GRAVITATION

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Q:5.2:

What is meant by force of gravitation?

Ans:

In the universe, there exists of force between the body to which everybody of the universe attracts every other body this force is known as force of gravitation.

Q:5.3:

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

Ans:

We attract the Earth and Earth attracts us but Earth attracts us with larger force because the mass of the Earth is large as compared to us.

Q:5.4:

What is a field force?

Ans:

The force that acts on a body with in certain region when the body is in contact or not is called field force. Gravitational force is a non-contact force, it acts on the body whether the body is in contact with the earth or not so it is a field force.

Q:5.5:

Why earlier scientists could not gas about the gravitational force?

Ans:

The earlier scientists could not guess about the gravitational force due to lack of observations, sensitive instruments, and lack of knowledge. Also, It is very weak force and its pressure cannot be detected until mass of one body in much greater than mass of other body.

Q:5.6:

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

Ans:

The force that acts on a body with in certain region whether the body is in contact or not is called field force. The gravitational force exists around the earth and his acting on the body is whether the bodies are in contact with the earth or not. So, we can say that gravitational force is a field force i.e. Gravitational force is non-contact force.

Q:5.7:

Explain what is meant by gravitational field strength:

Ans:

''In the gravitational field of the earth, the gravitational is called gravitational field strength of the earth. At any place its value is equal to the value of g at that point''

Q:5.8:

Why law of gravitation is important to us ?

Ans:
Love gravitation is important to us because it is used to:
- Calculate force of attraction between two masses.
- Calculate the mass of earth.
- Understand the working of satellites etc.

Q:5.9:
Explain the law of gravitation?
Ans:
In the universe, they are exists of force between the body is due to which everybody of the universe attracts every other body. This force is known as force of gravitation. According to Newton's Law of gravitation:
" Everybody in the universe attracts every other body without force which is directly proportional to the product of their message and inversely proportional to the square of the distance between their centres."

Q:5.10:
How the mass of Earth can be determined?
Ans:
Consider a body of mass M is placed on the surface of the earth. Let mass of the Earth is ME and radius of earth be R. The distance between the body and centre of the Earth is equal to the radius of the Earth R.

According to the law of gravitation, the gravitational force of the earth acting on the body is given by,

$$F = G \times mM_e / R^2$$

We know that the force of gravitation with which Earth attracts the body toward its Centre is equal to the weight of the body.
Therefore,

$$F = w = mg$$

$$mg = G \times mM_e / R^2$$

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

As we know that,

$$g = 10\ ms^{-2}$$

$$R = 6.4 \times 10^6$$

$$G = 6.673 \times 10^{-11} Nm^2\ Kg^{-2}$$

By putting the values of g< R and G in above equation,

$$M = (6.4 \times 10^6)^2\ (10) / 6.673 \times 10^{-11}$$

$$M = 6 \times 10^{24} kg$$

Conclusion:

thus, the mass of the earth is approximately 6×10^{24} kg.

Q:5.11:

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

Ans:

Yes we can determine the mass of the moon by the same method used to measure the mass of the earth with the help of law of gravitation. the formula is:

$$M_m = g_m R_m^2 / G$$

From the about relation it shows that we require,

g_m = gravitational acceleration on that surface we require,

R_m = radius of the Moon

G = gravitational constant

Q:5.12:

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

Ans:

We know that:

$$g = GMe / R$$

And

$$g_h = GM /(R+h)^2$$

The above relation shows that the value of "g" is inversely proportional to the square distance of body from the centre of the earth. It means value of the depends on altitude. As different places are at different altitude so value of g varies from place to place.

Q:5.13:

Explain how the value of g varies with altitude?

Ans:

As we know that:

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

To above equation shows that the acceleration due to gravity g depends on the radius of earth at its surface.

The value of g is inversely proportional to the square of the radius of the Earth. Acceleration due to gravity in 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 then at the hills.

Q:5.14:

What are artificial satellites?

Ans:

Scientists have sent many objects in space some of these revolve around the earth these are called artificial satellite **.**

Q:5.15:

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

Ans:

When a satellite moves around the earth in a nearly circular path, the gravitational force of attraction between earth and satellite provides the necessary, centripetal force for its motion. This gravitational force can be found by using Newton's Law of gravitation and finally we can find Orbit speed of satellite by using following that has been derived by using love gravitation.

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

Q:5.16:

On what factors the orbital speed of satellite depends?

Ans:

As we know that

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

So, we can say that orbital speed depends upon:

- The gravitational acceleration.
- Distance between the centre of the Earth and the satellite.

Q:5.17:

Why communication satellites are stationed at geostationary Orbits?

Ans:

Communication satellite are stationed at geostationary orbits because in these orbits the relative velocity of artificial satellites becomes zero with respect to the earth. Hence satellite in geometry Orbits remain all the time in front of the target part of the earth so we have not to change that direction of dish antenna again and again.

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NUMERICAL PROBLEMS

Q:5.1:

Find the gravitational force of attraction between two spheres each of mass 1000 kg. The distance between the centers of the sphere is 0.5 m.

Solution:

Given data:

mass of each sphere = $m_1 = m_2$ = 1000 kg

Distance between their centers = d = 0.5 m

To find:

Gravitational force between the spheres = F =?

Calculations:

From the law of gravitation, we have

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

By putting the values, we have

$$F = 6.67 \times 10^{-11} \times 1000 \times 1000 / (0.5)^2$$

$$F = 6.67 \times 10^{-5} / 0.25$$

$$F = 26.68 \times 10^{-5}$$

$$F = 5.67 \times 10^{-4}\ N$$

Result:

Hence, the gravitational force between the spheres will be 2.67×10^{-4} N.

Q:5.2:

The gravitational force between two identical lead spheres kept at 1 m apart is 0.006673 N. Find the masses.

Solution:

Given data:

Gravitational force between leads spheres = F = 0.006673 N

Distance between centers of leads spheres = r = 1 m

Gravitational constant = $6.67 \times 10^{-11}\ Nm^2kg^{-2}$

To find:

Mass of each lead Sphere = $m_1 = m_2$ =?

Calculations:

From law gravitation, we have

$$F = G\, m_1 m_2 / r^2$$

By putting the values, we have

$$m_1 \times m_2 = 0.006673 \times (1)^2 / 6.67 \times 10^{-11}$$

$$m_1 \times m_2 = 0.001000 \times 10^{11}$$

$$m_1 \times m_2 = 1.00 \times 10^8$$

$$m_1 = m_2 = m$$

$$m^2 = 1.00 \times 10^8$$

taking square root on both sides

$$m = 1.00 \times 10^4\ kg = 10{,}000kg$$

$$m_2 = 1.00 \times 10^4\ kg = 10{,}000kg$$

Result:

hence, the mass of each lead spheres will be 1×10^4 kg or 10,000kg.

Q:5.3;

Find the acceleration due to gravity on the surface of Mars. The mass of Mars is 6.43×10^{23} kg and its radius is 3370 km.

Solution:

Given data:

Mass of Mars = M = 6.42×10^{23}

Radius of Mars = R = 3370 km = 3370×10^{3} m = 3.37×10^{6} m

To find:

Gravitational acceleration = g =?

Calculations:

As we know that

$$g = G \times M / R^2$$

By putting the values, we have

$$g = 6.67 \times 10^{-11} \times 6.42 \times 10^{23} / (3.77 \times 10^{6})^2$$

$$g = 42.8214 \times 10^{12} / 411.3569 \times 10^{12}$$

$$g = 3.77 ms^{-2}$$

Result:

Hence, the gravitational acceleration on the surface of Mars will be 3.77 ms^{-2}.

Q:5.4:

The acceleration due to gravity on the surface of the moon is 1.62 ms^{-2}. The radius of the moon is 1740 km. Find the mass of the moon.

Solution:

Given data:

Gravitational acceleration on moon = g_m = 1.62 ms^{-2}

Radius of moon = R_m = 1740 km = 1740×10^{3} m = 1.74×10^{6}

Gravitational constant = G = 6.67×10^{-11} Nm^2kg^{-2}

To find:

Mass of moon = M =?

Calculations:

As we know that

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

Putting the values, we have

$$M = 1.62 \times (1.74 \times 10^6)^2 / 6.67 \times 10^{-11}$$

$$M = 1.62 \times 3.0276 \times 10^{12} / 6.67 \times 10^{-11}$$

$$M = 4.90 \times 10^{12} / 6.67 \times 10^{-11}$$

$$M = 0.735 \times 10^{23}$$

$$M = 7.35 \times 10^{22} kg$$

Result:

Hence,the mass of the moon is 7.35×10^{22} kg .

Q:5.5:

Calculate the value of g at a height of 3600 km above the surface of the Earth.

Solution:

Given data:

Height above the surface of Earth = h = 3600 km = 3600 x 10 = 3.6×10^6 m

Gravitational constant = G = $6.67 \times 10^{-11} Nm^2kg^{-2}$

Mass of Earth = M = 6×10^{24}kg

To find :

Gravitational acceleration = g =?

Calculations:

As we know that

$$g = GM / (R+h)^2$$

By putting the values, we have

$$g = 6.67 \times 10^{-11} \times 6 \times 10^{24} / (6.4 \times 10^6 + 3.6 \times 10^6)^2$$

$$g = 40.02 \times 10^{13} / (10 \times 10^6)^2$$

$$g = 40.02 \times 10^{13} / 1 \times 10^{14}$$

$$g = 40.02 \times 10^{-1}$$

$$g = 4.002\ ms^{-2}$$

$$g = 4.0 ms^{-2}$$

Result:

Hence, gravitational acceleration at height 3600 km above the surface of the earth will be 4.0 ms^{-2}.

Q:5.6:

Find the value of g due to the earth at geostationary satellite. The radius of the geostationary orbit is 48700 km.

Solution:

given data:

Radius of the satellite = R = 48700 km = 48700 x 10^3 m = 4.87 x 10^7 m

Mass of Earth = M = 6 x 10^{24} kg

Gravitational constant = R = 6.67 x 10^{-11} Nm^2kg^{-2}

To find:

Gravitational acceleration = g_h = ?

Calculations:

As we know that

$$g = GM / (R + h)^2$$

By putting the values, we have

$$g = 6.67 \times 10^{-11} \times 6 \times 10^{24} / (4.87 \times 10^{7})^2$$

$$g = 40.02 \times 10^{13} / 23.72 \times 10^{14}$$

$$g = 1.68 \times 10^{-1}$$

$$g = 0.168\ ms^{-2}$$

$$g = 0.17\ ms^{-2}$$

Result:

Hence, the value of g on geostationary orbit will be 0.17 ms^{-2}.

Q:5.7:

The value of the g is 4.0 ms^{-2} at a distance of 10000 km from the centre of the Earth. Find the mass of the Earth.

Solution:

Given data:

Gravitaional acceleration = g_h = 4.0ms^{-2}

Distance from centre of Earth = R + h = 10000 km = 1×10^{7} m

Gravitational constant = G = $6.67 \times 10^{-11} Nm^2 kg^{-2}$

To find:

Mass of Earth = M =?

Solution:

AS we know that

$$g_h = GM_e /(R + h)^2$$

By putting the values, we have

$$M_e = g_h (R + h)^2 / G$$
$$M_e = 4 \times (1.0 \times 10^7)^2 / 6.67 \times 10^{-11}$$
$$M_e = 4 \times 10^{14} / 6.67 \times 10^{-11}$$
$$M = 0.599 \times 10^{25}$$
$$M_e = 5.99 \times 10^{24}$$
$$M_e = 6 \times 10^{24} \text{ kg}$$

Result:

Hence, the mass of Earth is 6×10^{24} kg.

Q:5.8:

At what altitude the value of g would become one-fourth than on the surface of the Earth?

Solution:

Given data:

Gravitational acceleration = g = 10 m^{-2}

Gravitational acceleration at height = g_h = g / 4 = 10 / 4 = 0.25 ms^{-2}

Gravitational constant = G = $6.67 \times 10^{-11} Nm^2kg^{-2}$

mass of earth = M = 6×10^{24} kg

To find:

Height of the satellite = h =?

Calculations:

As we know that

$$g_h = GM_e / (R + h)^2$$
$$g/4 = GM_e / (R + h)^2$$

Again we know that

$$M_e = gR^2 / G$$

$$GM_e = gR^2$$

Putting the value of GM_e in the equation

$$g/4 = gR^2 / (R + h)^2$$

Taking square root on both sides

$$\sqrt{(R + h)^2} = \sqrt{4R^2}$$

$$R + h = 2R$$

$$h = 2R - R$$

$$h = R$$

Result:

Hence, required altitude will be equal to one earth's radius.

Q:5.9:

A polar satellite is launched at 850 km earth find its orbital speed.

Solution:

Given data:

Height of satellite = h = 850 km

$$= 850 \times 1000$$

$$= 8.5 \times 10^5 \text{ m}$$

Mass of Earth = Me = 6×10^{24} kg

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

To find:

Orbital speed of satellite = V_o =?

Calculations:

We know that

$$V_o \sqrt{g_h (R+h)}$$

Putting the value of g_h

$$V_o = \sqrt{GM_e / (R + h)^2 \times (R + h)}$$

$$V_o = \sqrt{GM_e / R + h}$$

$$= \sqrt{(6.673 \times 10^{-11})(6 \times 10^{24}) / 6.4 \times 10^6 + 8.5 \times 10^5}$$

$$= \sqrt{4.0038 \times 10^{14} / 7250000}$$

$$V_o = \sqrt{55224827.59}$$

$$V_o = 7431\ ms^{-1}$$

Result:

Hence, the orbital speed of Polar satellite will be 7431 ms^{-1}.

Q:5.10:

Communication satellite is launched at 42000 km above Earth. And it's orbital speed.

Solution:

Given data:

Height of satellite = h =42000 km = 42000 x 10^3 m = 4.2 x 10^7 m

Mass of Earth = M = 6 x 10^{24} kg

Gravitational constant = G = 6.673 x 10^{-11} Nm^2kg^{-2}

To find:

Orbital speed of satellite = V_o = ?

Calculations:

As we know that

$$V_o = \sqrt{g_h (R+h)}$$

Putting the values of g_h

$$V_o = \sqrt{GM_e / (R+h)^2 \times (R+h)}$$

$$V_o = \sqrt{GM_e / (R+h)}$$

By putting the values, we have

$$V_o = \sqrt{(6.673 \times 10^{-11})(6 \times 10^{24}) / 6.4 \times 10^{6} + 4.2 \times 10^{7}}$$

$$V_o = \sqrt{4.0038 \times 10^{14} / 48400000}$$

$$V_o = \sqrt{8272314.05}$$

$$V_o = 2876\ ms^{-1}$$

Result:

Hence, the orbital speed of communication satellite will be $2876ms^{-1}$.