QB365 Question Bank Software Study Materials

Gravitation Important 2 Marks Questions With Answers (Book Back and Creative)

11th Standard

Physics

Total Marks : 60

2 Marks

30 x 2 = 60

1) State Kepler's three laws.

Answer : **1. Law of orbits**

Each planet moves around the Sun in an elliptical orbit with the Sun at one of the foci.

2. Law of area

The radial vector (line joining the Sun to a planet) sweeps equal areas in equal intervals of time.

3. Law of period

The square of the time period of revolution of a planet around the Sun in its elliptical orbit is directly proportional to the cube of the semi major axis of the ellipse. It can be written as :

$T^2 \propto a^3$

$\frac{T^2}{a^3} = \text{constant.}$

2) State Newton's Universal law of gravitation.

Answer : Newton's law of gravitation states that a particle of mass M_1 attracts any other particle of mass M_2 in the universe with an attractive force. The strength of this force of attraction was found to be directly proportional to the product of their masses and is inversely proportional to the square of the distance between them.

$\vec{F} = -\frac{GM_1M_2}{r^2}\hat{r}$

3) Will the angular momentum of a planet be conserved? Justify your answer.

Answer : Yes, the angular momentum of a planet is conserved.

During the orbitary motion of the planets around the Sun, the line of action of gravitational force passes through the axis, the external torque is zero. Hence the angular momentum is conserved.

Torque, $\tau = \frac{dL}{dt}$

If torque is zero then angular momentum (L) is constant i.e., it is conserved.

4) Is potential energy the property of a single object? Justify.

Answer : No, potential energy is not the property of a single object. But, it is the gravitational potential energy of the system consisting of two masses m_1 and m_2 separated by a distance r, is the gravitational potential energy difference of the system when the masses are separated by an infinite distance and by distance r.

$\mathrm{U(r) = U(r) - U(\alpha)}$

$\therefore \mathrm{U(\alpha) = 0}$

5) Define gravitational potential.

Answer : The gravitational potential at a distance r due to a mass is defined as the amount of work required to bring unit mass from infinity to the distance r and it is denoted as V(r).

$\mathrm{V(r) = -\frac{Gm}{r}}$

6) Define weight.

Answer : The weight of an object is defined as the downward force whose magnitude W is equal to the upward force that must be applied to the object to hold it at rest or at constant velocity relative to the Earth.

7) Why is there no lunar eclipse and solar eclipse every month?

Answer : If the orbits of the Moon and Earth lie on the same plane, during full Moon of every month, we can observe lunar eclipse. If this is so during new Moon we can observe solar eclipse. But Moon's orbit is tilted 5^o with respect to Earth's orbit. Due to this 5^o tilt, only during certain periods of the year, the Sun, Earth and Moon align in straight line leading to either lunar

eclipse or solar eclipse depending on the alignment.

8) If the Earth's pull on the Moon suddenly disappears, what will happen to the Moon?

Answer : Moon will start to move in spiral path towards the earth and it may hit on the surface of the Earth.

9) If the Earth has no tilt, what happens to the seasons of the Earth?

Answer : If the Earth has us tilt then there would not be seasons of the Earth.

10) An unknown planet orbits the Sun with distance twice the semi-major axis distance of the Earth's orbit. If the Earth's time period is T_1, what is the time period of this unknown planet?

Answer : Let the distance of the Earth = R_E

The distance of unknown planet = R_P = 2 R_E

Let the time period of the Earth be T_1

The time period of the unknown planet be T_2

$$\text{Time period } T = 2\pi\sqrt{\frac{R_E}{g}}$$

$$T \propto \sqrt{R_E}$$

$$\therefore \frac{T_1}{T_2} = \sqrt{\frac{R_E}{R_P}} = \sqrt{\frac{R_E}{2R_E}}$$

$$\therefore \frac{T_1}{T_2} = \frac{1}{\sqrt{2}}$$

$$T_2 = \sqrt{2}T_1$$

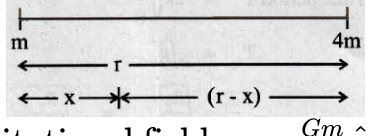
11) If the masses and mutual distance between the two objects are doubled, what is the change in the gravitational force between them?

Answer : Gravitational force F = $\frac{GM_1M_2}{r^2}\hat{r}$

Since mass and mutual distances are double there is no change in the gravitational force between them.

12) Two bodies of masses m and 4m are placed at a distance r. Calculate the gravitational potential at a point on the line joining them where the gravitational field is zero.

Answer :



$$\text{The gravitational field } = -\frac{Gm}{r^2}\hat{r}$$

$$\frac{Gm}{x^2} = \frac{G\times 4m}{(r-x)^2}$$

$$\frac{m}{x^2} = \frac{4m}{(r-x)^2}$$

$$\frac{1}{x^2} = \frac{4}{(r-x)^2}$$

$$\frac{1}{x} = \frac{2}{r-x}$$

r - x = 2x

$$r = 3x \quad \therefore x = \frac{r}{3}$$

$$\text{Gravitational potential } V = -\frac{Gm}{r} = -\frac{9Gm}{r}$$

13) The Moon I_0 orbits Jupiter once in 1.769 days. The orbital radius of the Moon I_0 is 421700 km. Calculate the mass of Jupiter?

Answer : Time period, T = 1.769 days

Orbital radius, r = 421700 x 10^3 m

$$T = 2\pi\sqrt{\frac{R^3}{GM}}$$

$$T^2 = \frac{4\pi^2\times R^3}{GM}$$

$$\therefore M = 4\pi^2 \times G \times \frac{R^3}{T^2}$$

$$T^2 \propto R^3$$

$$\frac{R^3}{T^2} = \left[\frac{421700\times 10^3}{1.769}\right]^{3/2} = \frac{(421.7\times 10^6)^3}{(1.769)^2}$$

$$= \frac{74991.3\times 10^3\times 10^{18}}{3.1293} = \frac{7499.14\times 10^{22}}{3.1293}$$

$$= 2396.4 \times 10^{22}$$

$$M = 4 \times 3.14 \times 6.67 \times 10^{-11} \times 2396.4 \times 10^{22}$$

$$= 1.898 \times 10^{27} \text{ kg}$$

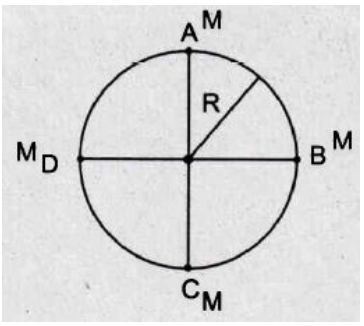
14) Four particles, each of mass M and equidistant from each other, move along a circle of radius R under the action of their mutual gravitational attraction. Calculate the speed of each particle.

Answer : The gravitational potential energy

$V = -\frac{GM^2}{R}\left[1 + \frac{4}{\sqrt{2}}\right]$

$V = -\frac{GM^2}{R}[1 + 2\sqrt{2}]$

Gravitational potential $V_o(r) = -\frac{4GM}{R}$

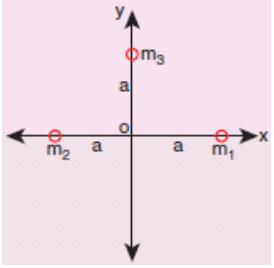


Centripetal acceleration $a = \frac{V^2}{R}$

Centripetal force $= \frac{MV^2}{R}$

$\therefore$ Speed $V = \frac{1}{2}\sqrt{\frac{GM}{R}(1 + 2\sqrt{2})}$

15) Calculate the gravitational field at point O due to three masses m_1, m_2 and m_3 whose positions are given by the following figure. If the masses m_1 and m_2 are equal what is the change in gravitational field at the point O?



Answer : From the figure, the distance of m_1 from the origin = a

From the figure, the distance of m_2 from the origin = a

Gravitational field $E = \frac{GM}{r^2}\hat{r}$

At the origin (Point O) the change in gravitational field is

$\vec{E} = \frac{GM}{a^2}\left[(m_1 - m_2)\,\hat{i} + m_3\hat{j}\right]$

It is given that

$m_1 = m_2$

$\therefore \vec{E} = \frac{GM}{a^2}\left[m_3\hat{j}\right]$

16) Calculate the change in g value in your district of Tamilnadu. (Hint: Get the latitude of your district of Tamilnadu from the Google). What is the difference in g values at Chennai and Kanyakumari?

Answer : $g_{\text{latitude'}}$ $g' = g - \omega^2 R\cos^2\lambda$

Value of latitude of g at Chennai $\simeq 13^\circ$

$\text{Cos}\,13^\circ = 0.2268\text{rad}$

$\omega = \frac{2\pi}{T} = \frac{2\pi}{24\times3600}$

$= \frac{2\pi}{86400} = \frac{2\times3.14}{86400}$

$\therefore \omega^2 R = \left(\frac{2\times3.14}{86400}\right)^2 \times \left(6400\times10^3\right)$

$= 3.4\times10^{-2}\ \text{m/s}^2$

$g_{\text{Cbeanai}} = g - \omega^2 R\cos^2\lambda$

$= 9.8 - \left(3.4\times10^{-2}\right)^2\cos(0.2268)^2$

$g_{\text{Chennai}} = 9.7677\ \text{m/s}^2$

Value of latitude at Kanyakumari

$= 8.088^\circ\text{N} = 8.08 = 8.1^\circ\text{N}$

$\omega = \frac{2\pi}{T} = \frac{2\times3.14}{86400}$

$\omega^2 R = \left(\frac{2\times3.14}{86400}\right)^2 \times \left(6400\times10^3\right)$

$= 3.4\times10^2\ \text{m/s}^2$

$g_{\text{Kanyakumari}} = g - \omega^2 R\cos^2\lambda$

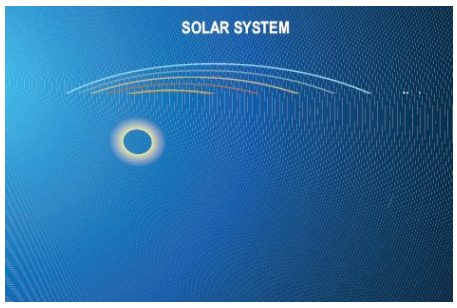
$= 9.8 - \left(3.4\times10^2\right)^2[\cos(8.1^\circ)]^2$

$g_{\text{Kanyakumari}} = 9.798\ \text{ms}^{-2}$

$\Delta g = 9.798 - 9.767 = 0.031\ \text{ms}^{-2}$

17) Qualitatively indicate the gravitational field of Sun on Mercury, Earth, and Jupiter shown in figure.

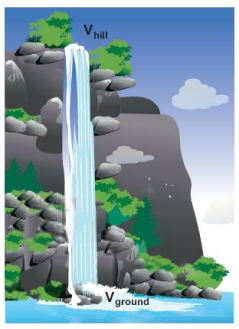
Answer : Since the gravitational field decreases as distance increases, Jupiter experiences a weak gravitational field due to the Sun. Since Mercury is the nearest to the Sun, it experiences the strongest gravitational field.



Solar System

18) Water falls from the top of a hill to the ground. Why? This is because the top of the hill is a point of higher gravitational potential than the surface of the Earth i.e. $V_{hill} > V_{ground}$

Answer : This is because the top of the hill is a point of higher gravitational potential than the surface of the Earth i.e $V_{hill} > V_{ground}$



Water falling from hill top

The motion of particles can be analyzed more easily using scalars like U(r) or V(r) than vector quantities like $\vec{F} or \vec{E}$. In modern theories of physics, the concept of potential plays a vital role.

19) Find out the value of g' in your school laboratory?

Answer : Calculate the latitude of the city or village where the school is located. The information is available in Google search. For example, the latitude of Chennai is approximately 13 degree.

$g' = g - \omega^2 R\cos^2\lambda$

Here $\omega^2 R = (2\times 3.14/86400)^2 \times (6400\times 10^3) = 3.4\times 10^{-2}$ m/s^{-2}.

It is to be noted that the value of λ. should be in radian and not in degree. 13 degree is equivalent to 0.2268 rad.

$g' = 9\ 8-(3\ 4\times 10^{-2})\times(\cos 0.2268)^2$

$g' = 9.7677$ ms^{-2}

20) Why is the energy of a satellite (or any other planet) negative?

Answer : The energy of a satellite is negative so that the satellite is bound to the Earth and it cannot escape from the Earth.

21) Why does a tennis ball bounce higher on a hall than on plains?

Answer : The value of g is less on hills because they are comparatively at a greater distance from the centre of the earth. ∴ The gravitational pull on the tennis bell is less on hill tops & so it bounces higher on hills than on plains.

22) What is the effect of rotation of the earth on the acceleration due to gravity?

Answer : The acceleration due to gravity decreases due to rotation of the earth. This effect is zero at poles & maximum at the equator.

23) By which law is the Kepler's law of areas identical? Is this Kepler's law kinematic?

Answer : (i) The law of conservation of angular momentum.
(ii) Yes,∵ Kepler's III law is. the relation between distance & time.

24) Does the change in gravitational potential energy of a body between to given points depend upon the nature of path followed why?

Answer : The change in gravitational Potential energy of a body depends only upon the position of the given points and is independent of the path followed. It is due to the fact that the gravitational force is a conservative force and work done by a conservative force depends only on the position of initial & final points and is independent of path followed.

25) If the mass of Earth is 80 times of that of a planet and diameter is double that of planet and 'g' on the Earth is 9.8 ms^{-2}. Calculate the value of 'g' on that planet?

Answer : Acceleration due to gravity $g = \frac{GM}{R^2}$

$g_p = \frac{GM_P}{R_P^2} and\ g_e = \frac{GM_e}{R_e^2}$

$\frac{g_P}{g_e} = \frac{GM_P}{R_P^2} \times \frac{R_e^2}{GM_e} = \frac{M_P}{M_e}\left(\frac{R_e}{R_P}\right)^2$

$g_p = g_e\left(\frac{M_p}{M_e}\right)\left(\frac{R_e}{R_P}\right) = 9.8\left(\frac{1}{80}\right)(2)^2 = 9.8 \times \frac{1}{20}$

gp = 0.49 ms^{-1}

26) Earth is continuously pulling Moon towards its centre, still it does not fall to the Earth. Give reason.

Answer : Gravitational force of attraction due to earth provides centripetal force that keeps the motion in orbit around the earth moreover. This gravitational force acts perpendicular to the velocity of the Moon.

27) What is the cause of retrograde motion of the planets with respect to Earth?

Answer : A combination of epicycle and circular motion around the Earth gave rise to retrograde motion of the planets with respect to Earth.

28) What is the time period of revolution of polar satellite of Earth?

Answer : It is about 100 minutes.

29) Calculate the value of escape speed of the Earth. Escape speed of the Earth is

Answer : $\mathrm{v_e} = \sqrt{2gR_E}$

$\mathrm{g} = 9.8\ \mathrm{ms^{-2}}, \mathrm{R_e} = 6400\ \mathrm{km} = 6400 \times 10^3\ \mathrm{m/s}$

$\therefore v_e = \sqrt{2 \times 9.8 \times 6400 \times 10^3} = 11.2 \times 10^3 = 11.2\ \mathrm{km\ s^{-1}}$

30) The Moon has no atmosphere. Give reason

Answer : Due to small value of 'g' on the Moon's surface its escape velocity is small (2.35 kms^{-1}). The air molecules have thermal velocities greater than the escape velocity. Hence the air molecules escape away from the atmosphere on the Moon.