]

$$= g\left[1-\frac{2\cdot 64\ km}{6400\ km}\right] = g\left[1-\frac{2}{100}\right] = g\left[\frac{49}{50}\right]$$

$= 960.40\ cm/sec^2$

12. $g' = g\left[1 - \frac{2h}{R}\right]$

$\therefore g' = g - \frac{2h}{R}g$

$$\boxed{\therefore g - g' = \frac{2h}{R}g}$$

13. at the center of earth forces from all the sides will be symetric.

14. $g_{outside} = g_{surface}\left[1 - \frac{2h}{R}\right]$

$g_{inside} = g_{surface}\left[1 - \frac{h}{R}\right]$

$\therefore \frac{g_{surface} - g_{outside}}{g_{surface}} \times 100 = 1$

$\therefore \frac{2h\, \cancel{g_{surface}}}{R\, \cancel{g_{surface}}} \times 100 = 1$

$\therefore \frac{2h}{R} \times 100 = 1.$

$\frac{-g_{inside} + g_{surface}}{g_{surface}} \times 100 = \frac{h\, \cancel{g_{surface}}}{R\, \cancel{g_{surface}}} \times 100$

$= \frac{1}{2}\% = 0.5\%.$

15. $g_{inside} = g_{surface}\left[1 - \frac{h}{R}\right]$

$$= g_{surface}\left[1 - \frac{R}{2R}\right]$$

$$= \frac{g_{surface}}{2}$$

$$\therefore \; W' = \frac{W}{2}$$

16. acceralation due to gravity is greater at poles.

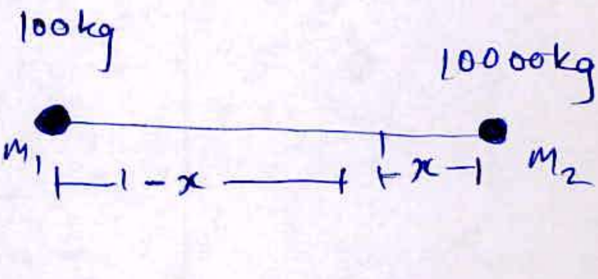
17. Weight will be maximum at poles.

18. g will remain same because,

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

Mass remains unchanged after shrinking & it is at the same distance as before.

19. $\frac{G M_1}{(1-x)^2} = \frac{G M_2}{x^2}$



$\therefore \dfrac{x^2}{(1-x)^2} = 100$

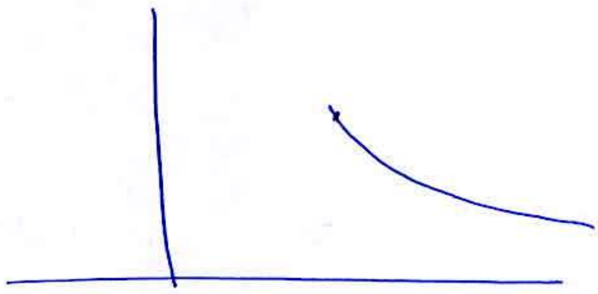
$\therefore \dfrac{x}{1-x} = 10$

$\therefore x = 10 - 10x$

$\therefore x = \dfrac{10}{11}$

$$\boxed{\therefore 1-x = \frac{1}{11}}$$

20. inside shell feild is zero & outside the shell it behaves as if Mass was placed at the center of the shell.



21.

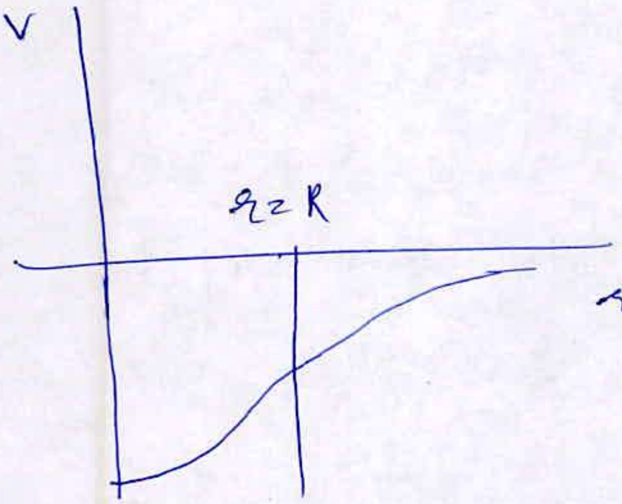
22 inside a shell net force is zero.

23. $V_{surface} = -\frac{GM}{R} = V.$

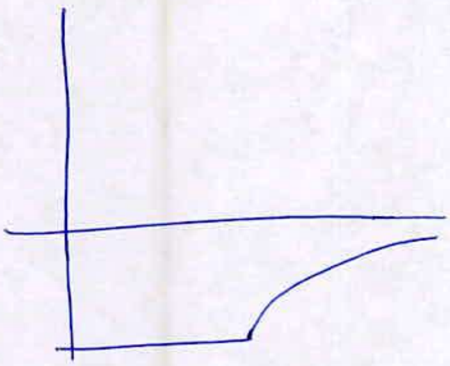
$V_{inside} = -\frac{GM}{2R}\left[3 - \left(\frac{r}{R}\right)^2\right]$

$= -\frac{3GM}{2R} = \frac{3}{2}\left(-\frac{GM}{R}\right) = \frac{3}{2}V.$

24.

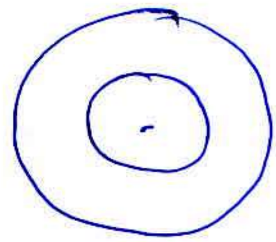


25.



inside $\vec{E} = 0$ hence potential is constant.

26) $V_{center} = V_{due\ to\ M} + V_{due\ to\ m}$



$$= -\frac{GM}{R} + \left(-\frac{Gm}{r}\right) = -G\left[\frac{M}{R} + \frac{m}{r}\right]$$

27) $$v_e = \sqrt{\frac{2GM_e}{R_e}}.$$

$$\therefore\ v_p = \sqrt{\frac{2GM_p}{R_e}} = \sqrt{\frac{2G6 \times M_e}{2R_e}}$$

$$= \sqrt{3\left(\frac{2GM_e}{R_e}\right)} = \sqrt{3}\, v_e$$

28. is independent of the mass of the object.

29. $$v_e = \sqrt{\frac{2GM_e}{R_e}}$$

$$v_0 = \sqrt{\frac{GM_e}{R_e}}$$

$$\therefore\ v_e = \sqrt{2}\, v_0$$

30. $v_0 = \sqrt{\frac{GM}{(R+h)}} = v$

$-\frac{GMm}{(R+h)} + \frac{1}{2} m v_e^2 = 0.$

$\therefore \frac{2GM}{(R+h)} = v_e^2$

$\therefore v_e = \sqrt{\frac{2GM}{(R+h)}}$

$\therefore v_e = \sqrt{2}\, v$

31. $E = \frac{1}{2} m v_e^2 = \frac{1}{2} \times 500 \times \frac{2GM}{R}$

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

$\therefore gR^2 = GM$

$\therefore E = \frac{1}{2} \times 500 \times 2 \times \frac{gR^{\cancel{2}}}{\cancel{R}}$

$= \frac{1}{2} \times 500 \times 2 \times 9.8 \times 6400 \times 10^3$

$= 3.1 \times 10^{10}$ J

32. $v_e = \sqrt{\frac{2GM_e}{R_e}} = \sqrt{2}$

$v_e' = \sqrt{\frac{2G(2M_e)}{(R_e/2)}} = \sqrt{\frac{2GM_e \times 4}{R_e}}$

$= 2\sqrt{\frac{2GM_e}{R}} = 2v_e$

33. $\frac{1}{2}m(10\times10^3)^2 - \frac{GMm}{R} = -\frac{GMm}{R'}$

$\therefore \quad g = \frac{GM}{R^2}$

$\frac{1}{2}\cancel{m}(10\times10^3)^2 - \frac{(gR^2)\cancel{m}}{\cancel{R}} = -\frac{GM\cancel{m}}{R'}$

$-\frac{gR^2}{R'} = \frac{1}{2}\cdot\times(10^4)^2 - gR$

$\boxed{\therefore \quad R' = 4R}$

34. less the escape velocity means total energy will be positive.

35. $v_p = \sqrt{\frac{2GM_p}{R_p}} = \sqrt{\frac{2G\left(\frac{4}{3}\pi R_p^3\right)\rho}{R_p}} = \sqrt{\frac{8G\pi}{3} R_p^2 \rho}$

35. $v_p = R_p \sqrt{\frac{8G\pi}{3}\rho}$

$v_e = R_e \sqrt{\frac{8G\pi\rho}{3}}$

$\therefore \frac{v_p}{v_e} = \frac{R_p}{R_e} = 2$

$\therefore \frac{v_p}{2} = v_e$

36. $\left| -\frac{GM}{R} \right| = E = \frac{GM}{R}$

$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{2E}$

37. $\frac{1}{2} m v_e^2 - P.E = 0$

$\therefore -\frac{1}{2} m v_e^2 = P.E$

$\therefore P.E = -\frac{1}{2} \times 1 \times (100)^2$

$= -\frac{1}{2} \times 10000$

$= -5000$ J

38. $P.E_1 = -\frac{GMm}{R+\frac{R}{5}} = -\frac{GMm\,5}{6R}$.

P.E at surface $= -\frac{GMm}{R}$

$\therefore$ $P.E_1 - P.E_{\text{at surface}} = -\frac{GMm5}{6R} + \frac{GMm}{R.}$

$= \frac{GMm}{R}\left[1-\frac{5}{6}\right] = \frac{GMm}{6R}$

$\therefore \frac{GM}{\cancel{}} = gR^2$ 4. $R = 5h$

$\therefore$ Increase in P.E $= \frac{gR^2m}{6R} = \frac{gmR}{6}$

$\therefore$ $= \frac{gm(5h)}{6}$

39. $-\Delta P.E = W$

$\therefore W = -\left[-\frac{Gm^2}{L} - \frac{Gm^2}{L} - \frac{Gm^2}{L}\right]$

$= \frac{3Gm^2}{L} = \frac{3\times G\times(10^{-2})^2}{0.1}$

$= 2\times 10^{-13}$ J

40. At infinity P.E is zero & -ve in all other places.

41. $v_0 = \sqrt{\frac{GM}{R}} = v$

$$v_0' = \sqrt{\frac{GM}{R+\frac{R}{2}}} = \sqrt{\frac{2GM}{3R}} = \sqrt{\frac{2}{3}}\,v$$

42. Conserving angular momentum,

$mva = mv'b$

$\therefore\ v' = \frac{va}{b}$

43. $$\frac{1}{2}m(\;+v')^2 - \frac{GMm}{r} = 0.$$

To escape net energy must be zero.

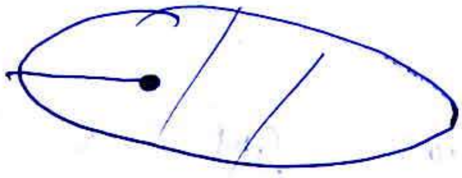
$$\therefore\ \frac{1}{2}\cancel{m}(\;+v')^2 = \frac{GM\cancel{m}}{r}$$

$$(\;+v') = \sqrt{\frac{2GM}{r}}$$

$$\cancel{v' = \sqrt{\frac{2GM}{r}} - \sqrt{\frac{GM}{r}} = (\sqrt{2}-1)v_0}$$

$$\therefore \; v' = \sqrt{2} \times v_0$$

44.



$$V_A = \sqrt{\frac{GM}{r_A + R}}$$

$$V_B = \sqrt{\frac{GM}{r_B + R}}$$

$$\therefore \; \frac{V_A}{V_B} = \sqrt{\frac{r_B + R}{r_A + R}}.$$

45.

$$\cancel{m}\omega^2 r = \frac{G\cancel{m}M}{r^2}$$

$$\omega = \sqrt{\frac{GM}{r^3}}$$

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{r^3}{GM}}.$$

$$\therefore \; \frac{T_1}{T_2} = \sqrt{\frac{(7R)^3}{(3.5R)^3}}$$

$$\therefore \; 24 \times \sqrt{\left(\frac{1}{2}\right)^3} = T_2.$$

$24 \times \frac{1}{2\sqrt{2}} = T_2 = \frac{12}{\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}} = 6\sqrt{2}\,hr$

46. $T = 2\pi\sqrt{\frac{\cancel{R}^3}{GM}} = 2\pi\sqrt{\frac{\cancel{R^3}}{G \times \frac{4}{3}\pi \cancel{R^3}\,\rho}}$

Hence if densities are same time period will be same.

47. Gravitational force won't change on shrinking.

48. $V_{rel} = \omega_S R - \omega_C R$.

$\therefore \omega_{rel} R = \omega_S R - \omega_C R$

$\therefore \omega_{rel} = \omega_S - \omega_C$

$\therefore T = \frac{2\pi}{\omega_{rel}} = \frac{2\pi}{\omega_S - \omega_C}$

49. $F \propto \frac{1}{r^n}$

$\therefore F = \frac{K}{r^n}$

$\therefore \frac{K}{r^n} = \frac{m\omega^2 r}{\cancel{r_0}}$

$$\therefore \omega^2 \propto \frac{1}{r^{n+1}}$$

$$\therefore \omega \propto \frac{1}{r^{(n+1)/2}}$$

$$\therefore T \propto r^{(n+1)/2}$$

50. 7R.

51. $v_0 = \frac{v_e}{2} = \sqrt{\frac{2GM}{4R}} = \sqrt{\frac{GM}{2R}}$

$$\therefore v_0 = \sqrt{\frac{GM}{r}} = \sqrt{\frac{GM}{2R}}$$

$$\therefore r = 2R.$$

hence height $= R$.

52. $\frac{1}{2}mv^2 - \frac{GMm}{r} = T.E$

$$\therefore \frac{1}{2} \frac{GMm}{r} - \frac{GmM}{r} = T.E$$

$$\therefore = -\frac{1}{2}\frac{GMm}{r} = T.E$$

$$= -\frac{1}{2}mv^2 = T.E$$

53. Initial Energy $= -\dfrac{GMm}{R}$.

Final Energy $= \dfrac{1}{2} m v^2 - \dfrac{GMm}{2R}$.

$= \dfrac{1}{2} \dfrac{GMm}{3R} - \dfrac{GMm}{3R}$

$= -\dfrac{1}{6} \dfrac{GmM}{R}$.

$\therefore \Delta E = \dfrac{GMm}{R} - \dfrac{1}{6}\dfrac{GmM}{R}$

$= \cancel{\dfrac{3}{4}\dfrac{GMm}{R}} \quad \dfrac{5}{6}\dfrac{GMm}{R}$

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

$= -\dfrac{G \times 7.36\times10^{22} \times 5.98\times10^{24}}{2\times 3.82 \times 10^{8}\ m}$

$= 3.84 \times 10^{28}$ J

55. $v_{inside} = -\dfrac{GM}{2R}\left[3 - \left(\dfrac{R_0}{R}\right)^2\right]$ 

$P.E = V_{inside}\, m = -\dfrac{GMm}{2R}\left[3 - \left(\dfrac{R_0}{R}\right)^2\right]$

55. Initial energy $= -\frac{GMm}{R_0}$

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

$\therefore \; -\frac{GMm}{R_0} = -\frac{GMm}{R} + \frac{1}{2}mv^2$

$\therefore \; v^2 = 2\left(-\frac{GM}{R_0} + \frac{GM}{R}\right)$

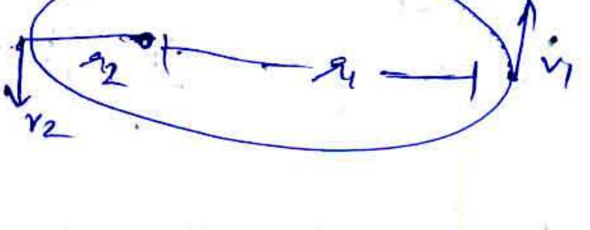
$v = \sqrt{2\left(GM\left(\frac{1}{R} - \frac{1}{R_0}\right)\right)}$

56. It moves in a parabolic path.

57. $mv_0R_0 = m\sqrt{\frac{GM}{R_0}} \times R_0$

$= m\sqrt{GMR_0}$

58. $mv_2r_2 = mr_1v_1$



$V_1 = \sqrt{\frac{2GM}{a}\left(\frac{1-e}{1+e}\right)}$

$\therefore \; mr_1\sqrt{\frac{2GM}{a}\left(\frac{1-e}{1+e}\right)} = m\sqrt{\frac{(a+ae)^2 \, 2GM}{a} \frac{(1-e)}{(1+e)}}$

$= m\sqrt{a\, 2GM_s\, (1-e)(1+e)}$

$= m\sqrt{2GM_s\, a(1-e^2)}$

$r_1 = a(1-e)$

$r_2 = a(1+e)$

$\frac{r_1 r_2}{r_1+r_2} = \frac{a^2(1-e^2)}{2a} = \frac{a(1-e^2)}{2}$

$\therefore m\sqrt{2GM_s \frac{r_1 r_2}{r_1+r_2}}$

59, Zero reaction force by satellite surface.

60. d. $\omega_1 = \omega_2 = 0$

61. d

62. c

63. d

64. a

65. $T'^2 \propto R'^3$

$\therefore T'^2 \propto (4R)^3$

$T' = 2^3 T$

$T' = 8T$

66. (d).

67. $\omega^2 = \sqrt{\frac{GM}{r^3}}$

$\therefore \omega^2 r^3 = \text{con}$

$\therefore n_2^2 d_2^3 = n_1^2 d_1^3$

68. $T^2 \propto R^3$

$\frac{T_1^2}{T_2^2} = \frac{R_1^3}{R_2^3}$

$T_1^2 = T_2^2 \times \left(\frac{R_1}{R_2}\right)^3$

$T_1 = T_2\left(\frac{2R}{R}\right)^{3/2}$

$= \sqrt{8}\, T_2$

$= 2\sqrt{2} \times 1$ yrs

$= 2\sqrt{2}$ yrs.

69. $v_a = \sqrt{\frac{2GM}{a}\left(\frac{1-e}{1+e}\right)}$

$v_p = \sqrt{\frac{2GM}{a}\left(\frac{1+e}{1-e}\right)}$

$\frac{v_p}{v_a} = \sqrt{\frac{(1+e)^2}{(1-e)^2}} = \frac{1+e}{1-e}$

$= 1.033$

70. $\frac{dA}{dt} = \frac{L}{2m} = \frac{\pi ab}{T}$

Angular momentum is constant.

71. $\frac{v_p}{v_a} = \frac{1+e}{1-e}$

72. $\omega^2 \times r^3 = \text{const}$

$\therefore \omega_2^2 \times 8r^3 = \omega^2 \times r^3$

$\therefore \omega_2^2 = \frac{\omega^2}{8}$

$\therefore \omega_2 = \frac{\omega}{2\sqrt{2}}$

Level 02

1) $F_1 = \dfrac{G\left(\frac{4}{3}\pi R^3\right)\rho\, m}{(2R)^2}$

$F_2 = F_1 - F'$ (F' due to spherical cavity)

$= F_1 - \dfrac{G\left[\frac{4}{3}\pi\left(\frac{R}{2}\right)^3\right]\rho\, m}{\left(\frac{3R}{2}\right)^2}$

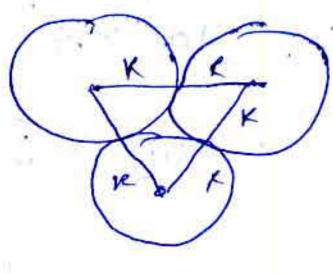
$\therefore \dfrac{F_2}{F_1} = 1 - \dfrac{\cancel{G}\,\frac{4}{3}\cancel{\pi}\left(\frac{R}{2}\right)^3 \cancel{\rho m}}{\cancel{G}\,\frac{4}{3}\pi R^3 \cancel{\rho m}} \times \dfrac{(2R)^2}{\left(\frac{3R}{2}\right)^2}$

$= 1 - \dfrac{1}{8} \times \dfrac{4R^2}{9R^2} \times 4$

$= 1 - \dfrac{2}{9}$

$= \dfrac{7}{9}$

2) $F = \dfrac{Gm^2}{(2R)^2}$



two forces are at an angle $60°$

$\therefore$ resultant $= 2F\cos\theta/2$

$$F_{re} = 2 \times \frac{GM^2}{4R^2} \cos 30'$$

$$F_R = 2 \times \frac{GM^2}{4R^2} \times \frac{\sqrt{3}}{2}.$$

$$= \frac{\sqrt{3}}{4} \frac{GM^2}{R^2}.$$

3. $F = \frac{G \times 10 \times 1000}{r^2} = 6.67 \times 10^{-7}$

$\therefore mg = 6.67 \times 10^{-7}$

$\therefore m = 6.67 \times 10^{-8} kg$

4. $g = \frac{GM}{R^2}$

if R decreases g increases.

$\therefore \frac{\Delta g}{g} = 2 \frac{\Delta R}{R}$

$= 2 \times 2\% = 4\%$

$K = \frac{1}{2} I \omega^2 = \frac{1}{2} \frac{2m}{5} R^2 \omega^2$

$\therefore \frac{\Delta K}{K} = \frac{2 \Delta R}{R} = 4\%.$

but K.E increases!

5. For spring clock Time period will remain uncharged but for simple pendulum Time period decreses.

6. $g = \frac{GM}{R^2}$

$g' = \frac{GM}{(2R)^2} = \frac{GM}{4R^2}$

$\therefore T_1 = 2\pi\sqrt{\frac{L}{g}}$

$\therefore T_2' = 2\pi\sqrt{\frac{L}{g'}} = 2\pi\sqrt{\frac{L}{g/4}} = 2 \times 2\pi\sqrt{\frac{L}{g}}$

$$\boxed{T_2 = 2 \times T_1}$$

7. for $T = 2\pi\sqrt{\frac{L}{g}}$ to remain same

l should be reduced as g reduces at an altitude.

8. After one minite lift spaceship is still in earth's gravitational pull.

9. $mg_1 = mg\left(1 - \frac{2H_1}{R}\right)$

$mg_2 = mg\left(1 - \frac{2H_2}{R}\right)$

$\therefore mg_2 - mg_1 = mg\left[\cancel{1} - \frac{2H_2}{R} - \cancel{1} + \frac{2H_1}{R}\right]$

$= mg\left[\frac{2H_1}{R} - \frac{2H_2}{R}\right]$

$= 2mg\left[\frac{H_1}{R} - \frac{H_2}{R}\right]$

10. $F = \frac{GMmx}{R^3}$ (inside earth)

$\therefore a = \frac{GMx}{R^3} = \omega^2 x$

$\therefore \omega = \sqrt{\frac{GM}{R^3}}$

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

$\therefore \frac{T}{4} = \frac{\pi}{2}\sqrt{\frac{R^3}{GM}} = t$

~~$t' = 2R$~~

$a = g$

$\therefore R = \frac{1}{2} g t_1^2$

$\therefore t' = \sqrt{\frac{2R}{g}}$

$\therefore t' = \sqrt{\frac{2R^3}{GM}}$

$\therefore \frac{t}{t'} = \frac{\frac{\pi}{2}\sqrt{\frac{R^3}{GM}}}{\sqrt{\frac{2R^3}{GM}}} = \frac{\pi}{2\sqrt{2}}$

11. $F = \frac{GMmy}{R^3}$ (inside)

$$\therefore \frac{F}{m} = \frac{GMy}{R^3} = \frac{Gy}{R^3} \times \left(\frac{4}{3}\pi R^3\right) \rho$$

$$= Gy \frac{4}{3}\pi \rho$$

12. $F = \frac{GM_e m x}{R_e^3}$ (inside earth).

13.

T pole = 2 seconds

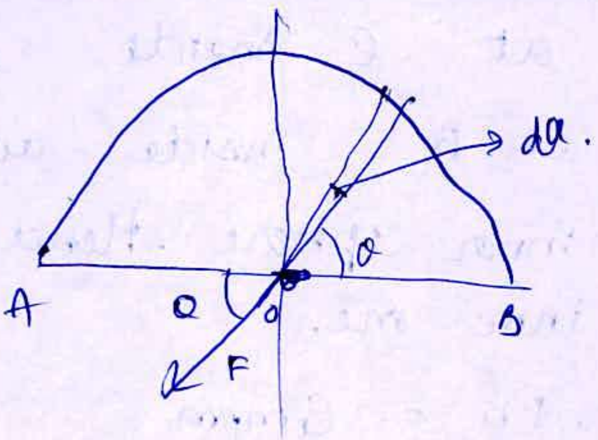
$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$\therefore \frac{\Delta T}{T} = \frac{1}{2} \times \frac{\Delta g}{g} = \frac{1}{2} \times 1\% = 0.005$$

$\therefore T' = 2.005$ s.

14. Because of symetricity gravitational force at the center is zero.
All the points on the circle $y^2+z^2 = 36$ are equidistant from centers of sphere with centered A & B. Same applies for $y^2+z^2=4$.

15.



$\vec{E} = -E\cos\theta\,\hat{i} - E\sin\theta\,\hat{j}$

· components along x axis will add up to zero.

$\therefore$

$$E_y = -E\sin\theta\,\hat{j}$$

$$= -\frac{G \times dm}{R^2}\sin\theta.$$

$$\therefore \frac{dm}{R\,d\theta} = \frac{M}{\pi R}$$

$$\therefore E_y = -\int_0^{\pi} G \times \frac{M}{\pi R} \times \frac{R\,d\theta}{R^2}\sin\theta$$

$$= \frac{GM}{\pi R^2}\int_0^{\pi}\sin\theta\,d\theta$$

$$= \frac{GM}{\pi R^2}\left[-\cos\theta\right]_0^{\pi}$$

$$= \frac{GM}{\pi R^2}\,2 = \frac{2GM}{\pi\left(\frac{L}{\pi}\right)^2} = 2\pi\frac{GM}{L^2}$$

16. at C inside both sphere hence zero.
at B inside outer sphere but outside inner sphere. Hence Force only ~~two~~ due to inner one.

$\therefore F_B = \frac{G m_2 m}{r_2^2}$

At A outside both sphere.

$\therefore F_A = \frac{G m_1 m}{r_1^2} + \frac{G m_2 m}{r_1^2}$

$= \cancel{G(m_1 + m_2)} \quad \frac{G(m_1 + m_2) m}{r_1^2}$

17. $r < R_1$ force is zero.

$R_2 > r > R_1$ same as that of solid sphere with cavity

$r > R_2$ mass placed at the center of sphere.

18. Superposition principle.

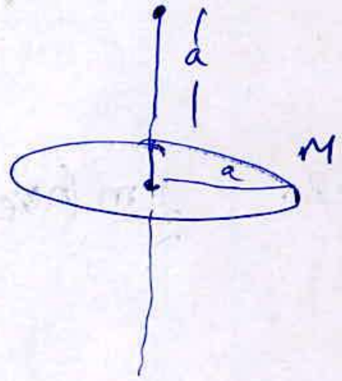
$F = F_1 - F_2$

$= \frac{GMx}{R^3} - G\left(\frac{M}{4}\right) \times 0$ [distance from center is 0]

$$= F_1 - 0$$

$$= \frac{GM\, R/2}{R^3} = \frac{GM}{2R^2}$$

19. $$V_{at\ a} = \frac{-GM}{\sqrt{a^2+r^2}}$$



$$U \text{ at } a = \frac{-GMm}{\sqrt{a^2+a^2}}$$

Energy conservation.

$$\frac{-GMm}{\sqrt{2a^2}} = -\frac{GmM}{a} + \frac{1}{2}mv^2$$

$$\therefore \frac{1}{2}mv^2 = \frac{GMm}{a} - \frac{GMm}{\sqrt{2}a}$$

$$\frac{1}{2}\cancel{m}v^2 = \frac{G\cancel{m}M}{a}\left(1-\frac{1}{\sqrt{2}}\right)$$

$$v = \sqrt{\frac{2GM}{a}\left(1-\frac{1}{\sqrt{2}}\right)}$$

20. W done by all force $= \Delta K.E$

$$W_{g.f} + -3 = \frac{1}{\cancel{2}} \times 1 \times \cancel{2} \times 2$$

$$W_{gf} = 5J$$

$$\Delta U = -W_{g.f} = -5J$$

$$\therefore \Delta V = \frac{-5}{1} \, J/kg$$

21. Every small element is at distance R.

$$\therefore V_I = -\frac{GM}{R} = -\frac{GM}{L/\pi} = -\frac{GM\pi}{L}$$

22. $$\frac{1}{2}m(\eta v_e)^2 - \frac{GMm}{R} = -\frac{GMm}{R'}$$

$$\therefore -\frac{GMm}{R'} = \frac{1}{\cancel{2}} m \eta^2 \times \frac{\cancel{2}GM}{R} - \frac{GMm}{R}$$

$$-\frac{GMm}{R'} = \frac{GMm}{R}(\eta^2 - 1)$$

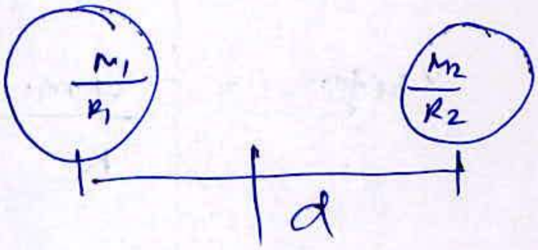
$$\therefore R' = \frac{R}{(1-\eta^2)}$$

$$\therefore R + h = \frac{R}{1-\eta^2}$$

$$\therefore h = \frac{R}{1-\eta^2} - R = R\left(\frac{\eta^2}{1-\eta^2}\right)$$

23.

$$\frac{1}{2} m v_1^2 - \frac{GM_1 m}{d/2} - \frac{GM_2 m}{d/2} = 0$$



$$\therefore \frac{1}{2} \cancel{m} v_1^2 = \frac{2GM_1 \cancel{m}}{d} + \frac{2GM_2 \cancel{m}}{d}$$

$$v_1^2 = \frac{4GM_1 + 4GM_2}{d}$$

$$\therefore v_1 = 2\sqrt{\frac{G}{d}(M_1+M_2)}$$

24.

$$\frac{1}{\cancel{2}} m\, \overset{2}{\cancel{4}} v_e^2 - \frac{GMm}{R} = \frac{1}{2} m v_1^2$$

$$\frac{1}{\cancel{2}} \overset{2}{\cancel{4}} \times m \frac{2GM}{R} - \frac{GMm}{R} = \frac{1}{2} m v_1^2$$

$$\therefore \frac{3GM\cancel{m}}{R} = \frac{1}{2} \cancel{m} v_1^2$$

$$\therefore v_1 = \sqrt{3 \times \frac{2GM}{R}} = \sqrt{3}\, v_e$$

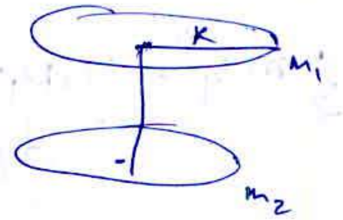
25.

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

$$g' = \frac{GM(1.005)}{R^2(1.005)^2} = \frac{GM}{R(1.005)}$$

Hence g decreases.

26. $V_{before} = -\dfrac{Gm_1}{R} - \dfrac{Gm_2}{\sqrt{2}R}$



$V_{after} = -\dfrac{Gm_1}{\sqrt{2}R} - \dfrac{Gm_2}{R}.$

$V_{before} - V_{after} = -\dfrac{Gm_1}{R} + \dfrac{Gm_1}{\sqrt{2}R} - \dfrac{Gm_2}{\sqrt{2}R} + \dfrac{Gm_2}{R}$

$m(\Delta V) = \Delta U = m\left[\dfrac{Gm_1}{R}\left(1-\dfrac{1}{\sqrt{2}}\right) - \dfrac{Gm_2}{R}\left(1-\dfrac{1}{\sqrt{2}}\right)\right]$

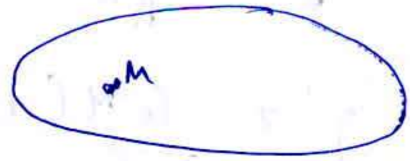
$\therefore \quad = \dfrac{G(m_1-m_2)m}{R}\left(1-\dfrac{1}{\sqrt{2}}\right)$

$= \dfrac{G(m_1-m_2)\,m\,(\sqrt{2}-1)}{\sqrt{2}R}$

27. Energy is lesser near to earth Hence after lossing energy it moves towards earth. As r decreases v increases.

28.

Total Energy $= -\dfrac{GMm}{2a}$



$-\dfrac{GMm}{2a} = \dfrac{1}{2}mv^2 - \dfrac{GMm}{r}$

$$\therefore \frac{1}{2}mv^2 = \frac{GMm}{r} - \frac{GMm}{2a}$$

$$\frac{1}{2}\cancel{m}v^2 = G\cancel{m}M\left(\frac{1}{r} - \frac{1}{2a}\right)$$

$$v^2 = 2GM\left(\frac{1}{r} - \frac{1}{2a}\right)$$

$$v = \sqrt{GM\left(\frac{2}{r} - \frac{1}{a}\right)}$$

29. $T^2 \propto R^3$

$$\therefore \frac{T_2}{T_1} = \frac{R_2^{3/2}}{R_1^{3/2}} = \left[\frac{\cancel{6400}^{\,8}}{\cancel{36000}_{\,45}}\right]^{3/2} = \left[\frac{8}{45}\right]^{3/2}$$

$$T_2 = 24 \times \left[\frac{8}{45}\right]^{3/2} \simeq 2\text{hr.}$$

30. $$T_2 = T_1\left(\frac{R_2}{R_1}\right)^{3/2} = \frac{T_1}{2\sqrt{2}} = \frac{365}{2\sqrt{2}} \simeq 129$$

31. $$\frac{\Delta T}{T} = \frac{3}{2}\frac{\Delta R}{R} \times 100 = \frac{3}{2} \times 0.01 \times 100 = 1.5\%$$

32. $$T_1 = \frac{2\pi}{\omega + \frac{v_0}{R}}$$

$$T_2 = \frac{2\pi}{\omega - v_0/R}$$

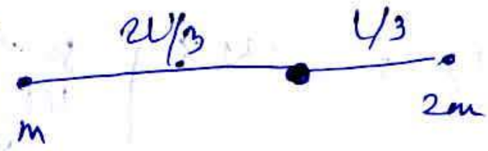
$$T_1 - T_2 = \frac{2\pi}{\omega - \frac{v_0}{R}} - \frac{2\pi}{\omega + \frac{v_0}{R}}$$

$$= 2\pi \left[\frac{\cancel{\omega} + \frac{v_0}{R} - \cancel{\omega} + \frac{v_0}{R}}{\omega^2 - \frac{v_0^2}{R^2}} \right]$$

$$= \frac{4\pi}{R^2\omega^2 - v_0^2} \frac{v_0}{R} R^2$$

$$= \frac{4\pi R v_0}{R^2\omega^2 - v_0^2} = \frac{4\pi v_0 R}{R^2\omega^2 - v_0^2}$$

33. $\frac{2ml}{3m}$ = distance of center of mass from m.



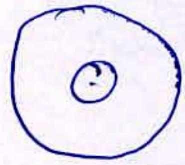
$$\therefore \frac{Gm\,\cancel{2m}}{l^2} = \cancel{2m}\,\omega^2 \frac{l}{3}$$

$$\therefore \frac{3GM}{l^3} = \omega^2.$$

$$\therefore \omega = \sqrt{\frac{3GM}{l^3}}$$

$$\therefore T = 2\pi\sqrt{\frac{l^3}{3Gm}}$$

34. $R_{moon} = \frac{R}{4}$



~~$\omega^2 = G$~~ $\omega_{sp}^2 = \cancel{g}\ \frac{GM_{moon}}{(2r_{moon})^3}$

$\omega_{RL}^2 = \frac{GM_{earth}}{(2R_e)^3}$

$\therefore T_{sp} = 2\pi\sqrt{\frac{(2r_{moon})^3}{GM_{moon}}}$

$T_{RL} = 2\pi\sqrt{\frac{(2R_e)^3}{GM_e}}$

$\frac{T_{sp}}{T_{RL}} = \sqrt{\frac{(2r_{moon})^3 \times M_e}{(2R_e)^3\ M_{moon}}}$

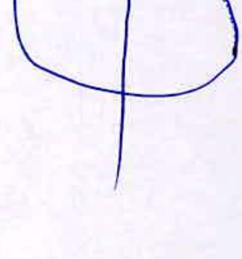
$= \sqrt{\frac{\cancel{R^3}}{8\times 8\ \cancel{R^3}}\ \frac{\cancel{M_e}}{\cancel{M_e}} \times 80}$

$= \sqrt{\frac{10}{8}} = \frac{\sqrt{5}}{2}$

35. $T' = 2T$

$\therefore (T') \propto (R)^{3/2}$

$\boxed{R' = 2^{2/3} R}$



36. $$\frac{\left|\frac{+GmM}{2r} - \frac{GMm}{\frac{3r}{2}}\right|}{\frac{GMm}{2r}} \times 100$$

$$\frac{\left|\frac{1}{2} - \frac{2}{3}\right|}{1/2} \times 100 = \left|1 - \frac{4}{3}\right| \times 100$$

$$= \frac{1}{3} \times 100 = 33.33\%$$

37. Energy before $= -\frac{GMm}{R}$.

Energy after $= -\frac{GMm}{2\beta R}$

$\therefore$ Work $= \Delta E$

$$= -\frac{GMm}{2\beta R} + \frac{GMm}{R}$$

$$= \frac{GMm}{R}\left(1 - \frac{1}{2\beta}\right)$$

$$= \frac{GMm}{R}\frac{(2\beta-1)}{2\beta}$$

Assertion, Reason.

1. Reason correctly explains.

2. Not the correct explanation, ~~Gravitational & electrical force~~

3. $G = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2}$ $g = 10 m/s^2$

4. $g = \frac{GM}{R^2}$ ~~to~~ as R changes g changes.

5. ~~The~~ pendulum will not ossilate hence infinite timperiod.

6. Reason is false.

7. Both are true. but not explains.

8. Because rotation it about polar axis value of g remains unchanged.

9. In circular orbit force is perpendicular to velocity hence work done is zero.

10. Both are true.

11. Because every thing is baunded to earth hence potential energy is -ve.

$F \propto R^{-5/2}$

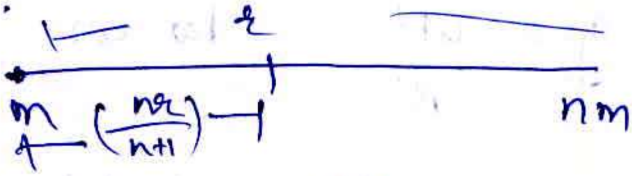
$\therefore m\omega^2 \cancel{R} \propto R^{-5/2}$

$\omega^2 \propto R^{-7/2}$

$\therefore T^2 \propto R^{7/2}$

39.

. rotate about their COM.



distance of center of mass from m $= \frac{nmr}{(n+1)m} = \frac{nr}{(n+1)}$

$$\therefore \frac{G\cancel{m}\,nm}{r^2} = \cancel{m}\,\omega^2 \left(\frac{nr}{n+1}\right)$$

$$\frac{G\cancel{n}m}{r^2} = \omega^2 \frac{\cancel{n}r}{(n+1)}$$

$$\therefore \omega^2 = \frac{Gm(n+1)}{r^3}$$

$$\therefore T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{r^3}{Gm(n+1)}}$$

12 Because angular momentum remains conserved satellite will not go outside the plane

13. Reason is false $v_0 = \sqrt{\frac{GM}{r}}$

14. $v_0 = \sqrt{\frac{GM}{r}}$ $v_e = \sqrt{\frac{2GM}{r}}$

$\therefore v_0 < v_e$

15. after dissipation of energy 'r' reduces ~~but~~ and hence speed increses.

16. Both are true.

17. Both are true.

18. Assertion is false.

19. Two different planets may or may not have same escape velocity.

$v_e = \sqrt{\frac{2GM_e}{R_e}}$ $v_p = \sqrt{\frac{2GM_p}{R_p}}$

Both are false.

20. $T^2 \propto R^3$

correctly explains.

21. $F = \frac{G m_1 m_2}{r^2}$ $= \frac{G(2m_1)(2m_2)}{4r^2}$

22. Reason is false.

23. If the object is outside earth then accralation due to gravity decreses.

24. Both are true.

25. $B.E = \frac{GM(m)}{2a}$ depend on mass of satellite.

26. Both are true.

27. Correclty explains.

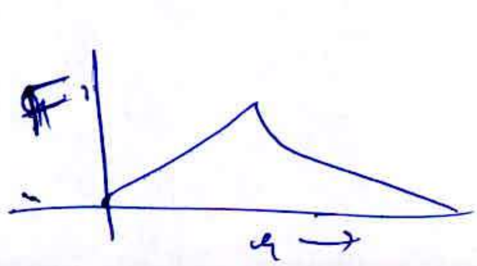
28. $T^2 \propto R^3$

29. Reason is false.

30. If the orbit is elliptical speed does not remains constant.

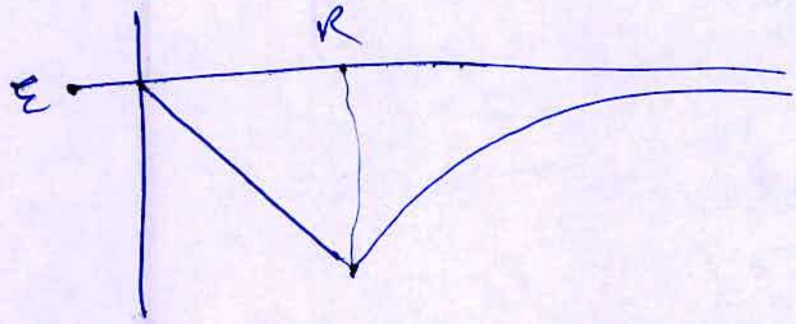
31. Because $h << R$

$\therefore v_0 \simeq \sqrt{\frac{GM_e}{R_e}}$

32. 

33. correctly explains

Previous year's questions

1. 

2. $v_e = 3\times10^{8}$

$\therefore 3\times10^{8} = \sqrt{\frac{GM}{R_e'}}$

$\therefore 9\times10^{16} = \frac{GM}{R_e'}$

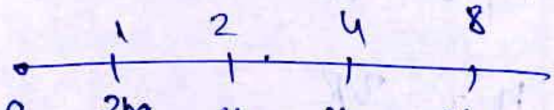
$\therefore R_e' = \frac{GM}{9\times10^{16}} = \frac{\cancel{R^2}\cancel{g}}{9\times10^{16}} =$

$= \frac{6.67\times10^{-11}\times5.98\times10^{24}}{9\times10^{16}}$

$= \frac{4}{9}\ \frac{\times10^{14}}{10\times16}$

$R_e' = 0.6\times10^{-2}$

$\simeq 10^{-2}$ m

3. 

$-\frac{GM}{1} - \frac{GM}{2} - \frac{GM}{4} - - -$

$$= -GM\left[1 + \frac{1}{2} + \frac{1}{4} - \cdots\right]$$

$$= -GM\left[\frac{1}{1-1/2}\right.$$

$$= -2GM$$

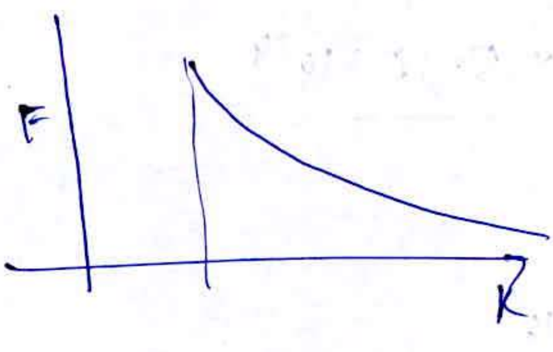
$$= -4G$$

---

1. $v_e = \sqrt{\frac{2GM}{r}}$ $v_o = \sqrt{\frac{GM}{r}}$

$$v_e = \sqrt{2}\, v_o$$

2. Inside shell feild is zero.



3. $g' = \frac{g}{16} = \frac{GM}{16R^2} = \frac{GM}{R_1^2}$

$\therefore R_1 = 4R$

$\therefore h = 3R$

4. $T_2 = T_1 \left(\frac{R_2}{R_1}\right)^{3/2}$

$= 24\left(\frac{8R}{6R}\right)^{3/2}$

$= 24 \times \frac{1}{2^{3/2}}$

$= \frac{24}{2\sqrt{2}} = \frac{12}{\sqrt{2}} = 6\sqrt{2}$ hrs.

5. $g = \frac{GM_p}{R_p^2} = \frac{GM_p}{\left(\frac{D_p}{2}\right)^2} = \frac{4GM_p}{D_p^2}$

6. $T_2 = T_1 \left(\frac{L_2}{L_1}\right)^{3/2}$

$= D \left(\frac{L_2}{L_1}\right)^{3/2}$ days.

7. angular momentum conservation.

8. $g - \omega^2 R = 0$

$\therefore \omega^2 = \frac{g}{R}$

$\therefore \omega = \sqrt{\frac{g}{R}}$

$\therefore \omega = 2.5 \times 10^{-3}$ rad/s

1. $m v_1 r_1 = m v_2 r_2$ (angular momen conservation)

$\therefore \frac{v_1}{v_2} = \frac{r_2}{r_1}$

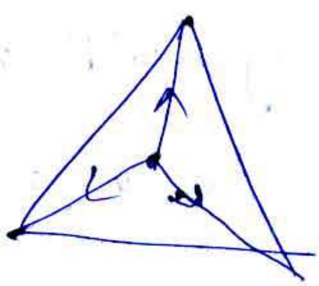
2. $\frac{GMm}{r^2} \times v = \text{Power} = \vec{F} \cdot \vec{v}$

Force will be max at surface.
also velocity is max at surface.
∴ Power is max at surface while returning because Force & velocity are in same direction.

3. $g = \frac{GM_e}{R_e^2}$

$\therefore M_e = \frac{g R_e^2}{G}$

4. force experienced is zero because of symmetricity.



5. $g_d = \left[1 - \frac{d}{R}\right]$

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6. here g is constant. $\boxed{S_n = u + \frac{a}{2}(2n-1)}$

$S_n = 0 + \frac{a}{2}(2n-1)$

$\therefore S_1 = \frac{a}{2} \times (2-1) = \frac{a}{2}$

$\therefore S_2 = \frac{a}{2}(4-1) = \frac{a}{2}3$

$\therefore S_3 = \frac{a}{2}(6-1) = \frac{a}{2}5.$

$\therefore S_1 : S_2 : S_3 \ldots = 1:3:5.$

7. $g' = \frac{GM}{(R')^2}$

$g' = \frac{g}{100} = \frac{GM}{(R')^2}$

$\therefore \frac{GM}{(R')^2} = \frac{GM}{R \times 100}$

$\therefore R' = 10R$

$\therefore$ height $= 9R$

8. $g_{moon} = \frac{GM_{moon}}{(R_{moon})^2} = \frac{g_e}{6}.$

$g_{earth} = \frac{GM_e}{R_e^2}$

$\therefore \frac{\cancel{G}M_{moon}}{(R_{moon})^2} = \frac{\cancel{G}M_e}{R_e^2 \times 6}$

$$M_{moon} = \frac{M_e}{81}$$

$$\therefore \frac{M_e}{81} \times \frac{6}{1} = \left(\frac{R_{moon}}{R_e}\right)^2 M_e$$

$$\therefore R_e = \frac{9}{\sqrt{6}} R_{moon}$$

9. $g = \frac{G}{R^2}\left(\frac{4\pi R^3}{3}\right)\rho$

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

$$\therefore \frac{g_e}{g_p} = \frac{G}{2G} \times \frac{R_e}{R_p}$$

$$g_e = g_p.$$

$$\boxed{\therefore \frac{R_p}{R_e} = \frac{1}{2}}$$

10. Speed of center of mass only changes if there is external force.

11. $g' = g\left[1 - \frac{d}{R}\right]$

$$\therefore \frac{978}{980} = 1 - \frac{d}{R}$$

$$\therefore d = R\left(1 - \frac{978}{980}\right) = \frac{R \times 2}{980} \approx 12.86\ km$$

12. $g' = \frac{g}{2} = \frac{GM}{2R^2} = \frac{GM}{R'^2}$

$\therefore R' = \sqrt{2}R$

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

$= 2650$ km.

13. $\frac{Gm^2}{(2R)^2} = \frac{\cancel{m}v^2}{R}$

$\frac{Gm}{4R} = v^2$

$\therefore v = \frac{1}{2}\sqrt{\frac{GM}{R}}$.

14. $F = \frac{Gm_s M_e}{r^2}$

$F' = \frac{GM_s M_e}{9r^2}$

$\therefore F - F' = \frac{GM_s M_e}{r^2}\left[1 - \frac{1}{9}\right]$

$= \frac{GM_s M_e}{r^2} \times \frac{8}{9}$

$\frac{F-F'}{F} \times 100 = \frac{8}{9} \times 100$

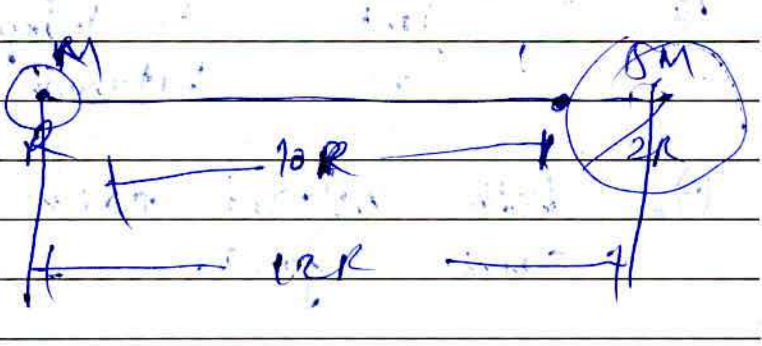
$\approx 89\%$.

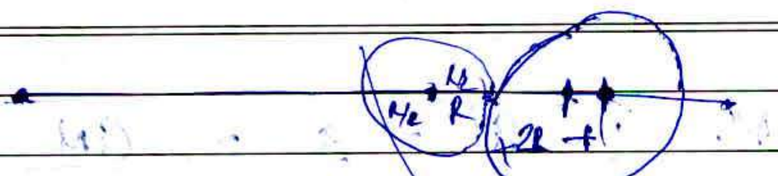
15.

Center of Mass from M is distance =

$= \frac{5M \times 12R}{6R}$

$= 10R$





$$\frac{Mx_2 + 5Mx_1}{6M} = 10R$$

$$x_2 + 5x_1 = 60R$$

$$x_2 + R/4 + 2R + x_1 = 12R.$$

$$x_2 + x_1 = 9R$$

$$x_2 + 5x_1 = 60R$$

$$4x_1 = 51R$$

$$x_1 = \frac{51R}{4}$$

$$x_2 = 9R - \frac{51R}{4}$$

$$=$$

Center of mass remains where it was.

$$\frac{Mx_2 + 5M(x_2 + 3R)}{6M} = 10R$$

$$x_2 + 5x_2 + 15R = 60R$$

$$6x_2 = 45R$$

$$x_2 = \frac{45R}{6} = \frac{15}{2}R = 7.5R$$

16. $F = \frac{GmM}{r^2}$ is independent of material between them.

17. Both attract each other with same force.

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

$g_e = G \times \frac{4\pi}{3} \rho_e R_e$

$g_p = G \times \frac{4\pi}{3} \times \rho_p R_p$

$\rho_e R_e = \rho_p R_p$

$\rho_p = 2\rho_e$

$\boxed{\therefore R_p = \frac{R_e}{2}}$

12. $v^2 = u^2 + 2as$

$v = 0$ u is same for both.

$\therefore u^2 = 2g \times 2$

On planet B,

$u^2 = 2 \times \frac{g}{9} \times s'$.

$\therefore 2 \times g \times 2 = 2 \times \frac{g}{9} \times s'$

$\boxed{\therefore s' = 18 m}$

13. $g' = \frac{g}{2}$

$\frac{GM}{(R')^2} = \frac{GM}{2R^2}$

$\therefore R' = \sqrt{2}R$

$\therefore R' = 2R$

$\therefore h = R$

6. No change because at poles g is unchanged due to rotation.

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

g is max at surface. Hence in deep mine or ~~at~~ height g will reduce & timeperiod will increase.

8. $g_1 = G \times \frac{4}{3}\pi R_1 \rho_1$

$\frac{g_1}{g_2} = \frac{R_1 \rho_1}{R_2 \rho_2} = \frac{r_1 d_1}{r_2 d_2}$

9. $g_h = \left(1 - \frac{2h}{R}\right)$

$g_d = \left(1 - \frac{d}{R}\right)$

at $d = 2R$

$g_h = g_d$

10. $g' = \frac{GM}{(3R)^2} = \boxed{\frac{GM}{9R^2}} = \frac{g}{9} = \frac{g}{9}$

2. $g_d = g\left(1-\frac{d}{R}\right)$

3. $-\frac{GMm}{R}$ = P.E before

$-\frac{GMm}{2R}$ = P.E after.

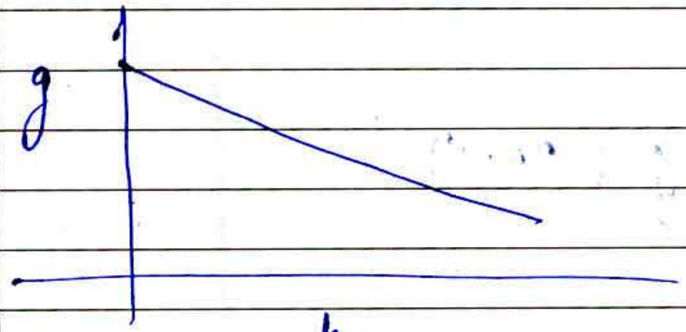
$\therefore \Delta P.E = \frac{GMm}{R}\left(1-\frac{1}{2}\right)$

$\Delta P.E = \frac{GMm}{2R}$

$\because GM = gR^2$

$\therefore \Delta P.E = \frac{mgR}{2}$

4. $g_d = g\left(1-\frac{d}{R}\right)$



5. $g' = g/4$

$\therefore \frac{GM}{(R')^2} = \frac{GM}{4R^2}$

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18. $g' = \frac{g}{2}$

$\therefore \frac{GM}{(R')^2} = \frac{GM}{R^2 2}$

$\therefore R' = \sqrt{2} R$

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

$= 0.71 \times R$.

19. $g = \frac{G\left(\frac{4\pi R^3}{3}\right)\rho}{R^2} = G\frac{4}{3}\pi R \rho$

$\therefore$ g on surface increases because of incrsd radius.

~~20.~~

1. $S_n = u + \frac{a}{2}(2n-1)$

$S_n = \frac{9h}{25}$

$\therefore \frac{9h}{25} = \frac{g}{2}(2n-1)$

$h = \frac{1}{2} g n^2$.

$\therefore \frac{9}{25} \times \frac{1}{\cancel{2}} g n^2 = \frac{\cancel{g}}{\cancel{2}}(2n-1)$

$\therefore 9n^2 = 25(2n-1)$.

$\therefore n = 5$ sec.

$\therefore h = \frac{1}{2} \times 9.8 \times 25 = 122.5$ m

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14. $g' = \frac{g}{4}$

$\frac{GM}{(R')^2} = \frac{GM}{4R^2}$

$R' = 2R$

$h = R$

15. $g - (\omega^2 R) x = 0$

$\therefore x = \frac{g}{\omega^2 R}$

$= \frac{g}{\omega^2 \; 6400 \times 10^3}$

$\simeq 17$

16. $g' = \frac{g}{100}$

$\therefore \quad \frac{GM}{(R')^2} = \frac{1}{100} \frac{GM}{R^2}$

$\therefore R' = 10R$

$\therefore h = 9R$

17. $g_h = g\left(1 - \frac{2h}{R}\right)$

$= g\left(1 - \frac{64}{64\,00}\right)$

$= g\left(\frac{99}{100}\right)$

$= 0.99\, g \; m/s^2$

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

$\therefore g' = 3g$

19. $g - \omega^2 R$ = Weight.

If ω is increased weight will decrease.

20. ~~de~~ Max at poles.

21. $g_d = g\left(1 - \frac{d}{R}\right)$

$g_d = \frac{g}{n}$

$\therefore \frac{1}{n} = 1 - \frac{d}{R}$

$\frac{d}{R} = 1 - \frac{1}{n}$

$\therefore d = R\left(\frac{n-1}{n}\right)$

22. $g' = \frac{GM}{(4R)^2} = \frac{1}{16} \times \frac{GM}{R^2} = \frac{g}{16}$.

23. $g_d = \left(1 - \frac{d}{R}\right) g$

$= g\left(1 - \frac{100}{6400}\right)$

$= g \times \frac{63}{64} \approx 9.66\ m/s^2$

24. 700 g wt. = W

$$g' = \frac{G \times \left(\frac{M_e}{7}\right)}{\left(\frac{R_e}{2}\right)^2}$$

$$= \frac{G \times M_e}{7} \times \frac{4}{R_e^2} = \frac{4}{7} g$$

$$\therefore \frac{4}{7} \times 700 = 400 \text{ g wt.}$$

25. On poles effect of rotation is nullified.

26. $g = \frac{GM}{R^2}$

$$\therefore g' = \frac{G\, 0.99M}{(0.99)^2 R^2}$$

$$= \frac{G \times M}{R^2} \times \frac{1}{0.99}$$

$$= \frac{g}{0.99}$$

$$\therefore \frac{\Delta g}{g} = \cancel{0.99}\ 1\%$$

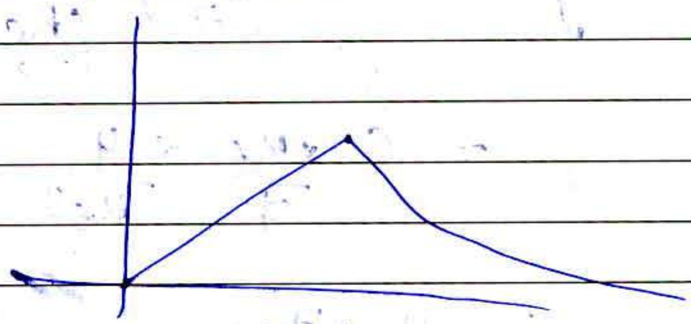
$$P.E = \frac{GMm}{R}$$

$$P.E' = \frac{G\, 0.99M\, m}{0.99 R}$$

$$= \frac{GMm}{R} \text{ (unchanged)}$$

27. ~~maxat~~ g is max at pole.

28. below earth surface g varies linearly.



29. $g_d = g\left(1 - \frac{d}{R}\right)$

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

$= \frac{g}{\left(1 + \frac{1600}{6400}\right)^2}$

$= \frac{g}{\left(1 + \frac{1}{4}\right)^2} = \frac{16}{81} g$

$g_d = \frac{8g}{81} = g\left(1 - \frac{d}{R}\right)$

$\boxed{\therefore\ d = 3.19 \times 10^6 m}$

30. $g_{mar} = \frac{G\left(\frac{M_e}{90}\right)}{\left(\frac{R_e}{3}\right)^2} = \frac{1}{10} \frac{GM_e}{R_e^2} = \frac{1}{10} g$

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1. $$v_e = \sqrt{\frac{2GM_e}{R_e}}$$

$$g = \frac{GM_e}{R_e^2}$$

$$\therefore GM_e = gR_e^2$$

$$\therefore V_e = \sqrt{\frac{2\times gR_e^2}{R_e}} = \sqrt{2gR_e}$$

2. $$v_e' = \sqrt{\frac{2\times G(2M_e)}{(R_e/2)}} = \sqrt{\frac{2G\times 2M_e \times 2}{R_e}}$$

$$= 2\sqrt{\frac{2GM_e}{R_e}} = 2V_e = 22.4\ \text{km/s}$$

3. Same as 1st ques.

4. $$-\frac{GmM}{2(2R)} = \text{initial Energy}$$

$$-\frac{GMm}{2(3R)} = \text{final Energy}$$

$$\therefore \Delta E = -\frac{GmM}{6R} + \frac{GmM}{4R}$$

$$= \frac{GMm}{R}\left[\frac{1}{4} - \frac{1}{6}\right]$$

$$= \frac{GMm}{R}\left[\frac{6-4}{24}\right]$$

$$= \frac{GMm}{R} \times \frac{2}{24}$$

$$= \frac{GMm}{R} \times \frac{1}{12}$$

5. $V_e = \sqrt{\frac{2GM_e}{R_e}}$

$= \sqrt{\frac{2\times G\frac{4}{3}\pi R_e^3}{R_e}}$

$= \sqrt{2\,G\times\frac{4}{3}\pi R_e^2}$

$= \sqrt{\frac{8G\pi}{3}}\,R_e$

$\therefore V_p = \sqrt{\frac{8G\pi}{3}}\times R_p$

$\therefore \boxed{\frac{V_A}{V_B} = 2}$

6. $\frac{1}{2}m\left(\frac{20\times10^3}{60\times60}\right)^2 - \frac{GMm}{R} = \frac{1}{2}mv^2$

$\therefore v^2 = \left(\frac{20\times10^3}{60\times60}\right)^2 - \frac{GM}{R}$

$\frac{GM}{R} = Rg$

$v = \sqrt{\left(\frac{20\times10^3}{60\times60}\right)^2 - Rg}$

$\Rightarrow v \approx 16.5$ km/hr.

7. $v_e' = \sqrt{\frac{2\times G\times\left(\frac{M_e}{2}\right)}{(R_e/4)}}$

$= \sqrt{\frac{2GM_e\,2}{R_e}} = \sqrt{2}v_e$

8. $-\frac{GmM}{R}$ = initial P.E

$-\frac{GMm}{(n+1)R}$ = final P.E

$\therefore \Delta P.E = \frac{GmM}{R} - \frac{GMm}{(n+1)R}$

$= \frac{GmM}{R}\left(1 - \frac{1}{n+1}\right)$

$= \frac{GMm}{R}\left(\frac{n}{n+1}\right)$

$\boxed{\frac{GM}{R} = Rg}$

$= Rgm\left(\frac{n}{n+1}\right)$

9. $v_{moon} = \sqrt{\frac{2 \times G\left(\frac{Me}{81}\right)}{Re/4}} = \frac{2}{9}\sqrt{\frac{2GMe}{Re}}$

$= \frac{2}{9} \times 11.2 = 2.5\, km/s$

10. • velocity upon reaching the surface should be same.

$\therefore v^2 = 2as \quad (u = 0)$

$\therefore 2g\, 0.5 = 2g' \times s$

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

$g' = G \times \frac{4}{3}\pi \frac{Re}{4} \times \frac{2}{3}\rho e$

$= \frac{1}{6} \times g$

$S = 0.5 \times 6$
$S = 3$

11. $P.E_{initial} = -\frac{G \times 10^{-2}\,kg \times 100\,kg}{(0.1)}$

$P.E_{final} = 0$.

$\therefore \Delta P.E = \frac{G \times 10^{-2} \times 100\,kg}{10^{-1}}$

$= G \times 10$
$= 6.67 \times 10^{-10}\,J$

12. $\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 - \frac{Gm_1m_2}{r} = 0$

final energy = Initial energy.

$m_1v_1 - m_2v_2 = 0$ [Momentum conservation]
$\therefore m_1v_1 = m_2v_2$

velocity of approach $= v_1 + v_2$

$= v_2 + \frac{m_2}{m_1}v_2 = v_2\left(\frac{m_1+m_2}{m_1}\right)$

$\frac{1}{2}m_2v_2^2 + \frac{1}{2}m_1 \times \left(\frac{m_2v_2}{m_1}\right)^2 = \frac{Gm_1m_2}{r}$

$\therefore \frac{1}{2}m_2v_2^2 + \frac{1}{2} \times \cancel{m_1}\frac{m_2^2}{m_1^{\cancel{2}}}v_2^2 = \frac{Gm_1m_2}{r}$

$\therefore v_2^2\frac{1}{2}\cancel{m_2}\left[1 + \frac{m_2}{m_1}\right] = \frac{Gm_1\cancel{m_2}}{r}$

$v_2 = \sqrt{\frac{2Gm_1^2}{r}\frac{1}{(m_1+m_2)}}$

Velocity of approach $= v_2 \left(\frac{m_1+m_2}{m_1}\right) = \sqrt{\frac{2Gm_1^2}{r(m_1+m_2)}} \times \frac{(m_1+m_2)}{m_1}$

$$= \sqrt{\frac{2G\cancel{m_1^2}}{r\cancel{(m_1+m_2)}} \times \frac{(m_1+m_2)^2}{\cancel{m_1^2}}} = \sqrt{\frac{2G(m_1+m_2)}{r}}$$

13. Initial P.E $= -\frac{GMm}{R}$

Final P.E $= -\frac{GMm}{2R}$

$\therefore$ final P.E $-$ Initial P.E $= -\frac{GMm}{2R} + \frac{GMm}{R}$

$$= \frac{GMm}{2R} = \left(\frac{GM}{R}\right)\frac{m}{2} = gR\frac{m}{2}$$

$g = \frac{GM}{R^2}$ $\therefore$

$\therefore gR = \frac{GM}{R}$

14. Same as question 13.

15. Total energy at platform should be zero.

$\therefore \frac{1}{2}m(fv_e)^2 - \frac{GMm}{2R} = 0.$

$\therefore \frac{1}{2}\cancel{m}(fv_e)^2 = \frac{GM\cancel{m}}{2R}$

$\therefore f^2 v_e = \sqrt{\frac{GM}{R}}$

$$\therefore f\sqrt{\frac{2GM}{R}} = \sqrt{\frac{GM}{R}}$$

$$\therefore f = \frac{1}{\sqrt{2}}$$

16. $$\frac{-GM_{moon}M_e}{r} = -7.79\times10^{28}\,J$$

$$\therefore r = \frac{7.79\times10^{28}}{G\times M_{moon}M_e}$$

$$\approx 3.80\times10^{8}\,m$$

17. $$\frac{1}{2}mv_i^2 - \frac{GMm}{10R_e} = \frac{1}{2}mv_f^2 - \frac{GMm}{R_e}$$

Initial Energy $\qquad$ final Energy

$$\therefore \frac{1}{2}v_f^2 = \frac{GM}{R_e} - \frac{GM}{10R_e} + \frac{1}{2}v_i^2$$

$$\therefore v_f^2 = 2\left(\frac{GM}{R_e} - \frac{GM}{10R_e}\right) + v_i^2$$

$$v_f^2 = \frac{2GM_e}{R_e}\left(1-\frac{1}{10}\right) + v_i^2$$

18. $v_e = \sqrt{\dfrac{2GM_e}{R_e}}$ question is incomplete.

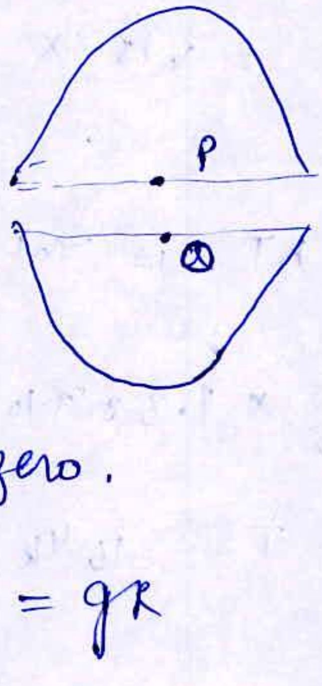
19. $v_e = \sqrt{\dfrac{2GM_e}{R_e}}$

$$v_e' = \sqrt{\frac{2GM_e}{R_e/4}} = \sqrt{4\left(\frac{2GM_e}{R_e}\right)} = 2\sqrt{\frac{2GM_e}{R_e}}$$

$$= 2v_e.$$

20. $\vec{I_p} + \vec{I_o} = 0.$

feild inside shell is zero.



$\therefore \; I_p - I_o = 0.$

$\therefore \; I_p = I_o$

both individually aren't zero.

21.

$g = \dfrac{GM}{R^2} \qquad \therefore \; \dfrac{GM}{R} = gR$

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

$$= \sqrt{2\times(3.1)^2 \; 8100 \times 10^3}$$

$$\simeq \frac{27.9}{\sqrt{5}} \text{ km/s}$$

22. $\frac{1}{2} m \cdot (4v_e)^2 - \frac{GmM}{R} = \frac{1}{2} m v_i^2$

[v_i = v at infinity]

$\frac{1}{2} m \times 16 v_e^2 - \frac{GMm}{R} = \frac{1}{2} m v_i^2$

$8 \times \frac{2GM}{R} - \frac{GM}{R} = \frac{1}{2} v_i^2$

$\frac{15 GM}{R} \times 2 = v_i^2$

$\therefore \sqrt{15 \left(\frac{2GM}{R}\right)} = v_i$

$\therefore v_i = \sqrt{15} \times v_e$

$= \sqrt{15} \times 11.2 \, km/s$

23. $\frac{3}{2}$ KT is the averge K.E per mole.

$\therefore \frac{3}{2} \times 1.38 \times 10^{-23} \times T = \frac{1}{2} m v_e^2$

$\therefore T = 10^4 k.$

24. $v_e = \sqrt{2gR}$

$v_e' = \sqrt{2gR'}$

$\frac{v_e'}{v_e} = \sqrt{\frac{R'}{R}} = \sqrt{k}$

25. $v_e = \sqrt{\frac{2GM_e'}{R_e'}} = \sqrt{\frac{2G(8M_e)}{2R_e}} = \sqrt{\frac{2GM_e \times 4}{R_e}}$

$= 2\sqrt{\frac{2GM_e}{R_e}} = 2v_e.$

26. Total Energy $= -\frac{GMm}{2r}$

Binding energy $= -$ Total energy $= \frac{GMm}{2r}.$

$\therefore \frac{GM}{R^2} = g$

$\therefore GM = gR^2$

$\therefore B.E = \frac{GMm}{2r} = \frac{gR^2m}{2r}.$

27. $\frac{1}{2}m\left(\frac{v_e}{3}\right)^2 - \frac{GMm}{R} = \cancel{0} - \frac{GmM}{R'}$

$\therefore -\frac{GmM}{R'} = \frac{1}{\cancel{2}} \times m \frac{\cancel{2}GM}{9R} - \frac{GMm}{R}$

$\frac{GMM}{R'} = \frac{GMm}{R} - \frac{GMm}{9R}$

$= \frac{GMm}{R}\left(1 - \frac{1}{9}\right)$

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

$\therefore R' = \frac{9R}{8} \quad \therefore h = R/8$

28. gravity.

29. $v_e' = \sqrt{\frac{2GM_e}{R_e'}} = \sqrt{\frac{2GM_e}{R_e/4}} = 2\sqrt{\frac{2GM_e}{R_e}}$

$= 2v_e = 22.4 \text{ km/s}.$

30. $v_e' = \sqrt{\frac{2GM'}{R'}} = \sqrt{\frac{2G\,3M_e}{3R_e}} = \sqrt{\frac{2GM_e}{R_e}} = v_e.$

31. $v_e' = \sqrt{\frac{2G \times (1000 M_e)}{10 R_e}} = \sqrt{\frac{2GM_e}{R_e}(100)} = 10\sqrt{\frac{2GM_e}{R_e}}$

$= 10 \times 11.2 = 112 \text{ km/s}$

32. $v_e = \sqrt{\frac{2GM_e}{R_e}}$ is independent of mass of projectile.

33. $V = -\frac{GM}{2R}\left[3 - \left(\frac{r}{R}\right)^2\right]$

$V_{surface} = -\frac{GM}{R}$

$V_{center} = -\frac{3}{2}\frac{GM}{R}$

$\therefore V_{center} = \frac{3}{2} V_{surface}$

34. $V_e' = \sqrt{\frac{2GM_e}{R_e'}} = 10 V_e = 10\sqrt{\frac{2GM_e}{R_e}}$

$\therefore \frac{\cancel{2GM_e}}{R_e'} = 100 \times \frac{\cancel{2GM_e}}{R_e}$

$\frac{R_e}{100} \Rightarrow R_e' = 64$ km.

~~35.~~

1. $F = m\omega^2 r$

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

$\therefore \omega^2 = \frac{GM_m}{r^3}$

$\therefore T = \frac{2\pi}{\omega}$

$\therefore T^2 = \frac{4\pi^2}{\omega^2} = \frac{4\pi^2 r^3}{GM_m}$

2. Both K.E & P.E.

3. $T^2 \propto R^3$ independent of mass.

4. $-\frac{GMm}{r} \longrightarrow -\frac{2GMm}{3r}$

$$\therefore \Delta E = \frac{GMm}{r} - \frac{2GMm}{3r}$$

$$= \frac{GMm}{r}\left(1 - \frac{2}{3}\right)$$

$$= \frac{GMm}{3r}$$

$$\frac{\Delta E}{E} \times 100 = \frac{\frac{GMm}{3r}}{\frac{GMm}{r}} \times 100 = \frac{100}{3} = 33.33\%$$

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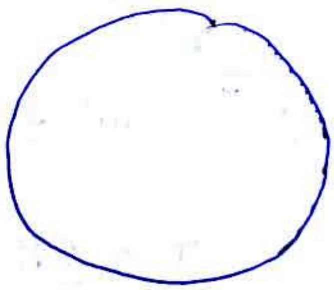
5. $g_p = \frac{GM_p}{R_p^2}$



$g_p = 2g_e$

$$g_p = \frac{G(M_e/2)}{\left(\frac{R_e}{2}\right)^2} \quad \left[\text{if } M_p = \frac{M_e}{2} \quad R_p = \frac{R_e}{2}\right]$$

$$= \frac{GM_e}{2R_e^2} \times 4 = 2\frac{GM_e}{R_e^2} = 2g$$

6. $F = \frac{GMm}{\left(\frac{3R}{2}\right)^2} = \frac{4GMm}{9R^2}$

$$\text{given} = \frac{GM \times 1}{R^2} = 10$$

$\therefore F = \frac{4}{9} \times \frac{GM \times 200}{R^2} = \frac{4}{9} \times 200 \times 10$

$= 889 \text{ N}$

7. $\simeq 6R \simeq 36000$ km.

8. $T_2 = T_1 \left(\frac{R_2}{R_1}\right)^{3/2}$

$= 90 \times \left(\frac{5R}{R}\right)^{3/2}$

$= 720$ min

9. $T_2 = T_1 \left(\frac{R_2}{R_1}\right)^{3/2}$

$= 24h \left(\frac{3R}{R}\right)^{3/2} = 4\sqrt{27}$ hr.

10. $-\frac{GMm}{2r} = T.E = E$

$P.E = -\frac{GMm}{r}$

$\therefore P.E = 2E$

11. period of revolution & period of rotation are equal.

12. $V_0 = \sqrt{\frac{2GM_e}{R_e}}$ is independent of mass of satellite.

13. $T_2 = T_1 \left(\frac{R_2}{R_1}\right)^{3/2}$

$= 5 \times (4)^{3/2} = 5 \times 8 = 40h.$

14. angular momentum is conserved not others.

15. $m V_a r_a$ = constant

since r_a is min v_a is max.

$\therefore \frac{1}{2}m(v_a^2)$ will be max.

16. $T_2 = T_1 \left(\frac{R_2}{R_1}\right)^{3/2}$

$= T_1 \times (4)^{3/2} = T_1 2^3 = 8T_1$

17. $\frac{1}{2}mv^2 = E$

$\therefore \sqrt{\frac{2E}{m}} = v$

$\therefore mvr$ = angular momentum

$= m\sqrt{\frac{2E}{m}}\, r$

$= \sqrt{2Emr^2}$

18. $v_A = \sqrt{\frac{GM}{4r}}$ $v_B = \sqrt{\frac{GM}{r}}$

$3v = \frac{1}{2}\sqrt{\frac{GM}{r}}$

$\therefore 6v = \sqrt{\frac{GM}{r}}$

$\boxed{\therefore v_B = 6v}$

19. $T_2 = T_1 \left(\frac{R_2}{R_1}\right)^{3/2}$

$= 24 \times (2)^{3/2}$ hr

$= 2\sqrt{2} \times 24$ hrs.

$= 2\sqrt{2}$ days.

20. $K.E = \frac{GMm}{2r}$

$P.E = -\frac{GMm}{r}$

$\therefore \frac{K.E}{P.E} = \frac{-1}{2}$

21. $-\frac{GMm}{R}$ → initial energy.

final energy $\rightarrow$ $\dfrac{-GMm}{2(3R)}$

$$\Delta E = \frac{5}{6}\frac{GMm}{R} = \frac{5}{6} \times Rgm$$

22. $T \propto R^{3/2}$

$$\therefore \frac{\Delta T}{T} = \frac{3}{2}\frac{\Delta R}{R}$$

$$\therefore \Delta T = \frac{3}{2}\left(\frac{T}{R}\right)\Delta R$$

23. $$-\frac{GMm}{2r} = T.E$$

$$\therefore T.E = -\frac{1}{2}m\left(\frac{GM}{r}\right) = -\frac{1}{2}mv^2$$

24. $$F \propto \frac{1}{R^n}$$

$$\therefore m\omega^2 R \propto \frac{1}{R^n}$$

$$\therefore \omega^2 \propto \frac{1}{R^{n+1}}$$

$$\therefore T^2 \propto R^{n+1}$$

$$\therefore T \propto R^{(n+1)/2}$$

25. $\frac{v_a}{v_p} = \frac{1+e}{1-e} = \simeq 1.0339$

26. tangential accuration is zero.

27. $T^2 \propto R^3$

$\therefore T_2 = T_1 \left(\frac{2R}{R}\right)^{3/2}$

$= T_1 \times (2)^{3/2}$

$= T_1 \times 2.8$

28. $T_2 = T_1 \left(\frac{R_2}{R_1}\right)^{3/2}$

$= T_1 \left(\frac{4R}{R}\right)^{3/2} = T_1 \times (4)^{3/2}$

$= T_1 \times 8 = 32h.$

29. $K.E = +\frac{GMm}{2r}$

$\therefore K.E \propto \frac{1}{R}$

30. $v_0 \sqrt{\frac{GMe}{Re}}$ independent of mass of satellite.

31. $v_0 = \sqrt{\frac{GM}{r}} = \sqrt{\frac{GM}{\frac{3}{2}R}} = \sqrt{\frac{2}{3}\frac{GM}{R}}$

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

$$\boxed{\therefore v_0 = \sqrt{\frac{2}{3}}\, v}$$

32. $T_2 = T_1 \left(\frac{R_2}{R_1}\right)^{3/2} = T_1 \, (2)^{3/2}$

$= 1 \text{ yr} \times 2\sqrt{2} = 2\sqrt{2} \text{ yr}.$

33. $v_1 = \sqrt{\frac{GM}{r_1}}$ $\qquad v_2 = \sqrt{\frac{GM}{r_2}}$

$r_1 > r_2 \Rightarrow v_1 < v_2$

34. $L = mvr$

$= m \times \sqrt{\frac{GM}{r}} \times r$

$= m\sqrt{GM} \times \sqrt{r}$

$\propto \sqrt{r}.$

35. mvr = constant

since r_a is min v_a will be max.

36. $\frac{dA}{dt}$ = constant (as per keepler's second law)

37. $T^2 \propto R^3$

$$T_2 = T_1 \left(\frac{R_2}{R_1}\right)^{3/2}$$

$$= T_1 \left(\frac{1}{2}\right)^{3/2}$$

$$= T_1 \times 2^{-3/2}$$

T_1 is lunar month.

38. $\frac{1}{2}m(v+v')^2 - \frac{GMm}{7R} = 0$

$K.E = \frac{GMm}{14R}$ $\therefore$ $v = \sqrt{\frac{GM}{\cancel{14}R}}$

$\therefore v + v' = v_e$

$\therefore \sqrt{\frac{GM\cancel{m}}{\cancel{14}R}} + v' = \sqrt{\frac{2GM}{7R}}$

$$v' = \left(\sqrt{2} - \frac{1}{\sqrt{\cancel{14}}}\right)\sqrt{\frac{GM}{R}}$$

$\underline{\%}$ $(\sqrt{\cancel{2}} - 1) \times 100$

$0.414 \times 100 = \underline{41.4\ \%}$

39. $\frac{T_1^2}{R_1^3} = \frac{T_2^2}{R_2^3}$

$\therefore \left(\frac{T_1}{T_2}\right)^2 = \left(\frac{R_1}{R_2}\right)^3$

40 $\frac{1}{2}m(v+v') - \frac{GMm}{R} = 0.$

$v+v' = v_e$

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

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

$\sqrt{\frac{GM}{R}} + v' = \sqrt{\frac{2GM}{R}}$

$v' = (\sqrt{2}-1)\sqrt{\frac{GM}{R}}$

$= 0.414\sqrt{Rg} \quad \left[\frac{GM}{R} = Rg\right]$

41. $T_2 = T_1\left(\frac{R_2}{R_1}\right)^{3/2} = 24 \times \left(\frac{6400}{36000}\right)^{3/2}$

$= 24\left[\frac{32}{180}\right]^{3/2} = 24\left[\frac{16}{90}\right]^{3/2} = 24\left[\frac{8}{45}\right]^{3/2}$

$\simeq 2$ hrs

42. $T_2 = T_1 \left(\frac{4R_1}{R_1} \right)^{3/2}$

$= 8T_1$ $\quad [T_1 = 1 \text{ day}]$

$= 8$ days.

43. mvr = constant

when distance from sun is minimum velocity is max & so is K.E.

44. V_0 is independent of mass of satellite.

45. Reason is false, angular momentum is conserved.

46. Length of the day is slowly increasing because earth's shape is changing.

47. $T^2 \propto R^3$

$T_2 = T_1 \left(\frac{R_2}{R_1} \right)^{3/2} = (365) \times \left(\frac{1}{2} \right)^{3/2}$

$\simeq 129$ days.

46. $F \propto r^{-5/2}$

$m\omega^2 r \propto r^{-5/2}$

$\omega^2 \propto r^{-7/2}$

$T^2 \propto r^{7/2}$

$F \propto r^{5/2}$

$m\omega^2 r \propto r^{5/2}$

$\omega^2 \propto r^{3/2}$

$T^2 \propto r^{-3/2}$