Solved Question on Class IX » Science » Gravitation » The Universal Law of Gravitation

Q.1. When we move from the poles to the equator. Hence, the value of ‘ g ’ decreases. Why

Ans: The shape of earth is an ellipse so when we move from the poles to the equator the radius of the earth R increases. Hence, the value of ‘ g ’ decreases because value 'g' is inversely proportional to the radius of earth. $g = GM/R^2$

Q. 2. What is the difference between centrifugal force and centripetal force?

Ans: Centripetal Force

(i) It is the force that keeps a body in circular path.

(ii) It acts toward the centre.

Centrifugal Force

(i) It is the pseudo force that tries to make a body fly off the circular path.

(ii) It acts outward the centre.

Q.3. Explain: Centrifugal force and Centripetal force?

Ans: A force which is required to move a body uniformly in a circle is known as centripetal force. This force acts along the radius and towards the centre of the circle,

Centrifugal force arises when a body is moving actually along a circular path, by virtue of tendency of the body to regain its natural straight line path. This force acts along the radius and away from the center of the circle.

Q.4 an astronaut has 80 kg mass on earth (a)what is his weight on earth? (b) what will be his mass and weight on mars where g=3.7 m/s2

Ans: Mass of astronaut = 80 kg

Weight on earth = mg = (80)(9.8) N = 784 N Weight on mars = mg' = (80)(3.7) N = 296 N

Q.5. A certain particle has a weight of 30N at a place where the acceleration due to gravity is 9.8 m/s2

(a) What are its mass and weight at a place where acceleration due to gravity is 3.5 m/s square

(b) What are its mass and weight at a place where acceleration due to gravity is 0

Ans (a) Weight of the body, W = 30 N =mg Mass of the body, m = W/g =30 /9.8=3.06 kg

New weight of the body, W' = mg' = (3.06) (3.5) N = 10.71 N

(b) . Mass remains the same but weight becomes zero.

Q. 6. What is the difference between gravity and gravitation?

Ans: Gravity is defined as the ability of earth to attract another body by virtue of their masses.

Gravitation is the phenomenon which explains the force of attraction between two masses separated by a certain distance. This force is known as Gravitational Force

Q.7. Two bodies of mass 10 kg and 12 kg are falling freely. What is the acceleration produced in the bodies due to force of gravity?

Ans: 9.8 m/s2.ast he acceleration due to gravity produced in both the bodies is the same as it is independent of the mass of the body.

Q.8. What will happen to the force of gravitation between two objects A and B if the distance between them is reduced to half?

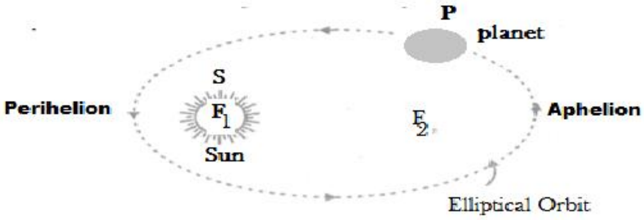
Ans: we know that, $F = \frac{1}{r^2}$ then, $F' = \frac{1}{\left(\frac{1}{2r}\right)^2} = 4\left(\frac{1}{r^2}\right) = 4(F)$

Hence, If the distance between two objects A and B is reduced to half the force of gravitation between two objects A and B increases 4 times

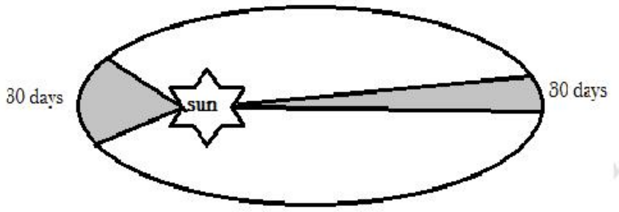
Q.9.What are Kepler's law of motions.

Answer:

First law : The orbit of a planet is an ellipse with the Sun at one of the two foci.



Second law: A line segment joining a planet and the Sun sweeps out equal areas during equal intervals of time.



The closest point to the Sun in a planet's orbit is called perihelion. The furthest point is called aphelion.

3. **KEPLER'S THIRD LAW : The cube of the mean distance of a plant the sun is directly proportional the square of time it takes to move around the sun.** The law can be expressed as :

$r^3 \propto T^2$

Or $r^3 = \text{constant} \times T^2$

Or $\frac{r^3}{T^2} = \text{constant}$

Where r = Mean distance of planet from the sun

and T = Time period of the planet (around the sun)

Q.10.What are these :((i) Product Rule (ii) Inverse Square rule (iii) Universal gravitational constant iv) Universal law of gravitation:

Ans: (i) Product rule: Force between two mass separated by a distance is directly proportional to the product of the two masses. $F \alpha m_1 \times m_2$

(ii) Inverse square law means that the force is inversely proportional to the square of the distance between two objects. Gravitational force is an example of inverse square law. The relation between the force of gravitation and distance is $F \propto \frac{1}{r^2}$

From (i) and (ii) $F \alpha \frac{m_1 m_2}{r^2} \Rightarrow F = G \frac{m_1 m_2}{r^2}$

(iii) Universal gravitational constant (G): The constant of proportionality is called the universal gravitational constant. Gravitational constant is defined as the force of attraction between two unit masses kept at unit distance. For example if we choose m_1, m_2 such that, $m_1 = m_2 = 1$ and keep them at a unit distance (r =1), gravitational constant is equal to gravitation force of attraction between them

(iv) Universal law of gravitation: a force of attraction between two masses separated by some distance. The gravitational force between two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Q. 11. What will happen to the force of gravitation between two objects A and B If the mass of the object A is doubled.

Ans: $F = m_1 \times m_2$

$F' = 2\, m_1 \times m_2 = 2(m_1 \times m_2) = 2F$. Thus, The force of gravitation between two objects A and B increases 2 times

Q. 12.Show that universal gravitational constant is nothing but force of gravitation between two unit masses separated by unit distance.

Ans: we know that, $F = GM/r^2$

If m=M=1kg and r =1m Then, F = G i.e., gravitational constant is equal to the force of gravitation.

Q. 13.A boy drops a stone from a cliff, which reaches the ground in 20 seconds. Calculate the height of the cliff.

Ans: The height of the cliff = S

S = ut+$\frac{1}{2}$ gt^2 = 0+$\frac{1}{2}$x 10 x 20 x 20 = 2000 m = 2km

Q.14. How does the force of gravitation between two objects change when the distance between them is reduced to half?

Answer: when the distance between the objects is reduced to half the gravitational force increases by four times the original force.

Q.15. The gravitational force acts on all objects in proportion to their masses. Why, then, a heavy object does not fall faster than a light object?

Answer: Acceleration due to gravity does not depend on mass of object. Hence, all bodies fall with the same acceleration provided there is no air or other resistance

Q.16.. The earth and the moon are attracted to each other by gravitational force. Does the earth attract the moon with a force that is greater or smaller or the same as the force with which the moon attracts the earth? Why?

Answer: According to Newton's 3rd law of motion Every action has equal reaction in opposite direction. Since, The earth surface attracts the moon with the same force with which the moon attracts the earth and cancel them

Q.17. If the moon attracts the earth, why does the earth not move towards the moon?

Answer: The earth is much larger than the moon so, the acceleration produced on the earth surface cannot be noticed.

Q.18.What is the importance of Universal Law of Gravitation?

Ans: There are many importance of Universal Law of Gravitation

1. The force of attraction that binds us to the earth,
2. The motion of planets moving around the sun,
3. The motion of moon around the earth
4. The occurring of tides due to sun and moon.

Q.19.What is Gravitation?

Answer: Gravitation is the force of attraction between two objects in the universe.

i) Gravitation may be the attraction of objects by the earth. Eg :- If a body is dropped from a certain height, it falls downwards due to earth's gravity. If a body is thrown upwards, it reaches a certain height and then falls downwards due to the earth's gravity.

ii) Gravitation may be the attraction between objects in outer spacemen :- Attraction between the earth and moon. Attraction between the sun and planets

Q.20. what is Centripetal force?

Answer: When a body moves in a circular path, it changes its direction at every point. The force which keeps the body in the circular path acts towards the centre of the circle. This force is called centripetal force.

If there is no centripetal force, the body will move in a straight line tangent to the circular path.

Q.21. Derive the inverse square rule of Newton from Kepler's law of periods.

Ans: Let a planet of mass m is moving with velocity v around the sun in circular orbit of radius r,

Then, Centripetal force F act on the orbiting planet (due to the sun) = F = $\frac{mv^2}{r}$

$\Rightarrow$ F α $\frac{v^2}{r}$ [The mass of given planet is constant] -------------------- (i)

According to Kepler's law of period $\frac{r^3}{T^2}$ = constant ------------(ii)

If the planet take time t to complete one revolution [2πr] around the sun ,Then velocity = V = $\frac{2\pi r}{T}$

$\Rightarrow$ v α $\frac{r}{T}$ [2π is constant for everybody]

$\Rightarrow v^2 \alpha \frac{r^2}{T^2} \times \frac{r}{r}$ $\Rightarrow v^2 \alpha \frac{r^3}{rT^2}$

Put this value in expression. (i)

F α $\frac{\frac{r^3}{rT^2}}{r}$ $\Rightarrow$ F α $\frac{r^3}{T^2} \times \frac{1}{r^2}$ $\Rightarrow$ F α $\frac{1}{r^2}$ [using (ii)

Hence, the force between the two bodies is inversely proportional to the square of the distance between them. it is known as the inverse square rule of Newton.

Q.22.State and prove helper's third law of planetary motion by assuming the orbit to be circular.

Answer: Kepler's third law of planetary motion (Law of periods) states that the square of the time period of revolution of a planet around the sun is directly proportional to the cube of the semi major axis of its elliptical orbit i.e.

$T^2 = R^3$ Where, T = time taken by the planet to revolve once around the sun. R= semi major axis of the elliptical orbit.

Suppose a planet of mass 'm' revolves around Sun of mass 'M' in semi major axis 'R' then the centripetal force on planet around the Sun is provided by Gravitational force between Sun and the planet to revolve in circular orbit, i.e.

$\frac{GMm}{R^2} = \frac{mv^2}{R} \Rightarrow \frac{GM}{R} = v^2$ ---------------(i)

Now we know velocity of planet is, $v = \frac{2\pi R}{T}$

Now,

$v^2 = \left(\frac{2\pi R}{T}\right)^2 = \frac{4\pi^2 R^2}{T^2}$---------------(ii)

From (i) and (ii)

$\frac{GM}{R} = \frac{4\pi^2 R^2}{T^2}$

$\frac{GM}{4\pi^2} = \frac{R^3}{T^2} \Rightarrow \frac{R^3}{T^2} = Constant$

Third law of planetary motion is proved.

Q.23.A stone is released from the top of a tower of height 19.6 m. calculates its final velocity just before touching the ground.

Ans: Given that, u = 0 m/s, g = 9.8 ms–2, s = 19.6 m

Now, $v^2 - u^2 = 2gs \Rightarrow v^2 - 0 = 2 \times 9.8 \times 19.6 = (19.6)^2 \Rightarrow$ v = 19.6 m/s (v is +ve due to downward direction)

Q.24.Calculate the value of g on the earth.

Ans: To calculate the value of g, we should put the values of G, M and R in Eq. namely, universal gravitational constant, G = 6.7 × 10–11 N m^2 kg-2, mass of the earth, M = 6 × 10^{24} kg, and radius of the earth, R = 6.4 × 106 m.

We know that, F = m a

Also, By universal law of gravitation,

F= G Mm/d2

$\Rightarrow$ m a = G Mm/d2 $\Rightarrow$ mg = G Mm/d2 $\Rightarrow$ g = G M/d2 $\Rightarrow$ g = $\frac{(6.7 \times 10{-}11\ \text{N m2 kg}-2 \times\ 6 \times 10^{24}\ \text{kg})}{(6.2x10^{24})^2\ m^2}$ $\Rightarrow$ g » 9.8 m/s2

Thus, the value of acceleration due to gravity of the earth,g= 9.8 ms-2

Q.25. A car falls off a ledge and drops to the ground in 0.5 s. Let g = 10 m s–2 (for simplifying the calculations).
(i) What is its speed on striking the ground? (ii) What is its average speed during the 0.5 s?
(iii) How high is the ledge from the ground?

Solution: Time, t = ½ second

Initial velocity, u = 0 m s–1

Acceleration due to gravity, g = 10 m s–2

Acceleration of the car, a = + 10 m s–2

(i) speed v = a t ⇒ v = 10 × 0.5 ⇒ V = 5 m s–1

(ii) average speed = (u +v)/2 = (0 + 5)/2 = 2.5 m/s

(iii) Distance traveled, $s = ½ a t^2$ ⇒ $S = ½ × 10 × (0.5)^2$ ⇒ S== ½ × 10 × 0.25 ⇒ S = 1.25 m

Thus,(i) Its speed on striking the ground = 5 m s–1

(ii) Its average speed during the 0.5 s = 2.5 m s–1

(iii) Height of the ledge from the ground = 1.25 m.

Q.26. An object is thrown vertically upwards and rises to a height of 10 m. Calculate (i) the velocity with which the object was thrown upwards and (ii) the time taken by the object to reach the highest point.

Solution: Distance traveled, s = 10 m Final velocity, v = 0 m s–1

Acceleration due to gravity, g = 9.8 m s–2

Acceleration of the object, a = –9.8 m s–2

(i) $v^2 = u^2 + 2a s$ ⇒ $0 = u^2 + 2 × (–9.8) × 10$ ⇒ $– u^2 = – 2 × 9.8 × 10$ ⇒ u = 14 m/s

(ii) v = u + a t ⇒ 0 = 14 – 9.8 × t ⇒ 9.8 × t = 14 ⇒ t = 1.43 s.

Thus, (i) Initial velocity, u = 14 m s–1, and (ii) Time taken, t = 1.43 s.

Q.27. Prove that the value of acceleration due to gravity at the moon is 1/6 the value of acceleration due to gravity at the earth.

Answer: Let us now derive a relation between the acceleration due to gravity on moon (g_m) and acceleration due to gravity on Earth (g_e).

$$\frac{g_e}{g_m} = \frac{\frac{g m_e}{(R_e)^2}}{\frac{g m_m}{(R_m)^2}} = \frac{m_e}{m_m}\, x \left(\frac{R_m}{R_e}\right)^2 = \frac{m_e}{m_m}\, x \left(\frac{R_m}{R_e}\right)^2$$

Where M_e and R_e are the mass and radius of the Earth respectively.and M_m and R_m are the mass and radius of the moon respectively.

We know that mass of the Earth is 100 times that of the moon and its radius is four times that of the moon.i.e.

Substitute the value:

$M_e = 100\, M_m$ and $R_e = 4\, R_m$

$$\frac{g_e}{g_m} = \frac{100x\ m_m}{m_m}\, x \left(\frac{R_m}{4\, R_m}\right)^2 = \frac{100}{16} = \frac{6}{1}$$

$$\Rightarrow\ g_m = \frac{1}{6}\, g_e$$

Which means that acceleration due to gravity on moon is $1/6^{th}$ that on the Earth.

Q.28. What do you mean by free fall?

Answer: The motion of a body under the influence of the force of gravity alone is called a free fall.

Q.29.What do you mean by acceleration due to gravity?

Answer: The acceleration produced in the motion of a body falling under the influence of the gravitational attraction of the earth is called as the acceleration due to gravity.

Q.30. what are the differences between the mass of an object and its weight?

Answer: Differences between mass and weight:

Mass	Weight
It is the quantity of matter contained in a body	Weight of a body is the force with which a body is attracted towards the centre of the earth.
Its value remains constant at all places	Its value (W = mg) changes from place to place due to the change in the value of acceleration due to the gravity 'g'.
It is a scalar quantity. 3. It is a vector quantity	It is measured by a pan balance.
It is measured by a spring balance.	
Mass of a body is never zero.	Weight of a body is zero at the centre of the earth because there, 'g' becomes zero.
Its unit is kg	It units is Newton or kg wt.

Q.31. Why is the weight of an object on the moon 1/6 its weight on the earth?

Answer: The mass of the moon of $\frac{1}{100}$ times and its radius $\frac{1}{4}$ times that of the earth. As a result, the gravitational attraction on the moon is about one sixth when compared to that on the earth. Hence, the weight of an object on the moon is of the weight on the earth.

Q.32. Using the data given at the end of the chapter, find first v /r for the moon where v is the velocity and r is the distance from the earth. The find the acceleration due to gravity at the distance of the moon using the inverse square Law. Take acceleration due to gravity near the earth as 9.8 m/s.

Ans: Mass of the Moon, M = 7.3×10^{22} kg ; Distance from the Earth = 384000 km = 3.84×10^{8} m

Radius of the Moon, R = 1740 km = 1.74×10^{6} m

$$\therefore \frac{v^2}{r} = \left(\sqrt{\frac{GM}{r}}\right)^2 \times \frac{1}{r} = \frac{GM}{r^2} = \frac{6.7\times10^{-11}\times7.3\times10^{22}}{(0.384\times10^{6})^2} = 3.3\times10^{-5}\ m/s^2$$

$$\text{Acceleration due to gravity } g = \frac{GM}{R^2} = \frac{6.7\times10^{-11}\times7.3\times10^{22}}{(1.74\times10^{6})^2} = 1.64\ m/s^2.$$

Q.33. A particle is dropped from a tower 180 m height. How long does it take to reach the ground? What is its velocity when it touches the ground? Make a table showing the distance covered by the particle, the velocity and acceleration at the end of each second.

Solution: Height h = 180 m ; Initial velocity u = 0 ;

We know that, $v^2 - u^2 = 2as \Rightarrow v^2 - (0) = 2 \times 10 \times 180 \Rightarrow v^2 = 3600 \Rightarrow v = 60$ m/s

We know that $v = u + gt \Rightarrow 60 = 0 + 10 \times t$ $\therefore$ Time taken t = = 6 s.

Q.35. A coconut is hanging on a tree at a height of 15 m from the ground. A boy launches a projectile vertically upwards with a velocity of 20 m/s. After what time will projectile pass by the coconut? Explain the two answers that you get in this problem.

Solution :For vertical upward motion of projectile,

Height of the coconut hanging on the tree = 15 m u = 20m/s g = -1m/s^2

$h = ut + ½ gt^2 \Rightarrow 15 = 20t + ½ - 10 \times t^2 \Rightarrow t^2 - 4t + 3 = 0 \Rightarrow (t-1)(t-3) = 0 \Rightarrow t = 1$ or, 3

(i) In 1s the projectile passes the coconut going upwards. (ii) In 3s the projectile passes the coconut coming downwards.

Q. 34. *If you weigh 60 kg on earth, how far must you go from the surface of the earth so that you weigh 30 kg ?*

Solution. Here,

Weight on earth, $W_e = 60$ kg

Weight at height h, $W_h = 30$ kg

Height, $h = ?$ (to be calculated)

From relation, $g = \frac{GM}{r^2}$

On earth surface, $r = R$

Hence, $g_e = \frac{GM}{R^2}$

At height h, $r = R + h$

Hence, $g_h = \frac{GM}{(R+h)^2}$

Now, $\frac{W_e}{W_h} = \frac{mg_e}{mg_h} = \frac{g_e}{g_h} = \frac{(R+h)^2}{R^2}$

or $\frac{(R+h)^2}{R^2} = \frac{W_e}{W_h}$

Putting values, we get, $\frac{(R+h)^2}{R^2} = \frac{60}{30} = 2$

i.e., $(R+h)^2 = 2R^2$

Taking square root,

$R + h = \sqrt{2}\,R$

or $h = \sqrt{2}\,R - R = (\sqrt{2} - 1)R$

$= (1.414 - 1)\,R \quad (\because \sqrt{2} = 1.414)$

$= 0.414\,R = 0.414 \times 6.4 \times 10^6 = 2.65 \times 10^6$

The required height is **2.65×10^6 m. Ans.**

Q.36.A man is standing at the top of a 60 m high tower. He throws a ball vertically upwards with a velocity of 20 m/s. After what time will the ball pass him going downwards? How long after its release will the ball reach the round?

Answer: Height of the tower h = 60 m ; Initial velocity u = - 20 m/s and Final velocity v = 0m/s

Time of ascent = Time of descent

∴ After 4s, the ball will pass him going downwards

Initial velocity = 20 m/s

We know that s = ut + ½ at⇒ 60 = 20 × t + × ½ x10 × t⇒ 60 = 20t + 5t ⇒ 5t + 20t – 60 = 0

⇒ t + 4t – 12 = 0 ⇒ t(t + 6) – 2(t + 6) = 0 ∴ t = 2 s

Hence the total time taken to reach the ground after its release = 4 + 2 = 6s.

Q.38. A helicopter is on mission to drop food for people stranded on a boat. It is at a height of 20 m and moving with a steady horizontal velocity of 2 m/s when it spots the nearest end of the boat immediately below it. It then drops the packets . If the length of the boat is 5m, will the people in the boat receive the packets?

Answer: Height h = 20 m ; Initial velocity u = 0 m/s

Acceleration due to gravity g = 10 m/s

Time taken by packet to reach ground= T

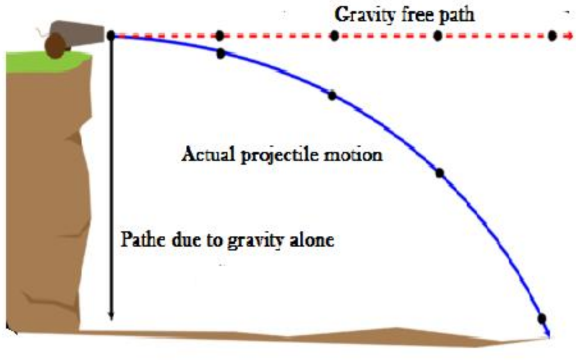
T= $\sqrt{\frac{2h}{g}} = \sqrt{\frac{2x20}{10}} = 2\ sec$

Let Horizontal range R

Distance travel by packet = Horizontal range R= sxt = 2x2 = 4m

Length of the boat = 5m

Therefore people in the boat will receive the packets.



Q.39. what is a Projectile?

Answer: Projectile motion is a form of motion in which an object or particle (called a projectile) is thrown near the earth's surface, and it moves along a curved path under the action of gravity only. The only force of significance that acts on the object is gravity, which acts downward to cause a downward acceleration. There are no horizontal forces needed to maintain the horizontal motion – consistent with the concept of inertia.

Q.40. Explain why an airplane moving through the air is not an example of projectile motion.

Answer: An object considered a 'projectile' only has the force of gravity acting on it, and no other. An airplane moving through the air, while experiencing a force of gravity from the Earth, also experiences a force from the engine (to be accurate, it is actually a force from the particles the engine shoots backwards) that keeps it moving, so it would not be considered a projectile.

Q.41. A rocket is launched to travel vertically upwards with a constant velocity of 20 m/s. After travelling for 35 s the rocket develops a snag and its fuel supply is cut off. The rocket then travels like a free body. What is the total height achieved by it? After what time of its launch will it come back to the Earth?

Solution: Initial velocity u = 20 m/s Final velocity v = 0m/s

Acceleration due to gravity g = -10 m/s

For the vertically upward motion, the equation of motion is

$v^2 = u^2 + 2gh \Rightarrow 0 = (20) + 2 \times (-10) \times h \Rightarrow 0 = 400 - 20h \Rightarrow \therefore$ Height achieved by the rocket h = = 20 m

For a freely falling body

$v^2 = u^2 + 2gh \Rightarrow v^2 = 0 + 2 \times 10 \times 20 \Rightarrow v^2 = 400 \quad \therefore v = 20$ m/s

Now u = 0, v = 20 m/s, g = 10 m/s $\Rightarrow v^2 = u^2 + gt \Rightarrow 20 = 0 + 10 \times t \quad \therefore$ Time taken t = = 2s

Therefore the rocket will come back to Earth after (35 +2) = 37 s.

Q.42: Why will a sheet of paper fall slower than one that is crumpled into a ball?

Ans: This is because the sheet of paper will experience larger air resistance due to its larger surface area than its surface area in ball form. Hence, a sheet of paper falls slower than paper crumpled as a ball.

Q.43. Two objects of masses M_1 and M_2 are dropped in vacuum from a height above the surface of Earth (M_1 is grater than M_2). Which one will reach the ground first and why?

Ans: Since acceleration is the time rate of change of velocity, and velocity is the time rate of change of position, objects dropped from the same height will feel the same acceleration, and so move with the same rate of increasing velocity, and so hit the ground at the same time, independent of their masses.

Q.44. Show mathematically that acceleration experienced by an object is independent of its mass.

Answer: Galileo (who came before Newton) is credited with the observation that objects dropped from a fixed height, fall to the ground with a motion described by a constant acceleration downwards.

From this observation and his second law, f= ma

Galileo also observed that objects of different weight, when dropped from the same height, will hit the ground at the same time. From this, Newton concluded that the gravitational force acting on an object must be proportional to the mass of the object, $F_{gravity} = mg$, since then Newton's second law would give:

$F_{gravity} = mg = ma$ Canceling the common factor of m on both sides gives: g = a Thus the acceleration of the falling object is constant and independent of the object's mass.

Q.45. what are the difference between g and G?

• G stands for the universal gravitational constant, whereas g stands for the gravitational acceleration at a certain point.

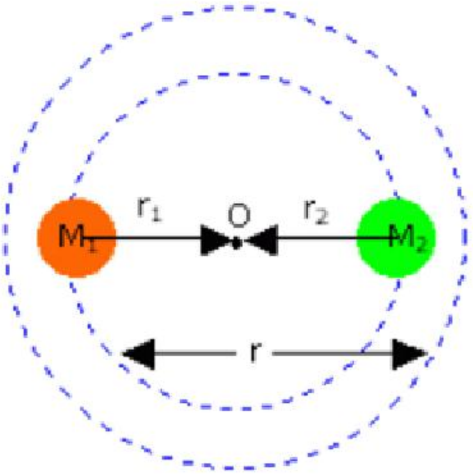
• G is a constant throughout space and time, but g is a variable quantity.

• Gravitational acceleration depends on the universal gravitational constant, but the universal gravitational constant is independent of the gravitational acceleration.

• The basic units of g are m/s^2, whereas the units of G are $m^3 s^{-2} kg^{-1}$

Q.45. Suggest a method for calculating the mass of the moon.

Solution: Let M be the mass of the Moon and M be the mass of Earth. Both Moon and Earth revolve round a common centre of mass O.



Taking the movements about O, we get $M_1r_1 = M_2r_2$ -------(1)

where r_1 and r_2 are the distances of the Moon and the Earth from O respectively and $r = r_1 + r_2$

From equation (1), we get $\frac{M_1}{M_2} = \frac{r_2}{r_1}$ or $\frac{M_1}{M_2} + 1 = \frac{r_2}{r_1} + 1$ or, $\frac{M_1 + M_2}{M_2} = \frac{r_1 + r_2}{r_1} = \frac{r}{r_1}$ (since $r_1 + r_2 = r$)

$r_1 = \frac{M_2 r}{M_1 + M_2}$ Similarly $r_2 = \frac{M_1 r}{M_1 + M_2}$

If v_1 and v_2 are the magnitudes of the velocities about the centre of mass and T the time period, then $v_1 = \frac{2\pi r_1}{T}$ and $v_2 = \frac{2\pi r_2}{T}$

$G\frac{M_1M_2}{r2} = \frac{M_2 v_2^2}{r2} = \frac{M_2}{r2} \times \frac{4\pi r_2^2}{T2} = \frac{4\pi^2 M_2 r_2}{T^2}$ or $\frac{GM_1}{r2} = \frac{4\pi^2 r_2}{T^2}$ Substituting $r_2 = \frac{M_1 r}{M_1 + M_2}$, we get $\frac{GM_1}{r2} = \frac{4\pi^2 M_1 r}{T^2(M_1 + M_2)}$

$M_1 + M_2 = \frac{4\pi^2 r^3}{GT^2}$ Neglecting M_2, $M_1 = \frac{4\pi^2 r^3}{GT^2}$

From the above formula mass of the moon can be calculated.

Q.46. Two objects of masses m1 and m2 having the same size is dropped simultaneously from heights h1 and h2 respectively. Find out the ratio of time they would take in reaching the ground. Will this ratio remain the same if (1) one of the objects is hollow and the other one is solid and (ii) both of them are hollow, size remaining the same in each case? Give reason.

Answer: As the two masses are dropped = 0, a = g (which does not depend upon mass)

From $s = ut + ½ at^2 \Rightarrow h_1 = 0 + ½ gt^2$ and $h_2 = 0 + ½ at^2$

$\therefore h_1 / h_2 = t_1 / t_2$

This ratio of time shall remain the same if

(i) One of the objects is hollow and the other one is solid - as the ratio is independent of masses.

(ii) Both the objects are hollow, as acc. due is gravity (g) does not depend upon mass and also whether the body is hollow/solid.

As size remains the same in each case, there is no effect of resistance due to air in the two cases.

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