Exercise-1

✍ **Marked Questions can be used as Revision Questions.**

OBJECTIVE QUESTIONS

Section (A) : Universal law of Gravitation

A-1. A mass M splits into two parts m and (M – m), which are then separated by a certain distance. What ratio (m/M) maximies the gravitational force between the parts ?
(1) $\frac{2}{3}$ (2) $\frac{3}{4}$ (3) $\frac{1}{2}$ (4) $\frac{1}{3}$

A-2. What would be the angular speed of earth, so that bodies lying on equator may appear weightless? ($g = 10 m/s^2$ and radius of earth = 6400 km)
(1) 1.25×10^{-3} rad/sec (2) 1.25×10^{-2} rad/sec
(3) 1.25×10^{-4} rad/sec (4) 1.25×10^{-1} rad/sec

A-3.✍ The speed with which the earth have to rotate on its axis so that a person on the equator would weight (3/5)th as much as present will be (Take the equatorial radius as 6400 km.)
(1) 3.28×10^{-4} rad/sec (2) 7.826×10^{-4} rad/sec
(3) 3.28×10^{-3} rad/sec (4) 7.28×10^{-3} rad/sec

Section (B) : Gravitational field and Potential

B-1. Two bodies of mass 100 kg and 10^4 kg are lying one meter apart. At what distance from 100 kg body will the intensity of gravitational field be zero
(1) $\frac{1}{9}$m (2) $\frac{1}{10}$m (3) $\frac{1}{11}$m (4) $\frac{10}{11}$m

B-2. Two bodies of mass 10^2 kg and 10^3 kg are lying 1m apart. The gravitational potential at the mid-point of the line joining them is
(1) 0 (2) –1.47 Joule/kg (3) 1.47 Joule/kg (4) -147×10^{-9} joule/kg

B-3✍ A spherical shell has mass M and radius R. A point mass m/2 kept inside the shell at a distance R/2 from centre. Then force of attraction on the mass is:
(1) $\frac{2\,G\,m^2}{R^2}$ (2) $\frac{G\,m^2}{R^2}$ (3) $\frac{G\,m^2}{2\,R}$ (4) zero

B-4 An object is placed at a distance of R/2 from the centre of earth. Knowing mass is distributed uniformly, acceleration of that object due to gravity at that point is: (g = acceleration due to gravity on the surface of earth and R is the radius of earth)
(1) g (2) 2 g (3) g/2 (4) none of these

Section (C) : Gravitational Potential Energy and Self Energy

C-1. On a planet (whose size is the same as that of earth and mass 4 times to the earth) the energy needed to lift a 2kg mass vertically upwards through 2m distance on the planet is ($g = 10 m/sec^2$ on surface of earth)
(1) 16 J (2) 32 J (3) 160 J (4) 320 J

C-2. If g is the acceleration due to gravity on the earth's surface, the gain in P.E. of an object of mass m raised from the surface of the earth to a height of the radius R of the earth is
(1) mgR (2) 2mgR (3) $\frac{1}{2}$ mgR (4) $\frac{1}{4}$ mgR

C-3. A missile is launched with a velocity less than the escape velocity. The sum of kinetic energy and potential energy will be
(1) positive (2) negative

(3) negative or positive, uncertain (4) zero

C-4. A planet is moving in an elliptic orbit. If T, V, E, L stand respectivley for its kinetic energy, gravitational potential energy, total energy and magnitude of angular momentum about the centre of force, which of the following statements is correct
(1) T is conserved
(2) V is always positive
(3) E is always negative
(4) L is conserved but the direction of vector $\vec{L}$ changes continuously

C-5. The gravitational field in a region is given by, $\vec{E} = 5\text{ N/kg }\hat{i} + 12\text{ N/kg }\hat{j}$. If the origin is taken as zero potential energy, then the potential energy at (0, 5) is: (for 1 kg mass)
(1) - 60 J (2) 60 J (3) - 30 J (4) none of these

C-6. A satellite is in a circular orbit around the earth has kinetic energy E_k. Minimum amount of energy that is added so that it escapes the earth's gravitational field is:
(1) E_k (2) $E_k/2$ (3) $E_k/4$ (4) $2E_k$

Section (D) : Kepler's law for Satellites, Orbital speed and Escape speed

D-1. Two satellites S_1 and S_2 revolve round a planet in the same direction in circular orbits. Their period of revolution are 1 hour and 8 hour respectively. The radius of S_1 is 10^4 km. The velocity of S_2 with respect to S_1 will be
(1) $\pi \times 10^4$ km/hr (2) $\pi/3 \times 10^4$ km/hr (3) $2\pi \times 10^4$ km/hr (4) $\pi/2 \times 10^4$ km/hr

D-2. In the above example the angular speed of S_2 as actually observed by an astronaut in S_1 is
(1) $\pi/3$ rad/hr (2) $\pi/3$ rad/sec (3) $\pi/6$ rad/hr (4) $2\pi/7$ rad/hr

D-3. The mass and radius of earth and moon are M_1, R_1 and M_2, R_2 respectively. Their centres are d distance apart. With what velocity should a particle of mass m be projected from the mid point of their centres so that it may escape out to infinity.
(1) $\sqrt{\frac{G(M_1+M_2)}{d}}$ (2) $\sqrt{\frac{2G(M_1+M_2)}{d}}$ (3) $\sqrt{\frac{4G(M_1+M_2)}{d}}$ (4) $\sqrt{\frac{GM_1M_2}{d}}$

D-4. A satellite is moving round the earth. In order to make it move to infinity, its velocity must be increased by
(1) 20% (2) it is impossible to do so
(3) 82.8% (4) 41.4%

D-5. A space shuttle is launched in a circular orbit near the earth's surface. The additional velocity be given to the space-shuttle to get free from the influence of gravitational force, will be
(1) 1.52 km/s (2) 2.75 km/s (3) 3.28 km/s (4) 5.18 km/s

D-6. If the radius of earth is to decrease by 4% and its density remains same, then its escape velocity will
(1) remain same (2) increase by 4% (3) decrease by 4% (4) increase by 2%

D-7. A body of mass m is situated at a distance $4R_e$ above the earth's surface, where R_e is the radius of earth. How much minimum energy be given to the body so that it may escape
(1) mgR_e (2) $2mgR_e$ (3) $\frac{mgR_e}{5}$ (4) $\frac{mgR_e}{16}$

D-8. The potential energy of a body of mass 3kg on the surface of a planet is 54 joule. The escape velocity will be
(1) 18m/s (2) 162 m/s (3) 36 m/s (4) 6 m/s

D-9. If the kinetic energy of a satellite orbiting around the ear:th is doubled then
(1) the satellite will escape into the space. (2) the satellite will fall down on the earth
(3) radius of its orbit will be doubled (4) radius of its orbit will become half

D-10. The escape velocity from the earth does not depend upon
(1) mass of earth (2) mass of the body (3) radius of earth (4) acceleration due to gravity

D-11. The relation between the escape velocity from the earth and the velocity of a satellite orbiting near the earth's surface is
(1) $v_e = v$ (2) $v_e = V\sqrt{2}$ (3) $v_e = 2v$ (4) $v_e = v/\sqrt{2}$

D-12. There is no atmosphere on moon because
(1) it is near the earth
(2) it is orbiting around the earth
(3) there was no gas at all
(4) the escape velocity of gas molecules is less than their root-mean square velocity

D-13. The escape velocity is
(1) 2gR (2) gR (3) $\sqrt{gR}$ (4) $\sqrt{2gR}$

D-14. An earth satellite is moved from one stable circular orbit to another higher stable circular orbit. Which one of the following quantities increases for the satellite as a result of this change
(1) gravitational force (2) gravitational potential energy
(3) centripetal acceleration (4) Linear orbital speed

D-15. The relay satellite transmits the television programme continuously from one part of the world to another because its
(1) period is greater than the period of rotation of the earth
(2) period is less than the period of rotation of the earth about its axis
(3) period has no relation with the period of the earth about its axis
(4) period is equal to the period of rotation of the earth about its axis

D-16. A satellite appears to be at rest when seen from the equator. Its height from the earth's surface is nearly
(1) 35800km (2) 358000 km
(3) 6400km (4) such a satellite cannot exist

D-17.✍ A body is dropped by a satellite in its geo-stationary orbit
(1) it will burn on entering into the atmosphere
(2) it will remain in the same place with respect to the earth
(3) it will reach the earth in 24 hours
(4) it will perform uncertain motion

D-18. A satellite of earth can move only in those orbits whose plane coincides with
(1) the plane of great circle of earth (2) the plane passing through the poles of earth
(3) the plane of a circle at any latitude of earth (4) none of these

D-19. If the universal constant of gravitation were decreasing uniformly with time, then a satellite in orbit would still maintain its
(1) radius (2) tangential speed
(3) angular momentum (4) period of revolution

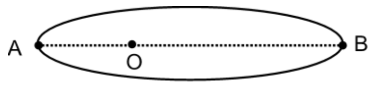
D-20. A satellite launching station should be
(1) near the equatorial region (2) near the polar region
(3) on the polar axis (4) all locations are equally good

D-21. The minimum number of satelites needed to be placed at the surface of earth for world-wide communication between any two locations is -
(1) 6 (2) 4 (3) 3 (4) 5

Section (E) : The Earth and other planets Gravity

E-1. The moon revolves round the earth 13 times in one year. If the ratio of sun-earth distance to earth-moon distance is 392, then the ratio of masses of sun and earth will be
(1) 365 (2) 356 (3) 3.56×10^5 (4) 1

E-2.✍ The earth is revolving round the sun in an elliptical orbit. If $\frac{OA}{OB} = x$, the ratio of speeds of earth at B and A will be



(1) x (2) $\sqrt{x}$
(3) x^2 (4) $x\sqrt{x}$

Exercise-2

✍ **Marked Questions can be used as Revision Questions.**

PART - I : OBJECTIVE QUESTIONS

1. Let gravitation field in a space be given as E = – (k/r). If the reference point is at d_i where potential is V_i then relation for potential is :
(1) $V = k \log \frac{1}{V_i} + 0$ (2) $V = k \log \frac{r}{d_i} + V_i$ (3) $V = \log \frac{r}{d_i} + kV_i$ (4) $V = \log \frac{r}{d_i} + \frac{V_i}{k}$

2. A very very large number of particles of same mass m are kept at horizontal distances of 1m, 2m, 4m, 8m and so on from (0,0) point. The total gravitational potential at this point is :
(1) – 8G m (2) – 3G m (3) – 4G m (4) – 2G m

3. Which of the following quantity is conserved for a satellite revolving around the earth in particular orbit?
(1) Angular velocity (2) Force (3) angular momentum (4) Velocity

4. Acceleration due to gravity on a planet is 10 times the value on the earth. Escape velocity for the planet and the earth are V_p and V_e respectively Assuming that the radii of the planet and the earth are the same, then
(1) $V_P = 10\ V_e$ (2) $V_P = \sqrt{10}\ V_e$ (3) $V_P = \frac{V_e}{\sqrt{10}}$ (4) $V_P = \frac{V_e}{10}$

5. The escape velocity from a planet is v_0. The escape velocity from a planet having twice the radius but same density will be
(1) $0.5\ v_0$ (2) v_0 (3) $2v_0$ (4) $4v_0$

6.✍ A body starts from rest at a point, distance R_0 from the centre of the earth of mass M, radius R. The velocity acquired by the body when it reaches the surface of the earth will be
(1) $GM\left(\frac{1}{R} - \frac{1}{R_0}\right)$ (2) $2\ GM\left(\frac{1}{R} - \frac{1}{R_0}\right)$ (3) $\sqrt{2GM\left(\frac{1}{R} - \frac{1}{R_0}\right)}$ (4) $2GM\sqrt{\left(\frac{1}{R} - \frac{1}{R_0}\right)}$

7.✍ Three equal masses each of mass 'm' are placed at the three-corners of an equilateral triangle of side 'a'.

(a) If a fourth particle of equal mass is placed at the centre of triangle, then net force acting on it, is equal to :

(1) $\frac{Gm^2}{a^2}$ (2) $\frac{4Gm^2}{3a^2}$ (3) $\frac{3Gm^2}{a^2}$ (4) zero

(b) In above problem, if fourth particle is at the mid-point of a side, then net force acting on it, is equal to:

(1) $\frac{Gm^2}{a^2}$ (2) $\frac{4Gm^2}{3a^2}$ (3) $\frac{3Gm^2}{a^2}$ (4) zero

(c) If above given three particles system of equilateral triangle side a is to be changed to side of 2a, then work done on the system is equal to :

(1) $\frac{3Gm^2}{a}$ (2) $\frac{3Gm^2}{2a}$ (3) $\frac{4Gm^2}{3a}$ (4) $\frac{Gm^2}{a}$

(d) In the above given three particle system, if two particles are kept fixed and third particle is released. Then speed of the particle when it reaches to the mid-point of the side connecting other two masses:

(1) $\sqrt{\frac{2Gm}{a}}$ (2) $2\sqrt{\frac{Gm}{a}}$ (3) $\sqrt{\frac{Gm}{a}}$ (4) $\sqrt{\frac{Gm}{2a}}$

8. Periodic-time of satellite revolving around the earth is - (ρ is density of earth)

(1) Proportional to $\frac{1}{\rho}$ (2) Proportional to $\frac{1}{\sqrt{\rho}}$ (3) Proportional ρ (4) does not depend on ρ.

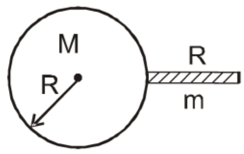
9. In case of an orbiting satellite if the radius of orbit is decreased :

(1) its Kinetic Energy decreases (2) its Potential Energy increase
(3) its Mechanical Energy decreases (4) its speed decreases

10. In case of earth :

(1) field is zero, both at centre and infinity
(2) potential is zero, both at centre and infinity
(3) potential is same, both at centre and infinity but not zero
(4) potential is maximum at the centre

11. A uniform thin rod of mass m 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



(1) $\frac{GMm}{2R^2}$ (2) $\frac{GMm}{4R^2}$

(3) $\frac{4GMm}{9R^2}$ (4) $\frac{GMm}{8R^2}$

12. Altitude at which acceleration due to gravity decreases by 0.1% approximately : (Radius of earth = 6400 km)

(1) 3.2 km (2) 6.4 km (3) 2.4 km (4) 1.6 km

13. An object is projected vertically up from the earth's surface with velocity $\sqrt{Rg}$ where R is the radius of the earth and 'g' is the acceleration due to earth on the surface of earth. The maximum height reached by the object.

(1) R (2) 2R (3) 3R (4) 4R

14. A body of mass m is lifted up from the surface of the earth to a height three times the radius of the earth. The change in potential energy of the body is (where g is acceleration due to gravity at the surface of earth.)

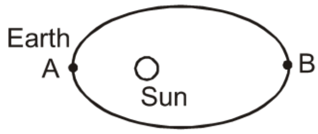
(1) 3mgR (2) 3/4 mgR (3) 1/3 mgR (4) 2/3 mgR

15. Time period of a simple pendulum on the equator is T_1 and at the pole is T_2. Then:
(1) $T_2 < T_1$ (2) $T_1 < T_2$ (3) $T_1 = T_2$ (4) none of these

16. A satellite is seen after every 6 hours over the equator. It is known that it rotates opposite to that of earth's direction. Then the angular velocity (in radians per hour) of the satellite about the centre of earth will be:

(1) $\pi/2$ (2) $\pi/3$ (3) $\pi/4$ (4) $\pi/8$

17. The earth is moving around the sun in an elliptical orbit. Point A is the closest and point B is the farthest point in the orbit , as shown. In comparison to the situation when the earth passes through point B **:**



(1) total energy of the earth-sun system is greater when the earth passes through point A.
(2) gravitational potential energy of the earth-sun system is greater when the earth passes through point A.
(3) kinetic energy of the earth due to the motion around the sun is greater when it passes through the point A.
(4) magnitude of angular momentum of the earth about the sun is greater when the earth passes through point A.

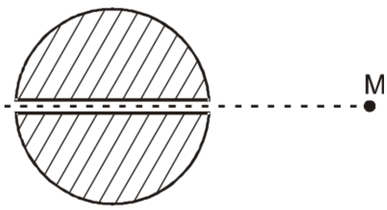
18. A satellite of mass m initially at rest on earth surface is launched into a circular orbit of double the radius of earth. The radius of earth is R_e. The minimum energy required to do so is :
(1) MgR_e (2) $\frac{gR_e}{4}$ (3) $-\frac{3mgR_e}{4}$ (4) $\frac{3}{4}mgR_e$.

19. Assuming that the law of gravitation is of the form $F = \frac{GMm}{r^3}$ and attractive. A body of mass m revolves in a circular path of radius r around a fixed body of mass M. Find on what power of r will the square of time period depend.
(1) 1 (2) 2 (3) 3 (4) 4

PART - II : MISCELLANEOUS QUESTIONS

Section (A) : Assertion/Reasoning

A-1. **STATEMENT-1 :** In free space a uniform spherical planet of mass M has a smooth narrow tunnel along the its diameter. This planet and another superdense small particle of mass M start approaching towards each other from rest under action of their gravitational forces . When the particle passes through the centre of the planet, sum of kinetic energies of both the bodies is maximum.



STATEMENT-2 : When the resultant of all forces acting on a particle or a particle like object (initially at rest) is constant in direction, the kinetic energy of the particle keeps on increasing.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

A-2. **STATEMENT -1**
An astronaut in an orbiting space station above the Earth experiences weightlessness.
and
STATEMENT -2
An object moving around the Earth under the influence of Earth's gravitational force is in a state of 'free-fall.
(1) STATEMENT -1 is True, STATEMENT -2 is True; STATEMENT -2 is a correct explanation

for STATEMENT -1
(2) STATEMENT -1 is True, STATEMENT -2 is True; STATEMENT -2 is NOT a correct explanation for STATEMENT -1
(3) STATEMENT -1 is True, STATEMENT -2 is False
(4) STATEMENT -1 is False, STATEMENT -2 is True.

Section (B) : Match The Column

B-1 Consider an isolated system of earth and a satellite such that the satellite revolves about stationary earth in a circular orbit. Neglect rotation of earth about its axis and assume both earth and satellite to be solid spherical bodies with uniform mass distribution. For the given system, match the statements in column-I with the statements in column-II.

Column-I	Column-II
(1) Time period of revolution of satellite around the earth is	(p) Independent of mass of satellite
(2) Orbital speed of satellite is	(q) Independent of radius of orbit
(3) Total mechanical energy of system of earth and satellite is	(r) Dependent on mass of earth
(4) Magnitude of gravitation field at centre of satellite is	(s) Independent of mass of earth

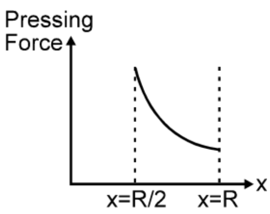
Section (C) : One Or More Than One Options Correct

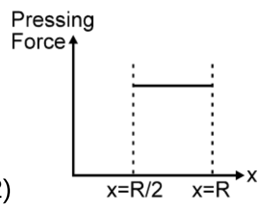
C-1. For a satellite to appear stationary w.r.t. an observer on earth
(1) It must be rotating about the earth's axis.
(2) It must be rotating in the equatorial plane.
(3) Its angular velocity must be from west to east.
(4) Its time period must be 24 hours.

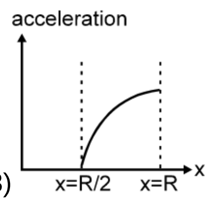
C-2. Inside an isolated uniform spherical shell :
(1) The gravitation potential is not zero
(2) The gravitational field is not zero
(3) The gravitational potential is same everywhere
(4) The gravitational field is same everywhere.

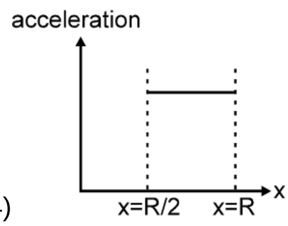
C-3. Which of the following statements are correct about a planet rotating around the sun in an elliptic orbit:
(1) its mechanical energy is constant
(2) its angular momentum about the sun is constant
(3) its areal velocity about the sun is constant
(4) its time period is proportional to r^3

C-4.✍ A tunnel is dug along a chord of the earth at a perpendicular distance 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 pressing force by the particle on the wall and the acceleration of the particle varies with x (distance of the particle from the centre) according to :

(1)


(2)


(3)


(4)


C-5. A planet revolving around sun in an elliptical orbit has a constant
(1) kinetic energy
(2) angular momentum about the sun
(3) potential energy
(4) Total energy

Exercise-3

✍ Marked Questions can be used as Revision Questions.
*** Marked Questions may have more than one correct option.**

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. A satellite of the earth is revolving in a circular orbit with a uniform speed v. If the gravitational force suddenly disappears, the statellite will **[AIEEE-2002, 4/300]**
(1) Continue to move with velocity v along the original orbit
(2) Move with a velocity v, tangentially to the original orbit
(3) Fall down with increasing velocity
(4) Ultimately come to rest somewhere on the original orbit

2. The time period of a satellite of earth is 5 hours. If the separation between the earth and the satellite is increased to 4 times the previous value, the new time period becomes **[AIEEE-2003, 4/300]**
(1) 10 hour (2) 80 hour (3) 40 hour (4) 20 hour

3. The escape velocity for a body projected vertically upwards from the surface of earth is 11 km/s. If the body is projected at an angle of 45º with the vertical, the escape velocity will be : **[AIEEE-2003,4/300]**
(1) $11\sqrt{2}$ km/s (2) 22 km/s (3) 11 km/s (4) $11/\sqrt{2}$ m/s

4. A satellite of mass m revolves around earth of radius R at a height x from its surface. If g is the acceleration due to gravity on the surface of the earth, the orbital speed of the satellite is : **[AIEEE-2004, 4/300]**
(1) gx (2) $\frac{gR}{R-x}$ (3) $\frac{gR^2}{R+x}$ (4) $\left(\frac{gR^2}{R+x}\right)^{1/2}$

5. The time period of an earth satellite in circular orbit is independent of : **[AIEEE-2004, 4/300]**
(1) the mass of the satellite
(2) radius of its orbit
(3) both the mass and radius of the orbit
(4) neither the mass of the satellite nor the radius of its orbit

6. If g is the acceleration due to gravity on 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 : **[AIEEE-2004, 4/300]**
(1) 2mgR (2) $\frac{1}{2}mgR$ (3) $\frac{1}{4}mgR$ (4) mgR

7. The change in the value of 'g' at a height 'h' above the surface of the earth is the same as at a depth 'd' below the surface of earth. When both 'd' and 'h' are much smaller than the radius of earth, then, which one of the following is correct ? **[AIEEE-2005, 4/300]**
(1) $d = \frac{h}{2}$ (2) $d = \frac{3h}{2}$ (3) d = 2h (4) d = h

8. A particle of mass 10 kg is kept on the surface of a uniform sphere of mass 100 kg and radius 10 cm. Find the work to be done against the gravitational force between them, to take the particle far away from the sphere (you may take $G = 6.67 \times 10^{-11}$ Nm^2/kg^2) **[AIEEE-2005, 4/300]**
(1) 13.34×10^{-10} J (2) 3.33×10^{-10} J (3) 6.67×10^{-9} J (4) 6.67×10^{-7} J

9. If g_E and g_m are the accelerations due to gravity on the surfaces of the earth and the moon respectively and if Millikan's oil drop expriment could be performed on the two surfaces, one will find the ratio $\frac{\text{Electronic charge on the moon}}{\text{electronic charge on the earth}}$ to be **[AIEEE-2007, 3/120]**
(1) 1 (2) 0 (3) g_E/g_M (4) g_M/g_E

10. A planet in a distant solar system is 10 times more massive than the earth and its radius is 10 times smaller. Given that the escape velocity from the earth is 11 km s^{-1}, the escape velocity from the surface of the planet would be **[AIEEE-2008, 3/105]**
(1) 11 km s^{-1} (2) 110 km s^{-1} (3) 0.11 km s^{-1} (4) 1.1 km s^{-1}

11. 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 **[AIEEE-2009, 4/144]**

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

12. Two bodies of masses m and 4 m are placed at a distance r. The gravitational potential at a point on the line joining them where the gravitational field is zero is : **[AIEEE - 2011, 4/120, –1]**

(1) zero (2) $-\frac{4Gm}{r}$ (3) $-\frac{6Gm}{r}$ (4) $-\frac{9Gm}{r}$

13. Two particles of equal mass 'm' go around a circle of radius R under the action of their mutual gravitational attraction. The speed of each partial with respect to their centre of mass is :
[AIEEE 2011, 11 May; 4/120, –1]

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

14. 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 m/s^2 and 6400 km respectively. The required energy for this work will be : **[AIEEE 2012 ; 4/120, –1]**

(1) 6.4×10^{11} Joules (2) 6.4×10^{8} Joules
(3) 6.4×10^{9} Joules (4) 6.4×10^{10} Joules

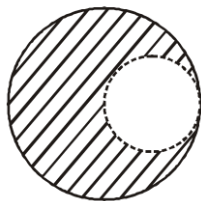
15. What is the minimum energy required to launch a satellite of mass m from the surface of a planet of mass M and radius R in a circular orbit at an altitude of 2R? **[JEE(Main) 2013; 4/120, –1]**

(1) $\frac{5GmM}{6R}$ (2) $\frac{2GmM}{3R}$ (3) $\frac{GmM}{2R}$ (4) $\frac{GmM}{3R}$

16. 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 attration. the speed of each particle is **[JEE(Main)2014; 4/120,–1]**

(1) $\sqrt{\frac{GM}{R}}$ (2) $\sqrt{2\sqrt{2}\frac{GM}{R}}$ (3) $\sqrt{\frac{GM}{R}\left(1+2\sqrt{2}\right)}$ (4) $\frac{1}{2}\sqrt{\frac{GM}{R}\left(1+2\sqrt{2}\right)}$

17. From a solid sphere of mass M and radius R, a spherical portion of radius R/2 is removed , as shown in the figure. Taking gravitational potential V = 0 at r = ∞, the potential at the centre of the cavity thus formed is (G = gravitational constant) **[JEE(Main)-2015; 4/120, –1]**

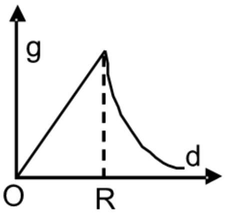


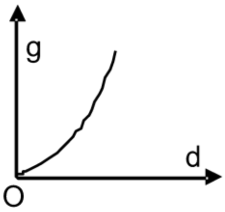
(1) $\frac{-GM}{2R}$ (2) $\frac{-GM}{R}$
(3) $\frac{-2GM}{3R}$ (4) $\frac{-2GM}{R}$

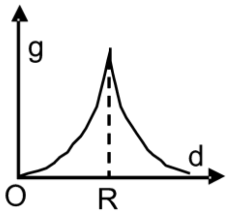
18. A satellite is revolving in a circular orbit at a height 'h' from the earth's surface (radius or earth R;h<<R). The minimum increase in its orbital velocity required ,so that the satellite could escape from the earth's gravitational field, is close to : (Neglect the effect of atmosphere.) **[JEE(Main)-2016 ; 4/120, –1]**

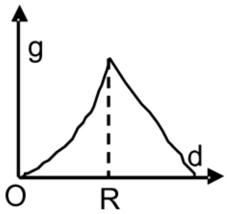
(1) $\sqrt{gR}$ (2) $\sqrt{\frac{gR}{2}}$ (3) $\sqrt{gR}\left(\sqrt{2}-1\right)$ (4) $\sqrt{2gR}$

19. The variation of acceleration due to gravity g with distance d from centre of the earth is best represented by (R = Earth's radius) **[JEE Main 2017; 4/120, –1]**

(1) 

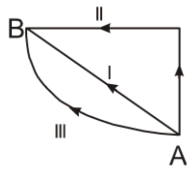
(2) 

(3) 

(4) 

PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. A particle of mass m is taken through the gravitational field produced by a source S, from A to B, along the three paths as shown in figure. If the work done along the paths I, II and III is W_I, W_{II} and W_{III} respectively, then



[JEE (Scr.) - 2003, 3/84]

(A) $W_I = W_{II} = W_{III}$ (B) $W_{II} > W_{III} = W_{II}$

(C) $W_{III} = W_{II} > W_I$ (D) $W_I > W_{II} > W_{III}$

2. A double star system consists of two stars A and B which have time period T_A and T_B. Radius R_A and R_B and mass M_A and M_B. Choose the correct option. **[JEE 2006; 3/184, –1]**

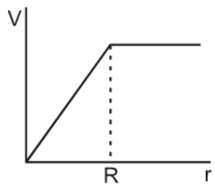
(A) If $T_A > T_B$ then $R_A > R_B$ (B) If $T_A > T_B$ then $M_A > M_B$

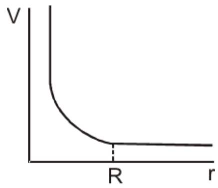
(C) $\left(\frac{T_A}{T_B}\right)^2 = \left(\frac{R_A}{R_B}\right)^3$ (D) $T_A = T_B$

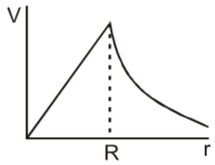
3. A spherically symmetric gravitational system of particles has a mass density **[JEE 2008; 3/82, –1]**

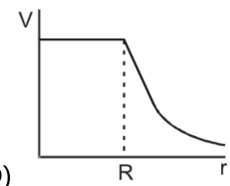
$$\rho = \begin{cases} \rho_0 & \text{for} \quad r \le R \\ 0 & \text{for} \quad r > R \end{cases}$$

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 ($0 < r < \infty$) from the centre of the system is represented by

(A) 

(B) 

(C) 

(D) 

4. **STATEMENT -1** **[JEE 2008; 3/82, –1]**

An astronaut in an orbiting space station above the Earth experiences weightlessness.

and

STATEMENT -2

An object moving around the Earth under the influence of Earth's gravitational force is in a state of 'free-fall.

(A) STATEMENT -1 is True, STATEMENT -2 is True; STATEMENT -2 is a correct explanation for STATEMENT -1

(B) STATEMENT -1 is True, STATEMENT -2 is True; STATEMENT -2 is NOT a correct explanation for STATEMENT -1

(C) STATEMENT -1 is True, STATEMENT -2 is False

(D) STATEMENT -1 is False, STATEMENT -2 is True.

5. 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 **[JEE 2011, 3/160, –1]**

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

6.* Two spherical planets P and Q have the same unfirom density ρ, masses M_P and M_Q, with surface areas A and 4A, respectively. A spherical planet R also has unfirom 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 respectivley. Then **[IIT-JEE-2012, Paper-2; 4/66; –1]**

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

7*. Two bodies, each of mass M, are kept fixed with a separation 2L. A particle of mass m is projected from the midpoint of the line joining their centres, perpendicular to the line. The gravitational constant is G. The correct statement(s) is (are) : **[JEE(Advanced) - 2013; 4/60, –1]**

(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.

8. 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} kgm^{-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 = 6×10^6 m and the acceleration due to gravity on Earth is 10 ms^{-2}) **[JEE (Advanced)-2014, 3/60, –1]**

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

Answers

EXERCISE # 1

Section (A)

A-1. (3) **A-2.** (1) **A-3.** (2)

Section (B)

B-1. (3) **B-2.** (4) **B-3.** (4)

B-4 (3)

Section (C)

C-1. (3) **C-2.** (3) **C-3.** (2)

C-4. (3) **C-5.** (1) **C-6.** (1)

Section (D)

D-1. (1) **D-2.** (1) **D-3.** (3)

D-4. (4) **D-5.** (3) **D-6.** (3)

D-7. (3) **D-8.** (4) **D-9.** (1)

D-10. (2) **D-11.** (2) **D-12.** (4)

D-13. (4) **D-14.** (2) **D-15.** (4)

D-16. (1) **D-17.** (2) **D-18.** (1)

D-19. (3) **D-20.** (1) **D-21.** (3)

Section (E)

E-1. (3) **E-2.** (1)

EXERCISE # 2

PART-I

1. (2) **2.** (4) **3.** (3)

4. (2) **5.** (3) **6.** (3)

7. (a) (4) **(b)** (2) **(c)** (2) **(d)** (2)

8. (2) **9.** (3) **10.** (1)

11. (1) **12.** (1) **13.** (1)

14. (2) **15.** (1) **16.** (3)

17. (3) **18.** (4) **19.** (4)

PART-II

Section (A)

A-1. (1) **A-2.** (1)

Section (B)

B-1 (1) p,r (2) p,r (3) r (4) p,r

Section (C)

C-1. (1,2,3,4) **C-2.** (1,3,4) **C-3.** (1,2,3)

C-4. (2, 3) **C-5.** (2,4)

EXERCISE # 3

PART-I

1. (2) **2.** (3) **3.** (3)

4. (4) **5.** (1) **6.** (2)

7. (3) **8.** (4) **9.** (1)

10. (2) **11.** (4) **12.** (4)

13. (1) **14.** (4) **15.** (1)

16. (4) **17.** (2) **18.** (3)

19. (1)

PART-II

1. (A) **2.** (D) **3.** (C)

4. (A) **5.** (B) **6.** (B,D)

7. (B,D) **8.** (B)