

PRACTICE EXERCISES

SINGLE CORRECT CHOICE TYPE QUESTIONS

This section contains Single Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct.

1. The gravitational force between a point like mass M and an infinitely long, thin rod of linear mass density λ at perpendicular distance L from M is

(A) $\frac{MG\lambda}{L}$	(B) $\frac{1}{2} \frac{MG\lambda}{L}$
(C) $\frac{2MG\lambda}{L}$	(D) infinite

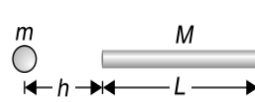
2. The radius of a planet is R . A satellite revolves around it in a circle of radius r with angular speed ω . The acceleration due to gravity on planet's surface will be

(A) $\frac{r^3\omega}{R}$	(B) $\frac{r^2\omega^3}{R}$
(C) $\frac{r^3\omega^2}{R^2}$	(D) $\frac{r^2\omega^2}{R}$

3. Consider a particle of mass m released from a point lying on the axis of a ring of mass M and radius r and at a distance r from the centre of ring. Assuming that the particle is moving under the gravitational attraction of the ring to reach the centre of the ring, then the velocity of the particle at the centre of the ring is

(A) $\sqrt{\frac{GM}{r}}$	(B) $\sqrt{\frac{2GM}{r}}$
(C) $\sqrt{\frac{2GM}{r(\sqrt{2}+1)}}$	(D) $\sqrt{\frac{2GM}{r}\left(1-\frac{1}{\sqrt{2}}\right)}$

4. A homogeneous bar of length L and mass M is at a distance h from a point mass m as shown. The force on m is F .



(A) $F = \frac{GMm}{(h+L)^2}$	(B) $F = \frac{GMm}{h^2}$
(C) $F = \frac{GMm}{h(h+L)}$	(D) $F = \frac{GMm}{L^2}$

5. A uniform ring of mass M and radius R is placed directly above a uniform sphere of mass $8M$ and of same radius R . The centre of the ring is at a distance of $d = \sqrt{3}R$ from the centre of the sphere. The gravitational attraction between the sphere and the ring is

(A) $\frac{8GM^2}{R^2}$	(B) $\frac{2GM^2}{\sqrt{3}R^2}$
(C) $\frac{3GM^2}{2R^2}$	(D) $\frac{\sqrt{3}GM^2}{R^2}$

6. A hole is drilled from the surface of earth to its centre. A particle is dropped from the surface of the earth. The speed of the particle when it reaches the centre of the earth in terms of its escape velocity (v_e) at the surface of earth is

(A) $\frac{v_e}{2}$	(B) v_e
(C) $\sqrt{2}v_e$	(D) $\frac{v_e}{\sqrt{2}}$

7. Two identical solid spheres of radius R placed in contact with each other, the gravitational attraction between them is proportional to

(A) R^2	(B) R^{-2}
(C) R^4	(D) R^{-4}

8. A planet has a mass and density both equal to eight times the mass and average density of the earth. If g be the acceleration due to gravity at the earth's surface, then acceleration due to gravity at the planet's surface is

(A) $2g$	(B) $4g$
(C) $8g$	(D) $16g$

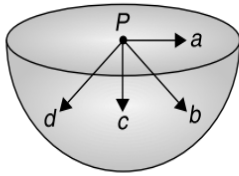
9. Gravitational force between two charged bodies is F_1 and electrostatic force between them is F_2 . They are at distance r from each other. Now the air between them is sucked out and distance is increased to $2r$. Then the new forces F'_1 and F'_2 are such that

(A) $F'_1 = \frac{F_1}{4}$	(B) $F'_2 = \frac{F_2}{4}$
(C) $F'_2 > \frac{F_2}{4}$	(D) $F'_1 > \frac{F_1}{4}$

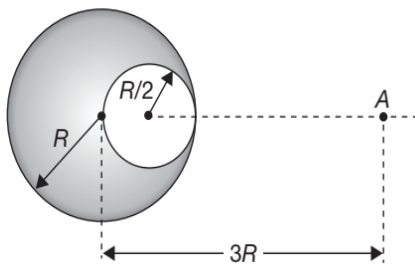
10. If g_h and g_d be the accelerations due to gravity at height h and at depth d , above and below the surface of earth respectively. Assuming $h < R$ and $d < R$ and if $g_h = g_d$ then,

(A) $d = h$	(B) $d = 2h$
(C) $h = 2d$	(D) data is insufficient to arrive at a conclusion

11. A hemispherical shell having uniform mass density is shown in Figure. The direction of gravitational field intensity at point P will be along

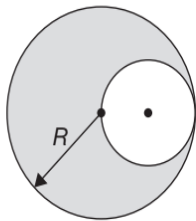


- (A) a (B) b
(C) c (D) d
12. What should be the velocity of a body thrown vertically upwards from the surface of earth (mass M and radius R) so that it may reach at a height of $7R$ from the surface?
- (A) $\sqrt{\frac{20GM}{11R}}$ (B) $\sqrt{\frac{20GM}{9R}}$
(C) $\sqrt{\frac{17GM}{9R}}$ (D) $\sqrt{\frac{7GM}{4R}}$
13. Rate of change of weight near the earth's surface varies with height (h) as
- (A) h (B) h^0
(C) h^{-1} (D) $h^{\frac{1}{2}}$
14. A uniform spherical planet of radius R has acceleration due to gravity at its surface g . Points P and Q located inside and outside the planet respectively have same acceleration due to gravity equal to $\frac{g}{4}$. Maximum possible separation between P and Q is
- (A) $\frac{7R}{4}$ (B) $\frac{9R}{4}$
(C) $\frac{3R}{2}$ (D) None of these
15. The radius of the earth is 6400 km and $g = 10 \text{ ms}^{-2}$. In order that the body of 5 kg weighs zero at the equator, the angular speed of the earth should be
- (A) $\frac{1}{80} \text{ rads}^{-1}$ (B) $\frac{1}{400} \text{ rads}^{-1}$
(C) $\frac{1}{800} \text{ rads}^{-1}$ (D) $\frac{1}{1600} \text{ rads}^{-1}$
16. If the radius of the earth were increased by a factor of 2, keeping the mass constant, then the factor by which its density has to be changed to keep g the same is
- (A) $\frac{1}{8}$ (B) $\frac{1}{4}$
(C) $\frac{1}{2}$ (D) 4
17. If radius of a solid sphere is decreased to half, keeping density of sphere unchanged, the slope of $E-r$ graph will
- (A) remain unchanged
(B) become two times
(C) become four times
(D) remain $\frac{1}{8}$ th
18. The potential energy of a body of mass m is $U = ax + by$ the magnitude of acceleration of the body will be
- (A) $\frac{ab}{m}$ (B) $\left(\frac{a+b}{m}\right)$
(C) $\frac{\sqrt{a^2+b^2}}{m}$ (D) $\frac{a^2+b^2}{m}$
19. The ratio of acceleration due to gravity at a depth h below the surface of earth and at a height h above the surface of earth for $h < R$
- (A) is constant
(B) increases parabolically with h
(C) increases linearly with h
(D) decreases parabolically with h
20. The gravitational field at a distance r from the centre of the sphere (having radius R , density ρ) inside it is
- (A) $\frac{4\rho G\pi r}{3}$ (B) $\frac{4\rho Gr^2}{3}$
(C) $\frac{4\rho GR^3}{3r^2}$ (D) $\frac{\rho GR^3}{\pi r}$
21. The ratio of the energy required to raise a satellite upto a height h above the earth (of radius R) to the kinetic energy of the satellite into the orbit there is
- (A) $h : R$ (B) $R : 2h$
(C) $2h : R$ (D) $R : h$
22. A mass m is raised slowly from a distance $2R$ from surface of earth to $3R$. Work done to do so against gravity will
- (A) $\frac{mgR}{10}$ (B) $\frac{mgR}{11}$
(C) $\frac{mgR}{12}$ (D) $\frac{mgR}{14}$
23. A solid sphere of uniform density and radius R applies a gravitational force of attraction equal to F_1 on a particle placed at a distance $3R$ from the centre of the sphere. A spherical cavity of radius $\frac{R}{2}$ is now made in the sphere as shown in the figure. The sphere with cavity now applies a gravitational force F_2 on the same particle. The ratio $\frac{F_2}{F_1}$ is



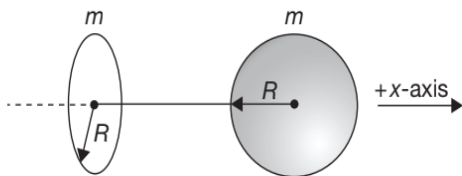
- (A) $\frac{9}{50}$ (B) $\frac{41}{50}$
 (C) $\frac{3}{50}$ (D) $\frac{11}{25}$

24. A spherical hole of radius $\frac{R}{2}$ is made in a solid sphere of radius R , mass M . The gravitational field at the centre of the hole due to the remaining mass is



- (A) zero (B) $\frac{GM}{8R^2}$
 (C) $\frac{GM}{2R^2}$ (D) $\frac{GM}{R^2}$

25. A ring of radius R , mass m and a solid sphere of same mass m and same radius R are placed with their centres on positive x -axis. The observer is moving from some finite distance on negative x -axis towards positive x -axis and the plane of the ring is perpendicular to x -axis. If the observer moves only upto the surface of the solid sphere, then the net gravitational field varies with the distance moved along x -axis as



- (A) (B)
 (C) (D)

26. A particle of mass M is placed at the centre of a uniform spherical shell of mass $3M$ and radius R . The gravitational potential at the surface of the shell is

- (A) $-\frac{GM}{R}$ (B) $-\frac{3GM}{R}$
 (C) $-\frac{2GM}{R}$ (D) $-\frac{4GM}{R}$

27. Two identical thin rings each of radius R are coaxially placed at a distance R . If the rings have a uniform mass distribution and each has mass m_1 and m_2 respectively, then the work done in moving a mass m from centre of one ring to that of the other is

- (A) zero (B) $\frac{Gm(m_1 - m_2)(\sqrt{2} - 1)}{\sqrt{2}R}$
 (C) $\frac{Gm\sqrt{2}(m_1 + m_2)}{R}$ (D) $\frac{Gmm_1(\sqrt{2} + 1)}{m_2R}$

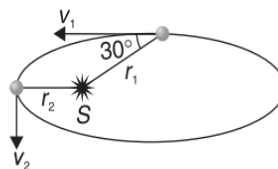
28. An infinite number of masses, each of 1 kg, are placed on the positive x -axis at 1 m, 2 m, 4 m, 8 m, ... from the origin. The value of the gravitational field at the origin due to this distribution is

- (A) $2G$ (B) $\frac{4G}{3}$
 (C) $\frac{3G}{4}$ (D) ∞

29. For a given density of planet, the orbital period of a satellite near the surface of planet of radius R is proportional to

- (A) R^2 (B) R^3
 (C) $R^{-1/2}$ (D) R^0

30. For a planet revolving around sun in an elliptical path as shown

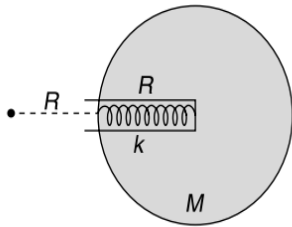


- (A) $v_1 r_1 = v_2 r_2$ (B) $2v_1 r_1 = v_2 r_2$
 (C) $v_1 r_1 = 2v_2 r_2$ (D) $2v_1 r_1 = \sqrt{3}v_2 r_2$

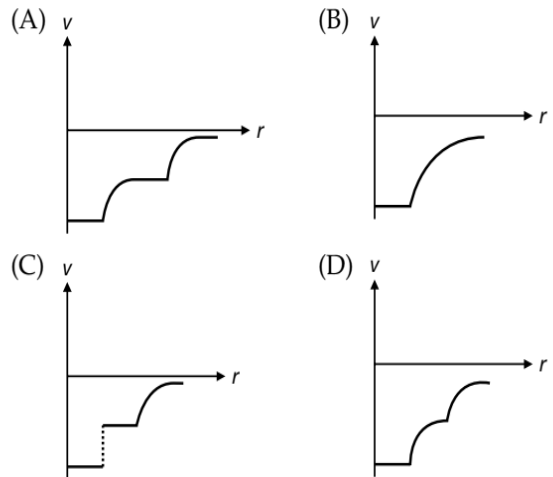
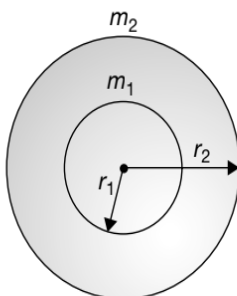
31. The magnitude of gravitational potential energy of the earth-satellite system is U with zero potential energy at infinite separation. If mass of satellite \ll mass of earth and the kinetic energy of satellite is K , then

- (A) $K = 2U$ (B) $K = \frac{U}{2}$
 (C) $K = U$ (D) $K = 4U$

32. A particle on earth's surface is given a velocity equal to its escape velocity. The total mechanical energy of the particle is
 (A) infinite (B) negative
 (C) positive (D) zero
33. A small ball of mass m is released at a height R above the earth surface, as shown in the given figure. The maximum depth of the ball to which it goes inside the earth through a narrow groove before coming to rest momentarily is $\frac{R}{2}$. The groove, contains an ideal spring of spring constant k and natural length R . The value of k , if R is the radius of earth and M mass of earth, is



- (A) $\frac{3GMm}{R^3}$ (B) $\frac{6GMm}{R^3}$
 (C) $\frac{9GMm}{R^3}$ (D) $\frac{12GMm}{R^3}$
34. A projectile is fired upwards from the surface of the earth with a velocity kv_e where v_e is the escape velocity and $k < 1$. If r is the maximum distance from the centre of the earth to which it rises and R is the radius of the earth, then r equals
 (A) $\frac{R}{k^2}$ (B) $\frac{R}{1-k^2}$
 (C) $\frac{2R}{k^2}$ (D) $\frac{2R}{1-k^2}$
35. The binding energy of a particle at the surface of earth is E . If a kinetic energy greater than E is given to this particle, then the total energy of particle will be
 (A) zero (B) infinite
 (C) > 0 (D) < 0
36. Two concentric spherical shells are as shown in figure. The $V-r$ graph will be



37. A star with a mass of more than three times that of the sun contracts so much upon cooling that it loses its capacity to radiate; neither material particles nor light are able to overcome its gravitational field (such an object is called a "black hole"). Taking mass of sun to be 2×10^{30} kg, the radius of such an object could be (approximately)
 (A) 6 km (B) 7 km
 (C) 8 km (D) 9 km
38. Four particles of equal mass M move along a circle of radius R under the action of their mutual gravitational attraction. The speed of each particle is
 (A) $\frac{GM}{R}$ (B) $\sqrt{2\sqrt{2}\frac{GM}{R}}$
 (C) $\sqrt{\left[\frac{GM}{R}(2\sqrt{2}+1)\right]}$ (D) $\sqrt{\left[\frac{GM}{R}\left(\frac{2\sqrt{2}+1}{4}\right)\right]}$
39. The gravitational field in a region of space is given by $\vec{E} = (4\hat{i} + \hat{j}) \text{ Nkg}^{-1}$. The work done by this field is zero when a particle is moved along the line
 (A) $y + 4x = 2$ (B) $4y + x = 6$
 (C) $x + y = 5$ (D) $y - 4x = 2$
40. The speed of a planet in an elliptical orbit with semi-major axis a about sun of mass M at a distance r from sun is
 (A) $\sqrt{GM\left(\frac{2}{r} - \frac{1}{a}\right)}$ (B) $\sqrt{GM\left(\frac{1}{r} - \frac{1}{a}\right)}$
 (C) $\sqrt{GM\left(\frac{1}{r} - \frac{2}{a}\right)}$ (D) $\sqrt{\frac{GM}{2a^2}}$
41. A body is projected up with a velocity equal to three fourth of the escape velocity from the surface of the earth. The maximum distance it reaches from the centre of the earth is (Radius of the earth is R)



- (A) $\frac{10R}{9}$ (B) $\frac{16R}{7}$
 (C) $\frac{9R}{8}$ (D) $\frac{10R}{3}$

42. The work done in slowly lifting a body from earth's surface to a height R (radius of earth) is equal to two times the work done in lifting the same body from earth's surface to a height h , then

- (A) $h = \frac{R}{6}$ (B) $h = \frac{R}{4}$
 (C) $h = \frac{R}{3}$ (D) $h = \frac{R}{2}$

43. A particle of mass m starts moving from rest along the line $y = b$ with constant acceleration a . The areal velocity of the position vector of the particle at time t is

- (A) constant (B) $\frac{abt}{2}$
 (C) $\frac{abt}{2m}$ (D) $\frac{a^2bt}{2m}$

44. A particle is placed in a field characterised by a value of gravitational potential given by $V = -kxy$, where k is a constant. If \vec{E}_g is the gravitational field then,

- (A) $\vec{E}_g = k(x\hat{i} + y\hat{j})$ and is conservative in nature.
 (B) $\vec{E}_g = k(y\hat{i} + x\hat{j})$ and is conservative in nature.
 (C) $\vec{E}_g = k(x\hat{i} + y\hat{j})$ and is non-conservative in nature.
 (D) $\vec{E}_g = k(y\hat{i} + x\hat{j})$ and is non-conservative in nature.

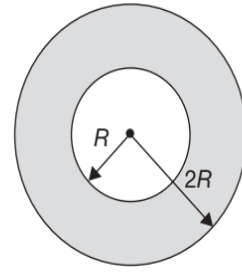
45. The gravitational potential of two homogeneous spherical shells A and B of same surface density at their respective centres are in the ratio 3 : 4. If the two shells coalesce into single one such that surface charge density remains same, then the ratio of potential at an internal point of the new shell to the potential inside shell A is

- (A) 3 : 2 (B) 4 : 3
 (C) 5 : 3 (D) 5 : 6

46. A satellite is revolving round the earth in an orbit of radius r with time period T . If the satellite is revolving round the earth in an orbit of radius $r + \Delta r$ ($\Delta r \ll r$) with time period $T + \Delta T$ ($\Delta T \ll T$) then,

- (A) $\frac{\Delta T}{T} = \frac{3 \Delta r}{2 r}$ (B) $\frac{\Delta T}{T} = \frac{2 \Delta r}{3 r}$
 (C) $\frac{\Delta T}{T} = \frac{\Delta r}{r}$ (D) $\frac{\Delta T}{T} = -\frac{\Delta r}{r}$

47. The gravitational potential at the centre of a sphere of radius $2R$ having a concentric spherical cavity of radius R and net mass M is

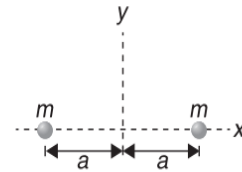


- (A) $-\frac{3GM}{7R}$ (B) $-\frac{9GM}{14R}$
 (C) $-\frac{5GM}{7R}$ (D) $-\frac{7GM}{14R}$

48. A particle is projected vertically upwards with a velocity \sqrt{gR} , where R denotes the radius of the earth and g the acceleration due to gravity on the surface of the earth. Then the maximum height ascended by the particle is

- (A) $\frac{R}{2}$ (B) R
 (C) $2R$ (D) $\frac{5R}{4}$

49. Two identical spherical balls each of mass m are placed as shown in figure. The variation of gravitational intensity g along the x -axis is best represented in

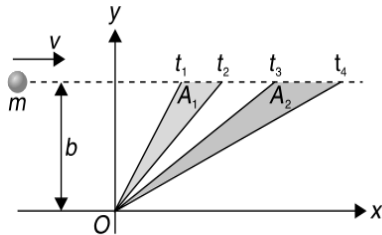


- (A) (B)
- (C) (D)

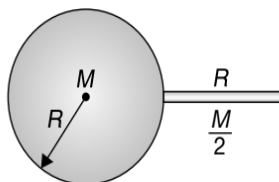
50. A mass is taken from surface to a height h . The change in potential energy in this process is equal to the change in potential energy if it is now taken from that point to infinity. Then,

- (A) $h = R$ (B) $h = 2R$
 (C) $h = \frac{3R}{2}$ (D) $h = 4R$

51. The time period of an earth satellite close to the surface of the earth is 83 minute. The time period of another earth satellite in an orbit at a distance of three earth radii from its surface will be
 (A) 83 minute (B) $83\sqrt{8}$ minute
 (C) 664 minute (D) 249 minute
52. A particle of mass m moves along a straight line with constant speed in the x direction at a distance b from the x -axis as shown and sweeps areas A_1 and A_2 , then



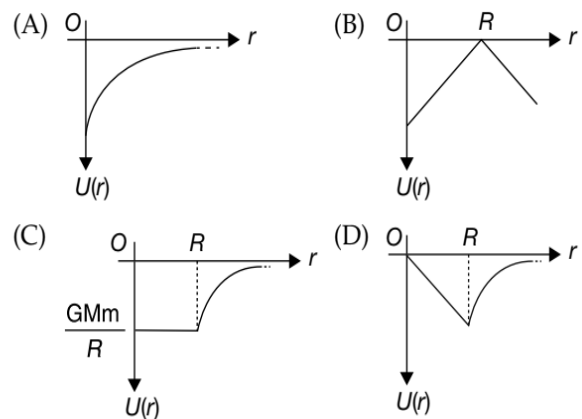
- (A) $A_1 > A_2$ if $t_4 - t_3 > t_2 - t_1$
 (B) $A_1 > A_2$ if $t_4 - t_3 < t_2 - t_1$
 (C) $A_1 = A_2$ if $t_4 - t_3 < t_2 - t_1$
 (D) A_1 is always equal to A_2
53. Two particles each of mass m are revolving in circular orbits of radius $r = 5R$ in opposite directions. They collide perfectly inelastically and fall to the ground. The speed of combined mass on striking the ground is
 (A) $2\sqrt{2}v_0$ (B) $\sqrt{2}v_0$
 (C) $2v_0$ (D) v_0
54. The ratio of Earth's orbital angular momentum (about the Sun) to its mass is $4.4 \times 10^{15} \text{ m}^2 \text{ s}^{-1}$. The area enclosed by the earth's orbit is approximately
 (A) $1 \times 10^{22} \text{ m}^2$ (B) $3 \times 10^{22} \text{ m}^2$
 (C) $5 \times 10^{22} \text{ m}^2$ (D) $7 \times 10^{22} \text{ m}^2$
55. A uniform thin rod of mass $\frac{M}{2}$ and length R is placed normally on surface of earth as shown. The mass of earth is M and its radius is R . Then the magnitude of gravitational force exerted by earth on the rod is



- (A) $\frac{GM^2}{4R^2}$ (B) $\frac{GM^2}{2R^2}$
 (C) $\frac{4GM^2}{9R^2}$ (D) $\frac{GM^2}{8R^2}$

56. A particle is projected from the surface of earth with velocity equal to its escape velocity at 45° with horizontal. The angle of its velocity with horizontal at height $h = R$, where horizontal at some point means a line parallel to tangent on earth just below that point, is
 (A) 30° (B) $\cos^{-1}\left(\frac{1}{3}\right)$
 (C) 60° (D) $\cos^{-1}\left(\frac{1}{4}\right)$

57. A shell of mass M and radius R has a point mass m placed at a distance r from its centre. The gravitational potential energy $U(r)$ vs r will be



58. In a double star system, the masses of the two stars are M and $3M$. The orbit radius of the lighter star is R . The time period of each star is

- (A) $8\pi\sqrt{\frac{R^3}{GM}}$ (B) $16\pi\sqrt{\frac{R^3}{GM}}$
 (C) $8\pi\sqrt{\frac{R^3}{27GM}}$ (D) None of these

59. A particle of mass m is projected upwards with velocity half the escape velocity. At the highest point, the potential energy of the particle is

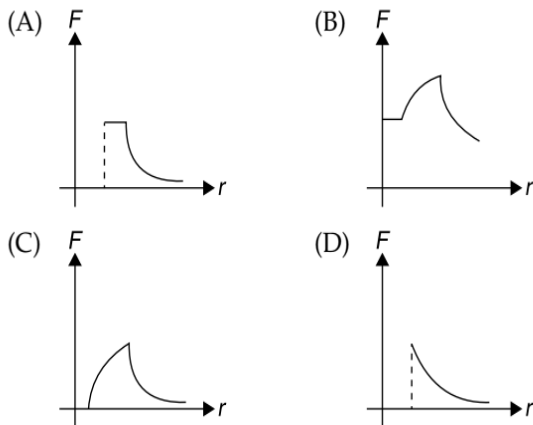
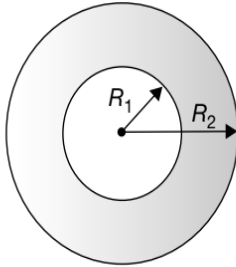
- (A) $-\frac{GMm}{2R}$ (B) $-\frac{GMm}{4R}$
 (C) $-\frac{3GMm}{4R}$ (D) $-\frac{2GMm}{3R}$

60. A satellite of mass m is moving around the earth in a circular orbit of radius r . If the mass of the earth is M , then the energy required to take the satellite to an orbit of radius $3r$ is

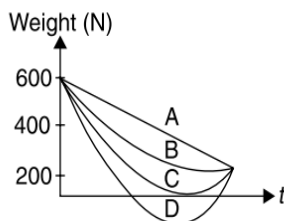
- (A) $\frac{GMm}{r}$ (B) $\frac{GMm}{2r}$
 (C) $\frac{GMm}{3r}$ (D) $\frac{GMm}{6r}$

61. Three particles each having a mass of 100 g are placed on the vertices of an equilateral triangle of side 20 cm. The work that has to be done to increase the side of this triangle to 40 cm is ($G = 6.67 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$)
- (A) $5 \times 10^{-8} \text{ J}$
 (B) $4 \times 10^{-10} \text{ J}$
 (C) $5 \times 10^{-12} \text{ J}$
 (D) $5 \times 10^{-15} \text{ J}$

62. A sphere of mass M and radius R_2 has a concentric cavity of radius R_1 as shown in figure. The force F exerted by the sphere on a particle of mass m located at a distance r from the centre of sphere varies as ($0 \leq r \leq \infty$)



63. Imagine the acceleration due to gravity on earth is 10 ms^{-2} and on mars is 4 ms^{-2} . A traveler of mass 60 kg goes from earth to mars by a rocket moving with constant velocity. If effect of other planets is assumed to be negligible, which one of the following graphs shown the variation of weight W (in N) of traveler with time t (in second)



- (A) A
 (B) B
 (C) C
 (D) D

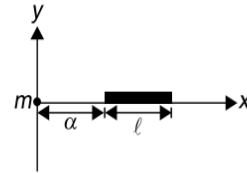
64. The gravitational field due to a mass distribution is $E = \frac{K}{x^3}$ in the x -direction, where K is a constant. Taking the gravitational potential to be zero infinity, its value at a distance x is

- (A) $\frac{K}{x}$
 (B) $\frac{K}{2x}$
 (C) $\frac{K}{x^2}$
 (D) $\frac{K}{2x^2}$

65. A system consists of n identical particles each of mass m . The total number of interactions possible is

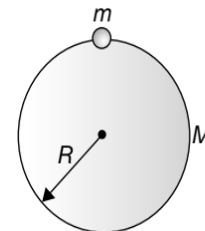
- (A) $n(n+1)$
 (B) $\frac{n(n+1)}{2}$
 (C) $n(n-1)$
 (D) $\frac{n(n-1)}{2}$

66. A straight rod of length l extends from $x = \alpha$ to $x = l + \alpha$. If the mass per unit length is $(a + bx^2)$. The gravitational force it exerts on a point mass m placed at $x = 0$ is given by



- (A) $Gm \left(a \left(\frac{1}{\alpha} - \frac{1}{\alpha+l} \right) + bl \right)$
 (B) $\frac{Gm(a + bx^2)}{l^2}$
 (C) $Gm \left(\alpha \left(\frac{1}{a} - \frac{1}{a+l} \right) + bl \right)$
 (D) $Gm \left(a \left(\frac{1}{\alpha+l} - \frac{1}{\alpha} \right) + bl \right)$

67. A thin spherical shell of mass M and radius R has a small hole. A particle of mass m is released at the mouth of the hole. Then the particle



- (A) will execute simple harmonic motion inside the shell.
 (B) will oscillate inside the shell, but the oscillations are not simple harmonic.
 (C) will not oscillate, but the speed of the particle will go on increasing.
 (D) stays at rest in its equilibrium position.

68. A small meteorite of mass m travelling towards the centre of earth strikes the earth at the equator. The earth is a uniform sphere of mass M and radius R . The length of the day was T before the meteorite struck. After the meteorite strikes the earth, the length of day increases by

- (A) $\frac{5mT}{2M}$ (B) $\frac{mT}{M}$
 (C) $\frac{4mT}{5M}$ (D) $\frac{M}{3mT}$

69. A ring of radius R has a total mass M distributed non-uniformly over its circumference. A point mass m is placed at the centre (C) of the ring. The work done in taking away this point mass from centre to infinity is

- (A) $-\frac{GMm}{R}$ (B) $\frac{GMm}{R}$
 (C) $\frac{GMm}{2R}$ (D) $-\frac{GMm}{2R}$

70. The gravitational self energy of a spherical shell of mass M and radius R is

- (A) $-\frac{GM^2}{4R}$ (B) $-\frac{GM^2}{R}$
 (C) $-\frac{3}{5}\frac{GM^2}{R}$ (D) $-\frac{GM^2}{2R}$

71. An artificial satellite is moving in a circular orbit around the earth at some height with a speed equal to half the magnitude of the escape velocity from the surface of earth. Suppose the satellite is stopped suddenly in its orbit and allowed to fall freely. On reaching earth its speed will be

- (A) \sqrt{gR} (B) $2\sqrt{gR}$
 (C) $3\sqrt{gR}$ (D) $5\sqrt{gR}$

72. The height above the surface of earth where the total energy of a satellite is equal to its potential energy at a height of $2R$ from surface of earth (if R is the radius of the earth) is

- (A) $\frac{R}{4}$ (B) $\frac{R}{2}$
 (C) $2R$ (D) $4R$

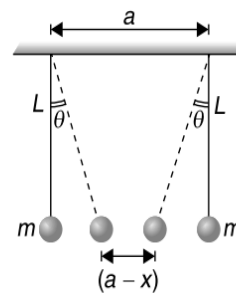
73. Two particles having masses m_1 and m_2 start moving towards each other from the state of rest from infinite separation. Their relative velocity of approach when they are interacting gravitationally at a separation r will be

- (A) $\sqrt{\frac{G(m_1 + m_2)}{r}}$ (B) $\sqrt{\frac{2G(m_1 + m_2)}{r}}$
 (C) $\sqrt{\frac{3G(m_1 + m_2)}{r}}$ (D) $\sqrt{\frac{4G(m_1 + m_2)}{r}}$

74. A particle is projected upward from the surface of earth with a speed equal to the orbital speed of a satellite near the earth's surface. If R be the radius of earth, then the height to which it would rise is

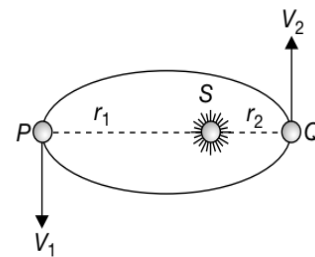
- (A) $\sqrt{2}R$ (B) $\frac{R}{\sqrt{2}}$
 (C) R (D) $2R$

75. Two small balls of mass m each are suspended side by side by two equal threads of length L . If the distance between the upper ends of the threads be a , the angle θ that the threads will make with the vertical due to attraction between the balls is



- (A) $\tan^{-1}\left[\frac{(a-x)g}{Gm}\right]$ (B) $\tan^{-1}\left[\frac{Gm}{(a-x)^2g}\right]$
 (C) $\tan^{-1}\left[\frac{(a-x)^2g}{Gm}\right]$ (D) $\tan^{-1}\left[\frac{(a^2-x^2)g}{Gm}\right]$

76. A planet is moving in an elliptical orbit around the sun as shown in figure. At positions P and Q it has respective speeds v_1 and v_2 and respective distances r_1 and r_2 from the sun, then $\frac{v_1}{v_2}$ equals

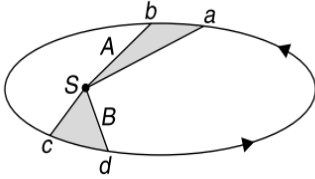


- (A) $\frac{r_1}{r_2}$ (B) $\frac{r_2}{r_1}$
 (C) $\sqrt{\frac{r_1}{r_2}}$ (D) $\left(\frac{r_1}{r_2}\right)^2$

77. A body is projected away from the earth with a speed $3v_e$ where v_e is the escape velocity. The speed of the body at infinity will be

- (A) v_e (B) $\sqrt{2}v_e$
 (C) $2v_e$ (D) $2\sqrt{2}v_e$

78. Two air bubbles in water
 (A) repel each other
 (B) attract each other
 (C) do not exert any force on each other
 (D) may attract or repel depending upon the distance between them
79. The figure shows the motion of a planet around the sun in an elliptic orbit with the sun at one focus. The shaded areas A and B can be assumed to be equal. If t_1 and t_2 represent the times taken by the planet to move from a to b and from c to d respectively, then



- (A) $t_1 < t_2$ (B) $t_1 > t_2$
 (C) $t_1 = t_2$ (D) Data Insufficient
80. A satellite of mass m orbits the earth in an elliptical orbit having aphelion distance r_a and perihelion distance r_p . The period of the orbit is T . The semi-major and semi-minor axes of the ellipse are $\frac{r_a + r_p}{2}$ and $\sqrt{r_p r_a}$ respectively. The angular momentum of the satellite is
- (A) $\frac{m\pi(r_a + r_p)\sqrt{r_a r_p}}{T}$
 (B) $\frac{2m\pi(r_a + r_p)\sqrt{r_a r_p}}{T}$
 (C) $\frac{m\pi(r_a + r_p)\sqrt{r_a r_p}}{2T}$
 (D) $\frac{m\pi(r_a + r_p)\sqrt{r_a r_p}}{4T}$
81. A satellite of mass m moves along an elliptical path around the earth. The areal velocity of the satellite is proportional to
- (A) m^{-1} (B) m
 (C) $m^{\frac{1}{2}}$ (D) m^0
82. The time period of an artificial satellite in a circular orbit of radius R is 2 days and its orbital velocity is v_0 . If time period of another satellite in a circular orbit is 16 days, then
- (A) its radius of orbit is $4R$ and orbit velocity is v_0
 (B) its radius of orbit is $2R$ and orbital velocity is v_0
 (C) its radius of orbit is $2R$ and orbital velocity is $\frac{v_0}{2}$
 (D) its radius of orbit is $4R$ and orbital velocity is $\frac{v_0}{2}$

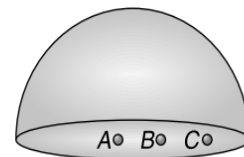
83. The period of revolution of an earth satellite close to the surface of earth is 90 minutes. The time period of another satellite in an orbit at an altitude of three times the radius of earth is
- (A) $90\sqrt{8}$ min (B) 270 min
 (C) 360 min (D) 720 min

84. Two particles of equal mass m go round a circle of radius R under the action of their mutual gravitational attraction. The speed of each particle is
- (A) $V = \frac{1}{2R}\sqrt{\frac{1}{Gm}}$ (B) $V = \sqrt{\frac{Gm}{2R}}$
 (C) $V = \frac{1}{2}\sqrt{\frac{Gm}{R}}$ (D) $V = \sqrt{\frac{4Gm}{R}}$

85. The minimum energy required to launch a satellite of mass m from the surface of earth (of mass M , radius R) in a circular orbit at an altitude $2R$ is
- (A) $\frac{GmM}{2R}$ (B) $\frac{GmM}{3R}$
 (C) $\frac{5GmM}{6R}$ (D) $\frac{2GmM}{3R}$

86. Consider a circular disc of mass M , radius R with surface mass density σ . The gravitational potential due to the disc at a point P lying on its axis at distance r from the centre is
- (A) $-2\pi\sigma Gr$
 (B) $-4\pi\sigma Gr$
 (C) $-2\pi\sigma Gr\left(1 - \frac{r}{\sqrt{r^2 + R^2}}\right)$
 (D) $-4\pi\sigma Gr\left(1 - \frac{r}{\sqrt{r^2 + R^2}}\right)$

87. Mass M is uniformly distributed only on curved surface of a thin hemispherical shell. A , B and C are three points on the circular base of hemisphere, such that A is the centre. Let the gravitational potential at points A , B and C be V_A , V_B , V_C respectively. Then



- (A) $V_A > V_B > V_C$
 (B) $V_C > V_B > V_A$
 (C) $V_B > V_A$ and $V_B > V_C$
 (D) $V_A = V_B = V_C$

88. An electron moves in a circular orbit at a distance from a proton with kinetic energy E . To escape to infinity, the energy which must be supplied to the electron is

- (A) $0.5E$ (B) $2E$
(C) E (D) $\sqrt{2}E$

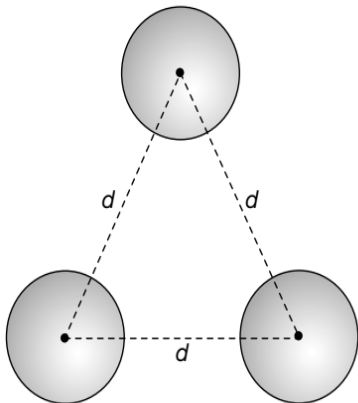
89. A body of mass m is kept at a small height h above the ground. If the radius of the earth is R and its mass is M , then the potential energy of the body and earth system, with the reference position being taken at infinity, is

- (A) $\frac{GMm}{R} + mgh$ (B) $\frac{-GMm}{R} + mgh$
(C) $\frac{GMm}{R} - mgh$ (D) $\frac{-GMm}{R} - mgh$

90. The gravitational field in a region is given by $\vec{I} = (2\hat{i} + 3\hat{j}) \text{ Nkg}^{-1}$. The work done in moving a particle from $(1, 1) \text{ m}$ to $(2, \frac{1}{3}) \text{ m}$ along the line $3y + 2x = 5$ is

- (A) Zero (B) $+20 \text{ J}$
(C) -15 J (D) $+18 \text{ J}$

91. Three solid spheres each of mass m and radius R are released from the position shown in figure. The speed of any one sphere at the time of collision would be



- (A) $\sqrt{Gm\left(\frac{1}{d} - \frac{3}{R}\right)}$ (B) $\sqrt{Gm\left(\frac{3}{d} - \frac{1}{R}\right)}$
(C) $\sqrt{Gm\left(\frac{2}{R} - \frac{1}{d}\right)}$ (D) $\sqrt{Gm\left(\frac{1}{R} - \frac{2}{d}\right)}$

92. The masses and the radii of earth and moon are respectively M_e, R_e and M_m, R_m . The distance between the centres is r . At what minimum velocity a particle of mass m be projected from the mid point of the distance between their centres so that it may escape into space?

- (A) $\sqrt{\frac{4G}{r}(M_e + M_m)}$ (B) $\frac{4G}{r}\sqrt{(M_e + M_m)}$
(C) $\sqrt{\frac{2G}{r}(M_e + M_m)}$ (D) $\frac{2G}{r}\sqrt{(M_e + M_m)}$

93. The potential energy of gravitational interaction of a point mass m and a thin uniform rod of mass M and length l , if they are located along a straight line at a distance a from each other is

- (A) $U = -\frac{GMm}{a} \log_e\left(\frac{a+l}{a}\right)$
(B) $U = GMm\left(\frac{1}{a} - \frac{1}{a+l}\right)$
(C) $U = -\frac{GMm}{l} \log_e\left(\frac{a+l}{a}\right)$
(D) $U = -\frac{GMm}{a}$

94. An object of mass 100 kg starts to fall from a height equal to radius of earth (R). Its speed when it has lost half the initial height is [M is mass of earth]

- (A) $\sqrt{\frac{100G}{3R}}$ (B) $\sqrt{\frac{GM}{6R}}$
(C) $\sqrt{\frac{50G}{3R}}$ (D) $\sqrt{\frac{GM}{3R}}$

95. The magnitude of the potential energy per unit mass of the object at the surface of earth is E . Then the escape velocity of the object is

- (A) $\sqrt{2E}$ (B) $2\sqrt{E}$
(C) \sqrt{E} (D) $\sqrt{\frac{E}{2}}$

96. If g is the acceleration due to gravity at the surface of the earth, then the energy required to launch a satellite of mass m from the surface of the earth into a circular orbit at an altitude of $2R$, R being the radius of the earth, is

- (A) $\frac{mgR}{6}$ (B) $\frac{mgR}{3}$
(C) $\frac{2mgR}{3}$ (D) $\frac{5}{6}mgR$

97. If the period of revolution of an artificial satellite just above the earth's surface is T and the density of earth is ρ , then ρT^2 equals

- (A) $\frac{3\pi}{G}$ (B) $\frac{3\pi}{2G}$
(C) $\frac{2\pi}{G}$ (D) $\frac{\pi}{G}$

98. Consider a mass m_0 enclosed by a closed imaginary surface S . Let \vec{E} be the gravitational field intensity due to m_0 at the surface element $d\vec{S}$ directed as outward normal to it. The surface integral of the gravitational field over S is

- (A) $-m_0G$ (B) $-4\pi m_0G$
 (C) $-\frac{m_0G}{4\pi}$ (D) None of above

99. If M_e is the mass of earth and M_m is the mass of moon ($M_e = 81M_m$). The potential energy of an object of mass m situated at a distance R from the centre of earth and r from the centre of moon, will be

- (A) $-GmM_m\left(\frac{R}{81} + r\right)\frac{1}{R^2}$ (B) $-GmM_e\left(\frac{81}{r} + \frac{1}{R}\right)$
 (C) $-GmM_m\left(\frac{81}{R} + \frac{1}{r}\right)$ (D) $GmM_m\left(\frac{81}{R} - \frac{1}{r}\right)$

100. A person brings a mass of 2 kg from A to B . The increase in kinetic energy of the mass is 4 J and the work done by the person on the mass is -10 J. The potential difference between A and B is ΔV , given by

- (A) 4 Jkg^{-1} (B) 7 Jkg^{-1}
 (C) -3 Jkg^{-1} (D) -7 Jkg^{-1}

101. A research satellite of mass 200 kg circles the Earth in an orbit of average radius $\frac{3R}{2}$, where R is the radius of the Earth. Assuming gravitational pull on a mass 1 kg on Earth's surface to be 10 N, the pull on the satellite will be

- (A) 880 N (B) 889 N
 (C) 890 N (D) 892 N

102. A satellite is revolving round the earth with orbital speed v_0 . If it stops suddenly, the speed with which it will strike the surface of earth (if v_e is the escape speed of the particle from the earth's surface), would be

- (A) $\frac{v_e^2}{v_0}$ (B) v_0
 (C) $\sqrt{v_e^2 - v_0^2}$ (D) $\sqrt{v_e^2 - 2v_0^2}$

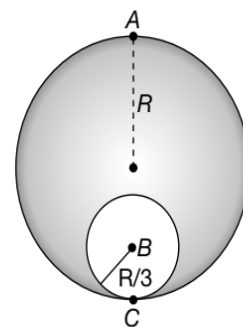
103. A planet is moving in an elliptic orbit. If T , U , E and L stand respectively, for its kinetic energy, gravitational potential energy, total energy and angular momentum about the centre of force, then

- (A) T is conserved
 (B) U is always positive
 (C) E is always negative
 (D) magnitude of L is conserved but its direction changes continuously

104. A planet revolves around the sun in an elliptical orbit of eccentricity e . If T is the time period of the planet, then the time spent by the planet between the ends of the minor axis close to the sun is

- (A) $\frac{T}{2}\left(1 - \frac{e}{\pi}\right)$ (B) $T\left(\frac{1}{4} - \frac{e}{2\pi}\right)$
 (C) $\left(\frac{e}{\pi} - 1\right)T$ (D) $\frac{T\pi}{e}$

105. Inside a uniform sphere of mass M and radius R , a cavity of radius $\frac{R}{3}$ is made in the sphere as shown. Select the correct statement.



- (A) Gravitational field inside the cavity is uniform
 (B) Gravitational field inside the cavity is non-uniform
 (C) The escape velocity of a particle projected from point A is $\sqrt{\frac{88GM}{15R}}$
 (D) Escape velocity is defined for earth and particle system only

106. The angular momentum (L) of earth revolving round the sun in circular orbit is proportional to r^n , where r is the orbital radius of the earth. The value of n is

- (A) 1 (B) 2
 (C) $-\frac{1}{2}$ (D) $\frac{1}{2}$

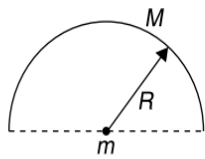
107. Consider a thin uniform spherical layer of mass M and radius R . The potential energy of gravitational interaction of matter forming this shell is

- (A) $-\frac{GM^2}{R}$ (B) $-\frac{1}{2}\frac{GM^2}{R}$
 (C) $-\frac{3}{2}\frac{GM^2}{R}$ (D) $-\frac{2}{3}\frac{GM^2}{R}$

108. By what percent the energy of a satellite has to be increased to shift it from an orbit of radius r to $\frac{3}{2}r$?

- (A) 15% (B) 20.3%
 (C) 33.3% (D) 66.7%

109. For a spherical shell of mass M and radius R , the energy required to double its radius is
- (A) $\frac{GM^2}{R}$ (B) $\frac{3GM^2}{2R}$
 (C) $\frac{GM^2}{4R}$ (D) $\frac{GM^2}{2R}$
110. A satellite is seen after every 6 hours over the equator. If it revolves from east to west, the angular velocity of the satellite about the centre of earth is
- (A) $\frac{\pi}{2}$ radhr⁻¹ (B) $\frac{\pi}{3}$ radhr⁻¹
 (C) $\frac{\pi}{4}$ radhr⁻¹ (D) $\frac{\pi}{8}$ radhr⁻¹
111. Consider a solid sphere of mass M and radius R , then the potential energy of gravitational interaction of matter forming this solid sphere is
- (A) $-\frac{GM^2}{R}$ (B) $-\frac{1}{2} \frac{GM^2}{R}$
 (C) $-\frac{3}{5} \frac{GM^2}{R}$ (D) $-\frac{3}{2} \frac{GM^2}{R}$
112. A planet of mass m is revolving in an elliptical orbit about the sun with an orbital period T . If $m \ll M_{\text{sun}}$ and A be the area of orbit, then the angular momentum of the planet is
- (A) $\frac{mA}{2T}$ (B) $\frac{mA}{4T}$
 (C) $\frac{2mA}{T}$ (D) $\frac{4mA}{T}$
113. An artificial satellite moving in circular orbit around the earth has a total (kinetic + potential) energy E_0 . Its potential energy and kinetic energy respectively are
- (A) $2E_0$ and $-2E_0$
 (B) $-2E_0$ and $3E_0$
 (C) $2E_0$ and $-E_0$
 (D) $-2E_0$ and $-E_0$
114. A satellite revolving in a circular equatorial orbit from west to east appears over a certain point on the equator every 8 hours. Its time period is
- (A) 16 hr (B) 8 hr
 (C) 6 hr (D) 32 hr
115. A "double star" is a composite system of two stars rotating about their centre of mass under their mutual gravitational attraction. Let us consider such a "double star" which has two stars of masses m and $2m$ at separation l . If T is the time period of rotation about their centre of mass then,
- (A) $T = 2\pi\sqrt{\frac{l^3}{mG}}$ (B) $T = 2\pi\sqrt{\frac{l^3}{2mG}}$
 (C) $T = 2\pi\sqrt{\frac{l^3}{3mG}}$ (D) $T = 2\pi\sqrt{\frac{l^3}{4mG}}$
116. What should be the angular velocity of earth about its own axis so that the weight of the body at equator would become $\frac{3}{4}$ th of its present value
- (A) $\frac{1}{400}$ rads⁻¹ (B) $\frac{1}{800}$ rads⁻¹
 (C) $\frac{1}{1600}$ rads⁻¹ (D) $\frac{1}{3200}$ rads⁻¹
117. Two bodies of masses m and M are placed a distance d apart. The gravitational potential at the position where the gravitational field due to them is zero is V .
- (A) $V = -\frac{G}{d}(m + M)$
 (B) $V = -\frac{Gm}{d}$
 (C) $V = -\frac{GM}{d}$
 (D) $V = -\frac{G}{d}(\sqrt{m} + \sqrt{M})^2$
118. A point $P(R\sqrt{3}, 0, 0)$ lies on the axis of a ring of mass M and radius R . The ring is located in $y-z$ plane with its centre at origin O . A small particle of mass m starts from P and reaches O under gravitational attraction only. Its speed at O will be
- (A) $\sqrt{\frac{GM}{R}}$ (B) $\sqrt{\frac{Gm}{R}}$
 (C) $\sqrt{\frac{GM}{\sqrt{2}R}}$ (D) $\sqrt{\frac{Gm}{\sqrt{2}R}}$
119. A point particle is held on the axis of a ring of mass m and radius r at a distance r from its center C . When released, it reaches C under the gravitational attraction of the ring. Its speed at C will be
- (A) $\sqrt{\frac{2Gm}{r}}$ (B) $\sqrt{\frac{2Gm}{r}}(\sqrt{2}-1)$
 (C) $\sqrt{\frac{2Gm}{r}\left(1-\frac{1}{\sqrt{2}}\right)}$ (D) $\sqrt{\frac{Gm}{r}}$
120. A particle of mass m is placed on the centre of a fixed uniform semi-circular ring of radius R and mass M as shown. Then work required to displace the particle slowly from centre of ring to infinity is (Assume only gravitational interaction of ring and particle)



- (A) $\frac{GMm}{R}$ (B) $-\frac{GMm}{R}$
 (C) $\frac{GMm}{\pi R}$ (D) $-\frac{GMm}{\pi R}$

121. Consider an infinite plane sheet of mass with surface mass density σ . The gravitational field intensity at a point P at perpendicular distance r from such a sheet is
 (A) zero (B) $-\sigma G$
 (C) $-2\pi\sigma G$ (D) $-4\pi\sigma G$
122. In PROBLEM 121, the gravitational potential at the point P is
 (A) zero (B) $-\sigma Gr$
 (C) $-2\pi\sigma Gr$ (D) $-4\pi\sigma Gr$

123. Two identical spherical masses are kept at some distance as shown. The potential energy when a mass m is taken from the surface of one sphere to the other

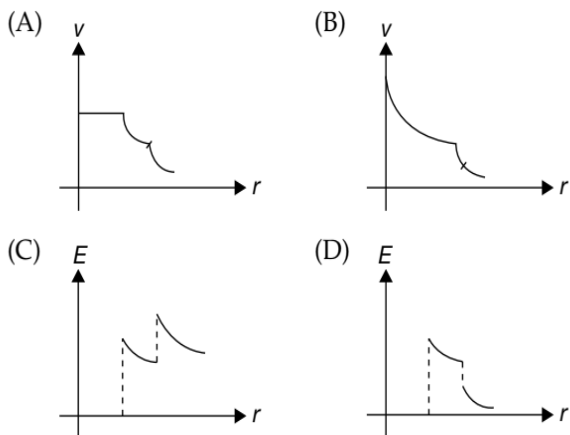
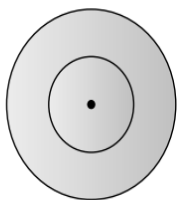


- (A) increases continuously
 (B) decreases continuously
 (C) first increases then decreases
 (D) first decreases then increases
124. The radius and mass of earth are increased by 0.5%. Which of the following statements are true at the surface of the earth?
 (a) g will decrease
 (b) Escape velocity will remain unchanged
 (c) Potential energy will remain unchanged
 (A) (a) only (B) both (a) and (b)
 (C) (a), (b) and (c) (D) both (b) and (c)

MULTIPLE CORRECT CHOICE TYPE QUESTIONS

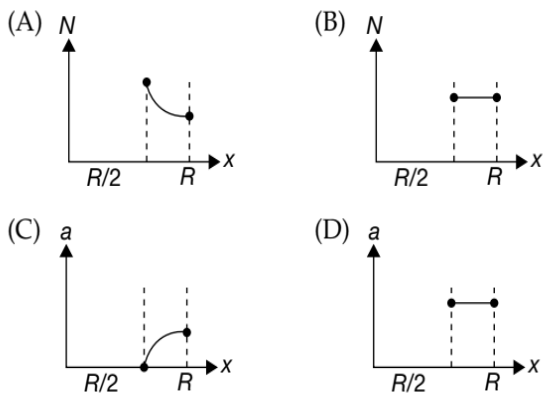
This section contains Multiple Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct.

1. An object is revolving around the earth of radius R_e at height h from earth's surface. Select the correct statement(s).
 (A) Its time period is independent of h .
 (B) Its time period depends on h .
 (C) Orbital velocity of an object depends on h .
 (D) If $h < R_e$ then the time period of this object revolving around the earth is 24 hrs.
2. If, at the surface of earth, the potential energy of a particle is U and potential is V , then the change in potential energy and the change in potential at a height $h = R$ are ΔU and ΔV , then
 (A) $\Delta U = -\frac{U}{2}$ (B) $\Delta U = \frac{U}{2}$
 (C) $\Delta V = \frac{V}{2}$ (D) $\Delta V = -\frac{V}{2}$
3. A shell of mass m_2 , radius r_2 lies inside and is concentric with a larger uniform shell of mass m_1 , radius r_1 . If E_p is the gravitational field at point P at distance r from the common centre then,
 (A) $E_p = G\left(\frac{m_1 + m_2}{r^2}\right)$ for $r > r_1$ & $r > r_2$
 (B) $E_p = G\frac{m_2}{r^2}$ for $r < r_1$ and $r > r_2$
 (C) $E_p = 0$ for $r < r_2$
 (D) $E_p \neq 0$ for $r < r_2$
4. In PROBLEM 3, if V_p is the gravitational potential at the point P then,
 (A) $V_p = -G\left(\frac{m_1 + m_2}{r}\right)$ for $r > r_1$ and $r > r_2$
 (B) $V_p = 0$ for $r < r_1$
 (C) $V_p = -G\left(\frac{m_1}{r_1} + \frac{m_2}{r}\right)$ for $r < r_1$ and $r > r_2$
 (D) $V_p = -G\left(\frac{m_1}{r_1} + \frac{m_2}{r_2}\right)$ for $r < r_2$
5. A satellite is to be stationed in an orbit such that it can be used for relay purposes (such a satellite is called a Geostationary satellite). The condition(s) to be fulfilled by such a satellite is/are
 (A) Its orbit must lie in equatorial plane
 (B) Its sense of revolution must be from west to east
 (C) Its orbital radius must be 42400 km
 (D) Its orbit must not be elliptical and should be circular
6. Two concentric spherical shells are as shown in figure. The magnitude of gravitational potential (V) and field strength (E) vary with distance (r) from centre as



7. A body is imparted a velocity v from the surface of the earth. If v_o is orbital velocity and v_e be the escape velocity then for
- (A) $v = v_o$, the body follows a circular track around the earth.
 - (B) $v > v_o$ but $< v_e$, the body follows elliptical path around the earth.
 - (C) $v < v_o$, the body follows elliptical path and returns to surface of earth.
 - (D) $v > v_e$, the body follows hyperbolic path and escapes the gravitational pull of the earth.

8. A tunnel is dug along a chord of the earth at a perpendicular distance $\frac{R}{2}$ from the earth's centre. The wall of the tunnel may be assumed to be frictionless. A particle is released from one end of the tunnel. The force N exerted by the particle on the wall and the acceleration a of the particle varies with x (distance of the particle from the centre) according to



9. The gravitational potential on the surface of a planet of radius R mass M is

- (A) g
- (B) $\frac{gM}{R}$
- (C) $\frac{-GM}{R}$
- (D) $-gR$

10. Let V and E be the gravitational potential and gravitational field. Then select the correct alternative(s)
- (A) the plot of V vs r is continuous for a spherical shell
 - (B) the plot of E vs r (distance from centre) is discontinuous for a spherical shell
 - (C) the plot of V vs r is continuous for a solid sphere
 - (D) the plot of E vs r is discontinuous for a solid sphere

11. Total energy of planet of mass m moving around the sun of mass M_s along an elliptical orbit depends on
- (A) Mass of the sun
 - (B) Mass of the planet
 - (C) Semi major axis
 - (D) Independent of mass of the sun

12. A planet is revolving round the sun. Its distance from the sun at Apogee is r_A and that at Perigee is r_p . The mass of planet and sun is m and M respectively, v_A and v_p is the velocity of planet at Apogee and Perigee respectively and T is the time period of revolution of planet round the sun.

- (A) $T^2 = \frac{\pi^2}{2Gm}(r_A + r_p)^3$
- (B) $T^2 = \frac{\pi^2}{2GM}(r_A + r_p)^3$
- (C) $v_A r_A = v_p r_p$
- (D) $v_A < v_p$; $r_A > r_p$

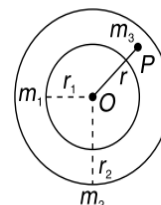
13. Two tunnels are dug from one side of the earth's surface to the other side, one along a diameter and the other along a chord. Now two particles are dropped from one end of each of the tunnels. Both the particles oscillate simple harmonically along the tunnels. Let T_1 and T_2 be the time periods and v_1 and v_2 be the maximum speed of the particles in the two tunnels. Then

- (A) $T_1 > T_2$
- (B) $T_1 = T_2$
- (C) $v_1 = v_2$
- (D) $v_1 > v_2$

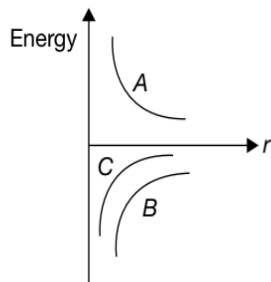
14. In some region, the gravitational field is zero. The gravitational potential in this region
- (A) may be zero
 - (B) cannot be zero
 - (C) must be constant
 - (D) may be variable

15. A planet is revolving round the sun in an elliptical orbit. The work done on the planet by the gravitational force of sun is zero

- (A) in some parts of the orbit
 (B) in any part of the orbit
 (C) in no part of the orbit
 (D) in one complete revolution
16. A point P is lying at a distance $r (< a)$ from the centre of shell of radius a . If E and V be the gravitational field and potential at the point P then,
- (A) $E = 0$ (B) $E = -\frac{GM}{r^2}$
 (C) $V = 0$ (D) $V = -\frac{GM}{a}$
17. Select the correct statement(s).
- (A) Acceleration due to gravity increases with increasing altitude.
 (B) Acceleration due to gravity decreases with increasing depth (assume the earth to be a sphere of uniform density)
 (C) Acceleration due to gravity is independent of mass of the body
 (D) The formula $-GMm\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$ is more accurate than the formula $mg(r_2 - r_1)$ for the difference of potential energy between two points r_2 and r_1 distance away from the centre of earth
18. Two objects of masses m and $4m$ are at rest at an infinite separation. They move towards each other under mutual gravitational attraction. If G is the universal gravitational constant. Then, at separation r
- (A) the total energy of the two objects is zero
 (B) their relative velocity of approach is $\sqrt{\frac{10Gm}{r}}$ in magnitude
 (C) the total kinetic energy of the objects is $\frac{4Gm^2}{r}$
 (D) net angular momentum of both the particles is zero about any point
19. Which of the following statement(s) is/are correct
- (A) An astronaut going from Earth to Moon will experience weightlessness once
 (B) When a thin uniform spherical shell gradually shrinks maintaining its shape, the gravitational potential at the centre decreases
 (C) In the case of spherical shell, the plot of potential versus distance from centre is continuous
 (D) In the case of spherical shell, the plot of gravitational field intensity I versus distance from centre is continuous
20. Two identical satellites are orbiting at distances R and $7R$ from the surface of the earth, R being the radius of the earth. The ratio of their
- (A) kinetic energies is 4
 (B) potential energies is 4
 (C) total energies is 4
 (D) total energies is 1
21. In circular orbit of a satellite of mass m , revolving around a planet of mass M in an orbit of radius r and having the period of revolution T , we have
- (A) orbital speed equals $\sqrt{\frac{GM}{r}}$
 (B) $T^2 \propto r^3$
 (C) kinetic energy equals $\frac{GMm}{2r}$
 (D) potential energy equals $-\frac{GMm}{2r}$
22. Which (one or more) of the following quantities remain constant during planetary motion in an elliptic orbit?
- (A) angular speed
 (B) areal speed
 (C) angular momentum
 (D) energy
23. A planet of mass m is revolving round the sun (of mass M_s) in an elliptical orbit. If \vec{v} is the velocity of the planet when its position vector from the sun is \vec{r} and the planet rotates in counter clockwise direction, then areal velocity has a direction
- (A) given by "Right Hand Thumb Rule".
 (B) given by "Left Hand Thumb Rule".
 (C) normal to the plane of orbit upwards.
 (D) normal to the plane of orbit downwards.
24. For a solid sphere, the magnitude of
- (A) gravitational potential is maximum at centre
 (B) gravitational potential is minimum at centre
 (C) field strength is maximum at centre
 (D) field strength is minimum at centre
25. Two concentric spherical shells have masses m_1 and m_2 and radii r_1 and r_2 . Select the correct statement(s).



- (A) Outer shell will have no contribution in gravitational field at point P
 (B) Force on P is directed towards O
 (C) Force on P is $\frac{Gm_1m_2}{r^2}$
 (D) Force on P is $\frac{Gm_1m_3}{r^2}$

26. For a satellite revolving in a circular orbit, let v_0 be the orbital speed, T be the time period of revolution, U be its potential energy and K the kinetic energy. Now if the value of G is decreased, then
 (A) v_0 will decrease (B) T will decrease
 (C) U will decrease (D) K will decrease
27. A double star in a system of two stars of masses m and $2m$, rotating about their centre of mass only under their mutual gravitational attraction. If r is the separation between these two stars then their time period of rotation about their centre of mass will be proportional to
 (A) r^2 (B) r
 (C) m^2 (D) m^{-2}
28. The acceleration due to earth's gravity decreases if
 (A) we go down from the surface of the earth towards its centre
 (B) we go up from the surface of the earth
 (C) we go from the equator towards of the poles
 (D) the rotational speed of the earth is increased
29. For a planet revolving round the sun in an elliptical orbit, the
 (A) potential energy is constant
 (B) kinetic energy is constant
 (C) total mechanical energy is constant
 (D) angular momentum about centre of sun is constant
30. A particle of mass m is moved from the surface of the earth to a height h . The work done by an external agency to do this is
 (A) mgh for $h < R$ (B) mgh for all h
 (C) $-\frac{1}{2}mgR$ for $h = R$ (D) $\frac{1}{2}mgR$ for $h = R$
31. A satellite is orbiting round the earth's surface in an orbit as close as possible to the surface of the earth. Then
 (A) The time period of revolution of satellite is independent of its mass and is minimum
 (B) The orbital speed of satellite is maximum
 (C) The total energy of the "earth plus satellite" system is minimum
 (D) The total energy of the "earth plus satellite" system is maximum
32. A student uses a simple pendulum of exactly 1 m length to determine g , the acceleration due to gravity. He uses a stop watch with the least count of 1 s for this and records 40 s for 20 oscillations. For this observation, which of the following statement(s) is (are) true?
 (A) Error ΔT in measuring T , the time period, is 0.05 s
 (B) Error ΔT in measuring T , the time period, is 1 s
 (C) Percentage error in the determination of g is 5%
 (D) Percentage error in the determination of g is 2.5%
33. Three point masses each of mass m are at the corners of an equilateral triangle of side l . The system rotates about the centre of the triangle with the separation of masses not changing during rotation. If T is the time period of rotation then,
 (A) $T \propto l^2$ (B) $T \propto l^2$
 (C) $T \propto m^2$ (D) $T \propto m^{-2}$
34. Three masses each of mass m are kept at corner of an equilateral triangle and are revolving under the effect of mutual gravitational force. Select the correct statement(s).
 (A) Radius of circular path followed by mass is $\frac{a}{2}$
 (B) Velocity of mass is $\sqrt{\frac{Gm}{a}}$
 (C) Binding energy of system is $\frac{3Gm^2}{2a}$
 (D) Time period of mass is $\sqrt{\frac{\pi a^3}{2Gm}}$
35. Figure shows the variation of energy with the orbit radius r of a satellite in a circular motion. Select the incorrect statement(s).
- 
- (A) C shows the total energy, B the kinetic energy and A the potential energy of the satellite
 (B) A shows the kinetic energy, B the total energy and C the potential energy of the satellite
 (C) A and B are the kinetic and potential energies and C the total energy of the satellite
 (D) C and A are the kinetic and potential energies respectively and B the total energy of the satellite
36. The potential at the surface of a planet of mass M and radius R is assumed to be zero. Choose the most appropriate option

- (A) The potential at infinity is zero
 (B) The potential at the centre of the planet is $-\frac{3GM}{2R}$
 (C) The potential at infinity is $\frac{GM}{R}$
 (D) The potential at the centre of planet is $-\frac{GM}{2R}$
37. A body of mass m is projected vertically upwards with velocity v from earth's surface and attains height h . If v_e is the escape velocity from the surface of earth then for
 (A) $v = v_e$ the body reaches infinity.
 (B) small v , maximum height h attained by the body is $\frac{v^2}{2g}$.
- (C) $h = R$, the projection kinetic energy is $\frac{mgR}{2}$.
 (D) $h = \frac{R}{2}$, total energy is negative.
38. A double star consists of two stars having masses m and $2m$ separated by a distance r . Which of the following statement(s) is/are incorrect?
 (A) Radius of circular path of star of mass $2m$ is $\frac{2r}{3}$
 (B) Kinetic energy of $2m$ mass star is double that of lighter star
 (C) Time period of revolution of both are not same
 (D) Angular momentum of lighter star is more

REASONING BASED QUESTIONS

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

Bubble (A) If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.

Bubble (B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.

Bubble (C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.

Bubble (D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

- Statement-1:** Kepler's Second Law can be understood by conservation of angular momentum principle.
Statement-2: Kepler's Second Law is related with areal velocity, which can further be proved to be based on conservation of angular momentum as $\frac{dA}{dt} = \frac{1}{2}r^2\omega$.
- Statement-1:** For the planets orbiting around the sun, angular speed, linear speed, kinetic energy changes with time, but angular momentum remains constant.
Statement-2: No torque is acting on the rotating planet, so its angular momentum is constant.
- Statement-1:** Escape velocity is independent of the angle of projection.
Statement-2: Escape velocity from the surface of earth is $\sqrt{2gR}$, where R is radius of earth.
- Statement-1:** A spherically symmetric shell produces no gravitational field anywhere.
Statement-2: The field due to various mass elements cancels out, everywhere inside the shell.
- Statement-1:** Gravitational potential is zero inside a shell.
Statement-2: Gravitational potential is equal to the work done in bringing a unit mass from infinity to a point inside gravitational field.
- Statement-1:** Rate of change of weight near the earth's surface with height h is independent of h .
Statement-2: Since gravitational potential is given by $V = -\frac{GM}{r}$.
- Statement-1:** The magnitude of gravitational potential at the surface of solid sphere is less than that of the centre of sphere.
Statement-2: Due to solid sphere, gravitational potential is same within the sphere.
- Statement-1:** For a satellite revolving very near to earth's surface the time period of revolution is given by 1 hour 24 minutes.
Statement-2: The period of revolution of a satellite depends only upon its height above the earth's surface.
- Statement-1:** Work done in gravitational field in cyclic process is zero.
Statement-2: Work done in conservative field does not depend upon path.
- Statement-1:** The value of acceleration due to gravity does not depend upon mass of the body.
Statement-2: Acceleration due to gravity is a constant quantity.

LINKED COMPREHENSION TYPE QUESTIONS

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options)

Comprehension 1

The mean radius of the earth's orbit around the sun is 1.5×10^{11} m and that of the orbit of mercury is 6×10^{10} m. Based on above information, answer the following questions.

- The mercury will revolve around the sun in nearly

(A) $\sqrt{\frac{2}{5}}$ year	(B) $\frac{2}{5}$ year
(C) $\left(\frac{2}{5}\right)^2$ year	(D) $\left(\frac{2}{5}\right)^{3/2}$ year
- The ratio of the orbital velocity of mercury to that of the earth is

(A) $\sqrt{\frac{5}{2}}$	(B) $\frac{2}{\sqrt{10}}$
(C) $2\sqrt{10}$	(D) $\frac{1}{2}\sqrt{10}$

Comprehension 2

The radius of the earth is R and acceleration due to gravity at its surface is g . A body of mass m is sent to a height of $\frac{R}{4}$ from the earth's surface. Based on above information, answer the following questions.

- The potential energy increases by

(A) $\frac{mgR}{3}$	(B) $\frac{mgR}{4}$
(C) $\frac{mgR}{5}$	(D) $\frac{mgR}{16}$
- The minimum speed with which the body must be thrown from the surface of the earth so as to reach the specified height is

(A) $\sqrt{\frac{1}{2}gR}$	(B) \sqrt{gR}
(C) $\sqrt{\frac{1}{5}gR}$	(D) $\sqrt{\frac{2}{5}gR}$

Comprehension 3

Two satellites S_1 and S_2 revolve round a planet in coplanar circular orbits in the same sense. Their periods of revolution are 1 hour and 8 hour, respectively. The radius of the orbit of S_1 is 10^4 km. Based on above information, answer the following questions.

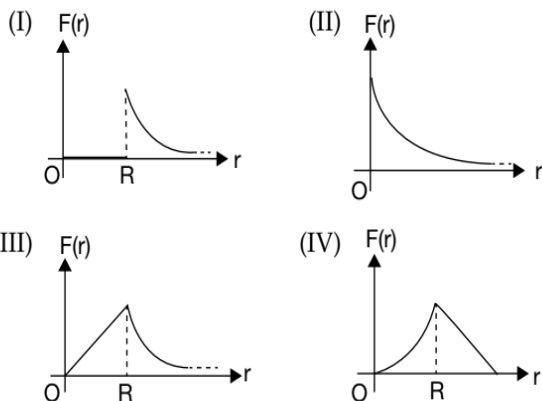
- The speed of S_2 relative to S_1 , when they are closest, in kmh^{-1} , is

(A) $10^4\pi$	(B) $2 \times 10^4\pi$
(C) $\frac{1}{2} \times 10^4\pi$	(D) $4 \times 10^4\pi$
- The angular speed of S_2 as observed by an astronaut in S_1 is

(A) $\frac{\pi}{2}$	(B) $\frac{\pi}{3}$
(C) $\frac{\pi}{4}$	(D) $\frac{\pi}{6}$

Comprehension 4

A particle of mass m is located at a distance r from the centre of a shell/sphere of mass M and radius R . The following plots (I), (II), (III) and (IV) show the variation of force $F(r)$ between the shell and mass or alternatively the variation of force between the sphere and the mass. Based on above information, answer the following questions.



- The appropriate variation of the force between the shell and the point mass is represented by

(A) I	(B) II
(C) III	(D) IV
- The appropriate variation of the force between the sphere and the point mass is represented by

(A) I	(B) II
(C) III	(D) IV

Comprehension 5

An artificial satellite is moving in a circular orbit around the earth with a speed equal to half the escape speed from the surface of earth. Now the satellite is stopped suddenly in its orbit and allowed to fall freely onto the earth. Assuming

the radius of the earth to be R , the acceleration due to gravity on earth's surface to be g . Based on above information, answer the following questions.

9. The height of the satellite above the surface of the earth must be
- (A) $\frac{R}{2}$ (B) $\frac{2R}{3}$
 (C) R (D) $2R$
10. The speed with which it hits the surface of the earth is
- (A) \sqrt{Rg} (B) $\sqrt{2Rg}$
 (C) $\sqrt{\frac{Rg}{2}}$ (D) $\frac{\sqrt{Rg}}{2}$

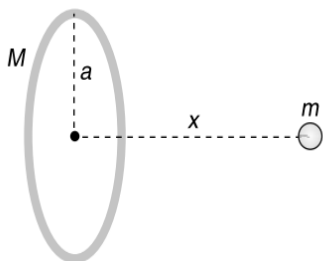
Comprehension 6

A smooth tunnel is dug across a diameter of earth and a particle is released from the surface of earth, the particle oscillates simple harmonically along it. Based on above information, answer the following questions.

11. Time period of the particle is equal to
- (A) $2\pi\sqrt{\frac{R^3}{GM}}$ (B) $2\pi\sqrt{\frac{R}{g}}$
 (C) 84.6 min (D) 24 hr
12. Maximum speed attained by the particle is
- (A) $\sqrt{\frac{2GM}{R}}$ (B) $\sqrt{\frac{GM}{R}}$
 (C) $\sqrt{\frac{3GM}{2R}}$ (D) $\sqrt{\frac{GM}{2R}}$

Comprehension 7

A particle of mass m is placed at a distance x from the centre of ring along the line through the centre of the ring and perpendicular to its plane.



Based on above information, answer the following questions.

13. Gravitational potential energy of this system
- (A) $-\frac{GMm}{\sqrt{a^2+x^2}}$ (B) $\frac{GMm}{a}$
 (C) $\frac{GMm}{x}$ (D) None of these

14. The force, when $x = 0$ is

(A) $\frac{GMm}{x^2}$ (B) $\frac{GMmx}{\sqrt{a^2+x^2}}$
 (C) $\frac{GMmx}{(a^2+x^2)^{3/2}}$ (D) zero

15. When given a small displacement x a from the centre of the ring, the particle of mass m will
- (A) move away from the centre
 (B) perform oscillations about the centre of ring
 (C) move to infinity and never return
 (D) None of these

Comprehension 8

A satellite of mass 5000 kg is projected in space with an initial speed of 4000 ms^{-1} making an angle of 30° with the radial direction from a distance $3.6 \times 10^7 \text{ m}$ away from the centre of the earth.

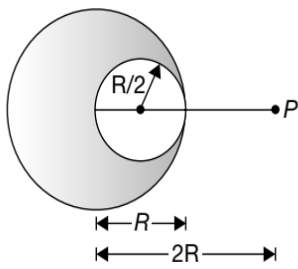
16. The angular momentum of satellite
- (A) $3.6 \times 10^7 \text{ Js}$ (B) $4.9 \times 10^7 \text{ Js}$
 (C) $9.2 \times 10^7 \text{ Js}$ (D) $3.6 \times 10^{14} \text{ Js}$
17. The energy of satellite is
- (A) $1.6 \times 10^7 \text{ joule}$ (B) $4.9 \times 10^7 \text{ joule}$
 (C) $0.2 \times 10^7 \text{ joule}$ (D) $-1.5 \times 10^{10} \text{ joule}$
18. The semi-major axis of the orbit of satellite
- (A) $6.6 \times 10^7 \text{ m}$ (B) $14.9 \times 10^7 \text{ m}$
 (C) $19.2 \times 10^7 \text{ m}$ (D) $1.6 \times 10^4 \text{ m}$
19. Semi-minor axis of the orbit of satellite
- (A) $16.6 \times 10^7 \text{ m}$ (B) $3.92 \times 10^7 \text{ m}$
 (C) $10.2 \times 10^{17} \text{ m}$ (D) $2.6 \times 10^4 \text{ m}$
20. The minimum distance of satellite from earth
- (A) $66.6 \times 10^7 \text{ m}$ (B) $14.9 \times 10^7 \text{ m}$
 (C) $1.29 \times 10^7 \text{ m}$ (D) $1.6 \times 10^4 \text{ m}$
21. The maximum distance of satellite from earth.
- (A) $6.6 \times 10^7 \text{ m}$ (B) $24.9 \times 10^7 \text{ m}$
 (C) $11.9 \times 10^7 \text{ m}$ (D) $1.6 \times 10^4 \text{ m}$

Comprehension 9

A solid sphere having uniform density and radius R exerts a gravitational force of attraction F_1 on a particle placed at P . The distance of P from the centre of the sphere is $2R$.

A spherical cavity of radius $\frac{R}{2}$ is now made in the sphere.

The sphere (with cavity) exerts a gravitational force F_2 on the same particle at P .



Based on the above facts, answer the following questions.

22. F_1 is

- (A) $\frac{GMm}{R^2}$ (B) $\frac{GMm}{2R^2}$
 (C) $\frac{GMm}{3R^2}$ (D) $\frac{GMm}{4R^2}$

23. F_2 is

- (A) $\frac{7}{13} \frac{GMm}{R^2}$ (B) $\frac{7}{16} \frac{GMm}{R^2}$
 (C) $\frac{7}{32} \frac{GMm}{R^2}$ (D) $\frac{7}{36} \frac{GMm}{R^2}$

24. The ratio $\frac{F_1}{F_2}$ is

- (A) $\frac{9}{7}$ (B) $\frac{7}{9}$
 (C) $\frac{1}{2}$ (D) $\frac{4}{3}$

Comprehension 10

A binary star system consists of two stars of masses m and $2m$. The separation between their centres is l . They revolve two about a point under their mutual gravitational interaction force. Based on the above facts, answer the following questions.

25. The system revolves about

- (A) the centre (B) the centre of mass
 (C) both (D) None of these

26. Heavier star revolves in an orbit of radius

- (A) l (B) $\frac{l}{2}$
 (C) $\frac{l}{3}$ (D) $\frac{l}{4}$

27. The system revolves with angular velocity ω (about an axis specified above) given by

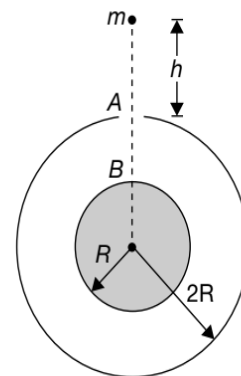
- (A) $\sqrt{\frac{Gm}{l^3}}$ (B) $\sqrt{\frac{2Gm}{l^3}}$
 (C) $\sqrt{\frac{3Gm}{l^3}}$ (D) $2\sqrt{\frac{Gm}{l^3}}$

28. If K_L be the kinetic energy of light body and K_H kinetic energy of heavy body then

- (A) $K_L + K_H = \frac{ml^2\omega^2}{3}$ (B) $K_L + K_H = \frac{2ml^2\omega^2}{9}$
 (C) $K_L + K_H = \frac{2ml^2\omega^2}{3}$ (D) $K_L + K_H = \frac{ml^2\omega^2}{9}$

Comprehension 11

A solid sphere of mass M and radius R is surrounded by a spherical shell of same mass M and radius $2R$ as shown. A small particle of mass m is released from rest from a height h ($> R$) above the shell. There is a hole in the shell.



Based on above information, answer the following questions.

29. The time taken by the particle just to enter the hole at A is

- (A) $2\sqrt{\frac{hR^2}{GM}}$ (B) $\sqrt{\frac{2hR^2}{GM}}$
 (C) $\sqrt{\frac{hR^2}{GM}}$ (D) None of these

30. The time taken by the particle to move from A to B is

- (A) $= \frac{R^2}{\sqrt{GMh}}$ (B) $> \frac{R^2}{\sqrt{GMh}}$
 (C) $< \frac{R^2}{\sqrt{GMh}}$ (D) None of these

31. The approximate speed with which the particle hits B is

- (A) $\sqrt{\frac{2GM}{R}}$ (B) $\sqrt{\frac{GM}{2R}}$
 (C) $\sqrt{\frac{3GM}{2R}}$ (D) $\sqrt{\frac{GM}{R}}$

Comprehension 12

The minimum and maximum distances of a satellite from the centre of the earth are $2R$ and $4R$, respectively, where R is the radius of earth and M is the mass of the

earth. Based on above information, answer the following questions.

32. The minimum speed of the satellite is

- (A) $\sqrt{\frac{GM}{9R}}$ (B) $\sqrt{\frac{GM}{5R}}$
 (C) $\sqrt{\frac{GM}{6R}}$ (D) $\sqrt{\frac{GM}{3R}}$

33. The maximum speed of the satellite is

- (A) $\sqrt{\frac{3GM}{2R}}$ (B) $\sqrt{\frac{2GM}{3R}}$
 (C) $\sqrt{\frac{2GM}{R}}$ (D) $\sqrt{\frac{5GM}{2R}}$

34. Radius of curvature at the point of minimum distance is

- (A) $\frac{8R}{3}$ (B) $\frac{5R}{3}$
 (C) $\frac{4R}{3}$ (D) $\frac{7R}{3}$

Comprehension 13

An Earth station receives data transmitted back in time from a future intergalactic expedition. The table summarizes the data for the moons of a planet what will be discovered in a distance galaxy.

	Radius	Gravitational Acceleration at the Surface	Orbital Radius	Orbital Period
Moon I			5×10^7 m	
Moon II			9×10^7 m	3×10^5 s
Moon III	2×10^5 m	0.20 ms^{-2}		2×10^6 s

Based on above information, answer the following questions.

35. In table, the mass of the planet is closest to

- (A) 1.2×10^{24} kg (B) 1.7×10^{24} kg
 (C) 2.4×10^{24} kg (D) 4.8×10^{24} kg

36. In table, the mass of Moon III is closest to

- (A) 2.4×10^{19} kg (B) 4.8×10^{19} kg
 (C) 1.2×10^{20} kg (D) 2.4×10^{20} kg

37. In table, the centripetal acceleration of Moon II due to orbital motion is closest to

- (A) 0.02 ms^{-2} (B) 0.04 ms^{-2}
 (C) 0.06 ms^{-2} (D) 0.08 ms^{-2}

MATRIX MATCH/COLUMN MATCH TYPE QUESTIONS

Each question in this section contains statements given in two columns, which have to be matched. The statements in COLUMN-I are labelled A, B, C and D, while the statements in COLUMN-II are labelled p, q, r, s (and t). Any given statement in COLUMN-I can have correct matching with **ONE OR MORE** statement(s) in COLUMN-II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

If the correct matches are $A \rightarrow p, s$ and t ; $B \rightarrow q$ and r ; $C \rightarrow p$ and q ; and $D \rightarrow s$ and t ; then the correct darkening of bubbles will look like the following:

	p	q	r	s	t
A	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
B	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

1. Match the gravitational field and potential in COLUMN-I to the respective quantities in COLUMN-II.

COLUMN-I	COLUMN-II
(A) $E_g = 0$	(p) Inside a spherical shell
(B) $E_g \neq 0$	(q) At centre of a solid sphere

COLUMN-I	COLUMN-II
(C) $V = 0$	(r) Inside the solid sphere (excluding centre)
(D) $V \neq 0$	(s) At centre of a circular ring
	(t) None of these

(Continued)

2. Density of a planet is two times the density of earth and radius of this planet is half the radius of earth. Match, the following. (As compared to earth).

COLUMN-I	COLUMN-II
(A) Gravitational strength at the surface of this planet	(p) Half
(B) Gravitational potential on the surface	(q) Same
(C) Gravitational potential at centre	(r) Two times
(D) Gravitational strength at centre	(s) Four times

3. In elliptical orbit of a planet, as the planet moves from aphelion position to perihelion position, match the following table:

COLUMN-I	COLUMN-II
(A) distance of planet from centre of sun	(p) remains same
(B) speed of planet	(q) decreases
(C) potential energy	(r) increases
(D) angular momentum about centre of sun	(s) zero
(E) change in mechanical energy	

4. Match the following

COLUMN-I	COLUMN-II
(A) Time period of a body orbiting the planet in circular orbit	(p) Independent of mass of body
(B) Orbital velocity of body	(q) Dependent of radius of orbit
(C) Mechanical energy of body	(r) Dependent of mass of planet
(D) Escape velocity of a body from surface of planet	(s) Constant in an orbit

5. If the angular speed of rotation of earth about its own axis decreases, then match the following

COLUMN-I	COLUMN-II
(A) Value of g at pole	(p) remains same
(B) Value of g at equator	(q) increases
(C) Distance of geostationary satellite	(r) decreases
(D) Energy of geostationary satellite	(s) None of these

6. Match the following

COLUMN-I	COLUMN-II
(A) Gravitational force	(p) Law of Conservation of Angular Momentum
(B) Kepler's First Law	(q) $T^2 \propto r^{3/2}$
(C) Kepler's Second Law	(r) Inverse square law
(D) Kepler's Third Law	(s) Orbit of planet is elliptical
	(t) Conservative

7. On the surface of earth the gravitational field is E and gravitational potential is V . Match the following

COLUMN-I	COLUMN-II
(A) At height $h = R$, value of E	(p) decreases by a factor $\frac{1}{4}$
(B) At depth $d = \frac{R}{2}$, value of E	(q) decreases by a factor $\frac{1}{2}$
(C) At height $h = R$, value of V	(r) increases by a factor $\frac{11}{8}$
(D) At depth $d = \frac{R}{2}$, value of V	(s) increases by a factor 2
	(t) decreases by a factor $\frac{11}{8}$

8. Consider a planet of mass M and radius R and a satellite is launched with velocity V from its surface. Match the following

COLUMN-I	COLUMN-II
(A) $V > \sqrt{\frac{2GM}{R}}$	(p) Ellipse
(B) $V = \sqrt{\frac{2GM}{R}}$	(q) Hyperbola
(C) $V < \sqrt{\frac{2GM}{R}}$	(r) Circle
(D) $V = \sqrt{\frac{GM}{R}}$	(s) Parabola

9. If the velocity of launch (v), escape velocity (v_e) and orbital velocity v_0 are related as shown in COLUMN-I, then match them with the corresponding quantities of COLUMN-II.

COLUMN-I	COLUMN-II
(A) When $v < v_0$	(p) The path of satellite is hyperbolic
(B) When $v = v_e = \sqrt{2}v_0$	(q) The satellite will strike the earth
(C) When $v > v_e$	(r) The orbit of satellite is elliptical
(D) $v_e > v > v_0$	(s) The path of satellite is parabolic

10. Let a satellite of mass m is revolving in a circular orbit of radius r around a planet of mass M such that system is bound. If E , U , K and B denotes total energy, potential energy, kinetic energy and binding energy respectively then match the following

COLUMN-I	COLUMN-II
(A) E	(p) $+\frac{GMm}{2r}$
(B) U	(q) $+\frac{GMm}{r}$
(C) K	(r) $-\frac{GMm}{r}$
(D) B	(s) $-\frac{GMm}{2r}$

11. Match the following for a planet revolving around sun in an elliptical orbit of semi-major axis a and semi-minor axis b .

COLUMN-I	COLUMN-II
(A) $T^2 \propto r^3$	(p) Kepler's First Law
(B) Areal velocity is constant	(q) Kepler's Second Law
(C) Orbital of planet is elliptical	(r) Kepler's Third Law
(D) $\frac{2\pi mab}{T} = \text{constant}$	(s) None of these

INTEGER/NUMERICAL ANSWER TYPE QUESTIONS

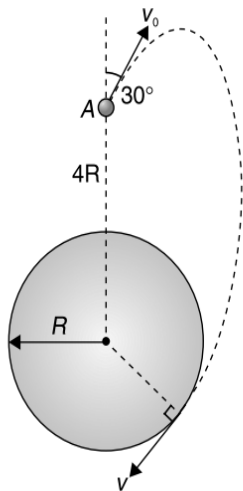
In this section, the answer to each question is a numerical value obtained after doing series of calculations based on the data given in the question(s).

- Calculate the ratio of the orbital radius of a communication satellite to the radius of earth so that it can cover 75% of the surface area of earth during its revolution. Take $(2.65)^2 \approx 7$.
- Calculate the work done, in newton, by the gravitational field when a particle is moved along the line $3y + 2x = 5$ in the region of gravitational field $\vec{E}_g = (2\hat{i} + 3\hat{j}) \text{ Nkg}^{-1}$, from $(1, 1) \text{ m}$ to $(-2, 3) \text{ m}$.
- A circular ring of mass M and radius R is placed in YZ plane with centre at origin. A particle of mass m is released from rest at a point $x = 2R$. The

speed with which it will cross the centre of ring is

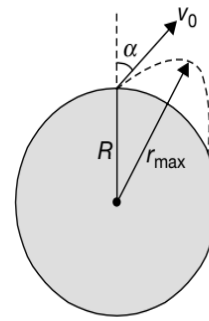
$$v = \left[x \left(1 - \frac{1}{y} \right) \frac{GM}{R} \right]^{\frac{1}{2}}. \text{ Find } \frac{y^2}{xz}.$$

- A particle is fired vertically upward with a speed of 15 kms^{-1} . Find the speed of the particle in kms^{-1} , when it goes out of the earth's gravitational pull.
- A particle is projected from point A (which lies at a distance $4R$ from the centre of the Earth), with a speed v_0 in a direction making 30° with the line joining the centre of the Earth and point A , as shown.



Calculate the speed v_0 of particle, in ms^{-1} , if particle passes grazing the surface of the earth. Consider that only the gravitational interaction between these two exists.

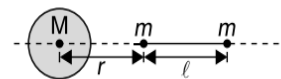
Given that $\frac{GM}{R} = 6.4 \times 10^7 \text{ m}^2\text{s}^{-2}$



6. A ring of radius $R = 4 \text{ m}$ made of a highly dense material has a mass $m_1 = 5.4 \times 10^9 \text{ kg}$ distributed uniformly over its circumference. A highly dense particle of mass $m_2 = 6 \times 10^8 \text{ kg}$ is placed on the axis of the ring at a distance $x_0 = 3 \text{ m}$ from the centre of the ring. Neglecting all other forces, except mutual gravitational interaction of the two, calculate
 - (a) displacement of the ring, in cm, when particle is at the centre of ring and
 - (b) speed of the particle, in cms^{-1} , at that instant.
7. Two particles each of mass M are fixed at positions $(0, a)$ and $(0, -a)$. Another particle of mass $\frac{M}{2}$ is thrown from origin along $+z$ axis so that it is just able to reach a point $(0, 0, 2\sqrt{3}a)$. The speed with which the particle was projected from the origin is calculated as $v = \sqrt{\frac{\alpha GM}{a} \left(1 - \frac{1}{\sqrt{\beta}}\right)}$. Find α and β .

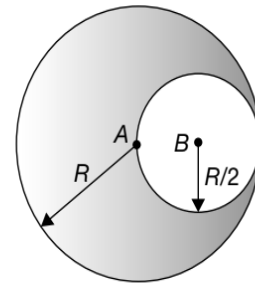
8. A projectile of mass m is fired from the surface of the earth at an angle $\alpha = 60^\circ$ from the vertical. The initial speed of the projectile is $v_0 = \sqrt{\frac{GM}{R}}$, where M and R are mass and radius of earth. The projectile rises to a height $\frac{R}{*}$, where $*$ is not readable. Find $*$. Neglect air resistance and the earth's rotation.

9. If a satellite is revolving around the earth in a circular orbit in a plane containing earth's axis of rotation. If the angular speed of satellite is equal to that of earth, calculate the time (in hour) taken by it to move from a point above north pole to a point above the equator.
10. A smooth tunnel is dug along the radius of earth that ends at centre. A ball is released from the surface of earth along tunnel. Coefficient of restitution for collision between the centre of the earth and ball is 0.5. Calculate the distance travelled by ball just before second collision at centre is xR . Given mass of the earth is M and radius of the earth is R , find x .
11. If the distance between the centres of Earth and Moon is D and mass of Earth is 81 times that of Moon. The distance from the centre of earth where the gravitational field will be zero is $\frac{xD}{y}$, then calculate the value of $(y - x)$.
12. If a planet was suddenly stopped in its orbit supposed to be circular, show that it would fall onto the sun in a time $\frac{1}{\sqrt{2^x}}$ times the period of the planet's revolution. Find x .
13. A large spherical mass M is fixed at one position and two identical masses m are kept on a line passing through the centre of M as shown in figure.



The point masses are connected by a rigid massless rod of length l and this assembly is free to move along the line connecting them. All three masses interact only through their mutual gravitational interaction. When the point mass nearer to M is at a distance $r = 3l$ from M the tension in the rod is zero for $m = k \left(\frac{M}{288}\right)$. Find the value of k .

14. Gravitational acceleration on the surface of a planet is $\frac{\sqrt{12}}{11}g$, where g is the gravitational acceleration on the surface of the earth. The average mass density of the planet is $\frac{4}{3}$ times that of the earth. If the escape speed on the surface of the earth is taken to be 11 km s^{-1} , find the escape speed on the surface of the planet in km s^{-1} .



15. A small point mass m is to be thrown with such a speed at a distance x from the axis of a long cylinder of radius R and density ρ , so that m starts revolving around the cylinder in a circular orbit of radius x with centre at the axis of cylinder. The speed with which point mass is thrown is found to be $v = R(*G\rho\pi)^{\frac{1}{*}}$, where $*$ is not readable. Calculate $*$.

16. A binary star consists of two stars A (mass $2.2M_{\odot}$) and B (mass $11M_{\odot}$), where M_{\odot} is the same mass of the sun. They are separated by distance d and are rotating about their centre of mass, which is stationary. Find the ratio of the total angular momentum of the binary star to the angular momentum of star B about the centre of mass.

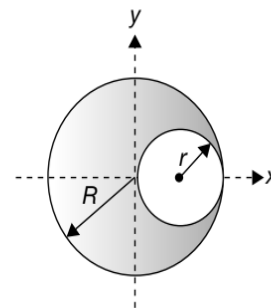
17. An artificial satellite is describing an equatorial orbit at 1600 km above the surface of the earth. Calculate its orbital speed, in ms^{-1} and the period of revolution, in seconds.

If the satellite is travelling in the same direction as the rotation of the earth (i.e., from west to east), calculate the interval (in seconds) between two successive times at which it will appear vertically overhead to an observer at a fixed point on the equator. Radius of earth is 6400 km and $g = \pi^2 \text{ms}^{-2}$ at the surface of earth.

18. Inside a fixed sphere of radius R and uniform density ρ , there is spherical cavity of radius $\frac{R}{2}$ such that surface of the cavity passes through the centre of the sphere as shown in figure. A particle of mass m is released from rest at centre B of the cavity. The velocity with which particle strikes the centre A of the sphere is v . Neglect earth's gravity. Initially sphere and particle are at rest. If the escape speed of the particle from surface of the outer bigger sphere is v_e . Then find $\frac{2v_e^2}{v^2}$.

19. A bullet is fired vertically upwards with velocity v from the surface of a spherical planet. When it reaches its maximum height, its acceleration due to the planet's gravity is $\frac{1}{9}$ th of its value at the surface of the planet. If the escape velocity from the planet is $v_{\text{esc}} = v\sqrt{N}$, then the value of N is (ignore energy loss due to atmosphere)

20. A sphere of radius R has its centre at the origin. It has uniform mass density ρ_0 except that there is a spherical hole of radius $r = \frac{1}{2}R$ whose centre is at $x = \frac{1}{2}R$, as shown in figure. The gravitational field at $x = 2R$ is $\left(\frac{a}{a+20}\right)\pi G\rho_0 R$. Find a .



21. A spaceship approaches the moon (of mass M and radius R) along a parabolic path which is almost tangential to its surface. At the moment of maximum approach, the brake rocket is fired to convert the spaceship into a satellite of the moon. The change in speed is found to be $(\sqrt{x} - 1)\sqrt{\frac{GM}{R}}$. Find x .

ARCHIVE: JEE MAIN
1. [Online September 2020]

The mass density of a spherical galaxy varies as $\frac{K}{r}$ over a large distance r from its center. In that region, a small star is in a circular orbit of radius R . Then the period of revolution, T depends on R as

- (A) $T \propto R$ (B) $T^2 \propto \frac{1}{R^3}$
 (C) $T^2 \propto R$ (D) $T^2 \propto R^3$

2. [Online September 2020]

The height h at which the weight of a body will be the same as that at the same depth h from the surface of the earth is (Radius of the earth is R and effect of the rotation of the earth is neglected)

- (A) $\frac{\sqrt{5}R - R}{2}$ (B) $\frac{\sqrt{5}}{2}R - R$
 (C) $\frac{R}{2}$ (D) $\frac{\sqrt{3}R - R}{2}$

3. [Online September 2020]

A satellite is moving in a low nearly circular orbit around the earth. Its radius is roughly equal to that of the earth's radius R_e . By firing rockets attached to it, its speed is instantaneously increased in the direction of its motion so that it becomes $\sqrt{\frac{3}{2}}$ times larger. Due to this, the farthest distance from the center of the earth that the satellite reaches is R , value of R is

- (A) $4R_e$ (B) $3R_e$
 (C) $2R_e$ (D) $2.5R_e$

4. [Online September 2020]

The mass density of a planet of radius R varies with the distance r from its center as $\rho(r) = \rho_0 \left(1 - \frac{r^2}{R^2}\right)$. Then the gravitational field is maximum at

- (A) $r = \frac{1}{\sqrt{3}}R$ (B) $r = \sqrt{\frac{5}{9}}R$
 (C) $r = \sqrt{\frac{3}{4}}R$ (D) $r = R$

5. [Online September 2020]

On the x -axis and a distance x from the origin, the gravitational field due to a mass distribution is given by $\frac{Ax}{(x^2 + a^2)^{3/2}}$ in the x -direction. The magnitude of gravitational potential on the x -axis at a distance x . Taking its value to be zero at infinity, is

- (A) $\frac{A}{(x^2 + a^2)^{1/2}}$ (B) $\frac{A}{(x^2 + a^2)^{3/2}}$
 (C) $A(x^2 + a^2)^{3/2}$ (D) $A(x^2 + a^2)^{1/2}$

6. [Online September 2020]

A body is moving in a low circular orbit about a planet of mass M and radius R . The radius of the orbit can be taken to be R itself. Then the ratio of the speed of this body in the orbit to the escape velocity from the planet is

- (A) 1 (B) 2
 (C) $\frac{1}{\sqrt{2}}$ (D) $\sqrt{2}$

7. [Online September 2020]

The value of the acceleration due to gravity is g_1 at a height $h = \frac{R}{2}$ (R = radius of the earth) from the surface of the earth. It is again equal to g_1 at a depth d below the surface of the earth. The ratio $\left(\frac{d}{R}\right)$ equals

- (A) $\frac{7}{9}$ (B) $\frac{4}{9}$
 (C) $\frac{1}{3}$ (D) $\frac{5}{9}$

8. [Online September 2020]

The acceleration due to gravity on the earth's surface at the poles is g and angular velocity of the earth about the axis passing through the pole is ω . An object is weighed at the equator and at a height h above the poles by using a spring balance. If the weights are found to be same, then h is: ($h < R$, where R is the radius of the earth)

- (A) $\frac{R^2\omega^2}{8g}$ (B) $\frac{R^2\omega^2}{4g}$
 (C) $\frac{R^2\omega^2}{g}$ (D) $\frac{R^2\omega^2}{2g}$

9. [Online September 2020]

A satellite is in an elliptical orbit around a planet P . It is observed that the velocity of the satellite when it is farthest from the planet is 6 times less than that when it is closest to the planet. The ratio of distances between the satellite and the planet at closest and farthest points is

- (A) 1:6 (B) 3:4
 (C) 1:3 (D) 1:2

10. [Online September 2020]

Two planets have masses M and $16M$ and their radii are a and $2a$, respectively. The separation between the centers of the planets is $10a$. A body of mass m is fired from the surface of the larger planet towards the smaller planet along the line joining their centers. For the body to be able to reach at the surface of smaller planet, the minimum firing speed needed is

- (A) $\sqrt{\frac{GM^2}{ma}}$ (B) $\frac{3}{2}\sqrt{\frac{5GM}{a}}$
 (C) $4\sqrt{\frac{GM}{a}}$ (D) $2\sqrt{\frac{GM}{a}}$

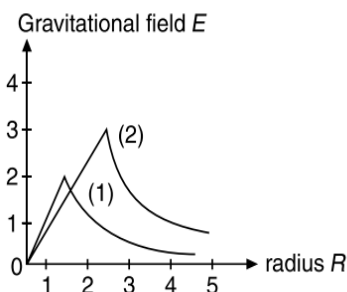
11. [Online January 2020]

A box weighs 196 N on a spring balance at the north pole. Its weight recorded on the same balance if it is shifted to the equator is close to (Take $g = 10 \text{ ms}^{-2}$ at the north pole and the radius of the earth = 6400 km)

- (A) 195.66 N (B) 194.66 N
 (C) 194.32 N (D) 195.32 N

12. [Online January 2020]

Consider two solid spheres of radii $R_1 = 1 \text{ m}$, $R_2 = 2 \text{ m}$ and masses M_1 and M_2 , respectively. The gravitational field due to sphere (1) and (2) are shown. The value of $\frac{M_1}{M_2}$ is



- (A) $\frac{1}{2}$ (B) $\frac{2}{3}$
 (C) $\frac{1}{3}$ (D) $\frac{1}{6}$

13. [Online January 2020]

A body A of mass m is moving in a circular orbit of radius R about a planet. Another body B of mass $\frac{m}{2}$ collides with A with a velocity which is half $\left(\frac{\bar{v}}{2}\right)$ the instantaneous velocity \bar{v} of A . The collision is completely inelastic. Then, the combined body

- (A) starts moving in an elliptical orbit around the planet.
 (B) continues to move in a circular orbit
 (C) Falls vertically downwards towards the planet
 (D) Escapes from the Planet's Gravitational field.

14. [Online January 2020]

Planet A has mass M and radius R . Planet B has half the mass and half the radius of Planet A . If the escape velocities from the Planets A and B are v_A and v_B , respectively, then $\frac{v_A}{v_B} = \frac{n}{4}$. The value of n is

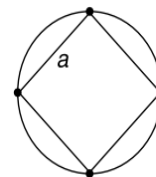
- (A) 4 (B) 1
 (C) 2 (D) 3

15. [Online January 2020]

An asteroid is moving directly towards the center of the earth. When at a distance of $10R$ (R is the radius of the earth) from the earth's center, it has a speed of 12 kms^{-1} . Neglecting the effect of earth's atmosphere, what will be the speed of the asteroid when it hits the surface of the earth (escape velocity from the earth is 11.2 kms^{-1})? Give your answer to the nearest integer in kms^{-1} .

16. [Online April 2019]

Four identical particles of mass M are located at the corners of a square of side a . What should be their speed if each of them revolves under the influence of others' gravitational field in a circular orbit circumscribing the square?



- (A) $1.41\sqrt{\frac{GM}{a}}$ (B) $1.16\sqrt{\frac{GM}{a}}$
 (C) $1.21\sqrt{\frac{GM}{a}}$ (D) $1.35\sqrt{\frac{GM}{a}}$

17. [Online April 2019]

A rocket has to be launched from earth in such a way that it never returns. If E is the minimum energy delivered by the rocket launcher, what should be the minimum energy that the launcher should have if the same rocket is to be launched from the surface of the moon? Assume that the density of the earth and the moon are equal and that the earth's volume is 64 times the volume of the moon.

- (A) $\frac{E}{64}$ (B) $\frac{E}{4}$
 (C) $\frac{E}{16}$ (D) $\frac{E}{32}$

18. [Online April 2019]

A solid sphere of mass M and radius a is surrounded by a uniform concentric spherical shell of thickness $2a$

and mass $2M$. The gravitational field at distance $3a$ from the centre will be

- (A) $\frac{GM}{9a^2}$ (B) $\frac{2GM}{9a^2}$
 (C) $\frac{GM}{3a^2}$ (D) $\frac{2GM}{3a^2}$

19. [Online April 2019]

A test particle is moving in a circular orbit in the gravitational field produced by a mass density $\rho(r) = \frac{K}{r^2}$. Identify the correct relation between the radius R of the particle's orbit and its period T

- (A) $\frac{T}{R}$ is a constant (B) TR is a constant
 (C) $\frac{T}{R^2}$ is a constant (D) $\frac{T^2}{R^3}$ is a constant

20. [Online April 2019]

The value of acceleration due to gravity at Earth's surface is 9.8 ms^{-2} . The altitude above its surface at which the acceleration due to gravity decreases to 4.9 ms^{-2} , is close to (Radius of earth = $6.4 \times 10^6 \text{ m}$)

- (A) $9.0 \times 10^6 \text{ m}$ (B) $6.4 \times 10^6 \text{ m}$
 (C) $1.6 \times 10^6 \text{ m}$ (D) $2.6 \times 10^6 \text{ m}$

21. [Online April 2019]

A spaceship orbits around a planet at a height of 20 km from its surface. Assuming that only gravitational field of the planet acts on the spaceship, what will be the number of complete revolutions made by the spaceship in 24 hours around the planet?

[Given: Mass of planet = $8 \times 10^{22} \text{ kg}$, Radius of planet = $2 \times 10^6 \text{ m}$, Gravitational constant $G = 6.67 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$]

- (A) 17 (B) 3
 (C) 11 (D) 9

22. [Online April 2019]

The ratio of the weights of a body on the Earth's surface to that on the surface of a planet is 9 : 4. The mass of the planet is $\frac{1}{9}$ th of that of the Earth. If R is the radius of the Earth, what is the radius of the planet? (Take the planets to have the same mass density)

- (A) $\frac{R}{4}$ (B) $\frac{R}{3}$
 (C) $\frac{R}{9}$ (D) $\frac{R}{2}$

23. [Online January 2019]

If the angular momentum of a planet of mass m , moving around the Sun in a circular orbit is L , about the center of the Sun, its areal velocity is

- (A) $\frac{L}{m}$ (B) $\frac{4L}{m}$
 (C) $\frac{L}{2m}$ (D) $\frac{2L}{m}$

24. [Online January 2019]

The energy required to take a satellite to a height h above Earth surface (radius of Earth = $6.4 \times 10^3 \text{ km}$) is E_1 and kinetic energy required for the satellite to be in a circular orbit at this height is E_2 . The value of h for which E_1 and E_2 are equal, is

- (A) $3.2 \times 10^3 \text{ km}$ (B) $1.6 \times 10^3 \text{ km}$
 (C) $1.28 \times 10^4 \text{ km}$ (D) $6.4 \times 10^3 \text{ km}$

25. [Online January 2019]

A satellite is moving with a constant speed v in circular orbit around the earth. An object of mass m is ejected from the satellite such that it just escapes from the gravitational pull of the earth. At the time of ejection, the kinetic energy of the object is

- (A) $2mv^2$ (B) mv^2
 (C) $\frac{1}{2}mv^2$ (D) $\frac{3}{2}mv^2$

26. [Online January 2019]

Two stars of masses $3 \times 10^{31} \text{ kg}$ each, and at distance $2 \times 10^{11} \text{ m}$ rotate in a plane about their common centre of mass O . A meteorite passes through O moving perpendicular to the star's rotation plane. In order to escape from the gravitational field of this double star, the minimum speed that meteorite should have at O is: (Take Gravitational constant $G = 6.67 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$)

- (A) $2.8 \times 10^5 \text{ ms}^{-1}$ (B) $1.4 \times 10^5 \text{ ms}^{-1}$
 (C) $2.4 \times 10^4 \text{ ms}^{-1}$ (D) $3.8 \times 10^4 \text{ ms}^{-1}$

27. [Online January 2019]

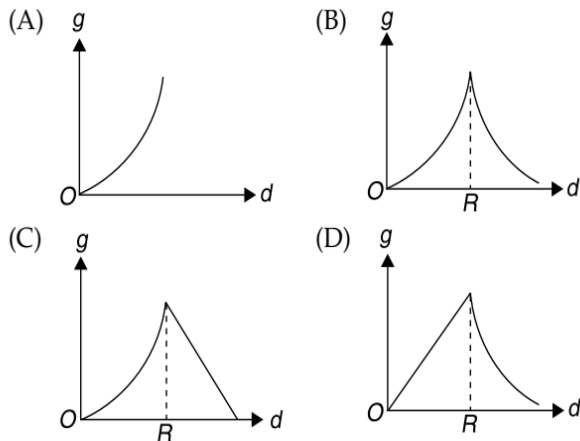
A satellite is revolving in a circular orbit at a height h from the earth surface, such that $h = R$ where R is the radius of the earth. Assuming that the effect of earth's atmosphere can be neglected the minimum increase in the speed required so that the satellite could escape from the gravitational field of earth is

- (A) $\sqrt{2gR}$ (B) $\sqrt{gR}(\sqrt{2}-1)$
 (C) \sqrt{gR} (D) $\sqrt{\frac{gR}{2}}$

- (A) 6×10^{-2} (B) 10^{-1}
 (C) 3×10^{-3} (D) 6×10^2

37. [2017]

The variation of acceleration due to gravity g with distance d from centre of the Earth is best represented by ($R =$ Earth's radius)



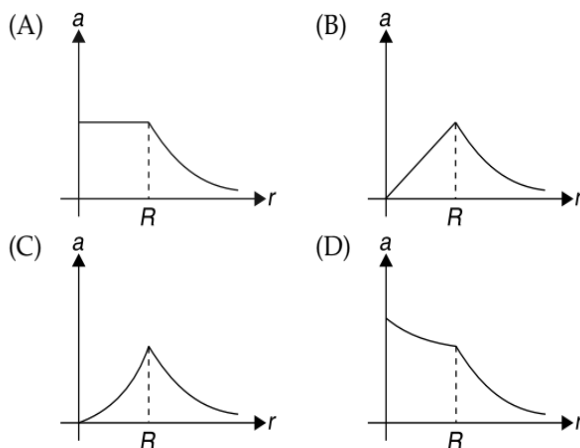
38. [Online 2017]

If the Earth has no rotational motion, the weight of a person on the equator is W . Determine the speed with which the earth would have to rotate about its axis so that the person at the equator will weigh $\frac{3}{4}W$. Radius of the Earth is 6400 km and $g = 10 \text{ ms}^{-2}$.

- (A) $0.63 \times 10^{-3} \text{ rads}^{-1}$ (B) $0.83 \times 10^{-3} \text{ rads}^{-1}$
 (C) $0.28 \times 10^{-3} \text{ rads}^{-1}$ (D) $1.1 \times 10^{-3} \text{ rads}^{-1}$

39. [Online 2017]

The mass density of a spherical body is given by $\rho(r) = \frac{k}{r}$ for $r \leq R$ and $\rho(r) = 0$ for $r > R$, where r is the distance from the centre. The correct graph that describes qualitatively the acceleration, a of a test particle as a function of r is



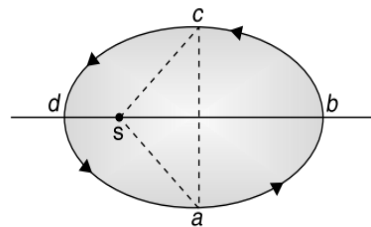
40. [2016]

A satellite is revolving in a circular orbit at a height h from the earth's surface (radius of earth R ; $h < R$). The minimum increase in its orbital velocity required, so that the satellite could escape from the earth's gravitational field, is close to (Neglect the effect of atmosphere)

- (A) $\sqrt{gR}(\sqrt{2} - 1)$ (B) $\sqrt{2gR}$
 (C) \sqrt{gR} (D) $\sqrt{\frac{gR}{2}}$

41. [Online 2016]

Figure shows elliptical path $abcd$ of a planet around the sun S such that the area of triangle csa is $\frac{1}{4}$ the area of the ellipse. (See figure) With bd as the major axis, and ca as the minor axis. If t_1 is the time taken for planet to go over path abc and t_2 for path taken over cda then



- (A) $t_1 = 4t_2$ (B) $t_1 = 2t_2$
 (C) $t_1 = 3t_2$ (D) $t_1 = t_2$

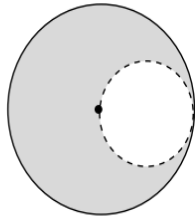
42. [Online 2016]

An astronaut of mass m is working on a satellite orbiting the earth at a distance h from the earth's surface. The radius of the earth is R , while its mass is M . The gravitational pull F_G on the astronaut is

- (A) Zero since astronaut feels weightless
 (B) $\frac{GMm}{(R+h)^2} < F_G < \frac{GMm}{R^2}$
 (C) $F_G = \frac{GMm}{(R+h)^2}$
 (D) $0 < F_G < \frac{GMm}{R^2}$

43. [2015]

From a solid sphere of mass M and radius R , a spherical portion of radius $\frac{R}{2}$ is removed, as shown in the figure. Taking gravitational potential $V = 0$ at $r = \infty$, the potential at the centre P of the cavity thus formed is ($G =$ gravitational constant)



- (A) $\frac{-GM}{2R}$ (B) $\frac{-GM}{R}$
 (C) $\frac{-2GM}{3R}$ (D) $\frac{-2GM}{R}$

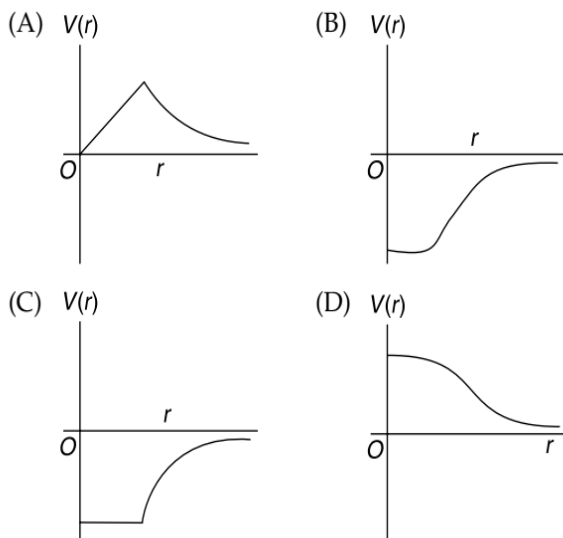
44. [Online 2015]

A very long (length L) cylindrical galaxy is made of uniformly distributed mass and has radius R ($R \ll L$). A star outside the galaxy is orbiting the galaxy in a plane perpendicular to the galaxy and passing through its centre. If the time period of star is T and its distance from the galaxy's axis is r , then

- (A) $T^2 \propto r^3$ (B) $T \propto r^2$
 (C) $T \propto r$ (D) $T \propto \sqrt{r}$

45. [Online 2015]

Which of the following most closely depicts the correct variation of the gravitational potential $V(r)$ due to a large planet of radius R and uniform mass density? (figures are not drawn to scale)


46. [2014]

Four particles, each of mass M and equidistant from each other, move along a circle of radius R under the action of their mutual gravitational attraction. The speed of each particle is

- (A) $\sqrt{\frac{GM}{R}}$ (B) $\sqrt{2\sqrt{2}\frac{GM}{R}}$
 (C) $\sqrt{\frac{GM}{R}(1+2\sqrt{2})}$ (D) $\frac{1}{2}\sqrt{\frac{GM}{R}(1+2\sqrt{2})}$

47. [2013]

What is the minimum energy required to launch a satellite of mass m from the surface of a planet of mass M and radius R in a circular orbit at an altitude of $2R$?

- (A) $\frac{5GmM}{6R}$ (B) $\frac{2GmM}{3R}$
 (C) $\frac{GmM}{2R}$ (D) $\frac{GmM}{3R}$

48. [2012]

The mass of a spaceship is 1000 kg. It is to be launched from the earth's surface out into free space. The value of g and R (radius of earth) are 10 ms^{-2} and 6400 km respectively. The required energy for this work will be

- (A) 6.4×10^8 Joules
 (B) 6.4×10^9 Joules
 (C) 6.4×10^{10} Joules
 (D) 6.4×10^{11} Joules

49. [2011]

Two bodies of masses m and $4m$ are placed at a distance r . The gravitational potential at a point on the line joining them where the gravitational field is zero is

- (A) zero (B) $-\frac{4Gm}{r}$
 (C) $-\frac{6Gm}{r}$ (D) $-\frac{9Gm}{r}$

50. [2009]

The height at which the acceleration due to gravity becomes $\frac{g}{9}$ (where g = the acceleration due to gravity on the surface of the earth) in terms of R , the radius of the earth is

- (A) $2R$ (B) $\frac{R}{\sqrt{2}}$
 (C) $\frac{R}{2}$ (D) $\sqrt{2}R$

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Single Correct Choice Type Problems

In this section each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct.

1. [JEE (Advanced) 2019]

Consider a spherical gaseous cloud of mass density $\rho(r)$ in free space where r is the radial distance from its centre. The gaseous cloud is made of particles of equal mass m moving in circular orbits about the common centre with the same kinetic energy K . The force acting on the particles is their mutual gravitational force. If $\rho(r)$ is constant in time, the particle number density $n(r) = \frac{\rho(r)}{m}$ is [G is universal gravitational constant]

- (A) $\frac{3K}{\pi r^2 m^2 G}$ (B) $\frac{K}{2\pi r^2 m^2 G}$
 (C) $\frac{K}{6\pi r^2 m^2 G}$ (D) $\frac{K}{\pi r^2 m^2 G}$

2. [JEE (Advanced) 2017]

A rocket is launched normal to the surface of the Earth, away from the Sun, along the line joining the Sun and the Earth. The sun is 3×10^5 times heavier than the Earth and is at a distance 2.5×10^4 times larger than the radius of Earth. The escape velocity from Earth's gravitational field is $v_e = 11.2 \text{ km s}^{-1}$. The minimum initial velocity (v_s) required for the rocket to be able to leave the Sun-Earth system is closest to (Ignore the rotation and revolution of the Earth and the presence of any other planet)

- (A) $v_s = 72 \text{ km s}^{-1}$ (B) $v_s = 22 \text{ km s}^{-1}$
 (C) $v_s = 42 \text{ km s}^{-1}$ (D) $v_s = 62 \text{ km s}^{-1}$

3. [JEE (Advanced) 2014]

A planet of radius $R = \frac{1}{10}$ (Radius of Earth) has the same mass density as earth. Scientists dig a well of depth $\frac{R}{5}$ on it and lower a wire of the same length and of linear mass density $10^{-3} \text{ kg m}^{-1}$ into it. If the wire is not touching anywhere, the force applied at the top of the wire by a person holding it in place is (take the radius of earth to be $6 \times 10^6 \text{ m}$ and the acceleration due to gravity of earth is 10 ms^{-2})

- (A) 96 N (B) 108 N
 (C) 120 N (D) 150 N

4. [IIT-JEE 2011]

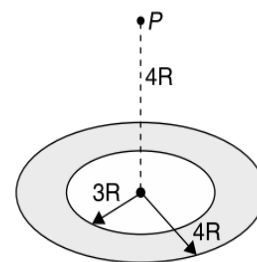
A satellite is moving with a constant speed v in a circular orbit about the earth. An object of mass m is ejected from the satellite such that it just escapes from

the gravitational pull of the earth. At the time of its ejection, the kinetic energy of the object is

- (A) $\frac{1}{2}mv^2$ (B) mv^2
 (C) $\frac{3}{2}mv^2$ (D) $2mv^2$

5. [IIT-JEE 2010]

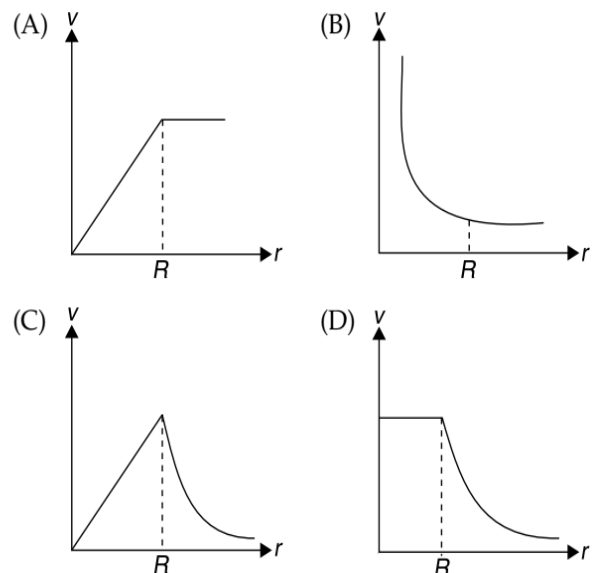
A thin uniform annular disc (shown in figure) of mass M has outer radius $4R$ and inner radius $3R$. The work required to take a unit mass from point P on its axis to infinity is



- (A) $\frac{2GM}{7R}(4\sqrt{2}-5)$ (B) $-\frac{2GM}{7R}(4\sqrt{2}-5)$
 (C) $\frac{GM}{4R}$ (D) $\frac{2GM}{5R}(\sqrt{2}-1)$

6. [IIT-JEE 2008]

A spherically symmetric gravitational system of particles has a mass density $\rho = \begin{cases} \rho_0 & \text{for } r \leq R \\ 0 & \text{for } r > R \end{cases}$, where ρ_0 is a constant. A test mass can undergo circular motion under the influence of the gravitational field of particles. Its speed v as a function of distance r from the centre of the system is represented by



7. [IIT-JEE 2006]

A double star system consists of two stars A and B which have time periods T_A and T_B . Radius R_A and R_B and mass M_A and M_B . Choose the correct option.

- (A) If $T_A > T_B$ then $R_A > R_B$
 (B) If $T_A > T_B$ then $M_A > M_B$
 (C) $\left(\frac{T_A}{T_B}\right)^2 = \left(\frac{R_A}{R_B}\right)^3$
 (D) $T_A = T_B$

8. [IIT-JEE 2002]

A geostationary satellite orbits around the earth in a circular orbit of radius 36000 km. Then, the time period of a spy satellite orbiting a few 100 km above the earth's surface ($R_e = 6400$ km) will approximately be

- (A) $\frac{1}{2}$ h
 (B) 1 h
 (C) 2 h
 (D) 4 h

9. [IIT-JEE 2001]

A simple pendulum has a time period T_1 when on the earth's surface and T_2 when taken to a height R above the earth's surface, where R is the radius of the earth. The value of $\frac{T_2}{T_1}$ is

- (A) 1
 (B) $\sqrt{2}$
 (C) 4
 (D) 2

10. [IIT-JEE 1998]

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

- (A) the acceleration of S is always directed towards the centre of the earth
 (B) the angular momentum of S about the centre 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

11. [IIT-JEE 1996]

If the distance between the earth and the sun were half its present value, the number of days in a year would have been

- (A) 64.5
 (B) 129
 (C) 182.5
 (D) 730

12. [IIT-JEE 1989]

Imagine a light planet revolving around a very massive star in a circular orbit of radius R with period T . If the gravitational force of attraction between the planet and the star is proportional to $R^{-5/2}$, the T^2 is proportional to

- (A) R^3
 (B) $R^{7/2}$
 (C) $R^{3/2}$
 (D) $R^{3.75}$

13. [IIT-JEE 1983]

If g is the acceleration due to gravity at the earth's surface, the gain in the potential energy of an object of mass m raised from the surface of the earth to a height equal to the radius R of the earth, is

- (A) $\frac{1}{2}mgR$
 (B) $2mgR$
 (C) mgR
 (D) $\frac{1}{4}mgR$

14. [IIT-JEE 1981]

If the radius of the earth were to shrink by one percent, its mass remaining the same, the acceleration due to gravity on the earth's surface would

- (A) decrease by 1%
 (B) remain unchanged
 (C) increase by 2%
 (D) decrease by 2%

Multiple Correct Choice Type Problems

In this section each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct.

1. [JEE (Advanced) 2015]

A spherical body of radius R consists of a fluid of constant density and is in equilibrium under its own gravity. If $P(r)$ is the pressure at r ($r < R$), then the correct options is/are

- (A) $P(r=0) = 0$
 (B) $\frac{P\left(r = \frac{3R}{4}\right)}{P\left(r = \frac{2R}{3}\right)} = \frac{63}{80}$
 (C) $\frac{P\left(r = \frac{3R}{5}\right)}{P\left(r = \frac{2R}{5}\right)} = \frac{16}{21}$
 (D) $\frac{P\left(r = \frac{R}{2}\right)}{P\left(r = \frac{R}{3}\right)} = \frac{20}{27}$

2. [JEE (Advanced) 2013]

Two bodies, each of mass M , are kept fixed with a separation $2L$. A particle of mass m is projected from the mid-point of the line joining their centres, perpendicular to the line. The gravitational constant is G . The correct statement(s) is (are)

- (A) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is

$$4\sqrt{\frac{GM}{L}}$$

- (B) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is

$$2\sqrt{\frac{GM}{L}}$$

- (C) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is

$$\sqrt{\frac{2GM}{L}}$$

- (D) The energy of the mass m remains constant

3. [IIT-JEE 2012]

Two spherical planets P and Q have the same uniform density ρ , masses M_P and M_Q and surface areas A and $4A$, respectively. A spherical planet R also has uniform density ρ and its mass is $(M_P + M_Q)$. The escape velocities from the planets P , Q and R are V_P , V_Q and V_R respectively. Then

- (A) $V_Q > V_R > V_P$ (B) $V_R > V_Q > V_P$
 (C) $\frac{V_R}{V_P} = 3$ (D) $\frac{V_R}{V_Q} = \frac{1}{2}$

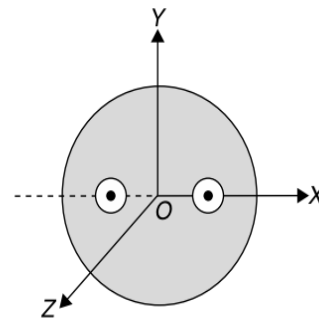
4. [IIT-JEE 1994]

The magnitudes of gravitational field at distances r_1 and r_2 from the centre of a uniform sphere of radius R and mass M are F_1 and F_2 , respectively. Then

- (A) $\frac{F_1}{F_2} = \frac{r_1}{r_2}$ if $r_1 < R$ and $r_2 < R$
 (B) $\frac{F_1}{F_2} = \frac{r_2^2}{r_1^2}$ if $r_1 > R$ and $r_2 > R$
 (C) $\frac{F_1}{F_2} = \frac{r_1}{r_2}$ if $r_1 > R$ and $r_2 > R$
 (D) $\frac{F_1}{F_2} = \frac{r_1^2}{r_2^2}$ if $r_1 < R$ and $r_2 < R$

5. [IIT-JEE 1993]

A solid sphere of uniform density and radius 4 unit is located with its centre at the origin of coordinates, O . Two spheres of equal radii of 1 unit, with their centres at $A(-2, 0, 0)$ and $B(2, 0, 0)$ respectively, are taken out of solid sphere, leaving behind spherical cavities as shown in figure.



- (A) The gravitational force due to this object at the origin is ZERO.
 (B) The gravitational force at the point $B(2, 0, 0)$ is ZERO.
 (C) The gravitational potential is the same at all points of the circle $y^2 + z^2 = 36$.
 (D) The gravitational potential is the same at all points on the circle $y^2 + z^2 = 4$.

Reasoning Based Questions

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

- Bubble (A)** If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.
Bubble (B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.
Bubble (C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.
Bubble (D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

1. [IIT-JEE 2008]

Statement-1: An astronaut in an orbiting space station above the earth experiences weightlessness.
Statement-2: An object moving around the earth under the influence of earth's gravitational force is in a state of free-fall.

Integer/Numerical Answer Type Questions

In this section, the answer to each question is a numerical value obtained after series of calculations based on the data provided in the question(s).

1. [JEE (Advanced) 2015]

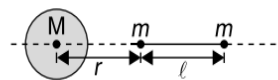
A bullet is fired vertically upwards with velocity v from the surface of a spherical planet. When it reaches its maximum height, its acceleration due to

the planet's gravity is $\frac{1}{4}$ th of its value at the surface of the planet. If the escape velocity from the planet is $v_{\text{esc}} = v\sqrt{N}$, then the value of N is (ignore energy loss due to atmosphere)

2. [JEE (Advanced) 2015]

A large spherical mass M is fixed at one position and two identical masses m are kept on a line passing through the centre of M (see figure). The point masses are connected by a rigid massless rod of length l and this assembly is free to move along the line connecting them. All three masses interact only through their mutual gravitational interaction. When the point mass

nearer to M is at a distance $r = 3l$ from M the tension in the rod is zero for $m = k\left(\frac{M}{288}\right)$. The value of k is



3. [IIT-JEE 2010]

Gravitational acceleration on the surface of a planet is $\frac{\sqrt{6}}{11}g$, where g is the gravitational acceleration on the surface of the earth. The average mass density of the planet is $\frac{2}{3}$ times that of the earth. If the escape speed on the surface of the earth is taken to be 11 km s^{-1} , find the escape speed on the surface of the planet in km s^{-1} .

ANSWER KEYS—TEST YOUR CONCEPTS AND PRACTICE EXERCISES
Test Your Concepts-I
(Based on Acceleration Due to Gravity, Gravitational Field and Applications)

- 2.4 kms⁻¹
- $-\frac{Gm_1m_2}{2r}$
- (a) $-\frac{GMm}{\sqrt{a^2+x^2}}$ (c) $-\frac{GMm \cdot x}{(x^2+a^2)^{3/2}}$ (e) 0
- $\frac{3GM^2}{d^2}$, along +x axis
- $\frac{a}{r^2}$
- 200 Nkg⁻¹, along +x direction
- $\frac{7}{3}$
- $\frac{2\pi GMm}{L^2}$
- $\frac{\pi RG\rho_0}{2}$
- $\frac{GM\lambda}{R}$
- 7.8×10^{-4} rads⁻¹
- $$\begin{cases} 0 & \text{for } r < R_1 \\ \frac{GM}{r^2} \left(\frac{r^3 - R_1^3}{R_2^3 - R_1^3} \right) & \text{for } R_1 < r < R_2 \\ \frac{GM}{r^2} & \text{for } r > R_2 \end{cases}$$
- 1600 km

Test Your Concepts-II
(Based on Gravitational Potential, Potential Energy and Applications)

- $-\frac{Gm^2}{a} \left(12 + \frac{12}{\sqrt{2}} + \frac{4}{\sqrt{3}} \right)$
- $-\frac{GMm_0}{L} \log_e \left(\frac{a+L}{a} \right)$
- $\frac{GMm}{R}$
- $-\frac{GMm}{r}$, remain the same
- $-\frac{3GMm}{2R}$

- $-\frac{G}{d} (\sqrt{m} + \sqrt{M})^2$
- $-\frac{3M}{R}$
- (a) $-\frac{GM^2}{2R}$ (b) $-\frac{3GM^2}{5R}$
- (a) $-2G\lambda \log_e \left(\frac{\ell + \sqrt{\ell^2 + a^2}}{a} \right)$
(b) $-G\lambda \log_e \left(\frac{a+L}{a-L} \right)$

Test Your Concepts-III
(Based on Relation Between Gravitational Field and Potential)

- 3 Jkg⁻¹
- $-(axy + byz) + C$
- (a) 1 Jkg⁻¹ (b) 1 Jkg⁻¹, conservative
- $-(6xy)\hat{i} - 3(x^2 + y^2z)\hat{j} - y^3\hat{k}$
- (a) $-2a(x\hat{i} - y\hat{j})$ (b) $-ayi\hat{i} - ax\hat{j}$
- $5\sqrt{2}$ Nkg⁻¹
- $10\sqrt{2}$ N
- $-(2ax\hat{i} + 2ay\hat{j} + 2bz\hat{k})$, $2\sqrt{a^2(x^2 + y^2) + b^2z^2}$
- $-2\hat{i} - 3\hat{j} + \hat{k}$

Test Your Concepts-IV
(Based on Conservation Laws, Escape Velocity and Applications)

- (a) $\left(\frac{n}{n+1} \right) mgR$ (b) $\sqrt{\frac{2ngR}{n+1}}$
- 11.2 kms⁻¹
- 2.1×10^{-5} ms⁻¹, 4.2×10^{-5} ms⁻¹
- $2\sqrt{\frac{GM}{L}}$
- $\frac{3}{2}\sqrt{\frac{5GM}{a}}$
- $\frac{r_0}{2-K} \left(1 + \sqrt{1 - K(2-K)\sin^2\phi} \right)$,
 $\frac{r_0}{2-K} \left(1 - \sqrt{1 - K(2-K)\sin^2\phi} \right)$

7. 0

 8. 42 kms^{-1}

9. $\sqrt{2G(m_1 + m_2) \left(\frac{2}{a} - \frac{1}{\ell} \right)}$

10. 9, 2

Test Your Concepts-V (Based on Satellites, Kepler's Laws and Applications)

1. 2, 2

 4. $(1 + \sin \alpha)r_0, (1 - \sin \alpha)r_0$

 5. $r = R$

6. (a) $2\pi \sqrt{\frac{d^3}{G(m_1 + m_2)}}$ (b) $\frac{m_2}{m_1}$
 (c) $\frac{m_2}{m_1}$ (d) $\mu \omega d^2$ (e) $\frac{1}{2} \mu \omega^2 d^2$

 7. $56\sqrt{2} \text{ hour}, 3829 \text{ kmhr}^{-1}$

 8. $r, \frac{5r}{3}$

9. (a) $\frac{GM^2}{4R^2}$ (b) $\sqrt{\frac{GM}{4R^3}}, 4\pi\sqrt{\frac{R^3}{GM}}$ (c) $\frac{GM^2}{4R}$

11. $\sqrt{2G(m_1 + m_2) \left[\frac{1}{R_1 + R_2} - \left\{ \frac{4\pi^2}{G(m_1 + m_2)T^2} \right\}^{1/3} \right]}$

Single Correct Choice Type Questions

1. C	2. C	3. D	4. C	5. D	6. D	7. C	8. C	9. C	10. B
11. C	12. D	13. B	14. B	15. C	16. C	17. A	18. C	19. C	20. A
21. C	22. C	23. B	24. C	25. B	26. D	27. B	28. B	29. D	30. C
31. B	32. D	33. D	34. B	35. C	36. D	37. D	38. D	39. A	40. A
41. B	42. C	43. B	44. B	45. C	46. A	47. B	48. B	49. A	50. A
51. C	52. B	53. A	54. D	55. A	56. C	57. C	58. C	59. C	60. C
61. C	62. C	63. C	64. D	65. D	66. A	67. D	68. A	69. B	70. D
71. A	72. B	73. B	74. C	75. B	76. B	77. D	78. B	79. C	80. A
81. D	82. D	83. D	84. C	85. C	86. C	87. D	88. C	89. B	90. A
91. D	92. A	93. C	94. D	95. A	96. D	97. A	98. B	99. C	100. D
101. B	102. D	103. C	104. B	105. A	106. D	107. B	108. C	109. C	110. C
111. C	112. C	113. C	114. C	115. C	116. C	117. D	118. A	119. C	120. A
121. C	122. C	123. C	124. C						

Multiple Correct Choice Type Questions

1. B, C	2. A, D	3. A, B, C	4. A, C, D	5. A, B, C, D
6. A, C	7. A, B, C, D	8. B, C	9. C, D	10. A, B, C
11. A, B, C	12. B, C, D	13. B, D	14. A, C	15. A, D
16. A, D	17. B, D	18. A, B, C, D	19. A, B, C	20. A, B, C
21. A, B, C	22. B, C	23. A, C	24. A, D	25. A, B, D
26. A, D	27. A, D	28. A, B, D	29. C, D	30. A, D
31. A, B, C	32. A, C	33. A, D	34. B, C	35. A, B, D
36. C, D	37. A, B, C, D	38. A, B, C		

Reasoning Based Questions

1. A	2. A	3. A	4. D	5. D	6. B	7. C	8. A	9. A	10. C
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Linked Comprehension Type Questions

1. D	2. A	3. C	4. D	5. A	6. B	7. A	8. C	9. C	10. A
11. A, B, C	12. B	13. A	14. D	15. B	16. D	17. D	18. A	19. B	20. C
21. C	22. D	23. D	24. A	25. B	26. C	27. C	28. A	29. A	30. C
31. D	32. C	33. B	34. A	35. D	36. C	37. B			

Matrix Match/Column Match Type Questions

1. $A \rightarrow (p, q, r)$	$B \rightarrow (r)$	$C \rightarrow (t)$	$D \rightarrow (p, q, r, s)$
2. $A \rightarrow (q)$	$B \rightarrow (p)$	$C \rightarrow (p)$	$D \rightarrow (q)$
3. $A \rightarrow (q)$	$B \rightarrow (r)$	$C \rightarrow (q)$	$D \rightarrow (p)$ $E \rightarrow (s)$
4. $A \rightarrow (p, q, r, s)$	$B \rightarrow (p, q, r, s)$	$C \rightarrow (q, r, s)$	$D \rightarrow (p, r)$
5. $A \rightarrow (p)$	$B \rightarrow (q)$	$C \rightarrow (q)$	$D \rightarrow (q)$
6. $A \rightarrow (r, t)$	$B \rightarrow (s)$	$C \rightarrow (p)$	$D \rightarrow (q)$
7. $A \rightarrow (p)$	$B \rightarrow (q)$	$C \rightarrow (s)$	$D \rightarrow (t)$
8. $A \rightarrow (q)$	$B \rightarrow (s)$	$C \rightarrow (p)$	$D \rightarrow (r)$
9. $A \rightarrow (r, q)$	$B \rightarrow (s)$	$C \rightarrow (p)$	$D \rightarrow (r)$
10. $A \rightarrow (s)$	$B \rightarrow (r)$	$C \rightarrow (p)$	$D \rightarrow (p)$
11. $A \rightarrow (r)$	$B \rightarrow (q)$	$C \rightarrow (p)$	$D \rightarrow (r)$

Integer/Numerical Answer Type Questions

1. 1.51	2. 0	3. 1.25	4. 10	5. 5656
6. (a) 30 (b) 18	7. $\alpha = 2$ and $\beta = 13$	8. 2	9. 6	10. 2
11. 1	12. 5	13. 7	14. 3	15. 2
16. 6	17. 7155, 7071, 7702	18. 7	19. 1.5	20. 7
21. 2				

ARCHIVE: JEE MAIN

1. C	2. A	3. B	4. B	5. A	6. C	7. D	8. D	9. A	10. B
11. D	12. D	13. A	14. A	15. 16	16. B	17. C	18. C	19. A	20. D
21. C	22. D	23. C	24. A	25. B	26. A	27. B	28. C	29. C	30. A
31. C	32. C	33. D	34. A	35. C	36. A	37. D	38. A	39. A	40. A
41. C	42. C	43. B	44. C	45. B	46. D	47. A	48. C	49. D	50. A

ARCHIVE: JEE ADVANCED

Single Correct Choice Type Problems

1. B	2. C	3. B	4. B	5. A	6. C	7. D	8. C	9. D	10. A
11. B	12. B	13. A	14. C						



Multiple Correct Choice Type Problems

1. B, C

2. B, D

3. B, D

4. A, B

5. A, C, D

Reasoning Based Questions

1. A

Matrix Match/Column Match Type Questions

1. 2

2. 7

3. 3