9th Physics

Chapter 5 Gravitation

Conceptual Questions

1. Newton's law of gravitation suggests that gravitational force acts between any two material objects. Then why two chairs in your room do not attract each other due to this force?

Because the gravitational force between the two chairs is extremely small as compared to their weights, so they are not attracted towards each other.

Explanation: Since the gravitational force between any two objects is

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

In order to be able to notice the gravitational force of attraction between any two objects, at least one of the objects on the earth should have an extremely large mass. Since no object on the earth have an extremely large mass, we cannot notice such forces. The two objects in a room do not move towards each other due to their small masses, which leads to a very small gravitational force.

<u>Example</u>: Say two chairs of mass 10 kg each are separated by 1 m. The force of gravitation between them is

$$F = G\frac{m_1 m_2}{d^2} = \frac{6.673 \times 10^{-11} \times 10 \times 10}{1}$$

$$= 6.673 \times 10^{-9} = 0.000000006673\ N$$

This force is very small, we can say that the force is not enough. So two chairs do not attract each other.

2. Why "G" is called universal gravitational Constant?

"G" is called universal Constant because its value is same for every pair of bodies and everywhere in the universe.

Explanation:

The value of "G" does not depend on the nature and size of bodies. It also does not depend on the nature of the medium between the two bodies. Its value throughout the universe is constant and is $6.673 \times 10^{-11}\ Nm^2/kg^2$.

That is why G is same for any two bodies and is called universal gravitational constant.

3. Why is it difficult to measure value of "G"?

It is difficult to measure the value of G.

Reason:

(i) The value of G is extremely small i.e $6.67 \times 10^{-11}\ Nm^2 kg^{-2}$.

(ii) Since the gravitational force between masses on the earth is very small, therefore it is very difficult to measure the value of G.

$$G = \frac{F \times d^2}{m_1 m_2} \qquad \because F = G\frac{m_1 m_2}{d^2}$$

So without knowing the value of F, we cannot find the value of G.

4. Where will your weight be greater, at Murree hills or at Karachi? Where will your mass be greater?

→ My weight at Karachi will be greater than my weight at Murree hills.

→ My mass will remain Same at all the places.

Explanation:

→ As we Know that

$$W = mg \Rightarrow W \propto g$$

Weight of the body depends upon the value of gravitational acceleration g which changes with altitude. As the distance from the Earth increases, the value of g decreases. Therefore, my weight at Karachi will be greater as it is at Sea level and at Murree it will be Smaller as it is at high altitude.

→ My mass will remain Same, it does not change with change of place. It remain Same at all the places.

5. If a man travels from North Pole to equator, what will be effect on his weight during this trip?

Weight of the man will be greater at the North Pole and will gradually decrease when he travels to the equator.

Explanation: As we Know

$$W = mg \Rightarrow W \propto g$$

Since the poles are near to the Center of the of the Earth as Compared to the equator, therefore, at the poles the value of g is greater than at the equator. That's why the weight of the man will be greater at the North Pole and will gradually decrease as he moves towards the equator.

6. Earth and an apple on a tree attract each other by the force of gravity. The apple falls on Earth but why the earth does not move towards apple?

Earth and an apple on a tree attract each other by the force of gravity. The apple falls on Earth but the earth does not move towards apple because mass of Earth is very large as Compared to apple.

<u>Explanation</u>: From Newton's 2nd Law of motion

$$F = ma \Rightarrow \frac{F}{m} = a \Rightarrow a = \frac{F}{m} \Rightarrow a \propto \frac{1}{m}$$

As acceleration is inversely proportional to mass i.e greater the mass of the body, Smaller will be acceleration produced in it and vice versa. As Earth's mass being extremely large as Compared to apple, it has negligible acceleration towards the apple, So, the apple moves towards the earth and not the earth towards the apple.

7. The mass of moon is 100 times less than the mass of earth and the radius of moon is 4 times less than the radius of earth. Show that value of g is 6 times less than value of g on earth?

<u>Data</u>:

$$M_m = \frac{M_e}{100}$$

$$R_m = \frac{R_e}{4}$$

To Prove:

$$g_m = \frac{g_e}{6}$$

Solution:

$$F = W = G\frac{mM_e}{R_e^2} \Rightarrow mg_e = G\frac{mM_e}{R_e^2} \Rightarrow g_e = G\frac{M_e}{R_e^2}$$

Value of g on Surface of Moon: $g_m = G\frac{M_m}{R_m^2}$

$$g_m = G\frac{M_m}{R_m^2}$$

$$= G\frac{\frac{M_e}{100}}{\left(\frac{R_e}{4}\right)^2}$$

$$= G\frac{M_e}{100} \div \frac{R_e^2}{16}$$

$$= G\frac{M_e}{100} \times \frac{16}{R_e^2}$$

$$= \frac{16}{100} G\frac{M_e}{R_e^2}$$

$$= \frac{1}{6.25} g_e \qquad \because g_e = G\frac{M_e}{R_e^2}$$

$$\boxed{g_m = \frac{g_e}{6}}$$

So gravitational acceleration on the Surface of Moon is almost 6 times less than the gravitational acceleration on the Surface of Earth.

8. If mass and radius of earth becomes double then what will be effect on the value of g on the Surface of the earth?

As we Know that

$$g_e = G\frac{M_e}{R_e^2} \quad \text{---} (1)$$

If mass and radius of earth becomes, then equation (1) becomes

$$g_e' = G\frac{2M_e}{(2R_e)^2}$$

$$= \frac{2 G M_e}{4R_e^2}$$

$$= \frac{1}{2} G \frac{M_e}{R_e^2}$$

$$\boxed{g_e' = \frac{1}{2} g_e} \qquad \because g_e = G\frac{M_e}{R_e^2}$$

So, if mass and radius of earth becomes double then the value of g reduces to half.

9. Artificial Satellites do not have engines like Cars then how can they keep on moving around the earth?

Artificial Satellites do not have engines like Cars but they keep on moving around the earth.

Explanation:

We know that Centripetal force keeps a body to move in a Circle.

$$F_c = \frac{mv^2}{r}$$

This Centripetal force is provided to Satellite by the gravitational force of Earth.

$$F_g = F_c$$

In Simple words, a Satellite rotates around the earth by using earth's gravitational force as Centripetal force.

→ Also as there is no air in space, it does not have to work against air resistance. Hence it doesn't lose any energy while rotating.

10. The orbital speed of a Satellite orbiting very close to earth (at negligible height) is "V_0". What will be the orbital speed of another Satellite revolving at a height equal to the radius of earth (in term of orbital speed of close orbiting Satellite).

$$V_0 = \sqrt{\frac{GM_e}{R_e + h}} \quad \text{——— ①}$$

Orbital speed of a Satellite orbiting very close to earth

① becomes $V_0 = \sqrt{\frac{GM_e}{R_e}}$ ∵ negligible height

Now if the Satellite is launched at a height equal to the radius of the earth, then orbital speed of the Satellite will be

① becomes $V_0' = \sqrt{\frac{GM_e}{R_e + R_e}}$ ∵ $h = R_e$

$$= \sqrt{\frac{GM_e}{2R_e}}$$

$$V_o' = \frac{1}{\sqrt{2}}\sqrt{\frac{GM_e}{R_e}}$$

$$= \frac{1}{1.414} V_o \quad \because V_o = \sqrt{\frac{GM_e}{R_e}}$$

$$= \frac{V_o}{1.414}$$

Thus, the orbital speed of the satellite will be 1.414 times less than the speed at the earth's surface.

For understanding:

$\frac{1}{\sqrt{2}} V_o$

$\frac{1}{1.414} V_o$	$0.707\, V_o$
Suppose $V_o = 5$	$V_o = 5$
$\frac{1}{1.414} \times 5$	$= 0.707 \times 5$
$= 3.53$	$= 3.53$

$$\text{difference} = 5 - 3.53$$

$$= 1.4$$