**Introduction to Gravitation**

The motion of objects under the influence of gravitational force on Earth is also examined closely. Students will also understand how weight varies from place to place and the conditions required for objects to float on water.

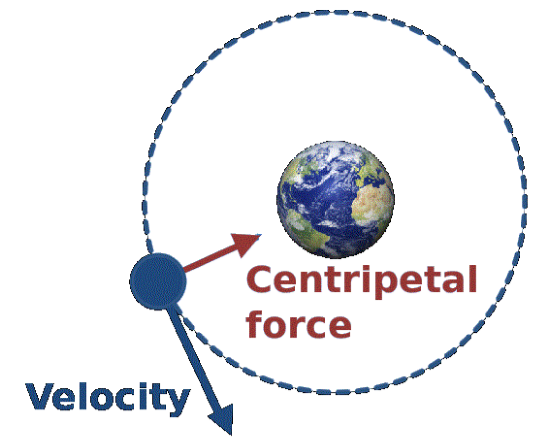
**What Is Gravitation?**

Gravitation or just gravity is the force of attraction between any two bodies. All the objects in the universe attract each other with a certain amount of force, but in most cases, the force is too weak to be observed due to the very large distance of separation. Besides, gravity’s range is infinite but the effect becomes weaker as objects move away.  
Some examples of gravity are:

* The force that causes the ball to come down is known as gravity
* Gravity keeps the planets in orbit around the sun.
* Gravity is the force that causes a rock to roll downhill.

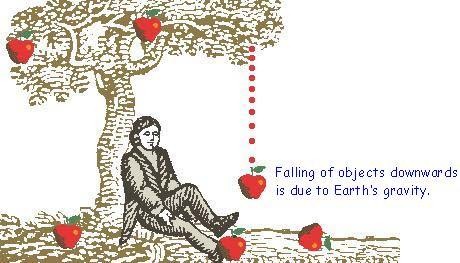
## ****What is the Centripetal Force****

* We know that an object in circular motion keeps on changing its direction.
* Due to this, the velocity of the object also changes.
* A force called **Centripetal Force** acts upon the object that keeps it moving in a circular path.
* The centripetal force is exerted from the centre of the path.
* Without the Centripetal Force objects cannot move in circular paths, they would always travel straight.
* **For Example**, The rotation of the Moon around the Earth is possible because of the centripetal force exerted by Earth.



**Newton's Observations**

* Why does Apple fall on Earth from a tree? – Because the earth attracts it towards itself.
* Can Apple attract the earth?  - Yes. It also attracts the earth as per Newton's third law (every action has an equal and opposite reaction). But the mass of the earth is much larger than Apple's mass thus the force applied by Apple appears negligible and Earth never moves towards it.
* Newton thus suggested that all objects in this universe attract each other. This force of attraction is called **Gravitational Force**.



## Type of Forces

There are four fundamental forces in the universe and they are:

* Gravitational force
* Electromagnetic force
* Strong nuclear force
* Weak nuclear force

### Gravitational Force

Gravitational force is the weakest force out of the four forces. When gravitational force is considered for massive objects, such as the sun, or giant planets, the gravitational force is considered to be strong as the masses of these objects are also large. On an atomic level, this force is considered weak.

### Electromagnetic Force

The electromagnetic force is a type of physical interaction that occurs between electrically charged particles. It acts between charged particles and is the combination of magnetic and electrical forces. The electromagnetic force can be attractive or repulsive.

### Strong Nuclear Force

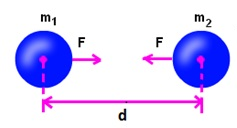
The strong force holds together quarks, the fundamental particles that make up the protons and neutrons of the atomic nucleus, and further holds together protons and neutrons to form atomic nuclei.

### Weak Nuclear Force

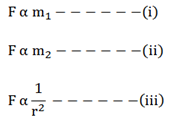
Weak force is the force existing between the elementary particles which are responsible for certain processes to take place at a low probability.

## The Universal Law of Gravitation

* According to the universal law of gravitation, every object attracts every other object with a force.
* This force is directly proportional to the product of their masses.
* This force is inversely proportional to the square of distances between them.
* Consider the figure given below. It depicts the force of attraction between two objects with masses m1 and m2 respectively that are ‘d’ distance apart.



* The figure below describes how the universal law of gravitation is derived mathematically.



From the above equation we can rewrite them as the following:

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If we remove the proportionality we get proportionality constant G as the following:

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The above equation is the mathematical representation of Newton’s Universal Law of gravitation

**Hence, G = Fr2/ m1 m2**

**SI Unit: Nm2/kg2**

Value of G = 6.673 × 10-11 Nm2 kg-2 (was found out by Henry Cavendish (1731- 1810))

* The proportionality constant G is also known as the **Universal Gravitational Constant**

Hence, the Newton’s Law of gravitation states that every object in the universe attracts every other object by a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

where G is the universal gravitation constant.

Value of G = 6.673\*10-11Nm2Kg-2

### Acceleration due to Gravity

and also,

Plug the values of G (6.673\*10-11Nm2Kg-2)

M(mass of Earth) = 6 \* 1024kg  and R= 6 \* 106 m , to get the value of g as ≈ 9.8ms-2

This is the acceleration due to gravity and the acceleration felt by any freely falling body towards the Earth.

The value of g keeps changing due to the variation of Earth’s radius.

### The Moon’s Falling – Moon’s Revolution around Earth

The moon revolves around the Earth due to centripetal force, which is the force of gravity of the Earth.  If the force of attraction between the Earth and the moon ceases, then the moon will continue to travel in a straight-line path tangential to its orbit around the Earth.

### Centripetal Force

When a body undergoes circular motion, it experiences a force that acts towards the centre of the circle. This centre-seeking force is called a centripetal force. Centripetal force is given by the following equation:

### Free Fall and Motion

When an object is under free fall, acceleration due to gravity is constant at g = 9.8ms-2.

Value of g does not depend on mass i.e any object big or small experiences the same acceleration due to gravity under free fall. All three equations of motion are valid for freely falling objects as it is under uniform motion.

The sign of convention → towards earth g is +ve / away from earth g is -ve.

When an object falls towards the earth due to the earth’s gravity and no other force is acting upon it, the object is said to be in a free-fall **state**. Free-falling objects are not even resisted by the air.

g = 9.8 m/s2 is also called the **Free-fall Acceleration**.

Value of ‘g' is the same on the earth, so the equations of motion for an object with uniform motion are valid where acceleration ‘a' is replaced by ‘g', as given under:

v = u + gt

s = ut + ½ gt2

2 g s = v2 – u2

Consider the equations of motion given in different scenarios:

When an object at rest falls towards earth – its initial velocity is zero

v = gt

s = t + ½ gt2

2 g s = v2

When an object with some initial velocity (u) falls towards earth –

v = u + gt

s = ut + ½ gt2

2 g s = v2 – u2

When an object is thrown upwards from the earth – the gravitational force acts in opposite direction, hence g is negative

v = u - gt

s = ut – ½ gt2

-2 g s = v2 – u2

**Weight and Mass**

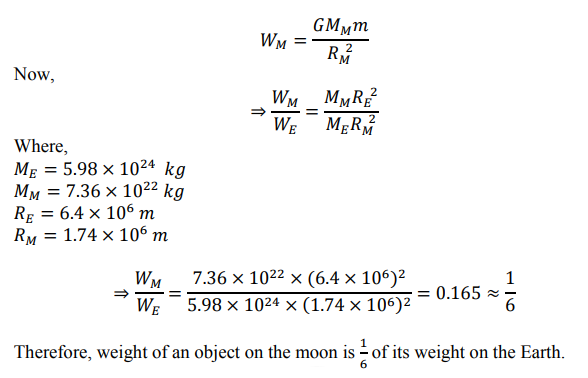
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| --- | --- |
| **Mass** | **Weight** |
| Mass is defined as the quantity of matter in an object. | The weight of an object is the force by which the gravitational pull of the earth attracts the object. |
| Mass is a scalar quantity | Weight is a vector quantity |
| The mass of an object is always constant as it depends upon the inertia of the object | The weight of an object can vary at different locations because of change in gravitational force of the earth |
| Mass can never be zero | Weight can be zero at places there is no gravitational force |
| Denoted as: m | Denoted  as W  F = mg  where m = mass of object  a = acceleration due to gravity  Similarly, W is force, so  W = mg |
| SI Unit: kg | SI unit: N |

The mass of an object is the measure of its inertia and is constant throughout the universe. The weight of an object keeps changing as the value of g changes. Weight is nothing but a force of attraction of the Earth on an object and is given by the following equation:

W = mg

## ****Weight of an object on the Moon****

Just like the Earth, the Moon also exerts a force upon objects. Hence, objects on the moon also have some weight. The weight will not be the same as on the earth. So, weight on the Moon can be calculated as -



### Thrust and Pressure

Force acting on an object perpendicular to the surface is called thrust. The effect of thrust depends on the area of contact. The pressure is thrust per unit area. SI unit is Pascal (Pa). Force acting on a smaller area applies more pressure than the same force acting on a larger area.

**Thrust**

* The force that acts in the perpendicular direction is called thrust.
* It is similar to force applied to an object
* It is a vector quantity.

**Pressure**

* The force that acts per unit area of the object is pressure.
* It is the thrust per unit area.
* Pressure is denoted by ‘P'
* P = thrust/ area = force/ area = F/A
* SI unit: N/m2 or Pa (Pascal)

### Pressure in Fluids

The pressure exerted by a fluid in a container is transmitted undiminished in all directions on the walls of the container.

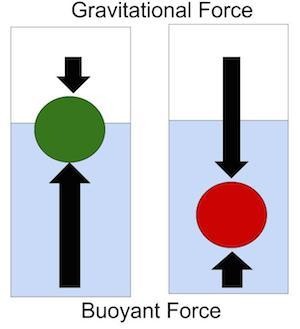
### ****Why do nails have sharp edges?****

We know that pressure is inversely proportional to area. As area increases, pressure decreases and vice versa. So, nails' sharp edges make it easier for them to get into the wall because more pressure is exerted on the wall from a single point.

* **Solids** - They exert pressure on the surface because of their weight.
* **Fluids (gases and liquids)** - They also have weight, therefore, they exert pressure on the surface and the walls of the container in which they are put in.

**Buoyancy**

* Whenever an object is immersed in a liquid, the liquid exerts a buoyant force or upthrust in the opposite direction of the gravitational force. This is also called the **Force of Buoyancy**.
* It depends upon the density of the fluid.
* Therefore an object is able to float in water when the gravitational force is less than the buoyant force.
* Similarly, an object sinks into the water when the gravitational force is larger than the buoyant force.



### ****Why does an object sink or float on water?****

* An object can sink or float on water based on its density with respect to water. The density is defined as mass per unit volume.
* Objects having a density less than water float in it. **For Example**, Cork flows in water because its density is lower than that of water.
* Objects that have a density higher than water sink in it. **For Example**, Iron nails sink in water because the density of iron is more than water's density.
* Thus, we can conclude that buoyancy depends upon:
  + The density of the liquid
  + The volume of the object (as the volume of object increases, its density decreases and vice-versa)

## ****Archimedes Principle****

According to the Archimedes principle, whenever an object is immersed in a liquid (fully or partially), the liquid exerts an upward force upon the object. The amount of that force is equivalent to the weight of the liquid displaced by the object.

This means that if the weight of an object is greater than the amount of liquid it displaces, the object will sink into the liquid. However, if the weight of an object is less than the amount of water it displaces, the object will sink.

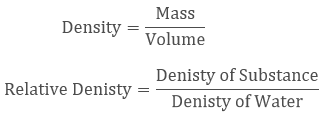
* Submarines have a tank called **Buoyancy Tank**. Whenever the submarine needs to be taken inside water the tank is filled which thus increases the weight of the submarine. Similarly, when the submarine is to appear above water the tank is emptied and the weight of the submarine becomes lighter and it rises above the water.
* Ships are heavier than water but their unique shape gives them a large volume. Their volume is larger than their weight and hence the water displaced by a ship provides it with the right upthrust so that it can float on water.

### ****Applications of Archimedes Principle****

* In evaluating relative density
* In designing ships and submarines
* In making lactometers and hydrometers

### ****What is relative density?****

When density can be expressed in comparison with water's density it is called **Relative Density**. It has no unit because it is a ratio of two similar quantities.



### ****Why is water chosen as a reference?****

Water is present everywhere on earth so it becomes easier to evaluate the density of a substance in relation to water.

How relative density can be used as a measure to determine if an object will sink or float in water?

|  |  |
| --- | --- |
| **Relative Density of an object** | **Float / Sink** |
| Greater than 1 | Sink in water |
| Less than 1 | Float in water |

**The Story of Gravity – Introduction to Gravitation: Kepler’s laws**

In astronomy, Kepler’s laws of planetary motion are three scientific laws describing the motion of planets around the sun.

* Kepler’s first law – The law of orbits
* Kepler’s second law – The law of equal areas
* Kepler’s third law – The law of periods

The orbit of a planet is an ellipse with the sun as its foci.  The line joining the planets and the sun sweeps equal areas in equal intervals of time.

**Cube of a mean distance of a planet from the sun ∝ Square of orbital time period T.**

**Question** What will happen to the gravitational force between two bodies if the masses of one body is doubled?

**Answer** If the mass of one body is doubled, force is also doubled.

**Question** Why is ‘G’ called the universal gravitational constant?

**Answer** The constant ‘G’ is universal because it is independent of the nature and sizes of bodies, the space where they are kept and at the time at which the force is considered.

**Question** Who formulated the universal law of gravitation?

**Answer** Isaac Newton

**Question** How is gravitation different from gravity?

**Answer** Gravitation is the force of attraction between any two bodies while gravity refers to attraction between any body and the earth.

**Question** What does a small value of G indicate?

**Answer** A small value of G indicates that the force of gravitational attraction between two ordinary sized objects is a very weak force.

**Question** At what place on the earth’s surface is the weight of a body maximum?

**Answer** At the poles.

**Question** At what place on the earth’s surface is the weight of a body minimum?

**Answer**  At the equator.

**Question** If the mass of a body is 9.8 kg on the earth, what would be its mass on the moon?

**Answer** It will remain the same on the moon, i.e., 9.8 kg.

**Question** Do fluids possess weight?

**Answer** Yes, fluids have weight.

**Question** Why can one jump higher on the surface of the moon than on the earth?

**Answer** Because the value of acceleration due to gravity (g) on the moon’s surface is nearly l/6th to that of the surface of the earth.

**Question** Define the standard kilogram.

**Answer** The standard kilogram is the mass of a block of a platinum alloy kept at the international bureau of weights and measures near Paris in France.

**Question** If the earth attracts two objects with equal force, can we say that their masses must be equal?

**Answer** No

**Question** Is weight a force?

**Answer** Yes.

**Question** What keeps the moon in uniform circular motion around the earth?  
**Answer** Gravitational force between moon and the earth keeps moon in uniform circular motion around the earth.

**Question** When a body is dropped from a height, what is its initial velocity?

**Answer** Zero.

**Question** When a body is thrown vertically upwards, what is its final velocity?

**Answer** Zero.

**Question** Is the time taken by a body to rise to the highest point equal to the time taken to fall from the same height?

**Answer** Yes.

**Question** Is the acceleration due to gravity acting on a freely falling body directly proportional to the (a) mass of the body? (b) time of fall of the body?

**Answer**

(a) No

(b) No

**Question** Suppose gravity of earth suddenly becomes zero, then which direction will the moon begin to move if no other celestial body affects it?

**Answer** The moon will begin to move in a straight line in the direction in which it was moving at that instant because the circular motion of moon is due to centripetal force provided by the gravitational force of the earth.

**Question** The earth is acted upon by gravitation of sun, even though it does not fall into the sun. Why?

**Answer** The gravitational force is responsible for providing the necessary centripetal force which allows the earth to move around the sun at the defined path or orbit. So, the earth does not fall into the sun.

**Question** If the small and big stones are dropped from the roof of a house simultaneously, they will reach the ground at the same time. Why?

**Answer** The acceleration due to gravity does not depend upon the mass of the stone or body. Both the bodies fall with the same acceleration towards the surface of the earth. Thus a big stone will fall with the same acceleration as a small stone. So, both the stones will reach the ground at the same time when dropped simultaneously.

**Question** The earth attracts an apple. Does the apple also attract the earth? If it does, why does the earth not move towards the apple?

**Answer** According to Newton’s third law of motion, action and reaction are equal and opposite. It means that the force on the apple due to earth’s attraction is equal to that on the earth due to apple’s attraction. But we know, acceleration ∝ 1/m.  
As the mass of the earth is very large as compared to that of the apple, the acceleration experienced by the earth will be so small that it will not be noticeable.

**Question** Mention any four phenomena that the universal law of gravitation was able to explain.

**Answer** The universal law of gravitation was able to explain successfully

* the force that binds us to the earth.
* the motion of the moon around the earth.
* the motion of planets around the sun.
* the tides due to the moon and the sun.

**Question** When does an object show weightlessness?

**Answer** Weightlessness is a state when an object does not weigh anything. It occurs only when a body is in a state of free fall under the effect of gravity alone.

**Question** Why does a body reach the ground quicker at poles than at the equator when dropped from the same height?

**Answer** The acceleration due to gravity is more at the poles than at the equator. The time taken for a body is less if the acceleration due to gravity is more when the initial velocities and the distance travelled are the same. So, when dropped from the same height a body reaches the ground quicker at the poles than at the equator.

**Question** What is the source of centripetal force that a planet requires to revolve around the sun? On what factors does that force depend?

**Answer** Gravitational force. This force depends on the product of the masses of the planet and sun and the distance between them.

**Question** Suppose that the radius of the earth becomes twice of its original radius without any change in its mass. Then what will happen to your weight?

**Answer** We know that

F = *GMm / r*2

as weight of a body is the force with which a body is attracted towards the earth,

∴ W = *GMm / r*2

If the radius of the earth becomes twice of its original radius, then

W = *GMm /* (2*r*)2

= *GMm /* 4*r* 2=*W /* 4

i.e., weight will be reduced to one-fourth of the original.

**Question** Prove that if the earth attracts two bodies placed at same distance from the centre of the earth with the same force, then their masses are equal.

**Answer** Let P and Q be the two bodies, the mass of body P = m1

And the mass of body Q=m2

As per the universal law of gravitation, the force of attraction between the earth and the body P is given by,

Fp = *G*×*Me*×*m*1 / *R*2 …..(1)

Where, R is the distance of the body from the centre of the earth.

Similarly, the force of attraction between the earth and the body Q is given by

FQ = *G*×*Me*×*m*2 / *R*2 …….(2)

Since, the two forces, i.e., Fp and FQ are equal, thus from (1) and (2),

*G*×*Me*×*m*1 / *R*2 = *G*×*Me*×*m*2 / *R*2

⇒ m1 = m2

**Question** Give three differences between acceleration due to gravity (g) and universal gravitational constant (G).

**Answer** Differences between g and G

|  |  |
| --- | --- |
| **Acceleration due to gravity (g)** | **Universal gravitational constant (G)** |
| 1.  Acceleration due to gravity is the acceleration acquired by a body due to the earth’s gravitational pull on it.  2.    g is a vector quantity.  3.   It is different at different places on the surface of the earth. Its value also varies from one celestial body to another. | 1. Gravitational constant is numerically equal to the force of attraction between two masses of 1 kg that are separated by a distance of 1 m.  2.  G is a scalar quantity.  3. The ‘G’ is a universal constant, i.e., its value is the same (i.e. 6.7 × 10-11 Nm2 kg-2) everywhere in the universe. |

**Question** On the earth, a stone is thrown from a height in a direction parallel to the earth’s surface while another stone is simultaneously dropped from the same height. Which stone would reach the ground first and why?

**Answer** For both the stones

Initial velocity, u = 0

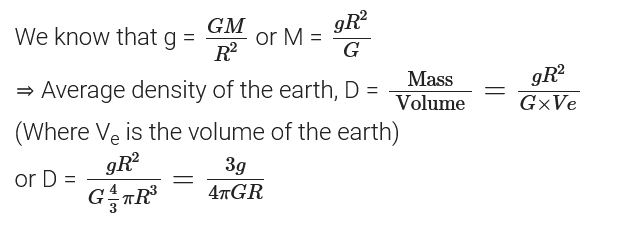
Acceleration in downward direction = g



Both stones will take the same time to reach the ground because the two stones fall from the same height.

**Question** Calculate the average density of the earth in terms of g, G and R.

**Answer**



**Question** Prove that if a body is thrown vertically upward, the time of ascent is equal to the time of descent.

**Answer** Upward motion

v = u + gt1

0 = u – gt1

t1 = *ug* …(1)

Downward motion

v = u + gt2

v = 0 + gt2

As the body falls back to the earth with the same velocity it was thrown vertically upwards.

∴ v = u

u = 0 + gt2

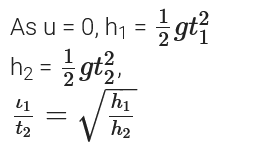
t2 = u/g …(2)

From (1) and (2), we get t1 = t2

⇒ Time of ascent = Time of descent

**Question** Two objects of masses ml and m2 having the same size are 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 (i) 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 reasons

**Answer**



Ratio will not change in either case because acceleration remains the same. In case of free fall acceleration does not depend upon mass and size.

**Question** Derive expression for force of attraction between two bodies and then define gravitational constant.

**Answer** “Every body 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 them.” Let us consider two bodies A and B of masses m1 and m2 which are separated by a distance r. Then the force of gravitation (F) acting on the two bodies is given by

F ∝ m1 × m2…(1)

ans F ∝ 1 / *r*2 ..(2)

Combining (1) and (2), we get

F ∝ *m*1×*m*2 / *r*2

or F = G × *m*1 x *m*2 / *r*2 ……..(3)

where G is a constant known as universal gravitational constant. Here, if the masses m1 and m2 of the two bodies are of 1 kg and the distance (r) between them is 1 m, then putting m1 = 1 kg, m2 = 1 kg and r = 1 m in the above formula, we get

G = F

Thus, the gravitational constant G is numerically equal to the force of gravitation which exists between two bodies of unit masses kept at a unit distance from each other.

**Question** Define acceleration due to gravity. Derive an expression for acceleration due to gravity in terms of mass of the earth (M) and universal gravitational constant (G).

**Answer** The acceleration produced in the motion of a body falling under the force of gravity is called acceleration due to gravity. It is denoted by ‘g’.

The force (F) of gravitational attraction on a body of mass m due to earth of mass M and radius R is given by

F = *G mM / R*2 …..(1)

We know from Newton’s second law of motion that the force is the product of mass and acceleration.

∴ F = ma

But the acceleration due to gravity is represented by the symbol g. Therefore, we can write

F = mg …(2)

From the equation (1) and (2), we get

mg = *G mM / R*2 or g = *GM / R*2 …(3)

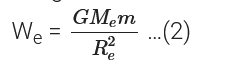
When body is at a distance V from centre of the earth then g = *GMr*2

**Question** Show that the weight of an object on the moon is 16 th of its weight on the earth.

**Answer** Suppose the mass of the moon is Mm and its radius is Rm. If a body of mass m is placed on the surface of moon, then weight of the body on the moon is

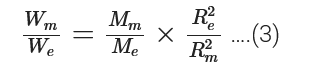


Weight of the same body on the earth’s surface will be



where Me = mass of earth and Re = radius of earth.

Dividing equation (1) by (2), we get

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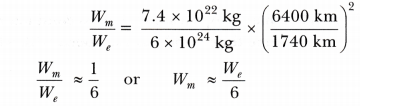
Now, mass of the earth, Me = 6 × 1024 kg

mass of the moon, Mm = 7.4 × 1022 kg

radius of the earth, Re = 6400 km

and radius of the moon, Rm = 1740 km

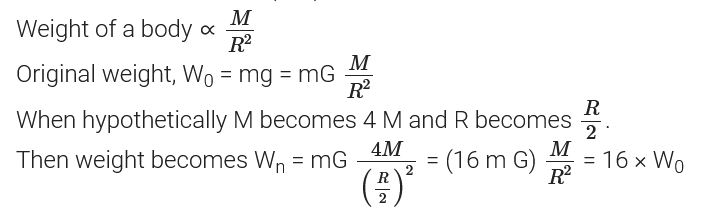
Thus, equation (3) becomes,



The weight of the body on the moon is about one-sixth of its weight on the earth.

**Question** How does the weight of an object vary with respect to mass and radius of the earth? In a hypothetical case, if the diameter of the earth becomes half of its present value and its mass becomes four times of its present value, then how would the weight of any object on the surface of the earth be affected?

**Answer** Weight of an object is directly proportional to the mass of the earth and inversely proportional to the square of the radius of the earth, i.e.,

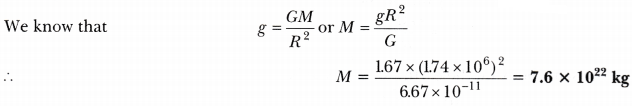


The weight will become 16 times.

**Question** On the moon’s surface, the acceleration due to gravity is 1.67 ms-2. If the radius of the moon is 1.74 × 106 m, calculate the mass of the moon.

(G = 6.67 × 1011 Nm2kg-2)

**Answer** Here, g = 1.67 ms-2, R = 1.74 × 106 m and G = 6.67 × 10-2 Nm2 kg-2



**Question** A force of 20 N acts upon a body whose weight is 9.8 N. What is the mass of the body and how much is its acceleration? Take g = 9.8 m/s2.

**Answer** Weight, W = mg,

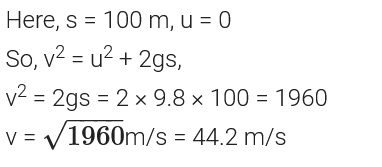
m = *W / g*,

m = 9.8 / 9.8 = 1 kg

So, acceleration =  Force / Mass =20 / 1 = 20 m/s2

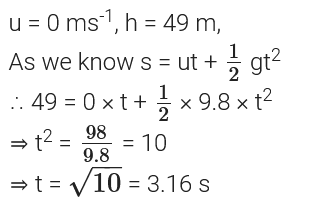
**Question** A stone is dropped from a cliff. What will be its speed when it has fallen 100 m?

**Answer**



**Question** From a cliff of 49 m high, a man drops a stone. One second later, he throws another stone. They both hit the ground at the same time. Find out the speed with which he threw the second stone.

**Answer**  For the first stone



i.e., First stone would take 3.16 s to reach the ground.

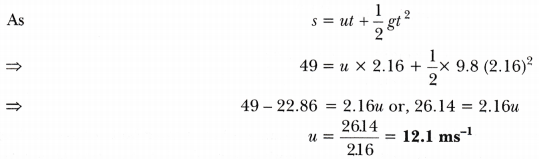
For the second stone,

the time taken by the second stone to reach the ground is one second less than that taken by the first stone as both the stones reach the ground at the same time.

That is, for the second stone, t = (3.16 – 1)s = 2.16s

∴ For the second stone,

g = 9.8 ms-2, h = 49 m, t = 2.16 s, u = ?



i.e., the second stone was thrown downward with a speed of 12.1 ms-1.

**Question** A stone is dropped from the top of a 40 m high tower. Calculate its speed after 2 s. Also find the speed with which the stone strikes the ground.

**Answer**

(i) As v = u + gt

∴ v = 0 + (-10) × 2 = -20 m/s

(ii) As v = u2 + 2 gs

or, v2 – 02 = 2(-10) × (-40)

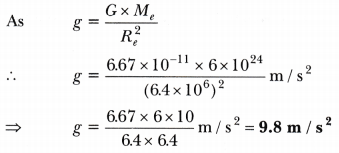
or, v = sqrt(800) = 20.2 m/s

**Question** Calculate the value of acceleration due to gravity g using the relation between g and G.

**Answer**  We know that G = 6.67 × 10-11 Nm2 kg-2

Mass of the earth, Me = 6 × 1024 kg

And Radius of the earth, Re = 6.4 × 106 m



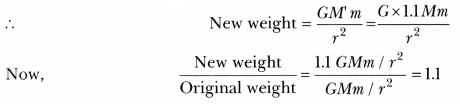
**Question** Suppose the mass of the earth somehow increases by 10% without any change in its size. What would happen to your weight? Suppose the radius of the earth becomes twice of its present radius without any change in its mass, what will happen to your weight?

**Answer** (i) Original weight = *GMmr*2, where M is the mass of the earth.

When M changes to new mass M’

New mass, M’=M + 10% of M

= M + 10100M = M + *M*10 = 11*M*10 = 1.1 M

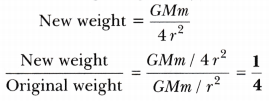


New weight becomes 1.1 times.

i.e., weight will increase by 10%.

(ii) Weight = *GMmr*2, where r is the radius of the earth.

When r changes to 2r, the new weight is given by

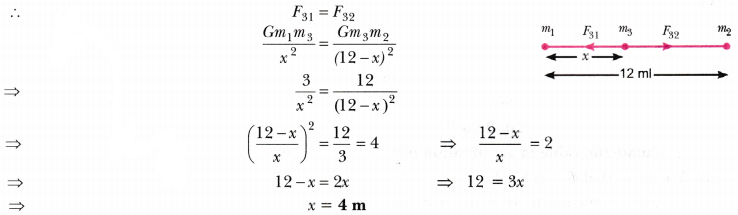


∴ New weight becomes 4 times.

**Question** Two bodies of masses 3 kg and 12 kg are placed at a distance 12 m. A third body of mass 0.5 kg is to be placed at such a point that the force acting on this body is zero. Find the position of that point.

**Answer** Given m1 = 3 kg; m2 = 12 kg

Let the mass, m3 = 0.5 kg be placed at a distance of ‘x’ m from m1, as shown in figure.  
Then force acting on m3 due to m1, is equal and opposite to the force acting on m3 due to m2.



The position of required point is at a distance of 4 m from mass of 3 kg.

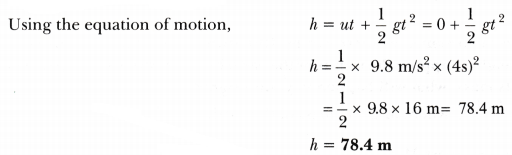
**Question** A stone dropped from the roof of a building takes 4s to reach the ground Calculate the height of the building.

**Answer**  Here, initial velocity, u = 0

Time taken to reach the ground, t = 4 s

Acceleration, a = g = 9.8 m/s2

Height of the building, h = ?



**Question** A ball is thrown up with a speed of 0.5 m/s.

(i) How high will it go before it begins to fall?

(ii) How long will it take to reach that height?

**Answer** Initial speed, u = 0.5 m/s

Acceleration, g = – 9.8 m/s2

Final speed, v = 0

(i) We know v2 – u2

= 0 – (0.5)2 = 2 × (-9.8) × h

or – 0.25 = -19.6 h

or h = 0.2519.6 = 0.0127 m

h = 1.27 cm

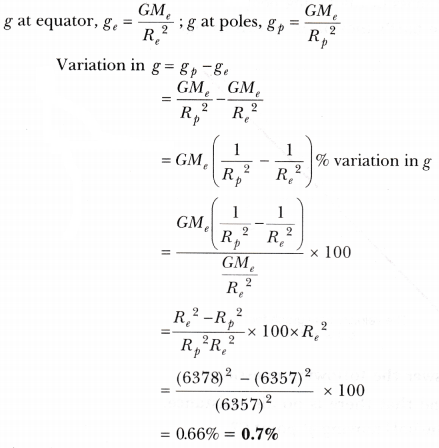
(ii) Putting the values in the formula v = u + gt

0 = 0.5 – 9.8t

or t = 0.59.8 = 0.05 s

**Question** Find the percentage change in the weight of a body when it is taken from the equator to the poles. The radius of the earth at the poles is 6357 km, the radius at the equator is 6378 km.

**Answer**



% Variation in the weight of a body = % Change in g = 0.7%.

**Question** Why does formation of tides takes place in sea or ocean?

**Answer** The tides in the sea formed by the rising and falling of water level in the sea are due to the gravitational force of attraction which the sun and the moon exert on the water surface in the sea.

**Question** Why does a body orbiting in space possess zero weight with respect to a spaceship?

**Answer** The astronaut and the spaceship are orbiting with same acceleration hence, the body does not exert any force on the sides of the spaceship. Therefore, the body appears to be floating weightlessly. It also implies that a body orbiting in space has zero weight with respect to a spaceship.

**Question** Identical packets are dropped from two aeroplanes—one above the equator and other above the north pole, both at height h. Assuming all conditions to be identical, will those packets take same time to reach the surface of earth? Justify your answer

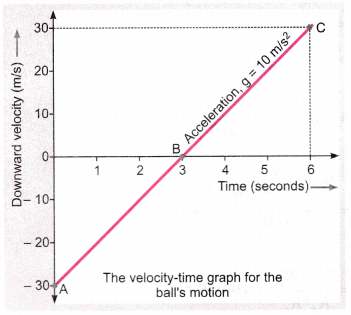
**Answer** The value of ‘g’ at the equator of the earth is lesser than that at poles. Therefore, the packets fall slowly at equator in comparison to the poles. Thus, the packets will remain in air for longer time interval, when it is dropped at the equator.

**Question** How does the force of attraction between the two bodies depend upon their masses and distance between them? A student thought that two bricks tied together would fall faster than a single one under the action of gravity. Do you agree with his hypothesis or not? Comment

**Answer** F ∝ m,1m2 and F ∝ 1 / *r*2

This hypothesis is not correct. The two bricks like a single body, fall with the same speed to reach the ground at the same time in case of free fall. This is because acceleration due to gravity is independent of the mass of the falling body.

**Question** Velocity-time graph for the ball’s motion is shown in figure.



Observe the graph and answer the following **Question**s.

Assume that g = 10 m/s2 and that there is no air resistance.

(a) In which direction is the ball moving at point C?

(b) At which point is the bal 1 stationary?

(c) At which point is the bal 1 at its maximum height?

(d) What is the ball’s acceleration at point C?

(e) What is the ball’s acceleration at point A?

(f) What is the bal l’s acceleration at point B?

(g) At which point does the bal 1 have the same speed as when it was thrown?

**Answer**  (a) Downward

(b) At point B

(c) At point B

(d) Acceleration = 10 ms-2

(e) Acceleration = -10 ms-2

(f) Acceleration = 10 ms-2

(g) At point C