# Objective Problems (Level 2)

1. A rocket is launched vertical from the surface of the earth of radius $R$ with an initial speed $v$. If atmospheric resistance is neglected, the maximum height attained by the rocket is

(a) $h = \dfrac{R}{\left(\dfrac{2gR}{v^2} - 1\right)}$ (b) $h = \dfrac{R}{\left(\dfrac{2gR}{v^2} + 1\right)}$

(c) $h = \dfrac{R^2}{\left(\dfrac{2gR}{v^2} - 1\right)}$ (d) $h = \dfrac{R^2}{\left(\dfrac{2gR}{v^2} + 1\right)}$

2. Suppose the gravitational force varies inversely as the $n^{th}$ power of distance. Then the time period of a planet in circular orbit of radius $r$ around the sun will be proportional to

(a) $r^{\frac{1}{2}(n+1)}$ (b) $r^{\frac{1}{2}(n-1)}$

(c) $r^n$ (d) $r^{\frac{1}{2}(n-2)}$

3. A solid sphere of mass $M$ and radius $R$ has a spherical cavity of radius $\dfrac{R}{2}$ such that the centre of cavity is at a distance $\dfrac{R}{2}$ from the centre of the sphere. A point mass $m$ is placed inside the cavity at a distance $\dfrac{R}{4}$ from the centre of sphere. The gravitational force on mass $m$ is

(a) $\dfrac{11GMm}{R^2}$ (b) $\dfrac{14GMm}{R^2}$

(c) $\dfrac{GMm}{2R^2}$ (d) $\dfrac{GMm}{R^2}$

4. The required kinetic energy of an object of mass $m$, so that it may escape, will be

(a) $\dfrac{1}{4}mgR$ (b) $\dfrac{1}{2}mgR$

(c) $mgR$ (d) $2mgR$

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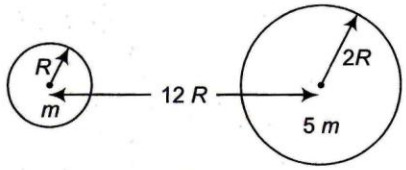
5. A body is projected vertically upwards from the surface of earth with a velocity equal to half the escape velocity. If $R$ be the radius of earth, maximum height attained by the body from the surface of earth is
(a) $\frac{R}{6}$ (b) $\frac{R}{3}$
(c) $\frac{2R}{3}$ (d) $R$

6. Pertaining to two planets, the ratio of escape velocities from respective surfaces is 1:2, the ratio of the time period of the same simple pendulum at their respective surfaces is 2:1 (in same order) Then the ratio of their average densities is
(a) 1:1 (b) 1:2 (c) 1:4 (d) 8:1

7. Four equal masses (each of mass $M$) are placed at the corners of a square of side $a$. The escape velocity of a body from the centre $O$ of the square is
(a) $4\sqrt{\frac{2GM}{a}}$ (b) $\sqrt{\frac{8\sqrt{2}GM}{a}}$
(c) $\frac{4GM}{a}$ (d) $\sqrt{\frac{4\sqrt{2}GM}{a}}$

8. 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) $\sqrt{\frac{GM}{2R}}$ (d) $\sqrt{\frac{Gm}{\sqrt{2}R}}$

9. Two spherical bodies of masses $m$ and 5 $m$ and radii $R$ and $2R$ respectively are released in free space with initial separation between their centres equal to 12 $R$. If they attract each other due to gravitational force only then the distance covered by smaller sphere just before collision will be




(a) 5 $R$ (b) 7.5 $R$ (c) 2.5 $R$ (d) 6 $R$

10. Energy of a satellite in circular orbit is $E_0$. The energy required to move the satellite to a circular orbit of 3 times the radius of the initial orbit is
(a) $\frac{2}{3}E_0$ (b) $2E_0$
(c) $\frac{E_0}{3}$ (d) $\frac{3}{2}E_0$

11. 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) $\frac{Gm(m_1 \pm m_2)(\sqrt{2}-1)}{\sqrt{2}R}$
(c) $\frac{Gm\sqrt{2}(m_1 \pm m_2)}{R}$ (d) $\frac{Gmm_1(\sqrt{2} \pm 1)}{m_2R}$

12. A person brings a mass of 1 kg infinity to a point $A$. Initially the mass was at rest but it moves at a speed of 2 m/s as it reached $A$. The work done by the person on the mass is –3 J. The potential at $A$ is
(a) – 3 J/kg (b) – 12 J/kg
(c) – 5 J/kg (d) None of these

13. A satellite is moving in a circular orbit round the earth with a diameter of orbit $2R$. At a certain point a rocket fixed to the satellite is fired such that it increases the velocity of the satellite tangentially. The resulting orbit of the satellite would be
(a) same as before
(b) circular orbit with diameter greater than 2 $R$.
(c) elliptical orbit with minimum distance from the earth equal to $R$.
(d) elliptical orbit with maximum distance from the earth equal to $R$.

14. A particle would take a time $t$ to move down a straight tube from the surface of earth (supposed to be a homogeneous sphere) to its centre. If gravity were to remain constant then the time would be $t$. The ratio of $\frac{t}{t'}$ will be
(a) $\frac{\pi}{2\sqrt{2}}$ (b) $\frac{\pi}{\sqrt{2}}$
(c) $\sqrt{2}\pi$ (d) $\frac{\pi}{\sqrt{2}}$

15. Two particles of mass $m$ and $M$ are initially at rest at infinite distance. Find their relative velocity of approach due to gravitational attraction when $d$ is their separation at any instant
(a) $\sqrt{\frac{2G(M+m)}{d}}$ (b) $\sqrt{\frac{G(M+m)}{d}}$
(c) $\sqrt{\frac{G(M+m)}{2d}}$ (d) $\sqrt{\frac{G(M+m)}{4d}}$

16. An earth satellite of mass $m$ revolves in a circular orbit at a height $h$ from the surface of the earth. $R$ is the radius of the earth and $g$ is acceleration due to gravity at the surface of the earth. The velocity of the satellite in the orbit is given by
(a) $\frac{gR^2}{R+h}$ (b) $gR$
(c) $\frac{gR}{R+h}$ (d) $\sqrt{\frac{gR^2}{R+h}}$

17. The orbital angular momentum of a satellite revolving at a distance $r$ form the centre is $L$. If the distance is increased to $16r$, then the new angular momentum will be
(a) 16 $L$ (b) 64 $L$
(c) $\frac{L}{4}$ (d) 4 $L$

18. The ratio of energy required to raise a satellite to a height $h$ above the earth surface to that required to put it into the orbit is
(a) $h:2R$ (b) $2h:R$
(c) $R:h$ (d) $h:R$

19. 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, then its velocity on reaching the surface of the earth is
(a) $\sqrt{(2gR)}$ (b) $\sqrt{(gR)}$
(c) $\sqrt{\frac{3}{2}gR}$ (d) $\sqrt{(4gR)}$

**20.** What is the energy required to launch a $m$ kg satellite from earth's surface in a circular orbit at an altitude of $2R$? ($R$ = radius of the earth)

(a) $\frac{2}{3}mgR$ (b) $mgR$

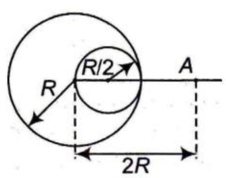
(c) $\frac{5}{6}mgR$ (d) $\frac{1}{3}mgR$

**21.** A body of supercondense material with mass twice the mass of earth but size very small compared to the size of earth starts from rest from $h << R$ above the earth's surface. It reaches earth in time

(a) $t = \sqrt{\frac{h}{g}}$ (b) $t = \sqrt{\frac{2h}{g}}$

(c) $t = \sqrt{\frac{2h}{3g}}$ (d) $t = \sqrt{\frac{4h}{3g}}$

**22.** 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 $2R$ 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) $\frac{5}{9}$ (b) $\frac{7}{8}$ (c) $\frac{3}{4}$ (d) $\frac{7}{9}$

**23.** The magnitudes of the gravitational force 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 (more than one are correct)

(a) $\frac{F_1}{F_2} = \frac{r_1}{r_2}$ if $r_1 < R$ and $r_2 < R$

(b) $\frac{F_1}{F_2} = \frac{r_1^2}{r_2^2}$ if $r_1 > R$ and $r_2 > R$

(c) $\frac{F_1}{F_2} = \frac{r_2}{r_1}$ if $r_1 < R$ and $r_2 < R$

(d) $\frac{F_1}{F_2} = \frac{r_2^2}{r_1^2}$ if $r_1 > R$ and $r_2 > R$

**24.** The escape velocity from earth is $v_e$. A body is projected with velocity $2v_e$. With what constant velocity will it move in the inter planetary space?

(a) $v_e$ (b) $\sqrt{2}v_e$ (c) $\sqrt{3}v_e$ (d) $\sqrt{5}v_e$

**25.** Suppose the gravitational attraction varies inversely as the distance from the earth. The orbital velocity of a satellite in such a case varies as $n$th power of distance, where $n$ is equal to

(a) $-1$ (b) zero

(c) $+1$ (d) $+2$

**26.** Let $E$ be the energy required to raise a satellite to height $h$ above earth's surface and $E'$ be the energy required to put the same satellite into orbit at that height. Then $\frac{E}{E'}$ is equal to

(a) $\frac{2h}{(R+2h)}$ (b) $\frac{2h}{(2R+3h)}$

(c) $\frac{R}{R+h}$ (d) $\frac{2R}{2h+R}$

**27.** Two spheres of masses $m$ and $2\,m$ are separated by distanc $d$. A particle of mass $\frac{m}{5}$ is projected straight from $2\,m$ towards $m$ with a velocity $v_0$. Which of the following statements is correct?

(a) Velocity of the particle decreases constantly

(b) Velocity of the particle increase constantly.

(c) Acceleration of the particle may become momentarily zero

(d) The particle may retrace its path depending on value of $v_0$

**28.** 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 would be ($v_e$ = escape velocity of a particle on earth's surface.)

(a) $\frac{v_e^2}{v_o}$ (b) $2v_o$

(c) $\sqrt{v_e^2 - v_o^2}$ (d) $\sqrt{v_e^2 - 2v_o^2}$

**29.** 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) $v = \sqrt{\frac{Gm}{R}}$ (b) $v = \sqrt{\frac{Gm}{2R}}$

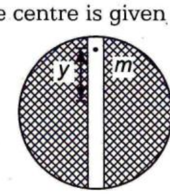
(c) $v = \frac{1}{2}\sqrt{\frac{Gm}{R}}$ (d) $v = \sqrt{\frac{4Gm}{R}}$

**30.** Four particles, each of 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) $\sqrt{2\sqrt{2}\frac{GM}{R}}$

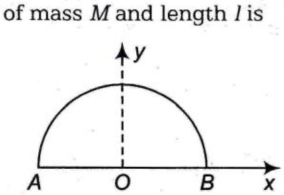
(c) $\sqrt{\frac{GM}{R}(2\sqrt{2}+1)}$ (d) $\sqrt{\frac{GM}{R}\left(\frac{2\sqrt{2}+1}{4}\right)}$

**31.** Suppose a vertical tunnel is along the diameter of earth, assumed to be a sphere of uniform mass density $\rho$. If a body of mass $m$ is thrown in this tunel, its acceleration at a distance $y$ from the centre is given by



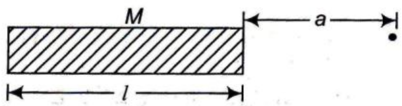

(a) $\frac{4\pi}{3}G\rho ym$ (b) $\frac{3}{4}\pi\rho y$ (c) $\frac{4}{3}\pi\rho y$ (d) $\frac{4}{3}\pi G\rho y$

**32.** Gravitational field at the centre of a semicircle formed by a thin wire $AB$ of mass $M$ and length $l$ is



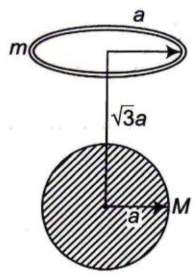
(a) $\frac{GM}{l^2}$ along x - axis (b) $\frac{GM}{\pi l^2}$ along y - axis
(c) $2\pi \frac{GM}{l^2}$ along x - axis (d) $\frac{2\pi GM}{l^2}$ along y - axis

33. A mass $m$ is at a distance $a$ from one end of a uniform rod of length $l$ and $M$. The gravitational force on the mass due to the rod is




(a) $\frac{GMm}{(a+l)}$ (b) $\frac{GmM}{a(l+a)}$
(c) $\frac{GMm}{a}$ (d) $\frac{GmM}{2(l+a)}$

34. A uniform ring of mass $m$ is lying at a distance $\sqrt{3}\,a$ form the centre of a sphere of mass $M$ just over the sphere (where $a$ is the radius of the ring as well as that of the sphere). Then magnitude of gravitational force between them is




(a) $\frac{GMm}{8a^2}$ (b) $\frac{GMm}{\sqrt{3}a^2}$
(c) $\sqrt{3}\frac{GMm}{a^2}$ (d) $\sqrt{3}\frac{GMm}{8a^2}$

35. A ring of mass $m_1$ and radius $R$ is fixed in space at some location. An external agent brings a point mass $m_2$ from infinity to centre of the ring .Work done by the external agent will be

(a) $-\frac{GM_1m_2}{R}$ (b) $\frac{GM_1m_2}{R}$
(c) $\frac{G\sqrt{m_1^2+m_2^2}}{R}$ (d) $\frac{GM_1m_2}{R(m_1^2+m_2^2)}$

36. Energy required in moving a body of mass $m$ from a distance $2R$ to $3R$ from centre of earth of mass $M$ is

(a) $\frac{GMm}{12R^2}$ (b) $\frac{GMm}{3R^2}$
(c) $\frac{GMm}{8R}$ (d) $\frac{GMm}{6R}$

37. A planet of mass $m$ moves around the sun of mass $M$ in an elliptical orbit. The maximum and minimum distance of the planet from the sun are $r_1$ and $r_2$ respectively. The time period of the planet is proportional to

(a) $r_1^{3/2}$ (b) $(r_1+r_2)^{3/2}$
(c) $(r_1-r_2)^{3/2}$ (d) $r_1^{3/2}$

38. A body attains a height equal to the radius of the earth. The velocity of the body with which it was projected is

(a) $\sqrt{\frac{GM}{R}}$ (b) $\sqrt{\frac{2GM}{R}}$
(c) $\sqrt{\frac{1}{4}\frac{GM}{R}}$ (d) $\sqrt{\frac{GM}{2R}}$

39. If the mass of moon is $\frac{M}{81}$, where $M$ is the mass of earth, find the distance of the point where gravitational field due to earth and moon cancel each other, from the centre of moon. Given that distance between centres of earth and moon is 60 $R$ where $R$ is the radius of earth

(a) 4 $R$ (b) 8 $R$ (c) 12 $R$ (d) 6 $R$

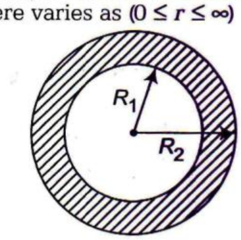
40. The minimum energy required to launch a $m$ kg satellite from earth's surface in a circular orbit at an altitude of 2 $R$ where $R$ is the radius of earth, will be

(a) $\frac{1}{6}mgR$ (b) $\frac{5}{6}mgR$
(c) $\frac{2}{3}mgR$ (d) $\frac{1}{5}mgR$

41. Three point masses each of mass $m$ rotate in a circle of radius $r$ with constant angular velocity $\omega$ due to their mutual gravitational attraction. If at any instant, the masses are on the vertex of an equilateral triangle of side $a$, then the value of $\omega$ is

(a) $\sqrt{\frac{Gm}{a^3}}$ (b) $\sqrt{\frac{3Gm}{a^3}}$
(c) $\sqrt{\frac{Gm}{3a^3}}$ (d) None of these

42. 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 a distance $r$ from the centre of sphere varies as $(0 \le r \le \infty)$

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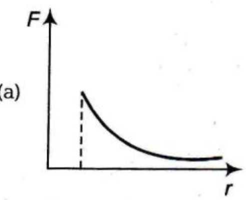


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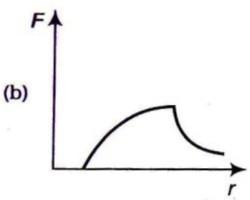


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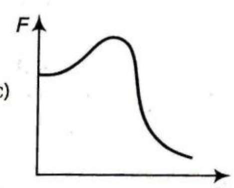


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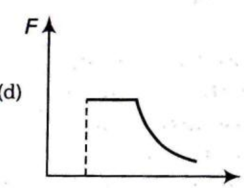


43. If an artificial satellite is moving in a circular orbit around the earth with a speed equal to half the magnitude of the escape velocity from the earth, the height of the satellite above the surface of the earth is

(a) 2 $R$ (b) $\frac{R}{2}$
(c) $R$ (d) $\frac{R}{4}$