Gravitation

1. 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]**

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

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

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]**

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

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

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 m/s^2 and 6400 km respectively. The required energy for this work will be **[AIEEE-2012]**

(1) 6.4×10^8 Joules

(2) 6.4×10^9 Joules

(3) 6.4×10^{10} Joules

(4) 6.4×10^{11} 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]**

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

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

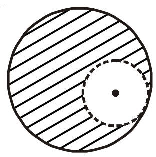
5. Four particles, each of mass M and equidistant from each other, move along a circle of radius R under the action of their mutual gravitational attraction. The speed of each particle is **[JEE (Main)-2014]**

(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 $\frac{R}{2}$ 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]**



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

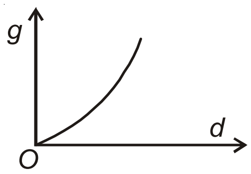
(3) $\frac{-2GM}{3R}$ (4) $\frac{-2GM}{R}$

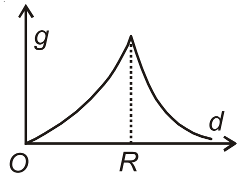
7. A satellite is revolving in a circular orbit at a height 'h' from the earth's surface (radius of earth R; $h \ll R$). The minimum increase in its orbital velocity required, so that the satellite could escape from the earth's gravitational field, is close to : (Neglect the effect of atmosphere.) **[JEE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

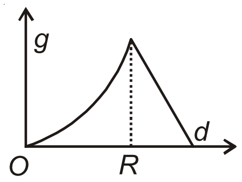
(1) $\sqrt{gR}$ (2) $\sqrt{gR/2}$

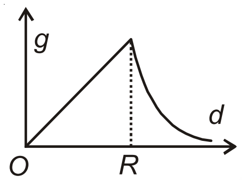
(3) $\sqrt{gR}(\sqrt{2}-1)$ (4) $\sqrt{2gR}$

8. 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]

(1) 

(2) 

(3) 

(4) 

9. If the angular momentum of a planet of mass m, moving around the Sun in a circular orbit is L, about the center of the Sun, its areal velocity is
[JEE (Main)-2019]

(1) $\frac{L}{m}$ (2) $\frac{4L}{m}$

(3) $\frac{L}{2m}$ (4) $\frac{2L}{m}$

10. The energy required to take a satellite to a height 'h' above Earth surface (radius of Earth $= 6.4 \times 10^3$ km) is E_1 and kinetic energy required for the satellite to be in a circular orbit at this height is E_2. The value of h for which E_1 and E_2 are equal, is
[JEE (Main)-2019]

(1) 3.2×10^3 km (2) 1.6×10^3 km

(3) 1.28×10^4 km (4) 6.4×10^3 km

11. A satellite is moving with a constant speed v in circular orbit around the earth. An object of mass 'm' is ejected from the satellite such that it just escapes from the gravitational pull of the earth. At the time of ejection, the kinetic energy of the object is **[JEE (Main)-2019]**

(1) $2mv^2$ (2) mv^2

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

12. Two stars of masses 3×10^{31} kg each, and at distance 2×10^{11} m rotate in a plane about their common centre of mass O. A meteorite passes through O moving perpendicular to the star's rotation plane. In order to escape from the gravitational field of this double star, the minimum speed that meteorite should have at O is

(Take Gravitational constant **[JEE (Main)-2019]**

$G = 6.67 \times 10^{-11}$ Nm^2 kg^{-2})

(1) 2.8×10^5 m/s (2) 1.4×10^5 m/s

(3) 2.4×10^4 m/s (4) 3.8×10^4 m/s

13. A satellite is revolving in a circular orbit at a height h from the earth surface, such that $h << R$ where R is the radius of the earth. Assuming that the effect of earth's atmosphere can be neglected the minimum increase in the speed required so that the satellite could escape from the gravitational field of eath is **[JEE (Main)-2019]**

(1) $\sqrt{2gR}$ (2) $\sqrt{gR}(\sqrt{2}-1)$

(3) $\sqrt{gR}$ (4) $\sqrt{\frac{gR}{2}}$

14. The mass and the diameter of a planet are three times the respective values for the Earth. The period of oscillation of a simple pendulum on the Earth is 2 s. The period of oscillation of the same pendulum on the planet would be
[JEE (Main)-2019]

(1) $\frac{2}{\sqrt{3}}$ s (2) $\frac{3}{2}$ s

(3) $\frac{\sqrt{3}}{2}$ s (4) $2\sqrt{3}$ s

15. A straight rod of length L extends from $x = a$ to $x = L + a$. The gravitational force it exerts on a point mass 'm' at $x = 0$, if the mass per unit length of the rod is $A + Bx^2$, is given by
[JEE (Main)-2019]

(1) $Gm\left[A\left(\frac{1}{a+L}-\frac{1}{a}\right)+BL\right]$

(2) $Gm\left[A\left(\frac{1}{a+L}-\frac{1}{a}\right)-BL\right]$

(3) $Gm\left[A\left(\frac{1}{a}-\frac{1}{a+L}\right)+BL\right]$

(4) $Gm\left[A\left(\frac{1}{a}-\frac{1}{a+L}\right)-BL\right]$

16. A satellite of mass M is in a circular orbit of radius R about the centre of the earth. A meteorite of the same mass, falling towards the earth, collides with the satellite completely inelastically. The speeds of the satellite and the meteorite are the same, just before the collision. The subsequent motion of the combined body will be **[JEE (Main)-2019]**

(1) Such that it escapes to infinity

(2) In a circular orbit of a different radius

(3) In an elliptical orbit

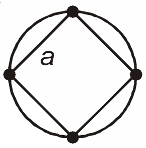
(4) In the same circular orbit of radius R

17. Two satellites, A and B, have masses m and 2 m respectively. A is in a circular orbit of radius R, and B is in a circular orbit of radius 2 R around the earth. The ratio of their kinetic energies, $\frac{T_A}{T_B}$ is **[JEE (Main)-2019]**

(1) 1 (2) $\frac{1}{2}$

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

18. Four identical particles of mass M are located at the corners of a square of side 'a'. What should be their speed if each of them revolves under the influence of others' gravitational field in a circular orbit circumscribing the square? **[JEE (Main)-2019]**



(1) $1.41\sqrt{\frac{GM}{a}}$ (2) $1.16\sqrt{\frac{GM}{a}}$

(3) $1.21\sqrt{\frac{GM}{a}}$ (4) $1.35\sqrt{\frac{GM}{a}}$

19. 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)-2019]**

(1) $\frac{E}{64}$ (2) $\frac{E}{4}$

(3) $\frac{E}{16}$ (4) $\frac{E}{32}$

20. A solid sphere of mass M and radius a is surrounded by a uniform concentric spherical shell of thickness $2a$ and mass $2M$. The gravitational field at distance $3a$ from the centre will be **[JEE (Main)-2019]**

(1) $\frac{GM}{9a^2}$ (2) $\frac{2GM}{9a^2}$

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

21. A test particle is moving in a circular orbit in the gravitational field produced by a mass density $\rho(r) = \frac{K}{r^2}$. Identify the correct relation between the radius R of the particle's orbit and its period T **[JEE (Main)-2019]**

(1) T/R is a constant

(2) TR is a constant

(3) T/R^2 is a constant

(4) T^2/R^3 is a constant

22. The value of acceleration due to gravity at Earth's surface is 9.8 ms^{-2}. The altitude above its surface at which the acceleration due to gravity decreases to 4.9 ms^{-2}, is close to : (Radius of earth = 6.4×10^6 m) **[JEE (Main)-2019]**

(1) 9.0×10^6 m (2) 6.4×10^6 m

(3) 1.6×10^6 m (4) 2.6×10^6 m

23. A spaceship orbits around a planet at a height of 20 km from its surface. Assuming that only gravitational field of the planet acts on the spaceship, what will be the number of complete revolutions made by the spaceship in 24 hours around the planet? **[JEE (Main)-2019]**

[Given: Mass of planet = 8×10^{22} kg,

Radius of planet = 2×10^6 m,

Gravitational constant $G = 6.67 \times 10^{-11}$ Nm^2/kg^2]

(1) 17 (2) 13

(3) 11 (4) 9

24. The ratio of the weights of a body on the Earth's surface to that on the surface of a planet is 9 : 4. The mass of the planet is $\frac{1}{9}$th of that of the Earth. If 'R' is the radius of the Earth, what is the radius of the planet ? (Take the planets to have the same mass density) **[JEE (Main)-2019]**

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

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

विद्या ददाति विनयम् LOCUS CLASSES

25. A stellite 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 $\frac{m}{10}$ 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)-2020]**

(1) $5m\left(u^2 - \frac{119}{200}\frac{GM}{R}\right)$

(2) $\frac{3m}{8}\left(u + \sqrt{\frac{5GM}{6R}}\right)^2$

(3) $\frac{m}{20}\left(u - \sqrt{\frac{2GM}{3R}}\right)^2$

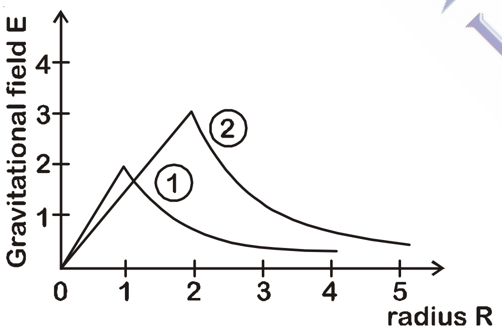
(4) $\frac{m}{20}\left(u^2 + \frac{113}{200}\frac{GM}{R}\right)$

26. A box weighs 196 N on a spring balance at the north pole. Its weight recorded on the same balance if it is shifted to the equator is close to (Take g = 10 ms^{-2} at the north pole and the radius of the earth = 6400 km) **[JEE (Main)-2020]**

(1) 194.66 N (2) 195.66 N

(3) 195.32 N (4) 194.32 N

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



[JEE (Main)-2020]

(1) $\frac{1}{6}$ (2) $\frac{1}{2}$

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

28. A body A of mass m is moving in a circular orbit of radius R about a planet. Another body B of mass $\frac{m}{2}$ collides with A with a velocity which is half $\left(\frac{\vec{v}}{2}\right)$ the instantaneous velocity $\vec{v}$ of A. The collision is completely inelastic. Then the combined body **[JEE (Main)-2020]**

(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

29. Planet A has mass M and radius R. Planet B has half the mass and half the radius of Planet A. If the escape velocities from the Planets A and B are v_A and v_B, respectively, then $\frac{v_A}{v_B} = \frac{n}{4}$. The value of n is **[JEE (Main)-2020]**

(1) 1 (2) 4

(3) 3 (4) 2

30. The mass density of a spherical galaxy varies as $\frac{K}{r}$ over a large distance 'r' from its centre. In that region, a small star is in a circular orbit of radius R. Then the period of revolution, T depends on R as **[JEE (Main)-2020]**

(1) $T^2 \propto \frac{1}{R^3}$ (2) $T^2 \propto R$

(3) $T \propto R$ (4) $T^2 \propto R^3$

31. The height 'h' at which the weight of a body will be the same as that at the same depth 'h' from the surface of the earth is (Radius of the earth is R and effect of the rotation of the earth is neglected) **[JEE (Main)-2020]**

(1) $\frac{\sqrt{5}R - R}{2}$ (2) $\frac{\sqrt{3}R - R}{2}$

(3) $\frac{R}{2}$ (4) $\frac{\sqrt{5}}{2}R - R$

32. A satellite is moving in a low nearly circular orbit around the earth. Its radius is roughly equal to that of the earth's radius R_e. By firing rockets attached to it, its speed is instantaneously increased in the direction of its motion so that it become $\sqrt{\frac{3}{2}}$ times

larger. Due to this the farthest distance from the centre of the earth that the satellite reaches is R. Value of R is **[JEE (Main)-2020]**

(1) $3R_e$ (2) $4R_e$

(3) $2.5R_e$ (4) $2R_e$

33. The mass density of a planet of radius R varies with the distance r from its centre as $\rho(r) = \rho_0\left(1 - \frac{r^2}{R^2}\right)$.

Then the gravitational field is maximum at

[JEE (Main)-2020]

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

(3) $r = \sqrt{\frac{5}{9}}R$ (4) r = R

34. On the x-axis and at a distance x from the origin, the gravitational field due to a mass distribution is given by $\frac{Ax}{(x^2 + a^2)^{3/2}}$ in the x-direction. The magnitude of gravitational potential on the x-axis at a distance x, taking its value to be zero at infinity, is **[JEE (Main)-2020]**

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

(3) $\frac{A}{(x^2 + a^2)^{1/2}}$ (4) $A(x^2 + a^2)^{1/2}$

35. A body is moving in a low circular orbit about a planet of mass M and radius R. The radius of the orbit can be taken to be R itself. Then the ratio of the speed of this body in the orbit to the escape velocity from the planet is **[JEE (Main)-2020]**

(1) 1 (2) $\sqrt{2}$

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

36. The value of the acceleration due to gravity is g_1 at a height $h = \frac{R}{2}$ (R = radius of the earth) from the surface of the earth. It is again equal to g_1 at a depth d below the surface of the earth. The ratio $\left(\frac{d}{R}\right)$ equals **[JEE (Main)-2020]**

(1) $\frac{5}{9}$ (2) $\frac{1}{3}$

(3) $\frac{7}{9}$ (4) $\frac{4}{9}$

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

[JEE (Main)-2020]

(1) $\frac{R^2\omega^2}{2g}$ (2) $\frac{R^2\omega^2}{g}$

(3) $\frac{R^2\omega^2}{8g}$ (4) $\frac{R^2\omega^2}{4g}$

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

[JEE (Main)-2020]

(1) 1 : 6 (2) 1 : 2

(3) 3 : 4 (4) 1 : 3

39. Two planets have masses M and $16M$ and their radii are a and $2a$, respectively. The separation between the centres of the planets is $10a$. A body of mass m is fired from the surface of the larger planet towards the smaller planet along the line joining their centres. For the body to be able to reach at the surface of smaller planet, the minimum firing speed needed is **[JEE (Main)-2020]**

(1) $\frac{3}{2}\sqrt{\frac{5GM}{a}}$ (2) $\sqrt{\frac{GM^2}{ma}}$

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

40. An asteroid is moving directly towards the centre of the earth. When at a distance of 10 R (R is the radius of the earth) from the earths centre, it has a speed of 12 km/s. Neglecting the effect of earths 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 km/s)? Give your answer to the nearest integer in kilometer/s _______. **[JEE (Main)-2020]**

❑ ❑ ❑

विद्या ददाति विनयं LOCUS CLASSES