# GRAVITATION

**1.** The acceleration due to gravity on the surface of earth is g. If the diameter of earth reduces to half of its original value and mass remains constant, then acceleration due to gravity on the surface of earth would be :

(1) g/4 (2) 2g
(3) g/2 (4) 4g

**2.** Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R ).

**Assertion (A) :** The angular speed of the moon in its orbit about the earth is more than the angular speed of the earth in its orbit about the sun.

**Reason (R)** : The moon takes less time to move around the earth than the time taken by the earth to move around the sun.

In the light of the above statements, choose the most appropriate answer from the options given below:

(1) (A) is correct but (R) is not correct
(2) Both (A) and (R) are correct and (R) is the correct explanation of (A)
(3) Both (A) and (R) are correct but (R) is not the correct explanation of (A)
(4) (A) is not correct but (R) is correct

**3.** At what distance above and below the surface of the earth a body will have same weight, (take radius of earth as R.)

(1) $\sqrt{5}R - R$ (2) $\frac{\sqrt{3}R - R}{2}$
(3) $\frac{R}{2}$ (4) $\frac{\sqrt{5}R - R}{2}$

**4.** A planet takes 200 days to complete one revolution around the Sun. If the distance of the planet from Sun is reduced to one fourth of the original distance, how many days will it take to complete one revolution?

(1) 25 (2) 50
(3) 100 (4) 20

**5.** The gravitational potential at a point above the surface of earth is $-5.12 \cdot 10^7\ J/kg$ and the acceleration due to gravity at that point is 6.4 $m/s^2$. Assume that the mean radius of earth to be 6400 km. The height of this point above the earth's surface is :

(1) 1600 km (2) 540 km
(3) 1200 km (4) 1000 km

**6.** Escape velocity of a body from earth is 11.2 km/s. If the radius of a planet be one-third the radius of earth and mass be one-sixth that of earth, the escape velocity from the plate is:

(1) 11.2 km/s (2) 8.4 km/s
(3) 4.2 km/s (4) 7.9 km/s

**7.** A simple pendulum is placed at a place where its distance from the earth's surface is equal to the radius of the earth. If the length of the string is 4m, then the time period of small oscillations will be _______s. [Take g $=\pi^2$ $ms^{-2}$]

**8.** Four identical particles of mass m are kept at the four corners of a square. If the gravitational force exerted on one of the masses by the other masses is $\left(\frac{2\sqrt{2}+1}{32}\right)\frac{Gm^2}{L^2}$, the length of the sides of the square is:

(1) $\frac{L}{2}$ (2) 4L
(3) 3L (4) 2L

**9.** The mass of the moon is 1/144 times the mass of a planet and its diameter 1/16 times the diameter of a planet. If the escape velocity on the planet is v, the escape velocity on the moon will be:

(1) $\frac{v}{3}$ (2) $\frac{v}{4}$
(3) $\frac{v}{12}$ (4) $\frac{v}{6}$

**10.** If R is the radius of the earth and the acceleration due to gravity on the surface of earth is $g = \pi^2\ m/s^2$, then the length of the second's pendulum at a height h = 2R from the surface of earth will be,:

(1) $\frac{2}{9}m$ (2) $\frac{1}{9}m$

(3) $\frac{4}{9}m$ (4) $\frac{8}{9}m$

**11.** A light planet is revolving around a massive star in a circular orbit of radius R with a period of revolution T. If the force of attraction between planet and star is proportional to $R^{-3/2}$ then choose the correct option :

(1) $T^2 \propto R^{5/2}$ (2) $T^2 \propto R^{7/2}$

(3) $T^2 \propto R^{3/2}$ (4) $T^2 \propto R^3$

**12.** A metal wire of uniform mass density having length L and mass M is bent to form a semicircular arc and a particle of mass m is placed at the centre of the arc. The gravitational force on the particle by the wire is:

(1) $\frac{GMm\pi}{2L^2}$ (2) 0

(3) $\frac{GmM\pi^2}{L^2}$ (4) $\frac{2GmM\pi}{L^2}$

**13.** Correct formula for height of a satellite from earth's surface is :

(1) $\left(\frac{T^2R^2g}{4\pi}\right)^{1/2} - R$ (2) $\left(\frac{T^2R^2g}{4\pi^2}\right)^{1/3} - R$

(3) $\left(\frac{T^2R^2}{4\pi^2 g}\right)^{1/3} - R$ (4) $\left(\frac{T^2R^2}{4\pi^2}\right)^{-1/3} + R$

**14.** A 90 kg body placed at 2R distance from surface of earth experiences gravitational pull of :

(R = Radius of earth, $g = 10\ ms^{-2}$)

(1) 300 N (2) 225 N

(3) 120 N (4) 100 N

**15.** In hydrogen like system the ratio of coulombian force and gravitational force between an electron and a proton is in the order of:

(1) $10^{39}$ (2) $10^{19}$

(3) $10^{29}$ (4) $10^{36}$

**16.** Match list-I with list-II:

| | List-I | | List-II |
|---|---|---|---|
| (A) | Kinetic energy of planet | (I) | $-\frac{GMm}{a}$ |
| (B) | Gravitation Potential energy of Sun-planet system. | (II) | $\frac{GMm}{2a}$ |
| (C) | Total mechanical energy of planet | (III) | $\frac{Gm}{r}$ |
| (D) | Escape energy at the surface of planet for unit mass object | (IV) | $-\frac{GMm}{2a}$ |

(Where a = radius of planet orbit, r = radius of planet, M = mass of Sun, m = mass of planet)

Choose the correct answer from the options given below:

(1) (A) – II, (B) – I, (C) – IV, (D) – III

(2) (A) – III, (B) – IV, (C) – I, (D) – II

(3) (A) – I, (B) – IV, (C) – II, (D) – III

(4) (A) – I, (B) – II, (C) – III, (D) – IV

**17.** A simple pendulum doing small oscillations at a place R height above earth surface has time period of $T_1 = 4$ s. $T_2$ would be it's time period if it is brought to a point which is at a height 2R from earth surface. Choose the correct relation [R = radius of Earth]:

(1) $T_1 = T_2$ (2) $2T_1 = 3T_2$

(3) $3T_1 = 2T_2$ (4) $2T_1 = T_2$

**18.** A satellite revolving around a planet in stationary orbit has time period 6 hours. The mass of planet is one-fourth the mass of earth. The radius orbit of planet is : (Given = Radius of geo-stationary orbit for earth is $4.2 \times 10^4$ km)

(1) $1.4 \times 10^4$ km

(2) $8.4 \times 10^4$ km

(3) $1.68 \times 10^5$ km

(4) $1.05 \times 10^4$ km

**19.** To project a body of mass m from earth's surface to infinity, the required kinetic energy is (assume, the radius of earth is $R_E$, g = acceleration due to gravity on the surface of earth) :

(1) $2mgR_E$ (2) $mgR_E$

(3) $\frac{1}{2}mgR_E$ (4) $4mgR_E$

**20.** Assuming the earth to be a sphere of uniform mass density, a body weighed 300 N on the surface of earth. How much it would weigh at R/4 depth under surface of earth ?

(1) 75 N (2) 375 N

(3) 300 N (4) 225 N

**21.** Two planets A and B having masses $m_1$ and $m_2$ move around the sun in circular orbits of $r_1$ and $r_2$ radii respectively. If angular momentum of A is L and that of B is 3L, the ratio of time period $\left(\frac{T_A}{T_B}\right)$ is:

(1) $\left(\frac{r_2}{r_1}\right)^{\frac{3}{2}}$ (2) $\left(\frac{r_1}{r_2}\right)^3$

(3) $\frac{1}{27}\left(\frac{m_2}{m_1}\right)^3$ (4) $27\left(\frac{m_1}{m_2}\right)^3$

**22.** Two satellite A and B go round a planet in circular orbits having radii 4 R and R respectively. If the speed of A is $3v$, the speed of B will be :

(1) $\frac{4}{3}v$ (2) $3v$

(3) $6v$ (4) $12v$

**23.** An astronaut takes a ball of mass m from earth to space. He throws the ball into a circular orbit about earth at an altitude of 318.5 km. From earth's surface to the orbit, the change in total mechanical energy of the ball is $x\frac{GM_e m}{21R_e}$. The value of x is (take $R_e$ = 6370 km):

(1) 11 (2) 9

(3) 12 (4) 10

**24.** A satellite of $10^3$ kg mass is revolving in circular orbit of radius 2R. If $\frac{10^4 R}{6} J$ energy is supplied to the satellite, it would revolve in a new circular orbit of radius :

(use g = 10 m/s$^2$, R = radius of earth)

(1) 2.5 R (2) 3 R

(3) 4 R (4) 6 R

## SOLUTIONS

**1. Ans. (4)**

**Sol.** $g = \frac{GM}{R^2} \Rightarrow g \propto \frac{1}{R^2}$

$\frac{g_2}{g_1} = \frac{R_1^2}{R_2^2}$; $g_2 = 4g_1 \left(R_2 = \frac{R_1}{2}\right)$

**2. Ans. (2)**

**Sol.** $\omega = \frac{2\pi}{T} \Rightarrow \omega \propto \frac{1}{T}$

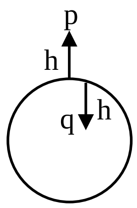
$T_{moon} = 27$ days

$T_{earth} = 365$ days 4 hour

$\Rightarrow \omega_{moon} > \omega_{earth}$

**3. Ans. (4)**

**Sol.** $g_p = \frac{gR^2}{(R+h)^2}$




$g_q = g\left(1 - \frac{h}{R}\right)$

$g_p = g_q$

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

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

Take $\frac{h}{R} = x$

So

$x^3 - x + x^2 = 0$

$x = \frac{\sqrt{5}-1}{2}$

$h = \frac{R}{2}\left(\sqrt{5}-1\right)$

**4. Ans. (1)**

**Sol.** $T^2 \propto r^3$

$\frac{T_1^2}{r_1^3} = \frac{T_2^2}{r_2^3}$

$\frac{(200)^2}{r^3} = \frac{T_2^2}{\left(\frac{r}{4}\right)^3}$

$\frac{200 \times 200}{4 \times 4 \times 4} = T_2^2$

$T_2 = \frac{200}{4 \times 2}$ $\quad T_2 = 25$ days

**5. Ans. (1)**

**Sol.** $-\frac{GM_E}{R_E + h} = -5.12 \times 10^{-7}$ .... (i)

$\frac{GM_E}{(R_E + h)^2} = 6.4$ .... (ii)

By (i) and (ii)

$\Rightarrow h = 16 \times 10^5 m = 1600$ km

**6. Ans. (4)**

**Sol.** $R_P = \frac{R_E}{3}$, $M_P = \frac{M_E}{6}$

$V_e = \sqrt{\frac{2GM_e}{R_e}}$ ...(i)

$V_P = \sqrt{\frac{2GM_P}{R_P}}$ ...(ii)

$\frac{V_e}{V_p} = \sqrt{2}$

$V_P = \frac{V_e}{\sqrt{2}} = \frac{11.2}{\sqrt{2}} = 7.9$ km/sec

**7. Ans. (8)**

**Sol.** Acceleration due to gravity $g' = \frac{g}{4}$

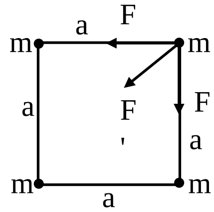
$T = 2\pi\sqrt{\frac{4\ell}{g}}$

$T = 2\pi\sqrt{\frac{4 \times 4}{g}}$

$T = 2\pi\frac{4}{\pi} = 8s$

**8. Ans. (2)**

**Sol.**




$F_{net} = \sqrt{2}F + F'$

$F = \frac{Gm^2}{a^2}$ and $F' = \frac{Gm^2}{(\sqrt{2}a)^2}$

$$F_{net} = \sqrt{2}\frac{Gm^2}{a^2} + \frac{Gm^2}{2a^2}$$

$$\left(\frac{2\sqrt{2}+1}{32}\right)\frac{Gm^2}{L^2} = \frac{Gm^2}{a^2}\left(\frac{2\sqrt{2}+1}{2}\right)$$

a = 4L

**9. Ans. (1)**

**Sol.** $V_{escape} = \sqrt{\frac{2GM}{R}}$

$$V_{planet} = \sqrt{\frac{2GM}{R}} = V$$

$$V_{Moon} = \sqrt{\frac{2GM \cdot 16}{144\,R}} = \frac{1}{3}\sqrt{\frac{2GM}{R}}$$

$$V_{Moon} = \frac{V_{Planet}}{3} = \frac{V}{3}$$

**10. Ans. (2)**

**Sol.** $g' = \frac{GMe}{(3R)^2} = \frac{1}{9}g$

$$T = 2\pi\sqrt{\frac{\ell}{g'}}$$

Since the time period of second pendulum is 2 sec.

T = 2 sec

$$2 = 2\pi\sqrt{\frac{\ell}{g}9}\,;$$

$$\boxed{\ell = \frac{1}{9}m}$$

**11. Ans. (1)**

**Sol.** $F = \frac{GMm}{R^{3/2}} = m\omega^2 R$

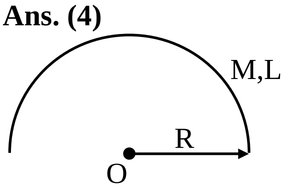
$$\omega^2 \propto \frac{1}{R^{5/2}}$$

$\because T = \frac{2\pi}{\omega}$ so

$T^2 \propto R^{5/2}$

**12. Ans. (4)**

**Sol.**




We have $R = \frac{L}{\pi}$

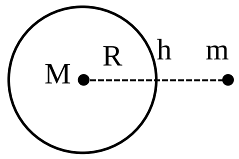
$$g_0 = \frac{2G\frac{M}{L}}{R} = \frac{2GM\pi}{L^2}$$

$$\therefore F_m = mg_0 = \frac{2GM\pi m}{L^2}$$

Hence option (4)

**13. Ans. (2)**

**Sol.**




$$\Rightarrow \frac{GMm}{(R+h)^2} = \frac{mv^2}{(R+h)}$$

$$\Rightarrow \frac{GM}{(R+h)} = v^2 \text{ ....(1)}$$

$\Rightarrow$ v = (R + h)ω

$$\Rightarrow v = (R+h)\frac{2\pi}{T} \text{ .......(2)}$$

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

$\Rightarrow$ GM = $gR^2$ ........(3)

Put value from (2) & (3) in eq. (1)

$$\Rightarrow \frac{gR^2}{(R+h)} = (R+h)^2\left(\frac{2\pi}{T}\right)^2$$

$$\Rightarrow \frac{T^2R^2g}{(2\pi)^2} = (R+h)^3$$

$$\Rightarrow \left[\frac{T^2R^2g}{(2\pi)^2}\right]^{1/3} - R = h$$

**14. Ans. (4)**

**Sol.** Value of g = $g_s\left(1+\frac{h}{R}\right)^{-2}$

$$= g_s(1+2)^{-2} = \frac{g_s}{9}$$

Here $g_s$ = gravitational acceleration at surface

Force = mg = 90 × $\frac{g_s}{9}$ = 100 N

**15. Ans. (1)**

**Sol.** $F_e = \frac{kQ_1Q_2}{r^2} = \frac{9 \cdot 10^9 \cdot 1.6 \cdot 10^{-19} \cdot 1.6 \cdot 10^{-19}}{r^2}$

$$F_g = \frac{Gm_1m_2}{r^2} = \frac{6.67 \cdot 10^{-11} \cdot 9.1 \cdot 10^{-31} \cdot 1.6 \cdot 10^{-27}}{r^2}$$

$$\frac{F_e}{F_g} \cong 0.23 \cdot 10^{40} \cong 2.3 \cdot 10^{39}$$

Option (1)

**16. Ans. (1)**

**Sol.** $KE = \frac{1}{2}mv^2 = \frac{GMm}{2a}$

PE = –2KE

TE = –KE

**17. Ans. (3)**

**Sol.** $T_1 = 2\pi\sqrt{\frac{\square}{GM}(2R)^2}$

$T_2 = 2\pi\sqrt{\frac{\square}{GM}(3R)^2} \quad \therefore \frac{T_1}{T_2} = \frac{2}{3}$

**18. Ans. (4)**

**Sol.** $T = \frac{2\pi\ ^{3/2}}{\sqrt{GM}}$

$\frac{T_1}{T_2} = \left(\frac{r_1}{r_2}\right)^{3/2}\left(\frac{M_2}{M_1}\right)^{1/2}$

$\frac{6}{24} = \frac{(r_1)^{3/2}}{(4.2 \cdot 10^4)^{3/2}}\left(\frac{M}{M/4}\right)^{1/2}$

$r_1 = 1.05 \times 10^4$ km

**19. Ans. (2)**

**Sol.** $\frac{1}{2}mv_e^2 = \frac{GMm}{R_E}$

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

$K = mgR_E$

**20. Ans. (4)**

**Sol.** At surface: mg = 300 N

$m = \frac{300}{g_s}$

At Depth $\frac{R}{4}$: $g_d = g_s\left[1 - \frac{d}{R}\right]$

$g_d = g_s\left[1 - \frac{R}{4R}\right]$; $g_d = \frac{3g_s}{4}$

weight at depth = m × $g_d$

$= m \cdot \frac{3g_s}{4} = \frac{3}{4} \cdot 300 = 225$ N

**21. Ans. (3)**

**Sol.** $\frac{\pi r_1^2}{T_A} = \frac{L}{2m_1}$ ……. (1)

$\frac{\pi r_2^2}{T_B} = \frac{3L}{2m_2}$ ……. (2)

$\Rightarrow \frac{T_A}{T_B} = 3.\frac{m_1}{m_2}.\left(\frac{r_1}{r_2}\right)^2$

$\left(\frac{T_A}{T_B}\right)^2 = \left(\frac{r_1}{r_2}\right)^3 \Rightarrow \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{T_A}{T_B}\right)^{\frac{4}{3}}$

$\Rightarrow \frac{1}{27}.\left(\frac{m_2}{m_1}\right)^3 = \left(\frac{T_A}{T_B}\right)$

**22. Ans. (3)**

**Sol.** $v = \sqrt{\frac{GM}{R}}$

$\frac{v_A}{v_B} = \sqrt{\frac{R_B}{R_A}} = \sqrt{\frac{R}{4R}} = \frac{1}{2}$

$v_B = 2v_A = 6v$

**23. Ans. (1)**

**Sol.** $h = 318.5 \approx \left(\frac{R_e}{20}\right)$

$T.E_i = \frac{-GM_e m}{R_e}$

$T.E_f = \frac{-GM_e m}{2(R_e + h)} = \frac{-GM_e m}{2\left(R_e + \frac{R_e}{20}\right)}$

$\Rightarrow T.E_f = \frac{-10GM_e m}{21R_e}$

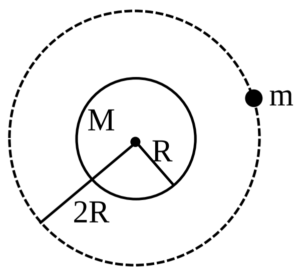
Change in total mechanical energy

$= TE_f - TE_i$

$= \frac{GM_e m}{Re}\left[1 - \frac{10}{21}\right] = \frac{11GM_e m}{21Re}$

**24. Ans. (4)**

**Sol.**




Total energy = $\frac{-GMm}{2(2R)}$

if energy = $\frac{10^4 R}{6}$ is added then

$\frac{-GMm}{4R} + \frac{10^4 R}{6} = \frac{-GMm}{2r}$

where r is new radius of revolving and $g = \frac{GM}{R^2}$

$-\frac{mgR}{4} + \frac{10^4 R}{6} = -\frac{mgR^2}{2r}$ ($m = 10^3$ kg)

$-\frac{10^3 \cdot 10 \cdot R}{4} + \frac{10^4 R}{6} = -\frac{10^3 \cdot 10 \cdot R^2}{2r}$

$-\frac{1}{4} + \frac{1}{6} = -\frac{R}{2r}$

r = 6R