



GOVERNMENT OF KARNATAKA

DEPARTMENT OF SCHOOL EDUCATION (PRE-UNIVERSITY)

18TH CROSS, MALLESHWARAM, BENGALURU – 560 012

CHAPTER-WISE MULTIPLE-CHOICE QUESTIONS FOR COMPETITIVE EXAM

SUBJECT: PHYSICS

NAME OF THE CHAPTER: I PUC – 7. GRAVITATION

SYNOPSIS

1. Universal Law of Gravitation

➤ If m_1 and m_2 are the masses of two particles separated by a distance r as shown, then according to *Newton's Law of Gravitation*, the gravitational attraction force by m_1 on m_2 is given by

$$\vec{F}_{12} = \frac{Gm_1m_2}{r^2} \hat{r}_{12}$$

where $\hat{r}_{12}$ is the unit vector in the direction of $\vec{F}_{12}$ as shown.

Similarly, the gravitational attraction force by m_2 on m_1 is given by

$$\vec{F}_{21} = \frac{Gm_1m_2}{r^2} \hat{r}_{21}$$

where $G = 6.67 \times 10^{-11} \text{ Nm}^2.\text{kg}^{-2}$ is called the *universal gravitational constant*.

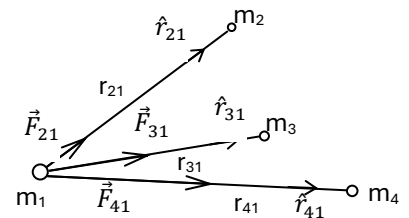
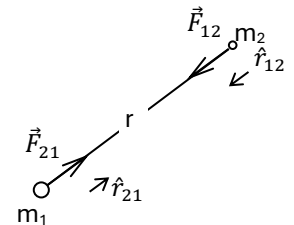
➤ The gravitational attraction force by m_1 on m_2 and force by m_2 on m_1 are action reaction pairs according to Newton's third law: That is $\vec{F}_{21} = -\vec{F}_{12}$

➤ The **total gravitational force** on a particle (say) m_1 by particles having masses $m_2, m_3, \dots$ etc is given by *superposition principle* as given below:

$$\vec{F}_{1,\text{net}} = \vec{F}_{21} + \vec{F}_{31} + \vec{F}_{41}$$

Or

$$\vec{F}_{1,\text{net}} = Gm_1 \left(\frac{m_2}{r_{21}^2} \hat{r}_{21} + \frac{m_3}{r_{31}^2} \hat{r}_{31} + \frac{m_4}{r_{41}^2} \hat{r}_{41} \right).$$



EXAMPLE 1

A particle of mass 13 kg is fixed at a point (5, 0) m. Another particle of mass 26 kg is situated at a point (0, 12) m. The gravitational force by 13 kg particle on 26 kg particle is of magnitude (G = universal gravitational constant)

- (A) G in newton (B) $2G$ in newton (C) $3G$ in newton (D) $4G$ in newton

Answer (B)

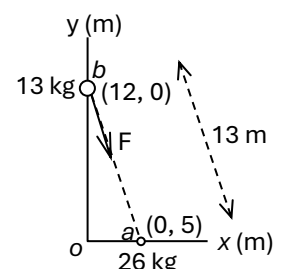
Example Solved:

The separation distance between 13 kg and 26 kg is : $r = \sqrt{oa^2 + ob^2}$

Or : $r = \sqrt{5^2 + 12^2} = 13\text{m}$

Hence according to the Univ., Law of Gravitation, : $F = \frac{Gm_1m_2}{r^2}$

Or : $F = \frac{G(13)(26)}{13^2} = 2G$



EXAMPLE 2

Four particles of masses m , $2m$, m and $2m$ are situated clockwise, at the vertices A, B, C and D respectively of a square ABCD. If the side of the square is 1 m, the total force on a particle of mass $3m$ at the center of the square is

- (A) $2Gm^2$ (B) $4Gm^2$ (C) $6Gm^2$ (D) 0

Answer (D)

Example Solved:

The force by particles of masses m on $3m$ at the center : $F = \frac{Gm \times 3m}{(1/\sqrt{2})^2} = 6Gm^2$

The force by particles of masses $2m$ on $3m$ at the center : $F' = \frac{G2m \times 3m}{(1/\sqrt{2})^2} = 12Gm^2$

Hence : $F' = 2F$

Also since forces F due to two m particles are equal and

opposite on $3m$,

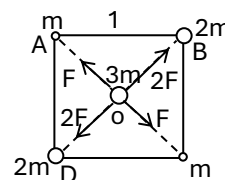
: they cancel in pairs.

For the same reason, forces $2F$

: also cancel in pairs.

The total force on $3m$ is

: $F_{\text{tot}} = 0$.



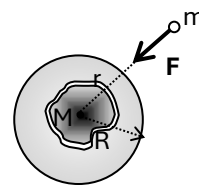
2. Shell Theorem

➤ If M is the mass of the spherical shell / spherically symmetric sphere having radius R , m is the mass of a particle outside it at a distance r from the center of the sphere ($r > R$), then the force on the particle is

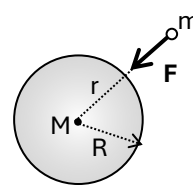
$$F = \frac{GMm}{r^2}$$

➤ This is as if the mass of the spherical shell (or sphere) is concentrated at its center.

➤ For a particle of mass m inside the spherical shell, the gravitational force experienced by it is ZERO.



Mass m outside a spherical shell



Mass m outside a symmetrical

EXAMPLE 3

A point object of mass 2 kg is placed inside a spherical shell of mass 20 kg and radius 2 m at a distance of 1 m from the center. The gravitational force on the shell due to the point object is (in terms of G)

- (A) 0 (B) 5 G in newton (C) 10 G in newton (D) 20 G in newton

Answer (D)

3. Universal Gravitational Constant

➤ Cavendish Experiment to find the universal gravitational constant:

Let m be the mass of two lead spheres connected to a light rod of length L which is suspended in the middle by a thin wire. Two fixed lead spheres having masses M each are as shown. The two smaller spheres experience attractive gravitational force and hence the horizontal rod rotates, twisting the wire by an angle θ at equilibrium.

For equilibrium,

torque due to gravitational attraction = restoring torque by the twisting of wire.

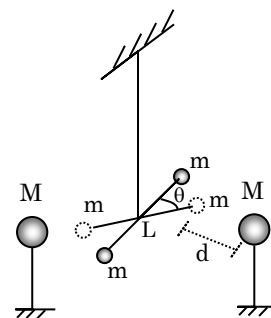
$$\Rightarrow \frac{GMm}{d^2} L = C\theta$$

Hence

$$G = \frac{C\theta d^2}{MmL}$$

where

C is the restoring torque per unit twist of the wire.



4. Acceleration due to gravity and its variation with height from the surface of a planet

➤ Let M be the mass of a spherical planet of radius R . Then the acceleration due to gravity (free fall acceleration) g_0 on its surface is given by $g_0 = \frac{GM}{R^2}$

➤ In terms of density ρ of the planet, the acceleration due to gravity can be expressed as

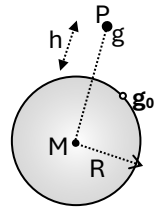
$$g_0 = \frac{4\pi G \rho R}{3}$$

➤ This acceleration due to gravity decreases with the increase of height from the surface according to

$$g = \frac{GM}{(R+h)^2} \Leftrightarrow g = \frac{g_0}{\left(1+\frac{h}{R}\right)^2}$$

➤ If the height h from the surface of the planet is very small compared with the radius of the planet, then

$$g = \frac{GM}{R^2} \left(1 - \frac{2h}{R}\right) \Leftrightarrow g = g_0 \left(1 - \frac{2h}{R}\right)$$

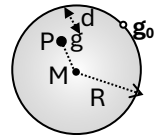


5. Variation of Acceleration due to Gravity with Depth from the Surface of a Planet

If R is the radius of a planet of mass M , the acceleration due to gravity at a depth of d from the surface of earth is given by

$$g = g_0 \left(1 - \frac{d}{R}\right)$$

where g_0 is the acceleration due to gravity on the surface of the planet.



EXAMPLE 4

The acceleration due to gravity at a height h from the surface of the moon is 0.9 m/s^2 . If the acceleration due to gravity on the surface of moon is 1.6 m/s^2 , then h is (R_M = radius of moon)

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

Answer (C)

Example Solved:

Since $g_M(h) \approx g_{0,M}$

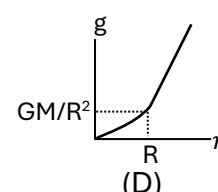
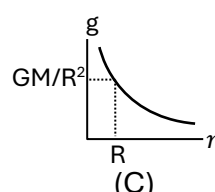
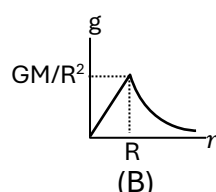
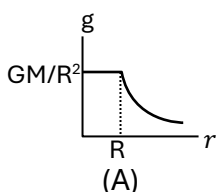
we can write $g_M(h) = \frac{g_{0,M}}{[1+(h/R_E)]^2} \Rightarrow 1.5 = \frac{1.6}{[1+(h/R_E)]^2}$

And $g_M(h) = \frac{g_{0,M}}{[1+(h/R_E)]^2} \Rightarrow$ put $x = h/R_M$

Which gives $\Rightarrow (1+x)^2 = \frac{1.6}{0.9} = \frac{16}{9} \Rightarrow 1+x = \frac{4}{3} \Rightarrow x = \frac{1}{3} \Rightarrow \frac{h}{R_M} = \frac{1}{3} \Rightarrow h = \frac{R_M}{3}$

EXAMPLE 5

The variation of acceleration due to gravity inside and outside the planet of mass M and radius R is correctly shown in (r = radial distance from the center of the planet)



Answer (C)

Example Solved:

According to equations for acceleration due to gravity, $g = \begin{cases} g_0 \left(1 - \frac{d}{R}\right) & \text{insidetheplanet} \\ \frac{g_0 R^2}{(R+h)^2} & \text{outsidetheplanet} \end{cases}$

By setting

: $R - d = r$ for inside and $R + h = r$ for outside,

we get

$$g = \begin{cases} g_0 \frac{r}{R} & \text{insidetheplanet} \\ \frac{g_0 R^2}{r^2} & \text{outsidetheplanet} \end{cases}$$

Hence inside, the acceleration due to gravity

: $g \propto r$ and

on the outside

: $g \propto \frac{1}{r^2}$

This variation is correctly shown in

: choice (B)

EXAMPLE 6

The radius of a planet X is twice that of Earth. Its density is 1.5 times that of the Earth. The acceleration due to gravity (in m/s^2) on the surface of the planet is (take acceleration due to gravity on the surface of Earth as 10 m/s^2)

(A) 10

(B) 20

(C) 30

(D) 1/30

Answer (3)

Example Solved:

The acceleration due to gravity on the surface of any planet is : $g_0 = \frac{4\pi G \rho R}{3}$

It is known that

: $R = 2 R_E$ and $\rho = 1.5 \rho_E$.

Thus

$$g_0 = \frac{4\pi G (1.5\rho)(2R_E)}{3}$$

Or

$$g_0 = 3 \times \frac{4\pi G \rho_E R_E}{3} = 3 \times g_{0,E} = 30 \text{ m/s}^2$$

EXAMPLE 7

The acceleration due to gravity of a planet at a height h ($\ll$ radius of that planet R) from its surface is equal to twice its value at a depth d from its surface. If $d - h = xR$, the value of x is

(A) 2

(B) 1

(C) 0.5

(D) 0.25

The acceleration due to gravity at a height h from the surface of a planet is : $g(h) = g_0 \left[1 - \frac{2h}{R}\right]$

The acceleration due to gravity at a depth d from the surface of a planet is : $g(d) = g_0 \left[1 - \frac{d}{R}\right]$

Since

: $g(h) = 2g(d)$,

Then

$$g_0 \left(1 - \frac{2h}{R}\right) = 2g_0 \left(1 - \frac{d}{R}\right)$$

Solving for $d - h$ we get

$$d - h = 0.5 R \Rightarrow x = 0.5$$

6. Gravitational Potential Energy of Two Point Masses

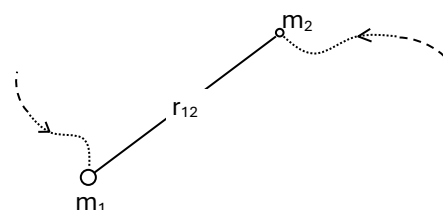
➤ If m_1 and m_2 are the two point masses separated by a distance r_{12} ,

then the gravitational PE of the masses is $U = -\frac{Gm_1 m_2}{r_{12}}$

➤ This PE is equal to the external work done to slowly bring the two point masses from infinity and assemble in place as shown.

Hence

$$W_{\text{ext}} = U = -\frac{Gm_1 m_2}{r_{12}}$$



EXAMPLE 8

Three point masses each having mass m are located at the vertices of an equilateral triangle of side a each.

The gravitational potential energy of the three point masses is

(A) $-\frac{3Gm^2}{a}$

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

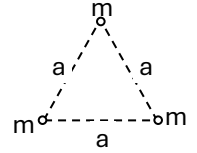
(C) $-\frac{Gm^2}{3a}$

(D) $-\frac{3Gm^2}{a^2}$

Answer (A)

Example Solved:

The gravitational PE of the three point masses is : $U = 3 \times -\frac{Gm \times m}{a} = -\frac{3Gm^2}{a}$

**7. Escape Speed:**

➤ If M is the mass of the planet, R is its radius, the escape velocity or escape speed on its surface is given by

$$v_{esc} = \sqrt{\frac{2GM}{R}} \Leftrightarrow v_{esc} = \sqrt{2g_0 R}$$

Where G is the Universal Gravitational Constant and g_0 is the acceleration due to gravity on the surface of the planet.

In terms of the density of the planet ρ we may write: $v_{esc} = 2R\sqrt{\frac{2\pi G\rho}{3}}$.

➤ When an object is launched to escape the gravitational influence of a planet of radius R and mass M , its total energy is zero : $E = 0 \Rightarrow K + U = 0$

Where K and U are the KE and PE at the point of launching the object.

EXAMPLE 9

The radius of a planet X is twice the radius of planet Y . If the escape speed on the surface of planet X is 0.5 times the escape speed on the surface of planet Y , the ratio of density of planet X to that of Y is

(A) 1

(B) 2

(C) 4

(D) 16

Answer (D)

Example Solved:

From the expression : $v_{esc} = 2R\sqrt{\frac{2\pi G\rho}{3}} \Rightarrow v_{esc} \propto R\sqrt{\rho} \Rightarrow v_{esc}^2 \propto R^2\rho \Rightarrow \rho \propto \left(\frac{v_{esc}}{R}\right)^2$

Hence : $\frac{\rho_X}{\rho_Y} = \left(\frac{v_{esc,X}}{v_{esc,Y}} \times \frac{R_Y}{R_X}\right)^2 = \left(\frac{2v_{esc,Y}}{v_{esc,Y}} \times \frac{R_Y}{0.5R_Y}\right)^2 = 16$

8. Kepler's Laws

➤ **First law:** Every planet moves around the Sun in elliptical orbit, with Sun being at one of the foci of that ellipse.

➤ **Second Law:** The areal velocity of a planet is always a constant.

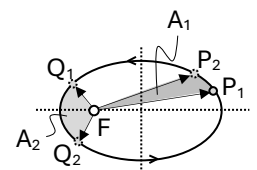
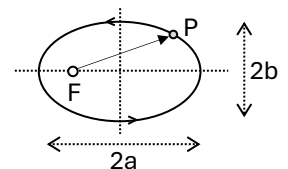
That is, the area swept by the radius vector (joining the planet to the Sun) in equal time intervals is equal.

➤ If A_1 and A_2 are the area swept by the radius vector in equal time intervals t , then

$$\frac{A_1}{t} = \frac{A_2}{t} \Rightarrow A_1 = A_2$$

➤ However, distances moved by the planet in the same time intervals

$$Q_1Q_2 > P_1P_2 \Rightarrow \frac{Q_1Q_2}{t} > \frac{P_1P_2}{t} \Rightarrow v_2 > v_1.$$



- Kepler's second law is the consequence of **conservation of angular momentum** of planet – Sun system.
- **Third Law:** The square of period of revolution of a planet is proportional to the cube of semi major axis a.

That is, $T^2 \propto a^3$.

In particular, if M is the mass of the Sun and G is the universal gravitational constant $T^2 = \frac{4\pi^2}{GM} a^3$

EXAMPLE 10

A satellite of mass m revolves around a planet of mass M in elliptical orbit of semi major and semi minor axes as a and b respectively. If T is the period of revolution of the satellite, then the area swept by the radius vector from the planet to satellite in time t is

(A) $A = \frac{\pi abmt}{MT}$ (B) $A = \frac{\pi abMt}{mT}$ (C) $A = \frac{\pi a^2 t}{T}$ (D) $A = \frac{\pi abt}{T}$

Answer (D)

Example Solved:

We know that the areal velocity of the satellite is constant : $\frac{A}{t} = \frac{\text{total area}}{\text{total time}} \Rightarrow \frac{A}{t} = \frac{\pi ab}{T} \Rightarrow A = \frac{\pi abt}{T}$

EXAMPLE 11

The radius of the orbit of planet A is four times that of planet B around the Sun. Then the period of revolution of planet A is times that of planet B.

(A) 2 (B) 4 (C) 6 (D) 8

Answer (D)

Example Solved:

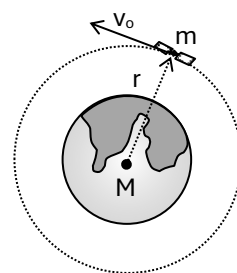
According to Kepler's third law : $T \propto R^{3/2} \Rightarrow \frac{T_A}{T_B} = \left[\frac{R_A}{R_B}\right]^{3/2} = \left[\frac{4R_B}{R_B}\right]^{3/2} = 8 \Rightarrow T_A = 8T_B$

9. Energy of Satellites their Orbital Velocity

- When a satellite of mass m revolves around a planet of mass M in a circular orbit of radius r, then the orbital velocity of the satellite is

$$v_o = \sqrt{\frac{GM}{r}}$$

where r is the orbital radius of the satellite.



- If the orbit of a satellite is very close to the planet $v_{esc} = \sqrt{2}v_o$. where

v_{esc} = escape speed of the satellite on the surface of the planet.

- The potential energy of the satellite – planet system is given by

$$U = -\frac{GMm}{r}$$

- The kinetic energy of the satellite is

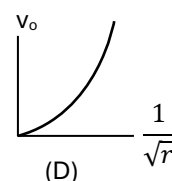
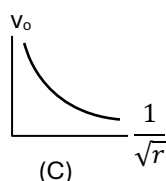
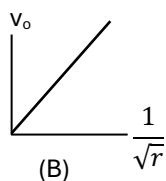
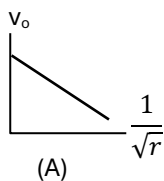
$$K = \frac{GMm}{2r}$$

- Hence the total energy of the satellite – Earth system is $E = U + K = -\frac{GMm}{2r}$.

- Hence the relation between the KE, PE and TE is : $E = U/2$ and $K = -U/2$

EXAMPLE 12

Which of the following graphs correctly shows the variation of the orbital speed v_o of a satellite around a planet with $\frac{1}{\sqrt{r}}$? (r is the orbital radius)



Answer (B)

Example Solved:

The orbital speed is given by $v_o = \sqrt{\frac{GM}{r}} \Rightarrow v_o = \sqrt{GM} \times \frac{1}{\sqrt{r}}$

Taking $\frac{1}{\sqrt{r}}$ as x and v_o as y , we have $v_o = \sqrt{GM} \times \frac{1}{\sqrt{r}} \Leftrightarrow y = kx$

Graph is a : straight line.

This type of variation is correctly shown in : choice (2)

EXAMPLE 13

The orbital velocity of a satellite of mass 500 kg around earth is 2.5 km/s. The total energy of the Earth - satellite system is nearly

(A) - 1.56 GJ

(B) + 1.56 GJ

(C) - 3.2 GJ

(D) + 3.2 GJ

Answer (A)

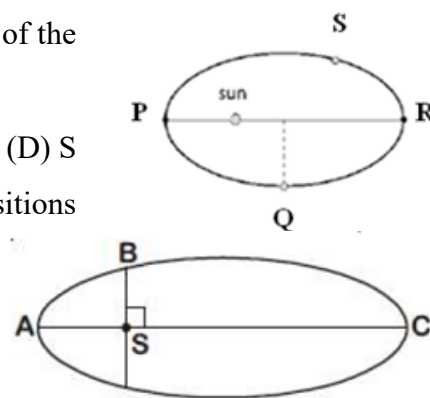
Example Solved:

The KE of the satellite is $K = \frac{1}{2} mv_o^2 = \frac{1}{2} \times 500 \times (2500)^2 = 1.56 \text{ GJ}$

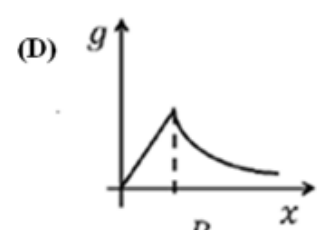
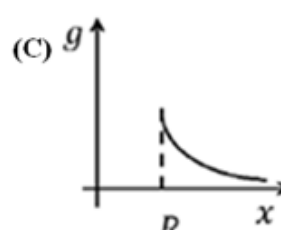
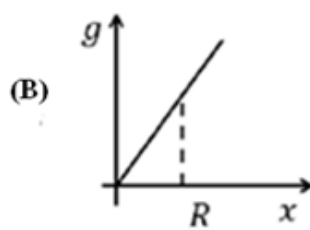
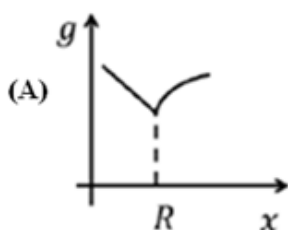
Hence the total energy of the satellite Earth system is $E = -K = -1.56 \text{ GJ}$

PRACTICE QUESTIONS – GRAVITATION

- The Kepler's laws for planetary motion are based on
 - Cavendish experiment
 - Copernicus experiment
 - Newton's experiment
 - Tycho Brahe's experiment
- Kepler's second law regarding constancy of areal velocity of a planet is a consequence of the law of conservation of:
 - energy
 - angular momentum
 - linear momentum
 - mass
- In planetary motion, the areal velocity of position vector of a planet depends on angular velocity (ω) and the distance of the planet from sun (r). If so, the correct relation for areal velocity is:
 - $\frac{dA}{dt} \propto \omega r$
 - $\frac{dA}{dt} \propto \omega^2 r$
 - $\frac{dA}{dt} \propto \omega r^2$
 - $\frac{dA}{dt} \propto \sqrt{\omega r}$
- A planet revolves round the Sun in an elliptical orbit. The linear speed of the planet will be maximum at
 - P
 - Q
 - R
 - S
- The kinetic energies of a planet in an elliptical orbit about the Sun, at positions A, B and C are K_A , K_B and K_C respectively. AC is the major axis and SB is perpendicular to AC at the position of the Sun S as shown in the figure. Then
 - $K_A > K_B > K_C$
 - $K_A < K_B < K_C$
 - $K_B < K_A < K_C$
 - $K_B < K_A < K_C$
- The gravitational force between two point masses is given by $F = k \frac{m_1 m_2}{r^2}$. The value of the constant k
 - depends on system of units only
 - depends on medium between masses only
 - depends on both (A) and (B)
 - is independent of both (A) and (B)
- There are two bodies of masses 100 kg and 10,000 kg separated by a distance 1 m. The gravitational force between the two is
 - 6.672×10^{-11} N
 - 6.672×10^{-5} N
 - 6.672×10^{-6} N
 - 6.672×10^{-4} N
- Two spheres of masses m and M are situated in air and the gravitational force between them is F . The separation between the masses is now increased to 3 times the initial value. The gravitational force will now be:
 - F
 - $\frac{F}{3}$
 - $\frac{F}{9}$
 - $3F$
- The distance between centres of the moon and earth is D . The mass of earth is 81 times the mass of the moon. At what distance from the centre of earth, the gravitational force is zero?
 - $\frac{D}{2}$
 - $\frac{2D}{3}$
 - $\frac{4D}{3}$
 - $\frac{9D}{10}$



10. Three equal masses of 4 kg each are placed at the vertices of an equilateral triangle and a mass of 8 kg is placed at the centroid of the triangle which is at a distance of 2 m from each of the vertices of the triangle. The force (in newton) acting on the mass of 8 kg is
- (A) 2 (B) $\sqrt{2}$ (C) 1 (D) zero
11. If the mass of a body is M on the surface of the earth of the mass of the same body on the surface of the moon is
- (A) zero (B) M/6 (C) M (D) 6M
12. An astronaut on a strange planet finds that acceleration due to gravity is twice as that on the surface of earth. Which of the following could explain this?
- (A) Mass of the planet is half as that of earth, but radius is same as that of earth.
 (B) Radius of the planet is half as that of earth, but the mass is the same as that of earth.
 (C) Both the mass and radius of the planet are twice as that of earth.
 (D) Both the mass and radius of the planet is half as that of earth.
13. The value of acceleration due to gravity at depth of 1600 km is equal to (Radius of earth = 6400 km)
- (A) 4.9 ms^{-2} (B) 9.8 ms^{-2} (C) 7.35 ms^{-2} (D) 19.6 ms^{-2}
14. A man weighs 80 kg on the surface of earth of radius R. At what height above the surface of earth his weight will be 40 kg?
- (A) 2 R (B) $\sqrt{2} R$ (C) $(\sqrt{2} - 1) R$ (D) $(\sqrt{2} + 1) R$
15. The acceleration due to gravity at a height 1 km above the earth is the same as at a depth d below the surface of earth. Then
- (A) d = 0.5 km (B) d = 1 km (C) d = 1.5 km (D) d = 2 km
16. If the radius of earth is reduced by 1% keeping its mass unchanged. The change in the acceleration due to gravity 'g' will be:
- (A) 2% increase (B) 1% increase (C) 2% decrease (D) 1% decrease
17. The radii of two planets are respectively R_1 and R_2 and their densities are respectively ρ_1 and ρ_2 . The ratio of the acceleration due to gravity at their surface is:
- (A) $g_1 : g_2 = (R_1 \rho_2) : (R_2 \rho_1)$ (B) $g_1 : g_2 = (\rho_1 / R_1^2) : (\rho_2 / R_2^2)$
 (C) $g_1 : g_2 = (R_1 R_2) : (\rho_1 \rho_2)$ (D) $g_1 : g_2 = (R_1 \rho_1) : (R_2 \rho_2)$
18. Variation of acceleration due to gravity (g) with distance 'x' from the centre of the earth is best represented by (R $\rightarrow$ Radius of the earth)



19. If the mass of the Sun were ten times smaller and the universal gravitational constant were ten times larger in magnitude, which of the following is not correct?
- (A) Time period of a simple pendulum on the Earth would decrease.
 (B) Walking on the ground would become more difficult.
 (C) Raindrops will fall faster.
 (D) 'g' on the Earth will not change.
20. If the earth stops rotating about its axis the value of 'g' at the equator will increase by an amount given by (R is radius of earth, ω is angular velocity of earth):
- (A) $R^2\omega$ (B) ω^2/R (C) R/ω^2 (D) $R\omega^2$
21. A mass 'm' on the surface of the earth is shifted to a height equal to the radius of the earth. If R is the radius and M is the mass of the earth, then work done in this process is
- (A) $\frac{m g R}{2}$ (B) mgR (C) $2mgR$ (D) $\frac{m g R}{4}$
22. A satellite of mass m is orbiting the earth (of radius R) at a height h from its surface. The total energy of the satellite in terms of g_0 , the value of acceleration due to gravity at the earth's surface, is
- (A) $\frac{m g_0 R^2}{2 (R+h)}$ (B) $-\frac{m g_0 R^2}{2 (R+h)}$ (C) $\frac{2m g_0 R^2}{(R+h)}$ (D) $-\frac{2m g_0 R^2}{(R+h)}$
23. The minimum energy required to launch a 'm' kg satellite from the earth's surface in a circular orbit at an altitude 2R, where R is the radius of earth is
- (A) $\frac{5}{3} m g R$ (B) $\frac{4}{3} m g R$ (C) $\frac{5}{6} m g R$ (D) $\frac{5}{4} m g R$
24. What height from the surface of earth the gravitation potential and the value of g are $-5.2 \times 10^7 \text{ J kg}^{-2}$ and 6.2 ms^{-2} respectively? Take the radius of earth as 6400 km
- (A) 2600 km (B) 1600 km (C) 1400 km (D) 2000 km
25. The earth's radius is R and acceleration due to gravity at its surface is g. If a body of mass 'm' falls from a height $h = \frac{R}{5}$ from earth's surface, its potential energy decreases by:
- (A) mgh (B) $\frac{4}{5} m g h$ (C) $\frac{5}{6} m g h$ (D) $\frac{6}{7} m g h$
26. The escape velocity from the earth's surface is 11 km/s. A certain planet has a radius twice that of the earth but its mean density is the same as that of the earth. The value of the escape velocity from this planet would be:
- (A) 22 km/s (B) 11 km/s (C) 5.5 km/s (D) 16.5 km/s
27. Given mass of the moon is $(1/81)^{\text{th}}$ of the mass of the earth and corresponding radius is $(1/4)^{\text{th}}$ of the earth. If escape velocity on earth surface is 11.2 kms^{-1} the value of same on the surface of the moon is:
- (A) 0.14 kms^{-1} (B) 0.5 kms^{-1} (C) 2.5 kms^{-1} (D) 5 kms^{-1}
28. A space station is at a height equal to the radius of the earth. If v_E is the escape velocity on the surface of the earth, the same on the space station is _____ times v_E .
- (A) $\frac{1}{\sqrt{2}}$ (B) $\frac{1}{\sqrt{3}}$ (C) $\frac{1}{2}$ (D) 14
29. The ratio of escape velocity at earth (v_e) to the escape velocity at a planet (v_p) whose radius and mean density are twice as that of earth is:
- (A) 1:2 (B) $1:2\sqrt{2}$ (C) 1:4 (D) $1:\sqrt{2}$

30. The amount of work that must be done on a body of mass m so that it escapes from the gravity of a planet of mass M and radius R is given by:
- (A) $\frac{3GMm}{4R}$ (B) $\frac{GMm}{R}$ (C) $\frac{3GMm}{2R}$ (D) $\frac{3GMm}{2R}$
31. How much energy will be necessary for making a body of 500 kg escape from the earth? ($g = 9.8 \text{ ms}^{-2}$, radius of the earth = $6.4 \times 10^6 \text{ m}$)
- (A) About $9.8 \times 10^6 \text{ J}$ (B) About $6.4 \times 10^8 \text{ J}$
(C) About $3.1 \times 10^{10} \text{ J}$ (D) About $27.4 \times 10^{12} \text{ J}$
32. Two satellites of masses m_1 and m_2 ($m_1 > m_2$) are revolving around the earth in a circular orbit of radii r_1 and r_2 ($r_1 > r_2$) respectively. Which of the following statements is true regarding their speeds v_1 and v_2 ?
- (A) $v_1 = v_2$ (B) $v_1 > v_2$ (C) $v_1 < v_2$ (D) $\frac{v_1}{r_1} = \frac{v_2}{r_2}$
33. What is a period of revolution of earth satellite? Ignore the height of satellite above the surface of earth. Given: (1) gravitational acceleration $g = 10 \text{ ms}^{-2}$ and (2) Radius of earth $R_E = 6400 \text{ km}$. Take $\pi = 3.14$
- (A) 83.73 min (B) 85 min (C) 90 min (D) 156 min
34. Two satellites A and B go around a planet P in circular orbits having radii $4R$ and R respectively. If the speed of satellite A is $3v$, the speed of the satellite B would be:
- (A) $6v$ (B) $4v/2$ (C) $3v/2$ (D) $12v$
35. The time period of an earth satellite in circular orbit is independent of:
- (A) the mass of the satellite
(B) radius of its orbit
(C) both the mass and radius of the orbit
(D) neither the mass of the satellite nor the radius of its orbit.
36. Two satellites of mass m and $9m$ are orbiting a planet in orbits of radius R . Their periods of revolution will be in the ratio of
- (A) 1:1 (B) 3:1 (C) 1:3 (D) 9:1
37. A satellite is orbiting close to the earth and has a kinetic energy K . The minimum extra kinetic energy required by it to just overcome the gravitation pull of the earth is
- (A) $\sqrt{3} K$ (B) K (C) $2\sqrt{2} K$ (D) $2K$
38. A satellite revolves very near to the earth surface. Its speed should be around
- (A) 5 kms^{-1} (B) 8 kms^{-1} (C) 2 kms^{-1} (D) 11 kms^{-1}
39. The ratio of the kinetic energy required for a satellite to escape from the earth's gravity to the kinetic energy required to be given to it so that it moves in a circular orbit just above the earth's surface is:
- (A) $\sqrt{2}$ (B) 2 (C) $2\sqrt{2}$ (D) 4
40. The time period of an artificial satellite in a circular orbit of radius R is 2 days and its orbital velocity is v_0 . If time period of another satellite in a circular orbit is 16 days then
- (A) its radius of orbit is $4R$ and orbital velocity is v_0 .
(B) its radius of orbit is $4R$ and orbital velocity is $\frac{v_0}{2}$.
(C) its radius of orbit is $2R$ and orbital velocity is v_0 .
(D) its radius of orbit is $2R$ and orbital velocity is $\frac{v_0}{2}$.

41. The earth is an approximate sphere. If the interior contained matter which is not of the same density everywhere, then on the surface of the earth, the acceleration due to gravity
- (A) will be directed towards the centre but not the same everywhere.
 - (B) will have the same value everywhere but not directed towards the centre.
 - (C) will be same everywhere in magnitude directed towards the centre.
 - (D) cannot be zero at any point.
42. As observed from earth, the sun appears to move in an approximate circular orbit. For the motion of another planet like mercury as observed from earth, this would
- (A) be similarly true.
 - (B) not be true because the force between earth and mercury is not inverse square law.
 - (C) not be true because the major gravitational force on mercury is due to sun.
 - (D) not be true because mercury is influenced by forces other than gravitational forces.
43. Different points in earth are at slightly different distances from the sun and hence experience different forces due to gravitation. For a rigid body, we know that if various forces act at various points in it, the resultant motion is as if a net force acts on the c.m. (centre of mass) causing translation and a net torque at the c.m. causing rotation around an axis through the c.m. For the earth-sun system (approximating the earth as a uniform density sphere)
- (A) the torque is zero.
 - (B) the torque causes the earth to spin.
 - (C) the rigid body result is not applicable since the earth is not even approximately a rigid body.
 - (D) the torque causes the earth to move around the sun.
44. Satellites orbiting the earth have finite life and sometimes debris of satellites fall to the earth. This is because,
- (A) the solar cells and batteries in satellites run out.
 - (B) the laws of gravitation predict a trajectory spiralling inwards.
 - (C) of viscous forces causing the speed of satellite and hence height to gradually decrease.
 - (D) of collisions with other satellites.
45. Both earth and moon are subject to the gravitational force of the sun. As observed from the sun, the orbit of the moon
- (A) will be elliptical.
 - (B) will not be strictly elliptical because the total gravitational force on it is not central.
 - (C) is not elliptical but will necessarily be a closed curve.
 - (D) deviates considerably from being elliptical due to influence of planets other than earth.
46. In our solar system, the inter-planetary region has chunks of matter (much smaller in size compared to planets) called asteroids. They
- (A) will not move around the sun since they have very small masses compared to sun.
 - (B) will move in an irregular way because of their small masses and will drift away into outer space.
 - (C) will move around the sun in closed orbits but not obey Kepler's laws.
 - (D) will move in orbits like planets and obey Kepler's laws.

47. Choose the wrong option.

- (A) Inertial mass is a measure of difficulty of accelerating a body by an external force whereas the gravitational mass is relevant in determining the gravitational force on it by an external mass.
- (B) That the gravitational mass and inertial mass are equal is an experimental result.
- (C) That the acceleration due to gravity on earth is the same for all bodies is due to the equality of gravitational mass and inertial mass.
- (D) Gravitational mass of a particle like proton can depend on the presence of neighbouring heavy objects but the inertial mass cannot.

48. Particles of masses $2M$, m and M are respectively at points A, B and C with $AB = \frac{1}{2}(BC)$. m is much-much smaller than M and at time $t = 0$, they are all at rest. At subsequent times before any collision takes place:



- (A) m will remain at rest.
- (B) m will move towards M .
- (C) m will move towards $2M$.
- (D) m will have oscillatory motion.

49. Which of the following option is correct?

- (A) Acceleration due to gravity decreases with increasing altitude.
- (B) Acceleration due to gravity increases with increasing depth (assume the earth to be a sphere of uniform density).
- (C) Acceleration due to gravity decreases with increasing latitude.
- (D) Acceleration due to gravity is independent of the mass of the earth.

50. If the law of gravitation, instead of being inverse-square law, becomes an inverse-cube law, then which of the following statement is correct?

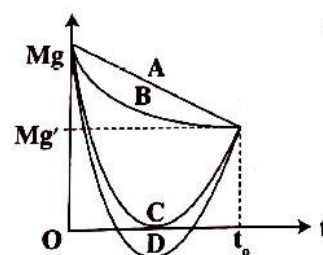
- (A) Planets will still have elliptic orbits.
- (B) Circular orbits of planets is not possible.
- (C) Projectile motion of a stone thrown by hand on the surface of the earth will be approximately parabolic.
- (D) There will be no gravitational force inside a spherical shell of uniform density.

KEY ANSWERS

1	2	3	4	5	6	7	8	9	10
D	B	C	A	A	A	B	B	D	D
11	12	13	14	15	16	17	18	19	20
C	D	C	C	D	A	D	D	D	D
21	22	23	24	25	26	27	28	29	30
A	B	C	D	C	A	C	A	B	B
31	32	33	34	35	36	37	38	39	40
C	C	A	A	A	A	B	B	B	B
41	42	43	44	45	46	47	48	49	50
D	C	A	C	B	D	D	C	A	C

PREVIOUS YEAR QUESTIONS (2020 ONWARDS)

1. The value of acceleration due to gravity at a height of 10 km from the surface of earth is x . At what depth inside the earth is the value of the acceleration due to gravity has the same value x ? (2020)
 (A) 10 km (B) 15 km (C) 5 km (D) 20 km
2. Two bodies of masses 8 kg are placed at the vertices A and B of an equilateral triangle ABC . A third body of mass 2 kg is placed at the centroid G of the triangle. If $AG = BG = CG = 1\text{ m}$, where should a fourth body of mass 4 kg be placed so that the resultant force on the 2 kg body is zero? (2021)
 (A) At C (B) At a point P on the line CG such that $PG = 1/\sqrt{2}\text{ m}$
 (C) At a point P on the line CG such that $PG = 0.5\text{ m}$
 (D) At a point P on the line CG such that $PG = 2\text{ km}$
3. When a planet revolves around the Sun, in general, for the planet: (2023)
 (A) linear momentum and aerial velocity are constant.
 (B) Kinetic and potential energy of the planet is constant.
 (C) angular momentum about the Sun and aerial velocity of the planet is constant.
 (D) linear momentum and linear velocity are constant
4. What is the value of acceleration due to gravity at a height equal to half the radius of the Earth, from its surface? (2024)
 (A) 4.4 ms^{-2} (B) 6.5 ms^{-2} (C) zero (D) 9.8 ms^{-2}
5. If r_p, v_p, L_p and r_a, v_a, L_a are radii, velocities and angular momenta of a planet at perihelion and aphelion of its elliptical orbit around the Sun respectively, then (2024)
 (A) $r_p < r_a, v_p < v_a, L_a < L_p$ (B) $r_p > r_a, v_p > v_a, L_a > L_p$
 (C) $r_p < r_a, v_p > v_a, L_a = L_p$ (D) $r_p > r_a, v_p < v_a, L_a = L_p$
6. The total energy of a satellite in a circular orbit at a distance $(R + h)$ from center of the Earth varies as [R is the radius of the Earth and h is height of the orbit from Earth's surface] (2025)
 (A) $\frac{1}{R+h}$ (B) $-\frac{1}{R+h}$ (C) $\frac{1}{(R+h)^2}$ (D) $-\frac{1}{(R+h)^2}$
7. Imagine a new planet having the same density as that of the earth, but it is two times bigger than the earth in size. If the acceleration due to gravity on the surface of the earth is g and that on the surface of the new planet is g' , then (2026)
 (A) $g' = \frac{g}{4}$ (B) $g' = 8g$ (C) $g' = 2g$ (D) $g' = 4g$
8. Suppose the acceleration due to gravity at the earth's surface is $g\text{ m/s}^2$ and at the surface of moon it is $g'\text{ m/s}^2$. An $M\text{ kg}$ passenger goes from the earth to the moon in a spaceship moving with a constant velocity (neglect all other objects in the sky). Which curve best represents the weight (net gravitational force) as a function of time? (2026)
 (A) A (B) B
 (C) C (D) D



KEY ANSWERS

1	2	3	4	5	6	7	8
D	B	C	A	C	A	C	C