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1. Two bodies of mass m and 9m are placed at a distance R. The gravitational potential on the line joining the bodies where the gravitational field equals zero, will be (G = gravitational constant): **(2023)**
(a) $-\frac{20GM}{R}$
(b) $-\frac{8Gm}{R}$
(c) $-\frac{12Gm}{R}$
(d) $-\frac{16Gm}{R}$

2. A satellite is orbiting just above the surface of the earth with period T. If d is the density of the earth and G is the universal constant of gravitation, the quantity $\frac{3\pi}{Gd}$ represents: **(2023)**
(a) $\sqrt{T}$
(b) T
(c) T^2
(d) T^3

3. A body of mass 60 g experiences a gravitational force of 3.0 N, when placed at a particular point. The magnitude of the gravitational field intensity at that point is: **(2022)**
(a) 50 N/kg
(b) 20 N/kg
(c) 180 N/kg
(d) 0.05 N/kg

4. Match List-I with List-II:

List I	List II
a) Gravitational constant (G)	i) $[L^2T^{-2}]$
b) Gravitational potential energy	ii) $[M^{-1}L^3T^{-2}]$
c) Gravitational potential	iii) $[LT^{-2}]$
d) Gravitational intensity	iv) $[ML^2T^{-2}]$

Choose the correct answer from the options given below: **(2022)**
(a) a) – ii); b) – iv); c) –i); d) – iii)
(b) a) – ii); b) – iv); c) –iii); d) – i)
(c) a) – iv); b) – ii); c) –i); d) – iii)
(d) a) – ii); b) – i); c) –iv); d) – iii)

5. A particle is released from height S from the surface of the Earth. At a certain height its kinetic energy is three times its potential energy. The height from the surface of earth and the speed of the particle at that instant are respectively: **(2021)**
(a) $\frac{S}{4}, \frac{\sqrt{3gS}}{2}$
(b) $\frac{S}{2}, \frac{\sqrt{3gS}}{2}$
(c) $\frac{S}{4}, \sqrt{\frac{3gS}{2}}$
(d) $\frac{S}{4}, \frac{3gS}{2}$

6. The escape velocity from the Earth's surface is v. The escape velocity from the surface of another planet having a radius, four times that of Earth and same mass density is: **(2021)**
(a) 2v
(b) 3v
(c) 4v
(d) v

7. A particle of mass 'm' is projected with a velocity $v = kVe(k < 1)$. from the surface of the earth. The <u>maximum height</u> above the surface reached by the particle is: **(2021)**
(a) $R\left(\frac{k}{1+k}\right)^2$
(b) $\frac{R^2k}{1+k}$
(c) $\frac{Rk^2}{1+k}$
(d) $R\left(\frac{k}{1-k}\right)^2$

8. A body weighs 72 N on the surface of the earth. What is the gravitation force on it, at a height equal to half the radius of the earth **(2020)**
(a) 32 N

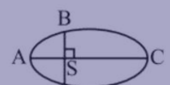
(b) 30 N
(c) 24 N
(d) 48 N

9. What is the depth at which the value of acceleration due to gravity becomes 1/n times the value that at the surface of earth? (radius of earth = R)**(2020 Covid Re-NEET)**
(a) R(n −1)/n
(b) Rn/(n −1)
(c) R/n
(d) R/n^2

10. A body weighs 200 N on the surface of the earth. How much will it weigh half way down to the centre of the earth? **(2019)**
(a) 150 N
(b) 200 N
(c) 250 N
(d) 100 N

11. The work done to raise a mass m from the surface of the earth to a height h, which is equal to the radius of the earth, is: **(2019)**
(a) mgR
(b) 2mgR
(c) $\frac{1}{2}mgR$
(d) $\frac{3}{2}mgR$

12. The kinetic energies of a planet in an elliptical orbit about the Sun, at positions A, B and C are K_A, K_B and K_C, respectively. AC is the major axis and SB is perpendicular to AC at the position of the Sun S as shown in the figure. Then **(2018)**



(a) $K_B < K_A < K_C$
(b) $K_A > K_B > K_C$
(c) $K_A < K_B < K_C$
(d) $K_B > K_A > K_C$

13. If the mass of the Sun were ten times smaller and the universal gravitational constant were ten times larger in magnitude, which of the following is not correct ? **(2018)**
(a) Time period of a simple pendulum on the Earth would decrease
(b) Walking on the ground would become more difficult
(c) Raindrops will fall faster.
(d) 'g' on the Earth will not change

14. The acceleration due to gravity at a height 1 km above the earth is the same as at a depth d below the surface of earth. Then: **(2017-Delhi)**
(a) $d = 1\ km$
(b) $d = \frac{3}{2}\ km$
(c) $d = 2\ km$
(d) $d = \frac{1}{2}\ km$

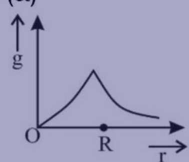
15. Two astronauts are floating in gravitational free space after having lost contact with their spaceship. The two will: **(2017-Delhi)**
(a) Move towards each other
(b) Move away from each other
(c) Will become stationary
(d) Keep floating at the same distance between them

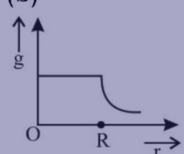
16. Imagine earth to be a solid sphere of mass M and radius R. If the value of acceleration due to gravity at a depth 'd' below earth's surface is same as its value at a height 'h' above its surface and equal to $\frac{g}{4}$ (where g is the value of acceleration due to gravity on the surface of earth), the ratio of $\frac{h}{d}$ will be: **(2017-Gujarat)**
(a) 1
(b) $\frac{4}{3}$
(c) $\frac{3}{2}$
(d) $\frac{2}{3}$

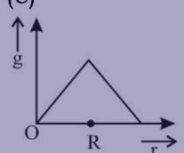
17. A satellite of mass m is in circular orbit of radius 3RE about earth (mass of earth M_E, radius of earth R_E). How much additional energy is required to transfer the satellite to an orbit of radius $9R_E$? **(2017-Gujarat)**
(a) $\frac{GM_Em}{3R_E}$
(b) $\frac{GM_Em}{18R_E}$
(c) $\frac{GM_Em}{2R_E}$

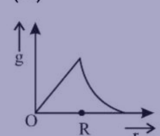
(d) $\frac{GM_E m}{9R_E}$

18. A satellite of mass m is orbiting the earth (of radius R) at a height h from its surface. The total energy of the satellite in terms of g_0, the value of acceleration due to gravity at the earth's surface, is: **(2016 - II)**
(a) $\frac{2mg_0R^2}{R+h}$
(b) $-\frac{2mg_0R^2}{R+h}$
(c) $\frac{mg_0R^2}{R(R+h)}$
(d) $\frac{mg_0R^2}{2(R+h)}$

19. Starting from the center of the earth having radius R, the variation of g (acceleration due to gravity) is shown by **(2016 - II)**
(a)


(b)


(c)


(d)


20. The ratio of escape velocity at earth (v_e) to the escape velocity at a planet (v_p) whose radius and mean density are twice as that of earth is: **(2016 - I)**
(a) 1 : 2
(b) $1 : 2\sqrt{2}$
(c) 1 : 4
(d) 1: 2

21. At what height from the surface of earth the gravitation potential and the value of g are $-5.4 \times 10^{-7}\, J\, kg^{-2}$ and $6.0\, ms^{-2}$ respectively. Take the radius of earth as 6400 km: **(2016 - I)**
(a) 2600 km
(b) 1600 km
(c) 1400 km
(d) 2000 km

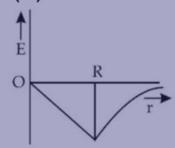
22. Kepler's third law states that square of period of revolution (T) of a planet around the sun, is proportional to third power of average distance r between sun and planet, i.e., $T^2 = Kr^3$ here K is constant. If the masses of sun and planet are M and m respectively then as per Newton's law of gravitation force of attraction between them is $F = \frac{GMm}{r^2}$ here G is gravitational constant. The relation between G and K is described as: **(2015)**
(a) $GMK = 4\pi^2$
(b) $K = G$
(c) $K = \frac{1}{G}$
(d) $GM = 4\pi^2$

23. A remote-sensing satellite of earth revolves in a circular orbit at a height of 0.25×10^6 m above the surface of earth. If earth's radius is $6.38 \times 10^6 m$ and $g = 9.8\, m/s^2$, then the orbital speed of the satellite is: **(2015 Re)**
(a) 6.67 km/s
(b) 7.76 km/s
(c) 8.56 km/s
(d) 9.13 km/s

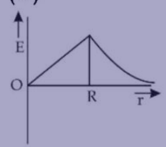
24. A satellite S is moving in an elliptical orbit around the earth. The mass of the satellite is very small compared to the mass of the earth. Then: **(2015 Re)**
(a) The acceleration of S is always directed towards the center of the earth
(b) The angular momentum of S about the center of the earth changes in direction, but its magnitude remains constant.
(c) The total mechanical energy of S varies periodically with time.
(d) The linear momentum of S remains constant in magnitude

25. Dependence of intensity of gravitational field (E) of earth with distance (r) from center of earth is correctly represented by: **(2014)**

(a)



(b)



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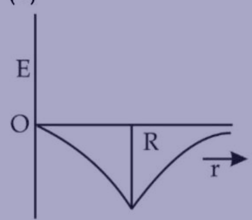
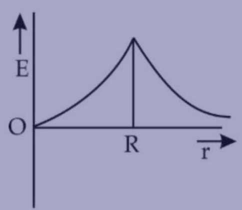


(d)



26. A black hole is an object whose gravitational field is so strong that even light cannot escape from it. To what approximate radius would earth (mass = $5.98 \times 10^{24}\ kg$) have to be compressed to be a black hole? **(2014)**
(a) $10^{-2} m$
(b) $10^{-6}\ m$
(c) $10\ m$
(d) $100\ m$

27. Infinite number of bodies, each of mass 2 kg are situated on x-axis at distance 1 m, 2 m, 4 m, 8 m, ... respectively, from the origin. The resulting gravitational potential due to this system at the origin will be: **(2013)**
(a) $-4G$
(b) $-G$
(c) $-\frac{8}{3}G$
(d) $-\frac{4}{3}G$

28. A body of mass 'm' taken from the earth's surface to the height equal to twice the radius (R) of the earth. The change in potential energy of body will be: **(2013)**
(a) 1/3 mgR
(b) 2 mgR
(c) 2/3 mgR
(d) 3 mgR

Answer Key

S1. Ans. (d)

S2. Ans. (c)

S3. Ans. (a)

S4. Ans. (a)

S5. Ans. (a)

S6. Ans. (c)

S7. Ans. (d)

S8. Ans. (a)

S9. Ans. (a)

S10. Ans. (d)

S11. Ans. (c)

S12. Ans. (b)

S13. Ans. (d)

S14. Ans. (c)

S15. Ans. (a)

S16. Ans. (b)

S17. Ans. (d)

S18. Ans. (d)

S19. Ans. (d)

S20. Ans. (b)

S21. Ans. (a)

S22. Ans. (a)

S23. Ans. (b)

S24. Ans. (a)

S25. Ans. (a)

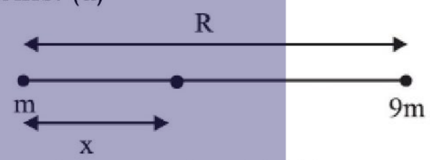
S26. Ans. (a)

S27. Ans. (a)

S28. Ans. (c)

Solutions

S1. Ans. (d)



Let the gravitational field is zero at a distance x from the mass m.

$$\frac{Gm}{x^2} = \frac{G9m}{(R-x)^2}$$

$\Rightarrow R - x = 3x$ or $x = \frac{R}{4}$

Gravitational potential at $\frac{R}{4}$

$$= -\frac{Gm}{\frac{R}{4}} - \frac{G9m}{\frac{3R}{4}}$$

$$= -\frac{4Gm}{R} - \frac{12Gm}{R}$$

$$= -\frac{16Gm}{R}$$

S2. Ans. (c)

Time period of satellite

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

$$= 2\pi\sqrt{\frac{R^3}{Gd\frac{4}{3}\pi R^3}}$$

$$\Rightarrow T = \sqrt{\frac{3\pi}{Gd}}$$

S3. Ans. (a)

$$I_g = \frac{F}{m}$$

$$= \frac{3}{60 \times 10^{-3}} = 50\ N/kg$$

S4. Ans. (a)

Gravitational constant $= [M^{-1}L^3T^{-2}]$

Gravitational potential energy $= [ML^2T^{-2}]$

Gravitational potential $= [L^2T^{-2}]$

Gravitational intensity $= [LT^{-2}]$

S5. Ans. (a)

Hint: PE + KE = mgs

At given point

KE = 3PE

So, 4PE = mgs

H = s/4

$$KE = KE = \frac{3mgs}{4} = \frac{1}{2}mV^2$$

$$V = \sqrt{\frac{3gs}{4}} = \frac{\sqrt{3gs}}{4}$$

S6. Ans. (c)

Hint: $V_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2G}{R}} \times \frac{4}{3}\pi R3\rho$

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

$\Rightarrow V_e \infty R$

$\Rightarrow V_e/\upsilon = \frac{4R}{R} \Rightarrow V_e = 4v$

S7. Ans. (d)

Hint: $\frac{GMn}{R} + \frac{1}{2}mk^2V_e^2 = \frac{GMm}{r}$

$$-\frac{GMn}{R} + \frac{1}{2}mk^2\frac{2GMm}{R} = \frac{GMn}{r}$$

$$-\frac{1}{R} + \frac{k^2}{R} = -\frac{1}{r}$$

$$\frac{1}{r} = \frac{1}{R} - \frac{k^2}{R}$$

$$\frac{1}{r} = \frac{1-k^2}{R}$$

$$r = \frac{R}{1-k^2}$$

S8. Ans. (a)

Hint: $w_s = mg_s = 72\ N$

$$w_h = mg_h = \frac{mg_s}{\left(1+\frac{h}{R}\right)^2} = \frac{72N}{\left(1+\frac{\frac{R}{2}}{2}\right)^2} = \frac{\frac{72}{9}}{4}$$

$W_h = 32\ N$

S9. Ans. (a)

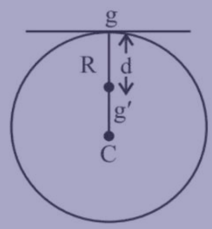
Hint: Inside the earth at depth d from the surface

$$g_{eff} = g\left(1 - \frac{d}{R}\right) \Rightarrow \frac{g}{n} = g\left(1 - \frac{d}{R}\right)$$

$$\Rightarrow d = \frac{(n-1)R}{n}$$

S10. Ans. (d)

Hint:



Acceleration due to gravity at a depth d from surface of earth

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

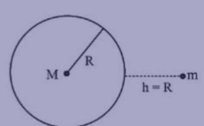
Here g = acceleration due to gravity at earth's surface Multiplying by mass 'm' on both sides of a.

$mg' = mg\left(1 - \frac{d}{R}\right); \left(\because d = \frac{R}{2}\right)$

$= 200\left(1 - \frac{R}{2R}\right) = \frac{200}{2} = 100 \text{ N}$

S11. Ans. (c)

Hint:



Initial potential energy

$U_i = \frac{-GMn}{R}$

Final potential energy at height h = R

$U_f = \frac{-GMn}{(R+R)}$

As work done = Change in PE

$\therefore W = U_f - U_i$

$= \frac{GMm}{2R} = \frac{gR^2m}{2R} = \frac{mgR}{2} \quad (\because GM = gR^2)$

S12. Ans. (b)

Hint: As angular momentum is conserved mvr = constant so $v_A > v_B > v_C$

hence

$K_A > K_B > K_C$

S13. Ans. (d)

Hint: If universal constant becomes 10 times, then on earth surface

$g = \frac{GM}{R^2} \qquad G' = 10\text{ G}$

$g' = 10\frac{10GM}{R^2} \qquad g' = 10g$

So g on earth surface will change

S14. Ans. (c)

Hint: Acceleration due to gravity at height 1 km above earth surface

$a_h = g\left[1 - \frac{2R}{R}\right]$

$= g\left[1 - \frac{2\times1}{R}\right]$

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

Acceleration due to gravity at depth 'd' below earth surface

$a_d = g\left[1 - \frac{d}{R}\right]$

$a_h = a_d$

$g\left[1 - \frac{2}{R}\right] = g\left[1 - \frac{d}{R}\right]$

$d = 2\text{ km}$

S15. Ans. (a)

Hint: Since two astronauts are floating in gravitational free space, the only force acting on the two astronauts is the gravitational pull of their masses

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

which is attractive in nature. Hence they move towards each other.

S16. Ans. (b)

Hint: $g_d = g\left[1 - \frac{d}{R}\right]$

$g_d = \frac{g}{4}$

$\frac{g}{4} = g\left[1 - \frac{d}{R}\right]$

$\frac{d}{R} = \frac{3}{4}$ ....(1)

$g_h = g\left[\frac{R}{R+h}\right]^2$

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

$\frac{g}{4} = g\left[\frac{R}{R+h}\right]^2$

$\frac{h}{R} = 1$ ....(2)

From Eqs. (1) and (2), we get

$\frac{d}{h} = \frac{3}{4} \qquad \frac{h}{d} = \frac{4}{3}$

S17. Ans. (d)

Hint: Satellite in a orbit of radius R

$$TE = -\frac{GM_c m}{2R_E}$$

When satellite in a orbit of radii $3R_E$

$$TE_1 = -\frac{GM_c m}{2(3R_E)}$$

When satellite in a orbit of radii $9R_E$

$$TE_2 = \frac{-GM_c m}{2(9R_E)}$$

$$\Delta TE = TE_2 - TE_1$$

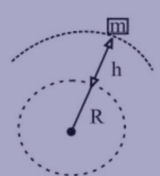
$$= -\frac{GM_c m}{18R_E} - \left[-\frac{GM_c m}{6R_E}\right]$$

$$= \frac{GM_c m}{R_E}\left[\frac{1}{6} - \frac{1}{18}\right]$$

$$= \frac{GM_c m}{9R_E}$$

S18. Ans. (d)

Hint:



$$PE = -\frac{GMm}{R+h}$$

$$KE = \frac{1}{2}m\left[\sqrt{\frac{GM}{R+h}}\right]^2$$

$$KE = \frac{GMm}{2(R+h)}$$

$$TE = \frac{-GMm}{R+h} + \frac{GMn}{2[R+h]}$$

$$= \frac{-GMn\,R^2}{2(R+h)R^2} \qquad \left[\because g = \frac{GM}{R^2}\right]$$

$$= \frac{-g_0 mR^2}{2[R+h]}$$

S19. Ans. (d)

Hint: $g = \left(\frac{GM_e}{R_e^3}\right) r$ for $0 < r \le R_e \Rightarrow g \propto r$

$g = \frac{GM_e}{r^2}$ for $r > R_e \Rightarrow g \propto \frac{1}{r^2}$

S20. Ans. (b)

Hint: g [in terms of mean density]

$$= \frac{4\pi GdR}{3} \Rightarrow V_e = \sqrt{2gR}$$

$$V_e = \sqrt{2 \times \frac{4}{3}\pi GdR.R}$$

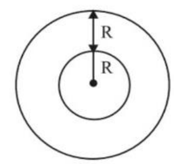
$$V_e = \sqrt{\frac{8}{3}\pi GdR^2}$$

$$V_p = \sqrt{\frac{8}{3}\pi G2d(2R)^2} \because d_p = 2d, R_p = 2R$$

$$\frac{V_e}{V_p} = \frac{1}{\sqrt{8}} \Rightarrow \frac{1}{2\sqrt{2}}$$

S21. Ans. (a)

Hint:



Gravitational Potential

$$= \frac{-GM}{R+h} = -5.4 \times 10^7 \text{J Kg}^{-2} \text{ ....(1)}$$

$$g = \frac{GM}{(R+h)^2} = 6 \text{ m/s}^2 \text{..........................(2)}$$

$$(1)/(2) = (R+h) = \frac{5.4\times10^7}{6} = 0.9 \times 10^7 \text{m}$$

= 9000 km

H = 9000 km – 6400 km = 2600 km

S22. Ans. (a)

Hint: $T_p^2 = Kr^3$ Given ....(1)

$$T_{planet} = \frac{2\pi r}{V_p}\left[\because V_p = \sqrt{\frac{GM}{r}}\right]$$

$$= \frac{2\pi r.r^{\frac{1}{2}}}{\sqrt{GM}}$$

$$T_p = \frac{2\pi r^{\frac{3}{2}}}{\sqrt{GM}} \text{ ....(2)}$$

Squaring Eq. (2), we have

$$T_P^2 = \frac{4\pi^2 r^3}{GM}$$

$$Kr^3 = \frac{4\pi^2 r^3}{GM} \Rightarrow K = \frac{4\pi^2}{GM}$$

S23. Ans. (b)

Hint: For the satellite revolving around earth

$$v_0 = \sqrt{\frac{GM_e}{(R_e+h)}} \quad \sqrt{\frac{GM_e}{R_e\left(+\frac{h}{R_e}\right)}} = \sqrt{\frac{gR}{1+\frac{h}{R_e}}}$$

Substituting the values

$$v_0 = \sqrt{60 \times 60^6} \text{ m/s}$$

$$v_0 = 7.76 \times 10^3 \text{ m/s} = 7.76 \text{ km/s}$$

S24. Ans. (a)

Hint:

Acceleration due to earth to the satellite is centripetal, hence directed towards centre. Angular momentum conservation holds good for comparable masses but

$M_{earth} \gg M_{satelite}$

S25. Ans. (a)

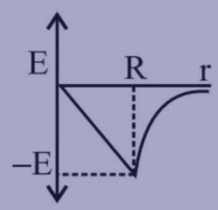
Hint: Gravitational field intensity

$\vec{E} = \frac{-GM}{R^2}$

For a point inside the earth $E = \frac{-GMr}{R^3}$

For a point inside the earth $E = \frac{-GM}{R^2}$

Where –ve sign indicates the attractive gravitational field



Accurate graph to show variation of E with r

S26. Ans. (a)

Hint: Escape velocity $(v_e) = \sqrt{\frac{2GM}{R}} = c =$ speed of light

$\Rightarrow R = \frac{2GM}{c^2} = \frac{2\times6.6\times10^{-11}\times5.98\times10^{24}}{(3\times10^8)^2}$ m

$= 10^{-2}$m

S27. Ans. (a)

Hint: $V = -G(2)\left[\frac{1}{1}+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\cdots..\right]$

Because it forms geometric progression

$S_{GP} = \frac{r^n-1}{r-1}; \qquad r = \frac{1}{2}$

$\frac{\left(\frac{1}{2}\right)^n-1}{-1/_2} = \frac{-1}{-1/_2} = 2$

$\therefore V = -2G \times S_{GP}$

$= -2G \times 2 = -4G$

S28. Ans. (c)

Hint: Change in P.E. $= -\frac{GMm}{3R} - \left(-\frac{GMm}{R}\right)$

$= \frac{2}{3}\frac{GMm}{R} = \frac{2}{3}$ mgR