Short Questions

5.2 What is meant by the force of gravitation?

Ans: The force of gravitation:

There exists a force due to which everybody of the universe attracts every other body. This force is called force of gravitation.

5.3 Do you attract the Earth or the Earth attracts you? Which one is attracting with a larger force? You or the Earth.

Ans: The answer of the question can be found two ways. First, we can use Newton's Third Law. If object "A" exerts a force on object "B", then object "B" will exert an equal force back on "A". This makes it pretty clear the forces are equal.

Second, we can use Newton's Law of Gravitational force. "The force that one mass exerts on second mass is proportional to the product of the two masses". This means if we calculate the force the Earth exerts on us, we multiply the Earth's mass times our mass. And if we calculate the force we exert on the Earth, we gain multiply the two masses. Other words we do the exact same calculation, so we will get the same answer.

5.4 What is a field force?

Ans: Field force:

The gravitational pull of the Earth acting on the body whether the body is in contact with the Earth or not is called field force.

5.5 Why earlier scientists could not guess about the gravitational force?

Ans: Earlier scientists could not guess the force of gravitation between two masses, because it is of very small value. it could be detected only by very sensitive instrument which were not invented at that time.

5.6 How can you say that gravitational force is a field force?

Ans: It is true that the force of gravity can be described as a force field. Any object having mass will create a gravitational attraction in all directions, with decreasing intensity as the distance from the object increases.

The weight of a body is due to the gravitational force with which the Earth attracts a body. Gravitational force is a non-contact force.

For example, the velocity of a body, thrown up, goes on decreasing while on return its velocity goes on increasing. This is due to the gravitational pull of the Earth acting on the body whether the body is in contact with the Earth or not. Such a force is called the field force. It is assumed that a gravitational field exists all around the Earth.

5.7 Explain, what is meant by gravitational field strength?

Ans: Gravitational field strength:

In the gravitational field of the Earth, the gravitational force per unit mass is called the gravitational field strength of the Earth. It is 10 Nkg^{-1} near the surface of the Earth.

The gravitational field becomes weaker and weaker as we go farther and farther away from the Earth. At any place its value is equal to the value of g at that point.

5.8 Why law of gravitation is important to us?

Ans: Importance of law of gravitation:

As universal law of gravitation is important in releasing satellites from the earth in the orbits and it also gives the reason that is why earth revolves around the sun.

The universal law of gravitation describes the phenomenon like the gravitational force between a planet and a star, rotation and revolution of heavenly bodies and galaxies.

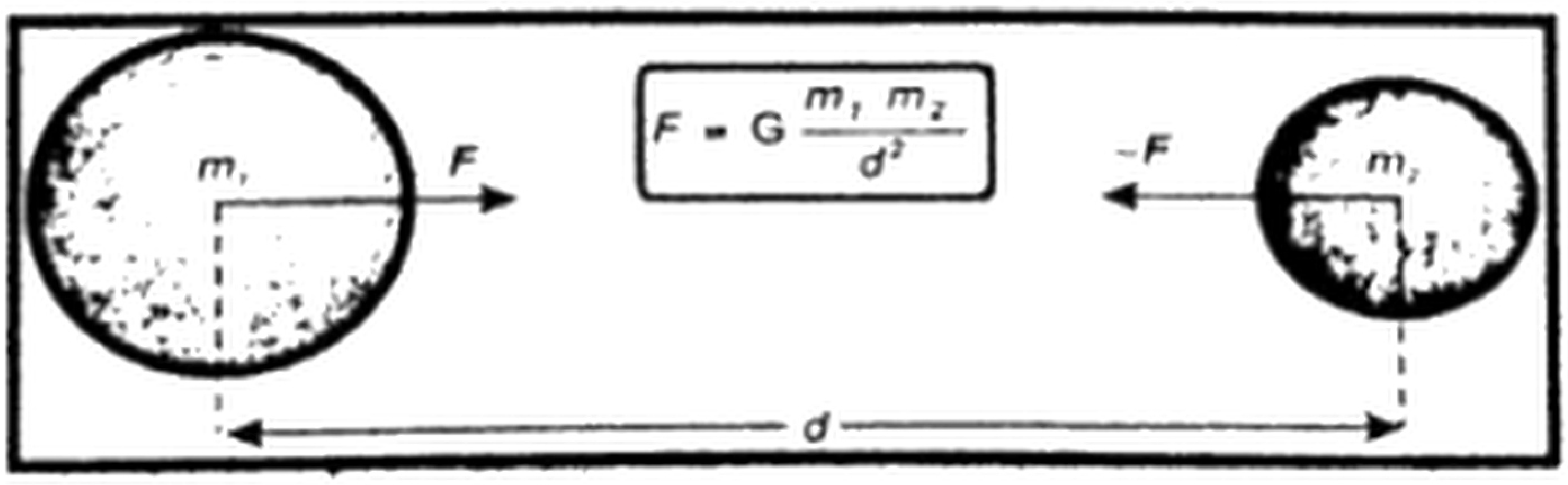
5.9 Explain the law of gravitation.

Ans: Law of gravitation:

Everybody in the universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers.

Explanation:

Consider two bodies of masses m_1 and m_2. The distance between the centers of masses is *d*.



According to the law of gravitation, the gravitational force of attraction F with which the two masses m_1 and m_2 separated by a distance d attract each other is given by:

$$F \propto m_1 m_2 \quad \ldots\ldots\ldots\ldots\ldots \quad (i)$$

$$F \propto 1/d^2 \quad \ldots\ldots\ldots\ldots\ldots \quad (ii)$$

By combining (i) and (ii) we get

$$F \propto m_1 m_2/d^2$$

or $$F = G\, m_1 m_2/d^2$$

Universal constant of gravitation (G):

Here G is the proportionality constant. It is called the universal constant of gravitation. Its value is same everywhere.

In SI units the value of G is $6.673 \times 10^{-11}\ Nm^2kg^{-2}$.

5.10 How the mass of Earth can be determined?

Ans: Mass of the earth:

Consider a body of mass *m* on the surface of the Earth. Let the mass of the Earth be M_e and radius of the Earth be *R*.

According to the law of gravitation, the gravitational force F of the Earth acting on a body is given by

$$F = G\, m\, M_e/ R^2 \quad \ldots\ldots\ldots\ldots \quad (i)$$

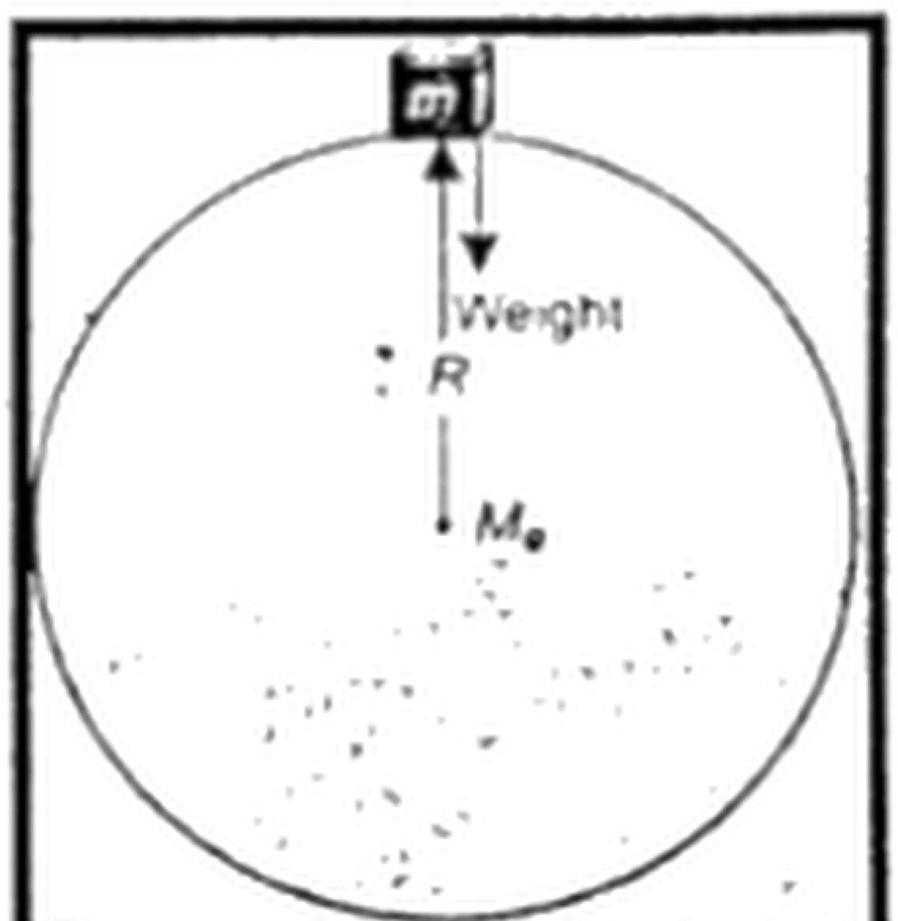


Figure: Weight of a body is equal to the gravitational force between the body and the Earth.

But the force with which Earth attracts a body towards its center is equal to its weight W.

Therefore,

$$F = W = mg$$

Or $$mg = G\, m\, M_e/ R^2$$

$$g = G M_e / R^2$$

and $$M_e = R^2 g / G$$

Mass M_e of the Earth can be determined on putting the values in equation

$$M_e = (6.4 \times 10^6 \text{ m})^2 \times 10 \text{ ms}^{-2} / 6.673 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2} = 6.0 \times 10^{24} \text{ kg}$$

Thus, the mass of the Earth is 6.0×10^{24} kg.

5.11 Can you determine the mass of our moon? If yes, then what you need to know?

Ans: Yes, we can find the mass of moon by using the law of gravitation.

$$M_m = R^2 gm / G$$

Where M_m = mass of moon

R = radius of moon

g_m = gravitational acceleration on moon

G = gravitational constant = $6.673 \times 10^{-11} \text{Nm}^2 \text{ kg}^{-2}$

5.12 Why does the value of g vary from place to place?

Ans: Variation of g with altitude:

The value of g is inversely proportional to the square of the radius of the Earth ($g \propto 1/R^2$).

But it does not remain constant. It decreases with altitude. Altitude is the height of an object or place above sea level. The value of g is greater at sea level than at the hills.

5.13 Explain how value of g varies with altitude.

Ans: Variation of g with altitude:

Equation $g = G M_e / R^2$ shows that, the value of acceleration due to gravity g depends on the radius of the Earth at its surface.

The value of g is inversely proportional to the square of the radius of the Earth ($g \propto 1/R^2$).

But it does not remain constant. It decreases with **altitude**. Altitude is the height of an object or place above sea level. The value of g is greater at sea level than at the hills.

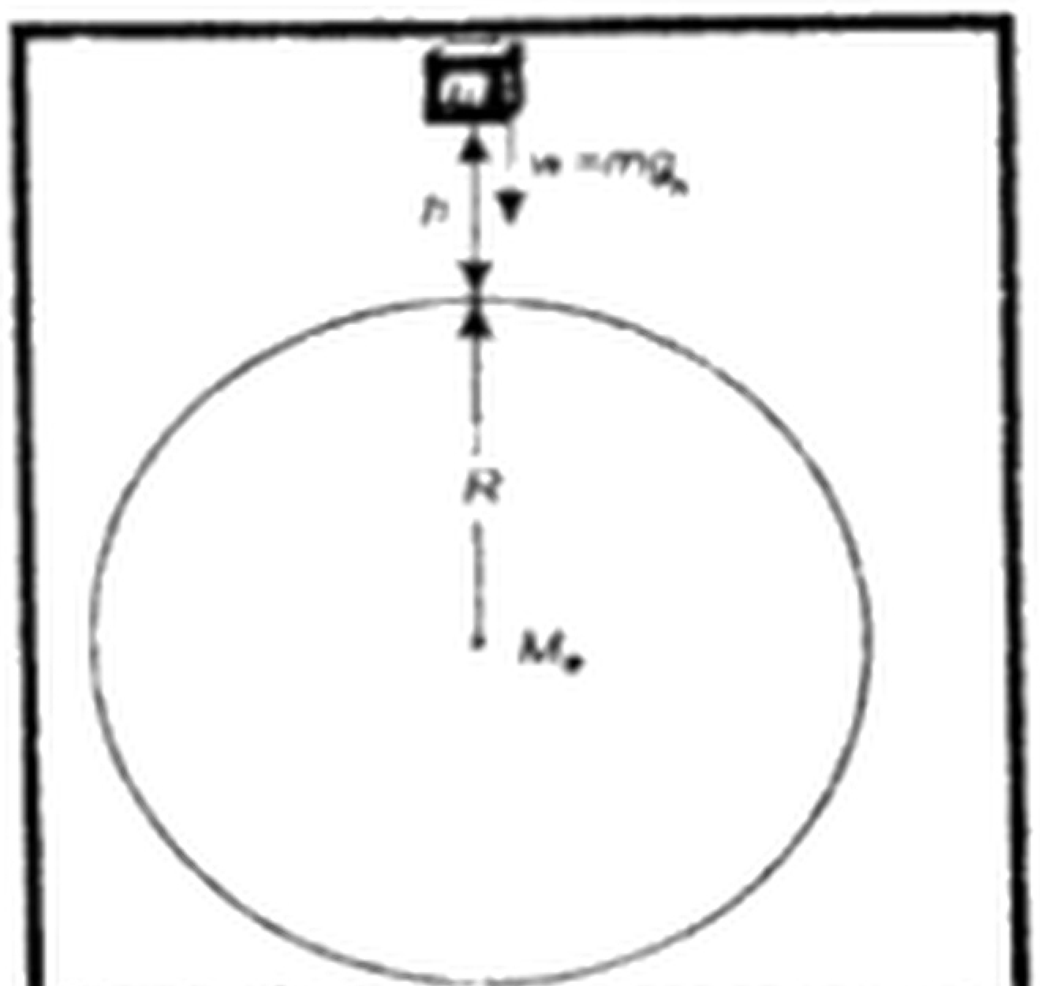
Explanation:

Consider a body of mass m at an altitude h.

The distance of the body from the center of the Earth becomes R+*h*.

Therefore, using equation ($g = G M_e / R^2$), we get

$g_h = G M_e / (R+h)^2$ .... (i)



Weight of a body decreases as its height increases from the surface of the Earth

Note:

According to the above equation, we come to know that at a height equal to one Earth radius above the surface of the Earth, g becomes one fourth (1/4) of its value on the Earth.

Similarly, at a distance of two Earths radius above the Earth's surface, the value of g becomes one ninth (1/9) of its value on the Earth.

5.14 What are artificial satellites?

Ans: Satellites:

An object that revolves around a planet is called a satellite. The moon revolves around the Earth so moon is a natural satellite of the Earth.

Artificial Satellites:

Scientists have sent many objects into space. Some of these objects revolve around the Earth. These are called artificial satellites.

Uses of Artificial Satellites:

Most of the artificial satellites orbiting around the Earth are used for communication purposes. Artificial satellites carry instruments or passengers to perform experiment in space.

A satellite is orbiting around the Earth at a height h above the surface of the Earth.

Communication satellites take 24 hours to complete their one revolution around the Earth.

5.15 How Newton's law of gravitation helps in understanding the motion of satellites?

Ans: Motion of Artificial Satellites:

A satellite requires centripetal force that keeps it to move around the Earth. The gravitational force of attraction between the satellite and the earth provides the necessary centripetal force.

Consider a satellite of mass m revolving around the Earth at an altitude h in an orbit of radius r_o with velocity v_o. The necessary centripetal force required is given by equation

$$F_c = m\, v_o^2 / r_o \quad \text{........} \quad \text{(i)}$$

This force is provided by the gravitational force of attraction between the Earth and the satellite and is equal to the weight of the satellite w' (mg_h). Thus

$$F_c = w' = mg_h \quad \text{........} \quad \text{(ii)}$$

From (i) and (ii) we get

$$mg_h = m\, v_o^2 / r_o$$

or $$v_o^2 = g_h r_o$$

or $$v_o = \sqrt{g_h r_o} \qquad \text{(iii)}$$

As $$r_o = R + h$$

$$v_o = \sqrt{g_h (R + h)} \qquad \text{(iv)}$$

Equation (iii) gives us the velocity, which a satellite must possess when launched in an orbit of radius $r_o = (R + h)$ around the Earth.

An approximation can be made for a satellite revolving close to the Earth such that R >> h.

$$R + h \approx R$$

And $$g_h \approx g$$

$$v_o = \sqrt{g R} \quad \text{........} \quad \text{(v)}$$

A satellite revolving around very close to the Earth, has speed v_o nearly 8 kms^{-1} or 29000 kmh^{-1}.

5.16 On what factors the orbital speed of a satellite depends?

Ans: Since orbital speed = $v_o = \sqrt{g_h (R + h)}$

Formula shows that orbital speed of a satellite depends upon g, R and h.

The orbital velocity of the satellite depends on its altitude above Earth. The nearer the Earth, the faster the required orbital velocity.

5.17 Why communication satellites are stationed at geostationary orbits?

Ans: Communication satellites and weather satellites are often given geostationary orbits, so that the satellite antennas that communicate with them do not have to move to track them, but can be pointed permanently at the position in the sky where they stay. A geostationary orbit is a particular type of geosynchronous orbit.