STRUCTURED QUESTIONS

NEWTON'S LAW OF GRAVITATION

1. a) Why do we not feel the gravitational force of attraction from the objects around us?
b) Define Gravitational field with an example.

Ans

(a) We do feel the gravitational force or attraction from the objects around us because the gravitational constant is so small that the force between us and the objects around us is amazingly low for any noticeable effects.

(b) A gravitational field is a region in which a mass experiences a force due to gravitational attraction

Examples

- The gravitational field around the Earth and every particle of mass that moves with it.
- The force acting between the Sun and the Earth.
- The force that is responsible for the revolution of the Moon around the Earth.
- The tides that are caused in the ocean are due to the force from the Moon.
- The force that is holding all the gases in the Sun.

2. a) Write down any three characteristics of Gravitational force.
b) Define gravitational field strength.

ANS:

CHARACTERISTICS OF GRAVITATIONAL FORCE:

1. It is the weakest non-contact force in nature.
2. It obeys the inverse square law.
3. It is directly proportional to the product of the masses of the two bodies.

GRAVITATIONAL FIELD STRENGTH.

It is defined as the gravitational force per unit mass experienced by a small test mass placed in the

3. a) State and explain Newton's law of gravitation. (See notes section)
b) Define 'field force.

Ans

A field force is described with the help of a vector quantity that determines the magnitude and direction of this force in the field at any point. All the field forces are non-contact in nature. There are two fundamental field forces in nature: the Gravitational force and the Electromagnetic

4. **Determine the gravitational force of attraction between Urwa and Ayesha standing at a distance of 50m apart. The mass of Urwa is 60kg and that of Ayesha is 70kg.**

DATA

mass of Urwa $m_1 = 60\ kg$

mass of Ayesha $m_2 = 70\ kg$

dsiatance $r = 50\ m$

TO DETERMINE

gravitational force $F = ?$

FORMULA

$$F = \frac{G\, m_1 m_2}{r^2}$$

SOLUTION

$$F = \frac{6.67 \times 10^{-11} \times 60 \times 70}{(50)^2}$$

$$F = \frac{2.8014 \times 10^{-7}}{2500}$$

$$F = 1.12 \times 10^{-10}\ N$$

7. Weight of Naveera is 700N on the Earth's surface. What will be Naveera's weight at the surface of Moon?

DATA

Weight of Naveera on Earth's surface

$W_E = 700N$

TO DETERMINE

Weight of Naveera on $Mooon$

$W_M = 700N$

FORMULA

$$W = mg$$

SOLUTION

mass of Naveera on Earth's surface

$$W_E = mg$$

$$m = \frac{W_E}{g} = \frac{700}{10} = 70\ kg$$

Weight of Naveera on $Mooon$

$$W_M = mg_m$$

$$W_M = (70)(1.6) = 112\ kg$$

8. a) Your weight decreases as you go up at high altitudes, without dieting. Explain.

b) If you step on a scale and it gives reading 55kg, is that a measure of your weight. If not, then which physical quantity it shows?

Ans

(a) Yes, people do tend to weigh slightly less at higher altitudes than at sea level. This is due to decreased **gravitational force** as you move away from the Earth's center. However, the difference in weight is very small and is not usually noticeable in everyday activities.

(b) When you step on a scale and it gives a reading of 55 kg, it is important to understand the distinction between weight and mass. The scale measures the force exerted by gravity on your body, which is known as weight. However, the reading of 55 kg is measured of your mass, not your weight. Weight is the force calculated by the equation $W=mg$, where m is mass and g is the acceleration due to gravity (approximately 10 m/s^2 on Earth). Therefore, the scale reading reflects your mass,

MASS OF EARTH

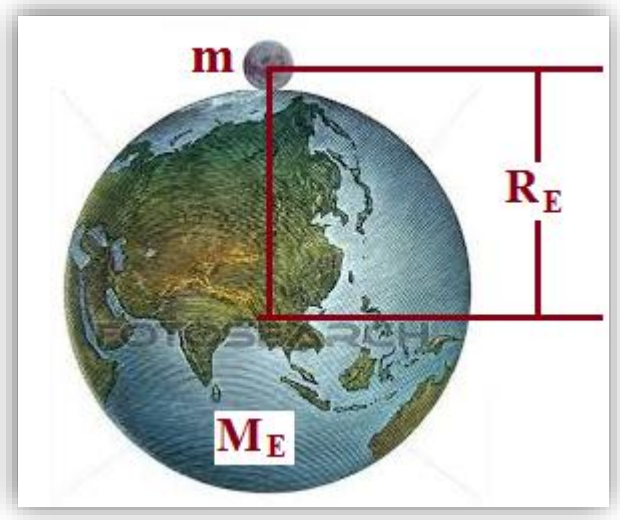
9. Calculate the mass of Earth by using Newton's law of gravitation.
(see answer in notes section)

10. If "M_E " is the mass of Earth, "R_E " radius of Earth, "G" is a universal gravitational constant, then find acceleration due to gravity "g";
i) On the surface of Earth.
ii) At the centre of Earth.

Ans **"g" on the surface of the Earth.**

According to Newton's law of universal gravitation, the gravitational force F of the Earth acting on the ball is:

$$F = G\frac{m\ Me}{R_e^2} \ \ldots\ldots\ldots (i)$$



The force with which Earth attracts the ball toward its centre is equal to the weight of the ball. Therefore

$$\mathrm{F} = \mathrm{W(weight)}$$

$$\mathrm{F} = \mathrm{m\ g} \ldots\ldots (\mathrm{ii})$$

Comparing equation (i) and (ii)

$$mg = G\frac{mM_E}{R_e^2}$$

$$g = \frac{GM_E}{R_e^2}$$

"g" AT THE CENTRE OF EARTH.

At the centre of Earth, the force due to the upper half of the Earth will cancel the force due to the lower half. Similarly, force due to any portion of the Earth at the centre will be cancelled due to the portion opposite to it. Thus, the gravitational force at the centre of any body will be 0. Since, from Newton's law, we know **F = mg**. Since the mass m of an object can never be 0. Therefore, when F=0, then g has to be 0. Thus, the value of g is zero at the centre of Earth.

11. A planet has mass four times of Earth and a radius two times that of Earth. If the value of "g" on the surface of Earth is $10ms^{-2}$. Calculate acceleration due to gravity on the planet.

Data:

$g_E = 10\ m/s^2$

$M_P = 4\ M_E$

$R_P = 2\ R_E$

To determine

$g_P = ?$

Formula

$$g_E = \frac{GM_E}{R_E^2}$$

SOLUTION:

At the surface of earth, the acceleration due to gravity is

$$g_E = \frac{GM_E}{R_E^2} - - - - - - - - - (i)$$

and at the surface of Planet,

$$g_P = \frac{GM_P}{R_P^2} - - - - - - - - (ii)$$

$M_P = 4\ M_E$

$R_P = 2\ R_E$

Putting the values in Eq (ii)

$$g_P = \frac{G \times 4M_E}{(2R_E)^2}$$

$$g_P = \frac{4}{4}\frac{G \times M_E}{R_E^2}$$

$$g_P = \frac{4}{4}\ g_E$$

$$g_P = g_E$$

12. Evaluate the acceleration due to gravity in terms of the mass of Earth " M_E ", radius of Earth "R_E " and universal gravitational constant "G":
i) At a distance twice the Earth's radius.
ii) At a distance, one-half the Earth's radius.

Data:

$g_E = 10\ m/s^2$

$g' = ?\ at\ earth's\ radius above\ earth's\ surface$

$R' = 2R_E$

$g' = ?\ at\ earth's\ radius above\ earth's\ surface$

$$R' = \frac{R_E}{2}$$

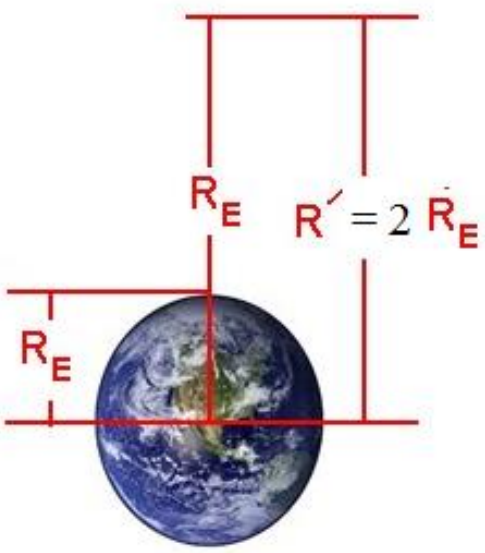
Expression of g at the surface of the earth,

$$g_E = \frac{GM_E}{R_E^2}$$

Expression of g' at the point one earth's radius above earth's surface

$$g' = \frac{GM_E}{R'^2}$$

$$g' = \frac{GM_E}{\left(\frac{R_E}{2}\right)^2}$$



SOLUTION

Expression of g at the surface of earth,

$$g_E = \frac{GM_E}{R_E^2}$$

Expression of g' at the point one-half the Earth's radius.

$$g' = \frac{GM_E}{R'^2}$$

$$g' = \frac{GM_E}{(2R_E)^2}$$

$$g' = \frac{1}{4}\left(\frac{GM_E}{R_E^2}\right)$$

$$g' = \frac{1}{4} g_E$$

$$g' = \frac{GM_E}{\left(\frac{R_2^2}{4}\right)}$$

$$g' = 4\ \frac{GM_E}{R_2^2}$$

$$g' = 4g_E$$

ARTIFICIAL SATELLITE

13. a) Calculate the speed of a satellite which orbits the Earth at an altitude of 400 kilometers above Earth's surface.
b) Write the name of any one natural satellite.

Ans (a)

Data:

$h = 400\ km$

$h = 400\ (1000) m = 400\ 000\ m$

$h = 4 \times 10^5\ m$

To determine

$v = ?$

Formula

$$v = \sqrt{\frac{G\ M}{R + h}}$$

SOLUTION:

Orbital speed is given by

$$v = \sqrt{\frac{G\ M}{R + h}}$$

$$v = \sqrt{\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{6.38 \times 10^6 + 4 \times 10^5}}$$

$$v = \sqrt{\frac{3.9886 \times 10^{14}}{6.78 \times 10^6}}$$

$$v = 7.67 \times 10^4\ m/s$$

(b) **The moon** is a natural satellite because it revolves around the Earth

14. a) Write down the names of four different types of orbits.
b) Define the terms
i) Critical Velocity.
ii) Communication Satellite.

Ans (a) : The names of four different orbits

1 Geostationary Orbit (GEO)
2 Low Earth Orbit (LEO)
3 Polar orbit (PO)
4 Sun-synchronous orbit (SSO)

Ans (b) **CRITICAL VELOCITY**

(i) The constant horizontal velocity is required to put the satellite into a stable circular orbit around the Earth.

(ii) A communications satellite is an artificial satellite that relays and amplifies radio telecommunication signals via a transponder; it creates a communication channel between a source transmitter and a receiver at different locations on Earth.

15. Derive the expression for the motion of a satellite. (see in the notes section)

$$v = \sqrt{\frac{G\,M}{R+h}}$$

16 a) Differentiate between the natural satellite and artificial satellite.
b) Name the parameters based on which orbits are characterised

Ans (a)

NATURAL SATELLITES	ARTIFICIAL SATELLITES
The planet revolves around another planet naturally is called “Natural Satellite”.	The objects that are sent into space by scientists to revolve around the Earth or other planets are called Artificial Satellite”.
Example The moon is a natural satellite because it revolves around the Earth naturally	Example Sputnik-1, Explorer-1 are amongst the artificial satellites

Ans (b)

Six key orbital parameters define a satellite's orbit: semi-major axis, eccentricity, inclination, longitude of the ascending node, argument of periapsis, and mean anomaly at epoch. These parameters uniquely identify an orbit and are known as the **Keplerian elements**.