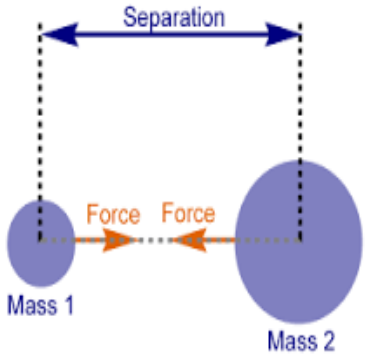
Gravitation

Q.1 state and explain Newton's law of gravitation?

Ans. **Newton's of universal gravitation :-** this law states that in this universe Avery two bodies attract each other with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance b/w them .



Explanation:- consider two bodies a and b as shown in figure let their masses are m_1 and m_2 respectively and the distance b/w them is "r" then according to Newton's law of gravitation the force of attraction :f: is given as:-

$F \varphi m_1m_2$ ..... (i)

$F \varphi 1/r_2$ .....(ii)

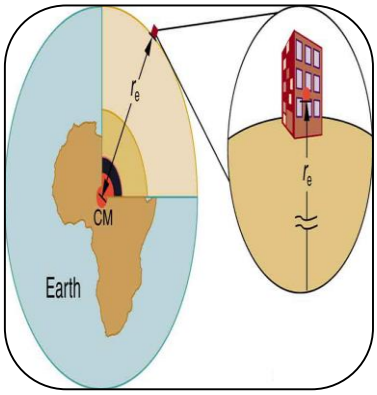
Combining eq (i) and eq (ii) we get.

$F \varphi m_1m_2\ 1/r_2$

$F = G\ m_1m_2\ 1/r_2$.....(iii)

Eq (iii) is the mathematical form of Newton's law of gravitation. Where "G" is gravitational constant and its value is equal to $6.673 \times 10^{-11=}$ $N.m^2/kg^2$

Q.2 using law of universal gravitation find mass of earth?



Ans. we can find mass of earth "Me" by using universal gravitation by following method suppose we have a body of mass "m" laying on the on the surface m of earth as shown in figure.

Let "m" is the mass of body "Me" is the mass of earth "Re" is the radius of earth which is the distance b/w the centers of body and earth. Now according to law of universal gravitation the force b/w earth and object is given by:-

$F = GMem/R_{e2}$ .....(i)

We also know that the force with which a body is attracted toward the center of earth is equal to its weight

ie F = W = =>~~m~~ F = mg .....(ii)

Combining eq (i) and eq (ii) we get.

$GMe\text{~~m~~}/R^{e2}$ = => $me = gRe^2$= ..... (iii)

⇨ $GMe = gRe^2$ => $Me\ gR^2 = /G$

Now as we know that $g = 10m/sec^2$

$Re = 6.4 \times 10^{6m}$ $G = 6.67 \times 10^{-11}$ NM $/kg^2$

Putting these values in eq (iii) we get

$Me = (10)\ (6.4 \times 10^6)^2/6.67 \times 10^{-11}$

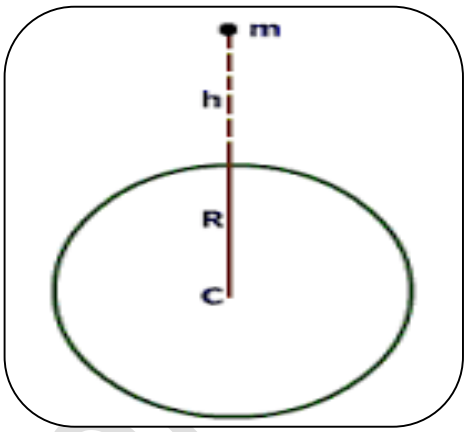
$Me = (10)\ (4096)\ (10^{12})\ /\ 6.67 \times 10^{-11}$

$Me = 409.6 \times 10^{12} \times 10^{11}\ /6.67$

$Me = 61 \times 10^{23}$ => $Me = 6 \times 10^{24}$ kg

Q.3 Explain variation of "g" with altitude?

Ans. considers an object laying on the surface of earth as shown in figure. Where me is mass of earth Re is radius of earth and "h" is the height of object from the surface of earth then according to law of universal gravitation the formula of mass of earth is given by



$Me = gRe^2/G \Rightarrow Me\ G = gRe^2$

$\Rightarrow g = Me\ G/Re^2$.....(i)

Eq (i) shows the formula with the help of which we can find value of "g" now according to figure we want to find value of "g" at point "A" i.e when body is laying at the surface of the earth where value of "g" is "go" and given by:=

$Go = \frac{GMe}{Re^2}$..... (ii)

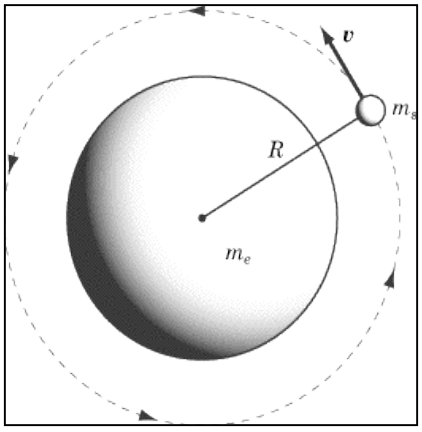
Now we find out value of "g" again when body is at hight "h" from the surface of earth and the distance b/w their centers is equal to "Re+ h" in figure the value of "g" at point "B" is shown by "g" which is given by:-

$G\ h = \frac{GMe}{(Re + h)^2}$.....(iii)=

So, eq (ii) and eq (iii) shows that the value of "g" is inversely proportion to the square of the distance from earth's center ie the value of "g" decreases with altitude. That's why the value of "g" is greater at poles than the equators. Similarly the value of "g" will be greater in plane areas as compare to hilly areas. For example value of "g" at Karachi will be greater than the value of "g" at muree.

Q.4 what is satellite? Derive the formula of orbital speed of an arbitral speed?

Ans. satellite:- A satellite is an object which can move around a planet. Suppose a satellite of mass "m" is revolving around the earth in a circular orbit of radius "r" as shown then according to Newton's law of gravitation the force of attraction b/w them is given by following:-



$F = (GMem)/r^2$..... (1)

As the satellite performs circular motion so, the gravitation force in this acts as centripetal fore.

I.e $F = (mv^2)/r$..... (2)

Comparing eq(i) and eq (ii) we get,

$(\cancel{m}v^2)/\cancel{r} = (GMe\cancel{m})/r^2$

$\Rightarrow v^2 = (G\ Me)/r$

$\Rightarrow \sqrt{\cancel{v^2}} = \sqrt{(G\ Me)/r} \Rightarrow V = \sqrt{(G\ Me)/r}$ ....(3)

As "r = Re +h" so, eq (iii) becomes

$V = \sqrt{(GMe)/(RE + h)}$.....(4)

Eq (4) is the formula for orbital speed of satellite.

CONCEPTUAL QUESTIONS

Q.1 what will be the weight of a body if it raised above the earth equal to its radius?

Ans. we that the weight of a body at earth's surface is given by.
$F = W\ (GMem)/Re^2$ $\Rightarrow Wo = (GMeM)/Re^2$ ……(i)
When it is raised above earth equal to earth's radius then "Re" became
"Re + Re = 2Reso. Eq (i) becomes
$Wh = (GMem)/(2Re)^2$ $\Rightarrow wh = (1/4)\ (GMem/Re^2)$
$Wh = (1/4)\ (wo)$ ……(ii)
So it a body is raised above earth's radius equal to its radius then its weight reduced one fourth times.

Q.2 moon is attracted by earth why it does not fall on ground?

Ans. moon is attracted by earth toward its center due to its tangential speed, but it does not fall on ground. Because the gravitational forces of earth on moon in this case is acting as centripetal force.

Q.3 why the water does not fall out of a bucket when it is whirled in a vertical center?

Ans. when water whirled in a vertical circle in a bucket it does not fall down because of centripetal force.

Q.4 why is it not easy to whirl a hammer by a longer chain?

Ans. it is not easy to whirl a hammer by a longer chain because the moment of inertia is greater and the moment of inertia depends upon mass of the body and radius of the circle. That's why we can't whirl a hammer easily by using longer chain.

Q.5 explains if a stone held in our hands released it falls tower earth center?

Ans. we know that everybody is attracted by earth toward it's center because of force of gravity so that's why when a stone held in our hands is released it falls toward the earth center.

Q.6 what is the value of "G" on moving?

Ans. the value of "G" is constant every where it does not depends upon the nature and size of the masses and nor it depends upon the nature of medium b/w bodies But it is same in all universe.

Q.7 if distance b/w the objects is tripled what is decrease in gravitational force?

Ans. gravitational force b/w bodies in 1st case is given by
$F_1\ (G\ m_1\ m_2)/r^2$……..(2)
When distance is tripled then r is replaced by 3r ie
$R_2 = (1/9)\ (Gm_1m_2/r^2)$ $\Rightarrow F^2 = 1/9\ (F^1)$
Hence force decrease by 1/9

Q.8 what is the difference b/w force of gravity and force of gravitation?

Ans. the force which exerts earth on bodies to attract them toward its center is called force of gravity. While the force of attraction b/w any two bodies in this universe is known as force of gravitation.

Q.9 if mass of earth is taken as doubled but remain in same size, what will happen to the value of "g" and "G"

Ans. (1) value of G:-it is a universal constant it does not depend upon masses of bodies it will remain the same.

(2) Value of "g" we know that $g_1 = (GMe)\ Re_2$……(i) when mass is doubled then $g_2 = G.2Me/Re_2$

$\Rightarrow g_2 = 2.\ (GMe/Re^2) \Rightarrow g^2 = 2\ (g1)$

Hence value of g is doubled if mass of earth is doubled.

Q.10 if mass in earth field is doubled what will happen to the force exerted?

Ans. when mass is single then, $F_1 = (GMem)/r^2$……..(1)

When mass is doubled then, $F_2 = (GM .2m)/r^2$

⇨ $F_2 = 2 (GMem/r^2) \Rightarrow F_2 = 2F_1$

Hence force b/w them is doubled if mass is doubled.

Q. 11 what provides the force that produces centripetal acceleration in an orbit?

Ans. The gravitational force provides the force that produces the centripetal acceleration in an orbit because gravitational force acts as centripetal force on satellite to move it in a circular path.

Q.12 A satellite is moving around the earth on which of the following does it depend (a) Mass of satellite (b) distance of satellite? (c) mass of earth?

Ans. we know that formula of speed of satellite is V = $\sqrt{GMe/r}$ so this equation shows that speed of satellite depends upon mass of earth.

Numerical problems

(1) Calculate the force of gravitation due to earth on child weight 10kg standing on ground [illegible]
= g = 1[illegible]m/sec^2
Gravitation force = F = ?
As we know that:-
F = w = mg
F = mg = 10 x 10 = 100 N

(2) Calculate the gravitation of force of attraction b/w a stone weighing 1kg and earth what will be acceleration produced in stone?
Mass of stone = m= 1kg
Mass of earth = Me = 6 x 10^{24} kg
Distance = Re = 6.4 x 10^6 m
(i) Gravitational force = F = ?
(ii) Acceleration of in force = F = ?
(a) We know Theta
F = GMem/Re^2
F = 6.673 x 10^{-11} x 6 x 10^4 x 1 /(6.4 x 10^6)^2
F 6.673 x 6 x 10^{13-12}/40.96
F = 0.977 x 10
F = 9.77N
F = 9.8 N
(b) Also g = $\frac{GMe}{Re2}$
G = 6.673 x 10 -11 x 6 x 10^{24}/(6.4 x 10^6)^2
G = 9.8 m/sec^2

(3) Find the gravitational force at attraction b/w lead spheres each of mass 1000 kg placed with their center 1m apart?
Solution:- $m_1 = m_2 = 1000$kg
R_1 = 1m gravitational foresees?
F = Gm_1 m_2 /r^2
F = 6.673 x 10^{-11}x 100 x 100/1^2
f = 6.673 x 10^{-11} x 10^3 x 10^3/1
f = 6.673 x $10^{-11 + 3+3}$
f = 6.673 x 10^{-5} W

(4) A body of mass 25kg is placed on the surface of earth? Calculate the gravitational force? If body is raised to a distance equal to radius of earth? How will the weight of the body change?
Solution:-
Mass of the body = m = 25kg
G = 10m/sec^2
(a) Gravitational force = F =?
(b) "W" at hight equal to "Re" =?
(i) As we know that

F = w = mg

=> f = mg = 25 x 10 = 250N

Weight at hight "h" is wh.

Wh = mgh……(i)

Where gh is given by.

Gh = $\frac{GMe}{(Re+h)2}$

Putting this value in eq (i)

Wh = m $[\frac{GMe}{CRe+h)2}]$.....(ii)

Now As h = /re so eq (ii) becomes

Wh = m $[\frac{GMe}{(Re+Re)2}]$

W h = m $[\frac{GMe}{(Re)2}]$

W h =$[\frac{GMem}{4Re2}]$

W h = $\frac{6.673 \times 6\ 10^{-11} \times 6 \times 10^{24} \times 25}{4 \times (6.4 \times 10 \times 10^{6})^2}$

Wh = $\frac{6.673 \times 6 \times 25 \times 10^{24-11}}{4 \times 6.4 \times 6.4 \times 10^{12}}$

Wh = $\frac{1000\ 95 \times 10^{13-12}}{163.\ 84}$

W h = 6.1 x 10

W h = 61N

(5) Two spherical objects masses of 10kg and 100g are 90cm apart. Find gravitational force b/w them?

Ans. Solution:-

M_1 = 10kg m_2 = 100kg

R = 90 cm = 0.9

Gravitationnel force = F = ?

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

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

$f = \frac{6.673 \times 10^{-11} \times 10 \times 100}{(0.9)^2}$ N

$F = \frac{6.673 \times 10^{-11} \times 10^3}{0.81}$ N

Type equation here.

$F = \frac{6.673 \times 10^{-11+3}}{0.81}$

F = 8.23 8 x 10^{-8} N

F = 8.24N

(6) Mass of earth is 6 x 10^{24} kg using law of universal gravitation find ladius of earth?

Ans. solution :- mass of earth = Me = 6 x 10^{24} kg

G = 6.673 x 10^{-11}N .m^2/kg^2

G = 10m/sec^2 Re =?

As we know that :-

$$G = \frac{GMe}{Re^2}$$

⇨ $$Re^2 = \frac{GMe}{G} \quad \sqrt{Re} = \sqrt{\frac{GMe}{g}}$$

$$Re = \sqrt{\frac{6.67\ x\ 10^{-11} \text{ x } 6 \text{ x } 10^{24}}{9.8}}$$

$$\textbf{Re} = \sqrt{\frac{\mathbf{6.673\ x\ 10\ x\ 10^{24-11}}}{9.8}}$$

$$Re = \sqrt{\frac{40\ n.038\ x\ 10^{13}}{9.8}}$$

$$Re = \sqrt{4.08\ x\ 10^{13}} = \sqrt{40\ .8\ mx\ 10^{12}}$$

Re = 6.4 x 10^6