# GRAVITATION

## PREVIOUS EAMCET QUESTIONS

**ENGINEERING**

1. A body is projected vertically upwards from the surface of the earth with a velocity equal to half the escape velocity. If R is the radius of the earth, maximum height attained by the body from the surface of the earth is: **(2009 E)**

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

Ans : 2

Sol: According to the law of conservation of energy,

Total energy of the body on the surface of earth = Total energy of the body at a height 'h' reached by it

$$\left(P.E+K.E\right)_{surface}=\left(P.E+K.E\right)_{\max.height}$$

$$-\frac{GMm}{R}+\frac{1}{2}m\left(\frac{Ve}{2}\right)^2$$

$$=-\frac{GMm}{R+h}+\frac{1}{2}m\left(0\right)^2 \quad ..........................(1)$$

But $V_e=\sqrt{\frac{2GM}{R}}$ ......................(2)

Sub (2) in (1) we get h = R/3

2. The orbit of geo-stationary satellite is circular, the time period of satellite depends on **(2008 E)**

1) mass of the Earth 2) radius of the orbit

3) height of the satellite from the surface of Earth 4) all the above

Ans : 4

Sol: The time period of geo-stationary satellite is $T^2=4\pi^2\frac{r^3}{GM}$

$\therefore$ Time period depends on

i) mass of earth

ii) radius of the orbit

iii) height of the satellite from the surface of earth

and is independent of mass of the satellite

3. The mass of a planet is half that of the earth and the radius of the planet is one fourth that of earth. If we plan to send an artificial satellite from the planet, the escape velocity will be, ($V_e=11kms^{-1}$) **(2007 E)**

1) $11kms^{-1}$ 2) $5.5\ kms^{-1}$ 3) $15.55\ kms^{-1}$ 4) $7.78\ kms^{-1}$

Ans: 3

Sol :

$$V_{escape}=\sqrt{\frac{2GM}{R}}$$

$$\frac{V_{planet}}{V_{earth}}=\sqrt{\frac{M_p}{M_e}\times\frac{R_e}{R_p}}$$

Given $V_{earth} = 11\ kms^{-1}$

$$M_p = \frac{M_e}{2},\ R_p = \frac{R_e}{4}$$

$$\therefore\ \frac{V_{planet}}{11} = \sqrt{\frac{M_e}{2\times M_e}\times\frac{R_e\times 4}{R_e}} \Rightarrow V_{planet} = 11\sqrt{2}\ kms^{-1} = 15.55 kms^{-1}$$

4. Assertion (A) : A particle of mass 'm' dropped into a hole made along the diameter of the earth particles is inversely proportional to the square of the distance between them from one end to the other end possesses simple harmonic motion.

Reason (R) : Gravitational force between any two **( 2006 E)**

1) Both A and R are true and R is the correct explanation of A

2) Both A and R are true and R is not the correct explanation of A

3) A is true but R is false

4) A is false but R is true

Ans: 1

Sol : A) As the particle moves along to and fro motion it executes S.H.M

B) From the relation $F = \frac{Gm_1m_2}{r^2}$ we can conclude $F \propto \frac{1}{r^2}$

5. Degenerate electron pressure will not be sufficient to prevent core collapse of white dwarf if its mass becomes 'n' times of our solar mass. Value of 'n' is **( 2005 E)**

1) 0.5 2) 0.8 3) 1 4) 1.4

Ans: 4

Sol : White dwarf = 1.4 solar mass

6. The escape velocity of a body on the earth's surface is $V_E$ A body is thrown up with a speed $\sqrt{5}V_E$. Assuming that the sun and planets do not influence the motion of the body, velocity of the body at infinite distance is **(2004 E)**

1) 0 2) $V_E$ 3) $\sqrt{2}V_E$ 4) $2V_E$

Ans: 4

Sol : From the law of conservation of energy

$(T.E)_{\text{surface of earth}} = (T.E)_{\text{infinite distance}}$

$$\left(K.E + P.E\right)_{surface} = \left(K.E + P.E\right)_{\inf inity}$$

$$\frac{1}{2}mv_e{}^2 + \left(\frac{-GMm}{R}\right) = \frac{1}{2}mv^2 + \left(\frac{-GMm}{r}\right)$$

but $r = \infty$

$$\Rightarrow \frac{1}{2}m\left(\sqrt{5}\sqrt{\frac{2GM}{R}}\right)^2 - \frac{GMm}{R} = \frac{1}{2}mv^2 + 0$$

$$\Rightarrow \frac{5GMm}{R} - \frac{GMm}{R} = \frac{1}{2}mv^2$$

$$\Rightarrow V = 2\sqrt{\frac{2Gm}{R}} = 2V_E$$

7. A satellite is launched into a circular orbit of radius "R' around the earth while a second satellite is launched into an orbit of radius 1.02 R. The percentage difference in the time periods of the two satellites is :

**(2003 E)**

1) 0.7 2) 1.0 3) 1.5 4) 3

Ans: 4

Sol : From keplers law $T^2 \propto r^3$

$\therefore$ By applying small approximation method

$$\Rightarrow 2\left(\frac{\Delta T}{T}\times 100\right) = 3\left(\frac{\Delta r}{r}\times 100\right)$$

$$\Rightarrow 2\left(\frac{\Delta T}{T}\times 100\right) = 3\left(\frac{1.02R - R}{R}\times 100\right)$$

$$\Rightarrow 2\left(\frac{\Delta T}{T}\times 100\right) = 3\times 0.02\times 100$$

$$\Rightarrow 2\left(\frac{\Delta T}{T}\times 100\right) = 3\times 2$$

$\Rightarrow \dfrac{\Delta T}{T}\times 100$ = Percentage difference in the time period = 3

8. A body is projected up with a velocity equal to 3/4 th of the escape velocity from the surface of the earth. The height it reaches is (Radius of the earth is R) **(2002 E)**

1) 10R/9 2) 7R/9 3) 9R/8 4) 10R/3

Ans: 3

Sol : From law of conservation of energy

$$(T.E)_{at\,surface} = (T.E)_{at\,height}$$

$$(K.E + P.E)_{surface} = (K.E + P.E)_{\max.height}$$

$$\frac{1}{2}mv^2 + \left(\frac{-GMm}{R}\right) = 0 + \left(\frac{-GMm}{R+h}\right)$$

but $V = \dfrac{3}{4}V_e = \dfrac{3}{4}\sqrt{\dfrac{2GM}{R}}$

$$\Rightarrow \frac{1}{2}m\times\frac{9}{16}\times\frac{2GM}{R} + \left(\frac{-GMm}{R}\right) = \frac{-GMm}{R+h}$$

$$\Rightarrow \frac{9GMm}{16R} - \frac{GMm}{R} = -\left(\frac{GMm}{R+h}\right)$$

$$\Rightarrow \frac{-7GMm}{16R} = -\left(\frac{GMm}{R+h}\right)$$

$$\Rightarrow \frac{7}{16R} = \frac{1}{R+h}$$

$$\Rightarrow 7R + 7h = 16R$$

$$\Rightarrow h = \frac{9R}{7}$$

9. Mass M is divided into two parts Xm and (1–X)m. For a given separation the value of X for which the gravitational attraction between the two pieces becomes maximum is **(2001 E)**

1) 1/2 2) 3/5 3) 1 4) 2

Ans: 1

Sol : From the Newton's law of gravitation

$$F = \frac{Gm_1m_2}{r^2}$$

$$= \frac{G(xm)(1-x)m}{r^2}$$

Substituting all the values of x we get the maximum force if $x = \frac{1}{2}$

10. R and r are the radii of the earth and moon respectively. $\rho_e$ and $\rho_m$ are the densities of earth and moon respectively. The ratio of the accelerations due to gravity on the surface of earth to moon is

1) $\frac{R}{r} = \frac{\rho_e}{\rho_m}$ 2) $\frac{r}{R} = \frac{\rho_e}{\rho_m}$ 3) $\frac{r}{R} = \frac{\rho_m}{\rho_e}$ 4) $\frac{R}{r} = \frac{\rho_m}{\rho_e}$

Ans: 1

Sol : From the relation

$$g = \frac{GM}{R^2} = \frac{G\left(4/3\pi R^3\right)\rho}{R^2}$$

[ since mass = volume × density]

$$\therefore g = \frac{4}{3}\pi RG\rho$$

$$\frac{g_e}{g_m} = \frac{R\,\rho_e}{r\,\rho_m}$$



11. The height of the point vertically above the earth's surface at which acceleration due to gravity becomes 1% of its value at the surface is : **[2000 E]**

1) 8R 2) 9R 3) 10R 4) 20R

Ans: 2

Sol : We know that $g = \frac{GM}{R^2}$ ………………………….(1)

Gravity at a height = $g_h = \frac{GM}{(R+h)^2}$ ……………(2)

Dividing (2) & (1)

$$\frac{g_h}{g} = \frac{R^2}{(R+h)^2}$$

given $\frac{g_h}{g} = 1\% = \frac{1}{100}$

$\Rightarrow \left(\frac{R+h}{R}\right)^2 = 100$

$\Rightarrow \frac{R+h}{R} = 10$

$\therefore h = 9R$

## MEDICAL

12. The acceleration due to gravity at a height 'h' above the earth's surface is $9ms^{-2}$. If g = $10^{-2}$ on the earth's surface, its value at a point at an equal distance 'h' below the surface of the earth is: **(2009 M)**

1) $9ms^{-2}$ 2) $8.5ms^{-2}$ 3) $10ms^{-2}$ 4) $9.5ms^{-2}$

Ans: 4

Sol : If h<<R

$g_h = g\left[1 - \frac{2h}{R}\right]$

$\Rightarrow 9 = 10\left[1 - \frac{2h}{R}\right]$

$\Rightarrow \frac{h}{R} = \frac{1}{20}$

At a depth 'h' below the surface of earth

$g_d = g\left[1 - \frac{h}{R}\right]$

$= 10\left[1 - \frac{1}{20}\right] = 10\left[\frac{19}{20}\right]$

= $9.5\ ms^{-2}$



13. If the Earth shrinks such that its density becomes 8 times to the present value then the new duration of the day in hours will be **( 2008 M)**

1) 24 2) 12 3) 6 4) 3

Ans:

Sol : As the mass remains constant $m_1 = m_2 \Rightarrow v_1 d_1 = v_2 d_2$

$\therefore \frac{4}{3}\pi R_1^3 d_1 = \frac{4}{3}\pi R_2^3 d_2$ volume of sphere = $\frac{4}{3}\pi R^3$

$R_1^3 d_1 = R_2^3 d_2$

But given $d_2 = 8d_1$

$\therefore R_1 = 2R_2$

According to the law of conservation of angular momentum

$I_1\omega_1 = I_2\omega_2$

$\frac{2}{5}MR_1^2 \times \frac{2\pi}{T_1} = \frac{2}{5}MR_2^2 \times \frac{2\pi}{T_2}$

$$\frac{T_2}{T_1} = \left(\frac{R_2}{R_1}\right)^2$$

$$\frac{T_2}{T_1} = \frac{1}{4}$$

$$\Rightarrow T_2 = \frac{24}{4} = 6 hours$$

14. A body of mass 'm' is raised from the surface of the earth to a height 'nR' (R -radius of earth). Magnitude of the change in the gravitational potential energy of the body is (g - acceleration due to gravity on the surface of earth) **( 2007 M)**

1) $\left(\frac{n}{n+1}\right)mgR$  2) $\left(\frac{n-1}{n}\right)mgR$  3) $\frac{mgR}{n}$  4) $\frac{mgR}{(n-1)}$

Ans: 1

Sol : gravitational potential energy on the surface of earth $-\frac{GMm}{R} = G_1$

Gravitational potential energy at a height $nR = -\frac{GMm}{R+nR} = \frac{-GMm}{R(n+1)} = G_2$

$$\Delta G = G_2 - G_1$$

$$= -\frac{GMm}{R(n+1)} - \left(-\frac{GMm}{R}\right)$$

$$= \frac{GMm}{R}\left(1 - \frac{1}{n+1}\right)$$

$$= \frac{GMm}{R}\left(\frac{n}{n+1}\right)$$

$$= mgR\left(\frac{n}{n+1}\right)$$

[ since $g = \frac{GM}{R^2}$ ]



15. How many times more, the mass of the original star is to be larger than that of the sun for the formation of 'Black Hole' ? (**2006 M)**

1) 2  2) 6  3) 8  4) 10

Ans: 4

Sol : Mass of original star = 10 (mass of black hole)

16. According to the size, identify the correct decreasing order in **(2005 M)**

a) Original star  b) Red giant  c) White Dwarf

1) a,b,c  2) b,c,a  3) c,a,b  4) b,a,c

Ans: 4

Sol : Red giant > original star > white dwarf

17. A spaceship is launched into a circular orbit of radius 'R' close to the surface of earth. The additional velocity to be imparted to the spaceship in the orbit to overcome the earth's gravitational pull is : (g = acceleration due to gravity) **(2004 M)**

1) $1.414 Rg$ 2) $1.414\sqrt{Rg}$ 3) $0.414 Rg$ 4) $0.414\sqrt{gR}$

Ans: 4

Sol : We know that $V_e = \sqrt{2}V_0$

$\therefore$ Additional velocity = $V_e - V_0$

$= \sqrt{2}V_0 - V_0$

$= V_0\left(\sqrt{2} - 1\right)$

= 0.414 $V_0$

But $V_0 = \sqrt{Rg}$

$\therefore \Delta V = 0.414\sqrt{Rg}$

18. The radius in kilometers, to which the present radius of the earth (R = 6400 km) is to be compressed so that the escape velocity is increased ten times is : **(2003 M)**

1) 6.4 2) 64 3) 640 4) 4800

Ans: 2

Sol :

$V_e = \sqrt{\frac{2GM}{R}}$ ........................(1)

$10V_e = \sqrt{\frac{2GM}{R_1}}$ ....................(2)

Dividing (1) & (2)

$\frac{1}{10} = \sqrt{\frac{R_1}{R}}$

Squaring on both sides and simplifying

$R_1 = \frac{R}{100} = 64Km$



19. Two satellites and are revolving round a planet in coplanar and concentric circular orbits of radii and in the same direction respectively. Their respective periods of revolution are 1 hr. and 8 hr. The radius of the orbit of satellite is equal to . Their relative speed when they are closest, in kmph is : **(2002 M)**

1) $\frac{\pi}{2}\times 10^4$ 2) $\pi \times 10^4$ 3) $2\pi \times 10^4$ 4) $4\pi \times 10^4$

Ans: 2

Sol : From Kepler's law

$T^2 \propto R^3$

$\therefore \left(\frac{T_2}{T_1}\right)^2 = \left(\frac{R_2}{R_1}\right)^3$

$$\left(\frac{8}{1}\right)^2 = \left(\frac{R_2}{10^4}\right)^3$$

$$\therefore R_2 = 4\times10^4 km$$

Speed of the satellite $S_1$

$$V_1 = \frac{2\pi R_1}{T_1} = 2\pi\times10^4 \text{ kmph}$$

Speed of the satellite S2

$$V_2 = \frac{2\pi R_2}{T_2} = \frac{2\pi\times4\times10^4}{8} = \pi\times10^4 \text{ kmph}$$

$$\therefore \text{Re}\,lative\,speed = V_1 - V_2 = \pi\times10^4 \text{ kmph}$$

20. When a satellite going around the earth in a circular orbit of radius r and speed v loses some of its energy , then **(2001 M)**

1) r and v both increase 2) r and v both decrease

3) r will increase and v will decrease 4) r will decrease and v will increase

Ans:4

Sol According to law of conservation of energy r will decrease and V will increase

21. The angular velocity to the earth with which it has to rotate so that acceleration due to gravity on 600 latitude becomes zero is **(2000 M)**

1) $2.5\times10^{-3}\text{rad}/\text{s}$ 2) $5\times10^{-1}\text{rad}/\text{s}$ 3) $10\times10^{3}\text{rad}/\text{s}$ 4) $7.8\times10^{-2}\text{rad}/\text{s}$

Ans :1

Sol: gravity at latitude $\phi = g_\phi$ $\therefore g_\phi = g - R\omega^2\cos^2\phi$

As $g_\phi$ is zero

$$\therefore g = R\omega^2\cos^2\phi$$

$$\therefore \omega = \sqrt{\frac{g}{R\cos^2\phi}}$$

$$= \sqrt{\frac{10}{6400\times10^3\times\frac{1}{4}}}$$

$= 2.5\times10^{-3}$ rads$^{-1}$

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