



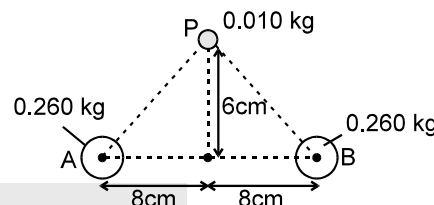
## Exercise-1

Marked Questions can be used as Revision Questions.

### PART - I : SUBJECTIVE QUESTIONS

#### Section (A) : Universal law of gravitation

- A-1. The typical adult human brain has a mass of about 1.4 kg. What force does a full moon exert on such a brain when it is directly above with its centre 378000 km away? (Mass of the moon =  $7.34 \times 10^{22}$  kg)
- A-2. Two uniform solid spheres of same material and same radius 'r' are touching each other. If the density is ' $\rho$ ' then find out gravitational force between them.
- A-3. Two uniform spheres, each of mass 0.260 kg are fixed at points 'A' and 'B' as shown in the figure. Find the magnitude and direction of the initial acceleration of a sphere with mass 0.010 kg if it is released from rest at point 'P' and acted only by forces of gravitational attraction of sphere at 'A' and 'B' (give your answer in terms of G).

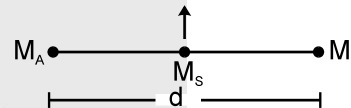


#### Section (B) : Gravitational field and potential

- B-1. The gravitational potential in a region is given by  $V = (20x + 40y)$  J/kg. Find out the gravitational field (in newton/kg) at a point having co-ordinates (2, 4). Also find out the magnitude of the gravitational force on a particle of 0.250 kg placed at the point (2, 4).
- B-2. Radius of the earth is  $6.4 \times 10^6$  m and the mean density is  $5.5 \times 10^3$  kg/m<sup>3</sup>. Find out the gravitational potential at the earth's surface.

#### Section (C) : Gravitational Potential Energy and Self Energy

- C-1. A body which is initially at rest at a height R above the surface of the earth of radius R, falls freely towards the earth. Find out its velocity on reaching the surface of earth. (Take g = acceleration due to gravity on the surface of the Earth).
- C-2. Two planets A and B are fixed at a distance d from each other as shown in the figure. If the mass of A is  $M_A$  and that of B is  $M_B$ , then find out the minimum velocity of a satellite of mass  $M_s$  projected from the mid point of two planets to infinity.



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

- D-1. A satellite is established in a circular orbit of radius r and another in a circular orbit of radius 1.01 r. How much nearly percentage the time period of second-satellite will be larger than the first satellite.
- D-2. Two identical stars of mass M, orbit around their centre of mass. Each orbit is circular and has radius R, so that the two stars are always on opposite sides on a diameter.
- Find the gravitational force of one star on the other.
  - Find the orbital speed of each star and the period of the orbit.
  - Find their common angular speed.
  - Find the minimum energy that would be required to separate the two stars to infinity.
  - If a meteorite passes through this centre of mass perpendicular to the orbital plane of the stars. What value must its speed exceed at that point if it escapes to infinity from the star system?
- D-3. Two earth satellites A and B each of equal mass are to be launched into circular orbits about earth's centre. Satellite 'A' is to orbit at an altitude of 6400 km and B at 19200 km. The radius of the earth is 6400 km. Determine-
- the ratio of the potential energy
  - the ratio of kinetic energy
  - which one has the greater total energy
- D-4. The Saturn is about six times farther from the Sun than The Mars. Which planet has :
- the greater period of revolution ?
  - the greater orbital speed and
  - the greater angular speed ?



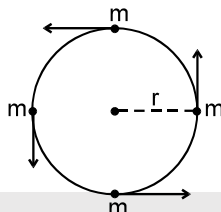
### Section (E) : The Earth and Other Planets Gravity

- E-1.** The acceleration due to gravity at a height  $(1/20)$ th the radius of the earth above earth's surface is  $9 \text{ m/s}^2$ . Find out its approximate value at a point at an equal distance below the surface of the earth.
- E-2.** If a pendulum has a period of exactly 1.00 sec. at the equator, what would be its period at the south pole ? Assume the earth to be spherical and rotational effect of the Earth is to be taken.

## PART - II : ONLY ONE OPTION CORRECT TYPE

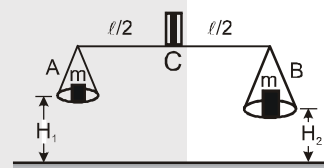
### Section (A) : Universal law of gravitation

- A-1.** Four similar particles of mass  $m$  are orbiting in a circle of radius  $r$  in the same direction and same speed because of their mutual gravitational attractive force as shown in the figure. Speed of a particle is given by



- (A)  $\left[ \frac{Gm}{r} \left( \frac{1+2\sqrt{2}}{4} \right) \right]^{\frac{1}{2}}$  (B)  $\sqrt[3]{\frac{Gm}{r}}$  (C)  $\sqrt{\frac{Gm}{r} (1+2\sqrt{2})}$  (D) zero

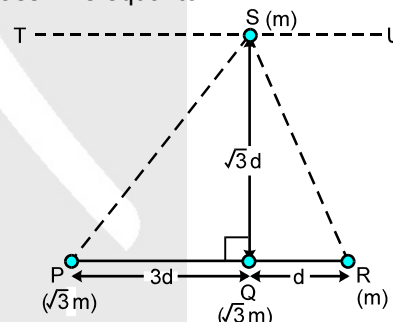
- A-2.** Two blocks of masses  $m$  each are hung from a balance as shown in the figure. The scale pan A is at height  $H_1$  whereas scale pan B is at height  $H_2$ . Net torque of weights acting on the system about point 'C', will be (length of the rod is  $\ell$  and  $H_1$  &  $H_2$  are  $\ll R$ ) ( $H_1 > H_2$ )



- (A)  $mg \left( \frac{1-2H_1}{R} \right) \ell$  (B)  $\frac{mg}{R} (H_1 - H_2) \ell$  (C)  $\frac{2mg}{R} (H_1 + H_2) \ell$  (D)  $2mg \frac{H_2 H_1}{H_1 + H_2} \ell$

- A-3.** Three particles P, Q and R are placed as per given figure. Masses of P, Q and R are  $\sqrt{3} \text{ m}$ ,  $\sqrt{3} \text{ m}$  and  $m$  respectively. The gravitational force on a fourth particle 'S' of mass  $m$  is equal to

- (A)  $\frac{\sqrt{3}GM^2}{2d^2}$  in ST direction only  
 (B)  $\frac{\sqrt{3}Gm^2}{2d^2}$  in SQ direction and  $\frac{\sqrt{3}Gm^2}{2d^2}$  in SU direction  
 (C)  $\frac{\sqrt{3}Gm^2}{2d^2}$  in SQ direction only  
 (D)  $\frac{\sqrt{3}Gm^2}{2d^2}$  in SQ direction and  $\frac{\sqrt{3}Gm^2}{2d^2}$  in ST direction



- A-4.** Three identical stars of mass  $M$  are located at the vertices of an equilateral triangle with side  $L$ . The speed at which they will move if they all revolve under the influence of one another's gravitational force in a circular orbit circumscribing the triangle while still preserving the equilateral triangle:

- (A)  $\sqrt{\frac{2GM}{L}}$  (B)  $\sqrt{\frac{GM}{L}}$  (C)  $2\sqrt{\frac{GM}{L}}$  (D) not possible at all

### Section (B) : Gravitational field and potential

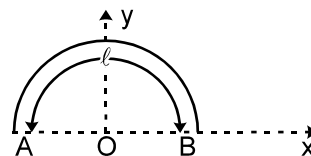
- B-1.** Let gravitation field in a space be given as  $E = - (k/r)$ . If the reference point is at distance  $d_i$  where potential is  $V_i$  then relation for potential is :

- (A)  $V = k \ln \frac{1}{V_i} + 0$  (B)  $V = k \ln \frac{r}{d_i} + V_i$  (C)  $V = \ln \frac{r}{d_i} + kV_i$  (D)  $V = \ln \frac{r}{d_i} + \frac{V_i}{k}$



- B-2.** Gravitational field at the centre of a semicircle formed by a thin wire AB of mass  $m$  and length  $\ell$  as shown in the figure is :

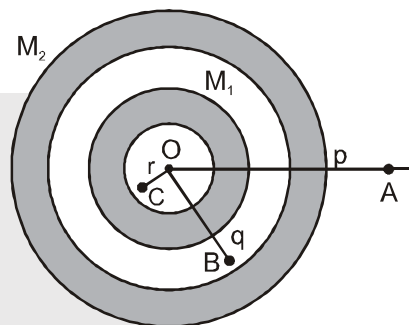
- (A)  $\frac{Gm}{\ell^2}$  along +x axis  
 (B)  $\frac{Gm}{\pi\ell^2}$  along +y axis  
 (C)  $\frac{2\pi Gm}{\ell^2}$  along +x axis  
 (D)  $\frac{2\pi Gm}{\ell^2}$  along +y axis



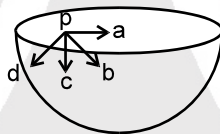
- B-3.** A very large number of particles of same mass  $m$  are kept at horizontal distances of  $1m, 2m, 4m, 8m$  and so on from  $(0, 0)$  point. The total gravitational potential at this point  $(0, 0)$  is :  
 (A)  $-8Gm$  (B)  $-3Gm$  (C)  $-4Gm$  (D)  $-2Gm$

- B-4.** Two concentric shells of uniform density of mass  $M_1$  and  $M_2$  are situated as shown in the figure. The forces experienced by a particle of mass  $m$  when placed at positions A, B and C respectively are (given  $OA = p, OB = q$  and  $OC = r$ ).

- (A) zero,  $G \frac{M_1 m}{q^2}$  and  $G \frac{(M_1 + M_2)m}{p^2}$   
 (B)  $G \frac{(M_1 + M_2)m}{p^2}$ ,  $G \frac{(M_1 + M_2)m}{q^2}$  and  $G \frac{M_1 m}{r^2}$   
 (C)  $G \frac{M_1 m}{q^2}$ ,  $G \frac{M_1 m}{q^2}$  and zero  
 (D)  $G \frac{(M_1 + M_2)m}{p^2}$ ,  $G \frac{M_1 m}{q^2}$  and zero



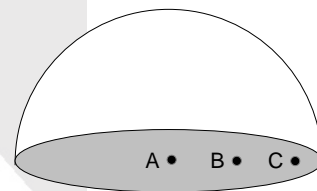
- B-5.** Figure show a hemispherical shell having uniform mass density. The direction of gravitational field intensity at point P will be along:



- (A) a (B) b (C) c (D) d

- B-6.** 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)  $V_A = V_B = V_C$



### Section (C) : Gravitational Potential Energy and Self Energy

- C-1.** 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

- (A)  $\sqrt{GM\left(\frac{1}{R} - \frac{1}{R_0}\right)}$  (B)  $\sqrt{3GM\left(\frac{1}{R} - \frac{1}{R_0}\right)}$  (C)  $\sqrt{2GM\left(\frac{1}{R} - \frac{1}{R_0}\right)}$  (D)  $2\sqrt{GM\left(\frac{1}{R} - \frac{1}{R_0}\right)}$

- C-2.** 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 :

- (A)  $\frac{Gm^2}{a^2}$  (B)  $\frac{4Gm^2}{3a^2}$  (C)  $\frac{3Gm^2}{a^2}$  (D) 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:

- (A)  $\frac{Gm^2}{a^2}$  (B)  $\frac{4Gm^2}{3a^2}$  (C)  $\frac{3Gm^2}{a^2}$  (D) 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 :

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

(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:

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

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

D-1. Periodic-time of satellite revolving around the earth is - ( $\rho$  is density of earth)

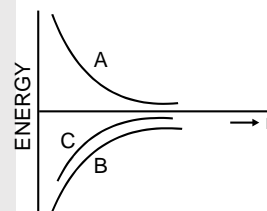
- (A) Proportional to  $\frac{1}{\rho}$  (B) Proportional to  $\frac{1}{\sqrt{\rho}}$  (C) Proportional  $\rho$  (D) does not depend on  $\rho$ .

D-2. An artificial satellite of the earth releases a package. If air resistance is neglected the point where the package will hit (with respect to the position at the time of release) will be

- (A) ahead (B) exactly below (C) behind (D) it will never reach the earth

D-3. The figure shows the variation of energy with the orbit radius of a body in circular planetary motion. Find the correct statement about the curves A, B and C :

- (A) A shows the kinetic energy, B the total energy and C the potential energy of the system  
 (B) C shows the total energy, B the kinetic energy and A the potential energy of the system  
 (C) C and A are kinetic and potential energies respectively and B is the total energy of the system  
 (D) A and B are the kinetic and potential energies respectively and C is the total energy of the system.



D-4. A planet of mass  $m$  revolves around the sun of mass  $M$  in an elliptical orbit. The minimum and maximum distance of the planet from the sun are  $r_1$  &  $r_2$  respectively. If the minimum velocity of the planet is  $\sqrt{\frac{2GM}{(r_1 + r_2)r_2}}$  then its maximum velocity will be :

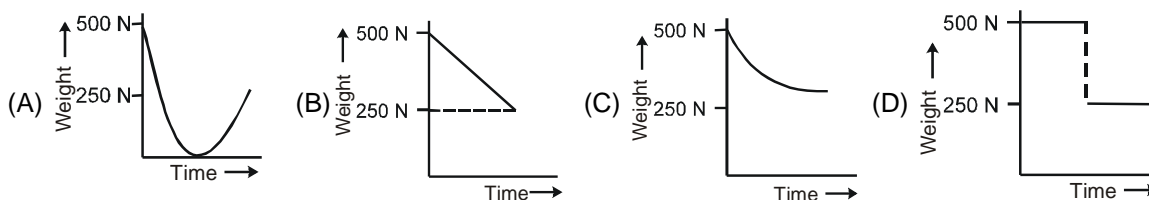
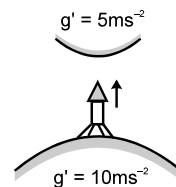
- (A)  $\sqrt{\frac{2GM}{(r_1 + r_2)r_1}}$  (B)  $g\sqrt{\frac{2GM}{(r_1 + r_2)r_2}}$  (C)  $\sqrt{\frac{2GM}{(r_1 + r_2)r_1}}$  (D)  $\sqrt{\frac{2GM}{r_1 + r_2}}$

D-5. 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  $45^\circ$  with the vertical, the escape velocity will be : [AIEEE2003, 4/300]

- (A)  $11\sqrt{2}$  km/s (B) 22 km/s (C) 11 km/s (D)  $11/\sqrt{2}$  m/s

### Section (E) : Earth and Other Planets Gravity

E-1. If acceleration due to gravity on the surface of earth is  $10 \text{ ms}^{-2}$  and let acceleration due to gravitational acceleration at surface of another planet of our solar system be  $5 \text{ ms}^{-2}$ . An astronaut weighing 50 kg on earth goes to this planet in a spaceship with a constant velocity. The weight of the astronaut with time of flight is roughly given by





## PART - III : MATCH THE COLUMN

1. A particle is taken to a distance  $r$  ( $> R$ ) from centre of the earth.  $R$  is radius of the earth. It is given velocity  $V$  which is perpendicular to radius. With the given values of  $V$  in column I you have to match the values of total energy of particle in column II and the resultant path of particle in column III. Here ' $G$ ' is the universal gravitational constant and ' $M$ ' is the mass of the earth.

### Column I (Velocity)

- (A)  $V = \sqrt{GM/r}$   
 (B)  $V = \sqrt{2GM/r}$   
 (C)  $V > \sqrt{2GM/r}$   
 (D)  $\sqrt{GM/r} < V < \sqrt{2GM/r}$

### Column II (Total energy)

- (p) Negative  
 (q) Positive  
 (r) Zero  
 (s) Infinite

### Column III (Path)

- (t) Elliptical  
 (u) Parabolic  
 (v) Hyperbolic  
 (w) Circular

2. Let  $V$  and  $E$  denote the gravitational potential and gravitational field respectively at a point due to certain uniform mass distribution described in four different situations of column-I. Assume the gravitational potential at infinity to be zero. The value of  $E$  and  $V$  are given in column-II. Match the statement in column-I with results in column-II.

### Column-I

- (A) At centre of thin spherical shell  
 (B) At centre of solid sphere  
 (C) A solid sphere has a non-concentric spherical cavity.  
     At the centre of the spherical cavity  
 (D) At centre of line joining two point masses of equal magnitude

### Column-II

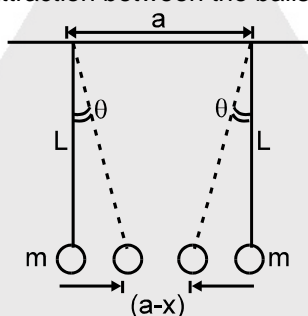
- (p)  $E = 0$   
 (q)  $E \neq 0$   
 (r)  $V \neq 0$   
 (s)  $V = 0$

## Exercise-2

Marked Questions may have for Revision Questions.

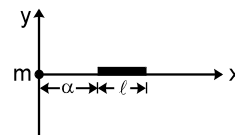
## PART - I : ONLY ONE OPTION CORRECT TYPE

1. Two small balls of mass  $m$  each are suspended side by side by two equal threads of length  $L$  as shown in the figure. If the distance between the upper ends of the threads be  $a$ , the angle  $\theta$  that the threads will make with the vertical due to attraction between the balls is :



- (A)  $\tan^{-1} \frac{(a-x)g}{mG}$       (B)  $\tan^{-1} \frac{mG}{(a-x)^2 g}$       (C)  $\tan^{-1} \frac{(a-x)^2 g}{mG}$       (D)  $\tan^{-1} \frac{(a^2 - x^2)g}{mG}$

2. A straight rod of length  $\ell$  extends from  $x = \alpha$  to  $x = \ell + \alpha$  as shown in the figure. 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

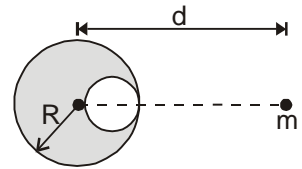


- (A)  $Gm \left( a \left( \frac{1}{\alpha} - \frac{1}{\alpha + \ell} \right) + b\ell \right)$       (B)  $\frac{Gm(a + bx^2)}{\ell^2}$   
 (C)  $Gm \left( \alpha \left( \frac{1}{a} - \frac{1}{a + \ell} \right) + b\ell \right)$       (D)  $Gm \left( a \left( \frac{1}{\alpha + \ell} - \frac{1}{\alpha}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



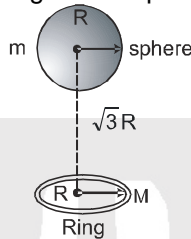


3. A spherical hollow cavity is made in a lead sphere of radius  $R$ , such that its surface touches the outside surface of the lead sphere and passes through its centre. The mass of the sphere before hollowing was  $M$ . With what gravitational force will the hollowed-out lead sphere attract a small sphere of mass ' $m$ ', which lies at a distance  $d$  from the centre of the lead sphere on the straight line connecting the centres of the spheres and that of the hollow, if  $d = 2R$  :



- (A)  $\frac{7GMm}{18R^2}$  (B)  $\frac{7GMm}{36R^2}$  (C)  $\frac{7GMm}{9R^2}$  (D)  $\frac{7GMm}{72R^2}$

4. A uniform ring of mass  $M$  is lying at a distance  $\sqrt{3}R$  from the centre of a uniform sphere of mass  $m$  just below the sphere as shown in the figure where  $R$  is the radius of the ring as well as that of the sphere. Then gravitational force exerted by the ring on the sphere is :



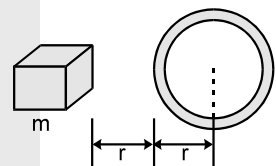
- (A)  $\frac{GMm}{8R^2}$  (B)  $\frac{GMm}{3R^2}$  (C)  $\sqrt{3} \frac{GMm}{R^2}$  (D)  $\sqrt{3} \frac{GMm}{8R^2}$

5. The gravitational potential of two homogeneous spherical shells A and B (separated by large distance) of same surface mass density at their respective centres are in the ratio 3 : 4. If the two shells coalesce into single one such that surface mass density remains same, then the ratio of potential at an internal point of the new shell to shell A is equal to :

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

6. A block of mass  $m$  is lying at a distance  $r$  from a spherical shell of mass  $m$  and radius  $r$  as shown in the figure. Then

- (A) only gravitational field inside the shell is zero  
(B) gravitational field and gravitational potential both are zero inside the shell  
(C) gravitational potential as well as gravitational field inside the shell are not zero  
(D) can't be ascertained.



7. In a spherical region, the density varies inversely with the distance from the centre. Gravitational field at a distance  $r$  from the centre is :

- (A) proportional to  $r$  (B) proportional to  $1/r$  (C) proportional to  $r^2$  (D) same everywhere

8. In above problem, the gravitational potential is -

- (A) linearly dependent on  $r$  (B) proportional to  $1/r$   
(C) proportional to  $r^2$  (D) same everywhere.

9. A body of mass  $m$  is lifted up from the surface of earth to a height three times the radius of the earth. The change in potential energy of the body is ( $g$  = gravity field at the surface of the earth)

- (A)  $mgR$  (B)  $3/4 mgR$  (C)  $1/3 mgR$  (D)  $2/3 mgR$

10. A point  $P$  lies on the axis of a fixed ring of mass  $M$  and radius  $R$ , at a distance  $2R$  from its centre  $O$ . A small particle starts from  $P$  and reaches  $O$  under gravitational attraction only. Its speed at  $O$  will be :

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

11. A projectile is fired from the surface of earth of radius  $R$  with a speed  $kv_e$  in radially outward direction (where  $v_e$  is the escape velocity and  $k < 1$ ). Neglecting air resistance, the maximum height from centre of earth is :

- (A)  $\frac{R}{k^2+1}$  (B)  $k^2 R$  (C)  $\frac{R}{1-k^2}$  (D)  $kR$

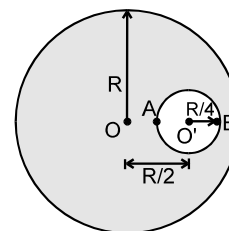




12. A satellite can be in a geostationary orbit around a planet at a distance  $r$  from the centre of the planet. If the angular velocity of the planet about its axis doubles, a satellite can now be in a geostationary orbit around the planet if its distance from the centre of the planet is :
- (A)  $\frac{r}{2}$  (B)  $\frac{r}{2\sqrt{2}}$  (C)  $\frac{r}{(4)^{1/3}}$  (D)  $\frac{r}{(2)^{1/3}}$
13. 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 hundred kilometers above the earth's surface ( $R_{\text{Earth}} = 6400$  km) will approximately be : [JEE (Scr) 2002, 3/84]
- (A) 1/2 hr (B) 1 hr (C) 2 hr (D) 4 hr
14. 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 : [AIEEE2004, 4/300]
- (A)  $gx$  (B)  $\frac{gR}{R-x}$  (C)  $\frac{gR^2}{R+x}$  (D)  $\left(\frac{gR^2}{R+x}\right)^{1/2}$
15. If Newton's inverse square law of gravitation had some dependence on radial distance other than  $r^{-2}$ , which one of Kepler's three laws of planetary motion would remain unchanged? [Olympiad (Stage-1) 2017]
- (A) First law on nature of orbits  
(B) Second law on constant areal velocity  
(C) Third law on dependence of orbital time period on orbit's semi major axis  
(D) None of the above
16. Assuming that the moon is a sphere of the same mean density as that of the earth and one quarter of its radius, the length of a second's pendulum on the moon (its length on the earth's surface is 99.2 cm) is
- (A) 24.8 cm (B) 49.6 cm (C) 99.2 (D)  $\frac{99.2}{\sqrt{2}}$  cm

## PART - II : NUMERICAL QUESTIONS

1. The two stars in a certain binary star system move in circular orbits. The first star,  $\alpha$  moves in an orbit of radius  $1.00 \times 10^9$  km. The other star,  $\beta$  moves in an orbit of radius  $5.00 \times 10^8$  km. What is the ratio of masses of star  $\beta$  to the star  $\alpha$  ?
2. Our sun, with mass  $2 \times 10^{30}$  kg revolves on the edge of our Milky Way galaxy, which can be assumed to be spherical, having radius  $10^{20}$  m. Also assume that many stars, identical to our sun are uniformly distributed in the spherical Milky Way galaxy. If the time period of the sun is  $10^{15}$  second and number of stars in the galaxy are nearly  $3 \times 10^{(a)}$ , find value of 'a' (take  $\pi^2 = 10$ ,  $G = 20/3 \times 10^{-11}$  in MKS)
3. The gravitational field in a region is given by  $\vec{E}(3\hat{i} - 4\hat{j})$  N/kg. Find out the work done (in joule) in displacing a particle of mass 1 kg by 1 m along the line  $4y = 3x + 9$ .
4. In a solid sphere of radius 'R' and density ' $\rho$ ' there is a spherical cavity of radius  $R/4$  as shown in figure. A particle of mass ' $m$ ' is released from rest from point 'B' (inside the cavity). Find out Velocity (in mm/sec.) of the particle at the instant when it strikes the cavity ( $R = 3$  m,  $\rho = \frac{10}{\pi} \times 10^3$  kg/m<sup>3</sup>,  $G = \frac{20}{3} \times 10^{-11}$  Nm<sup>2</sup>kg<sup>-2</sup>)
5. 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  $\frac{Nm g R}{2}$  is. Find the value of  $N$  :





6. A ring of radius  $R = 8\text{m}$  is made of a highly dense-material. Mass of the ring is  $m_R = 2.7 \times 10^9\text{ kg}$  distributed uniformly over its circumference. A particle of mass (dense)  $m_p = 3 \times 10^8\text{ kg}$  is placed on the axis of the ring at a distance  $x_0 = 6\text{m}$  from the centre. Neglect all other forces except gravitational interaction. Determine speed (in cm/sec.) of the particle at the instant when it passes through centre of ring.
7. Assume earth to be a sphere of uniform mass density. The energy needed to completely disassemble the planet earth against the gravitational pull amongst its constituent particles is  $x \times 10^{31}\text{ J}$ . Find the value of  $x$ , given the product of mass of earth and radius of earth to be  $2.5 \times 10^{31}\text{ kg-m}$  and  $g = 10\text{ m/s}^2$ . [JEE 1992, 10 Part (b)]
8. A projectile is fired vertically up from the bottom of a crater (big hole) on the moon. The depth of the crater is  $R/100$ , where  $R$  is the radius of the moon. If the initial velocity of the projectile is the same as the escape velocity from the moon surface. The maximum approximate height attained by the projectile above the lunar (moon) surface is  $xR$ . Find value of  $x$ . [JEE 2003 (Main), 4/60]
9. 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 (in hrs). [AIEEE 2003, 4/300]
10. If the radius of earth is  $R$  and height of a satellite above earth's surface is  $R$  then find the minimum co-latitude (in degree) which can directly receive a signal from satellite. (Satellite is in equatorial plane)

### PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. A double star is 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)  $r^{3/2}$  (B)  $r$  (C)  $m^{1/2}$  (D)  $m^{-1/2}$
2. Inside an isolated uniform spherical shell :  
(A) The gravitation potential is not zero (B) The gravitational field is not zero  
(C) The gravitational potential is same everywhere (D) The gravitational field is same everywhere.
3. 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 :
- (A)

(B)

(C)

(D)
4. In case of earth :  
(A) Gravitational field is zero, both at centre and infinity  
(B) Gravitational potential is zero, both at centre and infinity  
(C) Gravitational potential is same, both at centre and infinity but not zero  
(D) Gravitational potential is minimum at the centre
5. For a satellite to appear stationary w.r.t. an observer on earth  
(A) It must be rotating about the earth's axis.  
(B) It must be rotating in the equatorial plane.  
(C) Its angular velocity must be from west to east.  
(D) Its time period must be 24 hours.





6. Which of the following statements are correct about a planet rotating around the sun in an elliptic orbit:  
 (A) its mechanical energy is constant  
 (B) its angular momentum about the sun is constant  
 (C) its areal velocity about the sun is constant  
 (D) its time period is proportional to  $r^3$
7. A planet revolving around sun in an elliptical orbit has a constant  
 (A) kinetic energy (B) angular momentum about the sun  
 (C) potential energy (D) Total energy
8. A satellite close to the earth is in orbit above the equator with a period of revolution of 1.5 hours. If it is above a point P on the equator at some time, it will be above P again after time :  
 (A) 1.5 hours  
 (B) 1.6 hours if it is rotating from west to east  
 (C) 24/17 hours if it is rotating from east to west  
 (D) 24/17 hours if it is rotating from west to east
9. If a body is projected with speed lesser than escape velocity :  
 (A) the body can reach a certain height and may fall down following a straight line path  
 (B) the body can reach a certain height and may fall down following a parabolic path  
 (C) the body may orbit the earth in a circular orbit  
 (D) the body may orbit the earth in an elliptic orbit
10. An orbiting satellite in circular orbit will escape if :  
 (A) its speed is increased by  $(\sqrt{2} - 1)$   
 (B) its speed in the orbit is made  $\sqrt{1.5}$  times of its initial value  
 (C) its KE is doubled  
 (D) it stops moving in the orbit
11. In case of an orbiting satellite if the radius of orbit is decreased :  
 (A) its Kinetic Energy decreases (B) its Potential Energy decreases  
 (C) its Mechanical Energy decreases (D) its speed decreases
12. An object is weighed at the equator by a beam balance and a spring balance, giving readings  $W_b$  and  $W_s$  respectively. It is again weighed in the same manner at the north pole, giving readings of  $W_b'$  and  $W_s'$  respectively. Assume that intensity of earth gravitational field is the same every where on the earth's surface and that the balances are quite sensitive.  
 (A)  $W_b = W_b'$  (B)  $W_b = W_s$  (C)  $W_b' = W_s'$  (D)  $W_s' > W_s$

## PART - IV : COMPREHENSION

### Comprehension-1

A pair of stars rotates about their center of mass. One of the stars has a mass  $M$  and the other has mass  $m$  such that  $M = 2m$ . The distance between the centres of the stars is  $d$  ( $d$  being large compared to the size of either star).

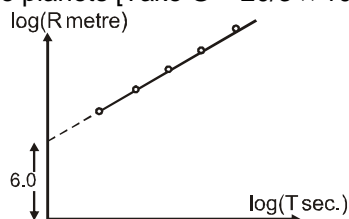
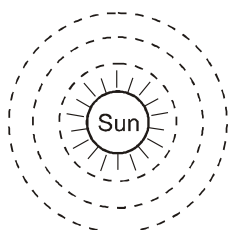
1. The period of rotation of the stars about their common centre of mass (in terms of  $d$ ,  $m$ ,  $G$ .) is  
 (A)  $\sqrt{\frac{4\pi^2}{Gm}} d^3$  (B)  $\sqrt{\frac{8\pi^2}{Gm}} d^3$  (C)  $\sqrt{\frac{2\pi^2}{3Gm}} d^3$  (D)  $\sqrt{\frac{4\pi^2}{3Gm}} d^3$
2. The ratio of the angular momentum of the two stars about their common centre of mass ( $L_m/L_M$ ) is  
 (A) 1 (B) 2 (C) 4 (D) 9
3. The ratio of kinetic energies of the two stars ( $K_m/K_M$ ) is  
 (A) 1 (B) 2 (C) 4 (D) 9



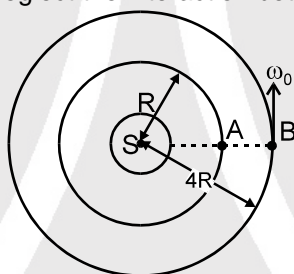
## Comprehension-2

Many planets are revolving around the fixed sun, in circular orbits of different radius ( $R$ ) and different time period ( $T$ ). To estimate the mass of the sun, the orbital radius ( $R$ ) and time period ( $T$ ) of planets were noted. Then  $\log_{10} T$  v/s  $\log_{10} R$  curve was plotted.

The curve was found to be approximately straight line (as shown in figure) having y intercept = 6.0 (Neglect the gravitational interaction among the planets [Take  $G = 20/3 \times 10^{-11}$  in MKS,  $\pi^2 = 10$ ])



4. The slope of the line should be :  
 (A) 1 (B)  $3/2$  (C)  $2/3$  (D)  $19/4$
5. Estimate the mass of the sun :  
 (A)  $6 \times 10^{29}$  kg (B)  $5 \times 10^{20}$  kg (C)  $8 \times 10^{25}$  kg (D)  $3 \times 10^{35}$  kg
6. Two planets A and B, having orbital radius  $R$  and  $4R$  are initially at the closest position and rotating in the same direction. If angular velocity of planet B is  $\omega_0$ , then after how much time will both the planets be again in the closest position? (Neglect the interaction between planets).



- (A)  $\frac{2\pi}{7\omega_0}$  (B)  $\frac{2\pi}{9\omega_0}$  (C)  $\frac{2\pi}{\omega_0}$  (D)  $\frac{2\pi}{5\omega_0}$

## Comprehension-3

An artificial satellite is moving in a circular orbit around the earth with a speed equal to half the magnitude of escape velocity from the surface of earth.  $R$  is the radius of earth and  $g$  is acceleration due to gravity at the surface of earth. ( $R = 6400$  km)

7. Then the distance of satellite from the surface of earth is  
 (A) 3200 km (B) 6400 km (C) 12800 km (D) 4800 km
8. The time period of revolution of satellite in the given orbit is  
 (A)  $2\pi\sqrt{\frac{2R}{g}}$  (B)  $2\pi\sqrt{\frac{4R}{g}}$  (C)  $2\pi\sqrt{\frac{8R}{g}}$  (D)  $2\pi\sqrt{\frac{6R}{g}}$
9. If the satellite is stopped suddenly in its orbit and allowed to fall freely onto the earth, the speed with which it hits the surface of the earth.  
 (A)  $\sqrt{gR}$  (B)  $\sqrt{1.5gR}$  (C)  $\sqrt{\frac{gR}{2}}$  (D)  $\sqrt{\frac{gR}{\sqrt{2}}}$



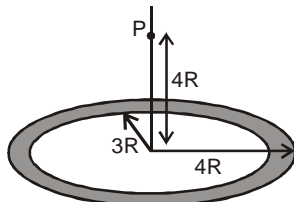
## Exercise-3

Marked Questions may have for Revision Questions.

\* Marked Questions may have more than one correct option.

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

1. A thin uniform annular disc (see 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 : [JEE 2010; 3/163, -1]

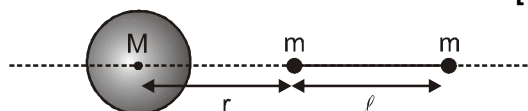


- (A)  $\frac{2GM}{7R}(4\sqrt{2}-5)$  (B)  $-\frac{2GM}{7R}(4\sqrt{2}-5)$  (C)  $\frac{GM}{4R}$  (D)  $\frac{2GM}{5R}(\sqrt{2}-1)$
2. A binary star consists of two stars A (mass  $2.2 M_s$ ) and B (mass  $11 M_s$ ) where  $M_s$  is the mass of the sun. They are separated by distance  $d$  and are rotating about their centre of mass, which is stationary. The ratio of the total angular momentum of the binary star to the angular momentum of star B about the centre of mass is : [JEE 2010; 3/163]
3. 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  $11 \text{ kms}^{-1}$ , the escape speed on the surface of the planet in  $\text{kms}^{-1}$  will be : [JEE 2010; 3/163]
4. 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)  $2mV^2$
5. Two spherical planets P and Q have the same uniform density  $\rho$ , masses  $M_P$  and  $M_Q$ , with surface areas  $A$  and  $4A$ , respectively. A spherical planet R also has uniform density  $\rho$  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 [IIT-JEE 2012; Paper-2; 4/66]
- (A)  $V_Q > V_R > V_P$  (B)  $V_R > V_Q > V_P$  (C)  $V_R/V_P = 3$  (D)  $V_P/V_Q = 1/2$
6. 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; 3/60, -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.
7. A planet of radius  $R = \frac{1}{10} \times$  (radius of Earth) has the same mass density as Earth. Scientists dig a well of depth  $R/5$  on it and lower a wire of the same length and of linear mass density  $10^{-3} \text{ kgm}^{-1}$  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 =  $6 \times 10^6 \text{ m}$  and the acceleration due to gravity on Earth is  $10 \text{ ms}^{-2}$ ) [JEE (Advanced) 2014; 3/60, -1]
- (A) 96 N (B) 108 N (C) 120 N (D) 150 N



8. 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  $1/4^{\text{th}}$  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): **[JEE (Advanced) 2015; P-1, 4/88]**

9. A large spherical mass  $M$  is fixed at one position and two identical point 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  $\ell$  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  $r = 3\ell$  from  $M$ , the tension in the rod is zero for  $m = k\left(\frac{M}{288}\right)$ . The value of  $k$  is : **[JEE (Advanced) 2015; P-2, 4/88]**



- 10\*. 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 option(s) is (are): **[JEE (Advanced) 2015; P-2, 4/88, -2]**

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

11. 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  $3 \times 10^5$  times heavier than the Earth and is at a distance  $2.5 \times 10^4$  times larger than the radius of the 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) **[JEE (Advanced) 2017; P-2, 3/61, -1]**

(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)  $v_s = 62 \text{ km s}^{-1}$

12. A planet of mass  $M$ , has two natural satellites with masses  $m_1$  and  $m_2$ . The radii of their circular orbits are  $R_1$  and  $R_2$  respectively. Ignore the gravitational force between the satellites. Define  $v_1$ ,  $L_1$ ,  $K_1$  and  $T_1$  to be, respectively, the orbital speed, angular momentum, kinetic energy and time period of revolution of satellite 1; and  $v_2$ ,  $L_2$ ,  $K_2$  and  $T_2$  to be the corresponding quantities of satellite 2. Given  $m_1/m_2 = 2$  and  $R_1/R_2 = 1/4$ , match the ratios in List-I to the numbers in List-II.

## List-I

P.  $\frac{v_1}{v_2}$

Q.  $\frac{L_1}{L_2}$

R.  $\frac{K_1}{K_2}$

S.  $\frac{T_1}{T_2}$

## List-II

1.  $\frac{1}{8}$

2. 1

3. 2

4. 8

(A)  $P \rightarrow 4$  ;  $Q \rightarrow 2$  ;  $R \rightarrow 1$  ;  $S \rightarrow 3$

(C)  $P \rightarrow 2$  ;  $Q \rightarrow 3$  ;  $R \rightarrow 1$  ;  $S \rightarrow 4$

(B)  $P \rightarrow 3$  ;  $Q \rightarrow 2$  ;  $R \rightarrow 4$  ;  $S \rightarrow 1$

(D)  $P \rightarrow 2$  ;  $Q \rightarrow 3$  ;  $R \rightarrow 4$  ;  $S \rightarrow 1$

13. Consider a spherical gaseous cloud of mass density  $\rho(r)$  in a 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 their 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  $n(r) = \rho(r)/m$  is : ( $G$  = universal gravitational constant) **[JEE (Advanced) 2019; P-1, 3/60, -1]**

(A)  $\frac{K}{6\pi r^2 m^2 G}$

(B)  $\frac{K}{\pi r^2 m^2 G}$

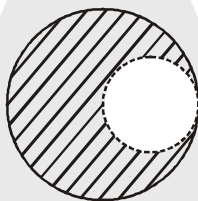
(C)  $\frac{3K}{\pi r^2 m^2 G}$

(D)  $\frac{K}{2\pi r^2 m^2 G}$



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

1. 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 : [AIEEE 2011; 4/120, -1]  
 (1) zero                      (2)  $-\frac{4Gm}{r}$                       (3)  $-\frac{6Gm}{r}$                       (4)  $-\frac{9Gm}{r}$
2. 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 particle 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)  $\sqrt{\frac{Gm}{R}}$
3. 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  $10 \text{ m/s}^2$  and 6400 km respectively. The required energy for this work will be : [AIEEE 2012 ; 4/120, -1]  
 (1)  $6.4 \times 10^{11} \text{ Joules}$       (2)  $6.4 \times 10^8 \text{ Joules}$       (3)  $6.4 \times 10^9 \text{ Joules}$       (4)  $6.4 \times 10^{10} \text{ Joules}$
4. 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)  $\frac{5GmM}{6R}$                       (2)  $\frac{2GmM}{3R}$                       (3)  $\frac{GmM}{2R}$                       (4)  $\frac{GmM}{3R}$
5. Four particles, each of mass  $M$  on vertices of a square, move along a circle of radius  $R$  under the action of their mutual gravitational attraction. 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)  $\sqrt{\frac{GM}{R}(1+2\sqrt{2})}$                       (4)  $\frac{1}{2}\sqrt{\frac{GM}{R}(1+2\sqrt{2})}$
6. 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  $r = \infty$ , 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)  $\frac{-2GM}{R}$
7. A satellite is revolving in a circular orbit at a height ' $h$ ' from the earth's surface (radius of earth  $R$ ;  $h \ll R$ ). 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)  $\sqrt{gR/2}$                       (3)  $\sqrt{gR}(\sqrt{2}-1)$                       (4)  $\sqrt{2gR}$
8. 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.

[JEE (Main), 8 April 2019\_shift-1; 4/120]

- (1)  $\frac{E}{4}$                       (2)  $\frac{E}{16}$                       (3)  $\frac{E}{32}$                       (4)  $\frac{E}{64}$



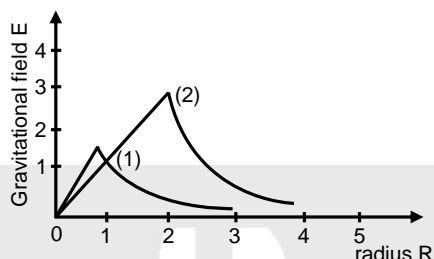
9. A satellite of mass  $m$  is launched vertically upwards with an initial speed  $u$  from the surface of the earth. After it reaches height  $R$  ( $R$  = radius of the earth), it ejects a rocket of mass  $m/10$  so that subsequently the satellite moves in a circular orbit. The kinetic energy of the rocket is ( $G$  is the gravitational constant;  $M$  is the mass of the earth) :

[JEE (Main), 7 January 2020\_shift-1 ; 4/100]

(1)  $\frac{m}{20} \left( u^2 + \frac{113}{200} \frac{GM}{R} \right)$  (2)  $5m \left( u^2 - \frac{119}{200} \frac{GM}{R} \right)$  (3)  $\frac{3m}{8} \left( u + \sqrt{\frac{5GM}{6R}} \right)^2$  (4)  $\frac{m}{20} \left( u - \sqrt{\frac{2GM}{3R}} \right)^2$

10. 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  $M_1/M_2$  is:

[JEE (Main), 8 January 2020\_shift-1 ; 4/100]



- (1)  $2/3$  (2)  $1/3$  (3)  $1/2$  (4)  $1/6$

11. An asteroid is moving directly towards the centre of the earth. when at a distance of  $10R$  ( $R$  is the radius of the earth) from the earth's centre, it has a speed of  $12\text{ km/s}$ . 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  $11.2\text{ km/s}$ )? Give your answer to the nearest integer in  $\text{km/s}$ \_\_\_\_\_

[JEE (Main) 8 January 2020\_shift-2 ; 4/100]

12. A body A of mass  $m$  is moving in a circular orbit of radius  $R$  about a planet. Another body B of mass  $m/2$  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 :

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- (1) Escapes from the planet's Gravitational field  
(2) Continues to move in a circular orbit  
(3) Falls vertically downwards towards the planet  
(4) Starts moving in an elliptical orbit around the planet





# Answers

## EXERCISE-1

### PART - I

#### Section (A) :

A-1.  $4.8 \times 10^{-5} \text{ N}$     A-2.  $\frac{4}{9} \pi^2 \rho^2 G r^4$

A-3.  $31.2 \text{ G m/sec}^2 = 2.1 \times 10^{-9} \text{ m/s}^2$ , towards mid-point

#### Section (B) :

B-1.  $-20\hat{i} - 40\hat{j}$ ,  $|\vec{F}| = 5\sqrt{5} \text{ N}$ ,  $\vec{F} = -5\hat{i} - 10\hat{j}$

B-2.  $6.3 \times 10^7 \text{ J/Kg}$

#### Section (C) :

C-1.  $\sqrt{gR}$     C-2.  $2\sqrt{\frac{G(M_A + M_B)}{d}}$

#### Section (D) :

D-1. 1.5%

D-2. (a)  $F = \frac{GM^2}{4R^2}$     (b)  $\sqrt{\frac{GM}{4R}}$ ;  $T = 4\pi\sqrt{\frac{R^3}{GM}}$

(c)  $\sqrt{\frac{GM}{4R^3}}$     (d)  $\frac{GM^2}{4R}$     (e)  $\sqrt{\frac{4GM}{R}}$

D-3. (a)  $\frac{U_A}{U_B} = \frac{25600}{12800} = 2$

(b)  $\frac{K_A}{K_B} = \frac{m_A}{m_B} \frac{r_B}{r_A} = 2$

(c) B is having more energy.

D-4. (a) The Saturn    (b) The Mars  
(c) The Mars

#### Section (E) :

E-1.  $9.5 \text{ m/s}^2$     E-2. 0.998 s

### PART - II

#### Section (A) :

A-1. (A)    A-2. (B)    A-3. (C)

A-4. (B)

#### Section (B) :

B-1. (B)    B-2. (D)    B-3. (D)

B-4. (D)    B-5. (C)    B-6. (D)

#### Section (C) :

C-1. (C)

C-2. (a) (D); (b) (B); (c) (B); (d) (B)

#### Section (D) :

D-1. (B)    D-2. (D)    D-3. (D)

D-4. (A)    D-5. (C)

#### Section (E) :

E-1. (A)

### PART - III

1. I    II    III

A    p    w

B    r    u

C    q    v

D    p    t

2. (A) p, r; (B) p, r; (C) q, r; (D) p, r

## EXERCISE-2

### PART - I

1. (B)    2. (A)    3. (B)

4. (D)    5. (C)    6. (C)

7. (D)    8. (A)    9. (B)

10. (D)    11. (C)    12. (C)

13. (C)    14. (D)    15. (B)

16. (A)

### PART - II

1. 02.00    2. 11.00    3. 00.00

4. 02.00    5. 01.00    6. 09.00

7. 15.00    8. 99.00    9. 40.00

10. 30.00

### PART - III

1. (AD)    2. (ACD)    3. (BC)

4. (AD)    5. (ABCD)    6. (ABC)

7. (BD)    8. (BC)    9. (ABCD)

10. (AC)    11. (BC)    12. (ACD)

### PART - IV

1. (D)    2. (B)    3. (B)

4. (C)    5. (A)    6. (A)

7. (B)    8. (C)    9. (A)

## EXERCISE-3

### PART - I

1. (A)    2. 6    3. 3

4. (B)    5. (BD)    6. (BC)

7. (B)    8. 2    9. 7

10. (BC)    11. (C)    12. (B)

13. (D)

### PART - II

1. (4)    2. (1)    3. (4)

4. (1)    5. (4)    6. (2)

7. (3)    8. (2)    9. (2)

10. (4)    11. 16    12. (4)