Exercise -3(A) Page: 59

1. Explain giving two examples each of:
(a) Contact forces, and (b) non-contact forces

Solution:

(a) Contact forces – These are the forces that act upon bodies when they are in physical contact are known as contact forces. Example-Force exerted on two bodies while the process of collision, frictional force

(b) Non-contact forces – These are the forces that are experienced by the bodies without any physical contact is known as non-contact force. Example – Electrostatic force and gravitational force.

2. Classify the following amongst contact and non-contact forces:
(a) Frictional force
(b) Normal reaction force
(c) Force of tension in a string
(d) Gravitational force
(e) Electrostatic force
(f) Magnetic force

Solution:

Contact force	Non-contact force
Frictional force	Gravitational force
Normal reaction force	Electrostatic force
Force tension in a string	Magnetic force

3. Give on example in each case where:
(a) The force is of contact, and
(b) Force is at a distance.

Solution:

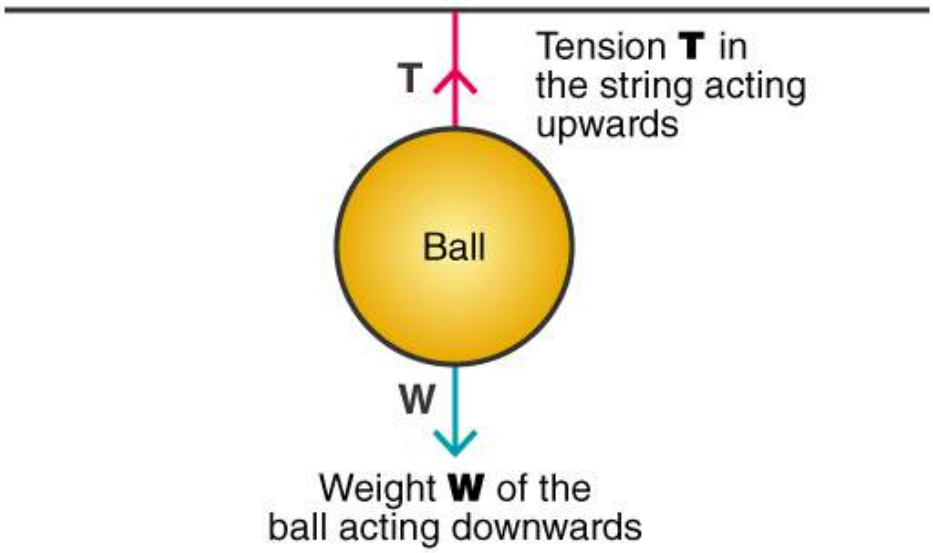
(a) The force is of contact – force exerted on two bodies during the process of collision

(b) Force is at a distance – force persistent between magnetic poles – magnetic force

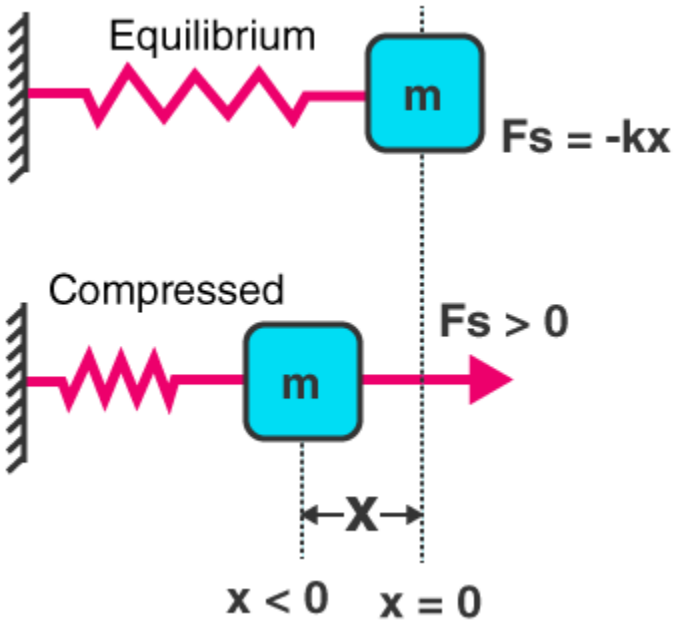
4. (a) A ball is hanging by a string from the ceiling of the roof. Draw a neat labelled diagram showing the forces acting on the ball and the string.
(b) A spring is compressed against a rigid wall. Draw a neat labelled diagram showing the forces acting on the spring.
(c) A wooden block is placed on a table top. Name the forces acting on the block and draw a neat and labelled diagram to show the point of application and direction of these forces.

Solution:

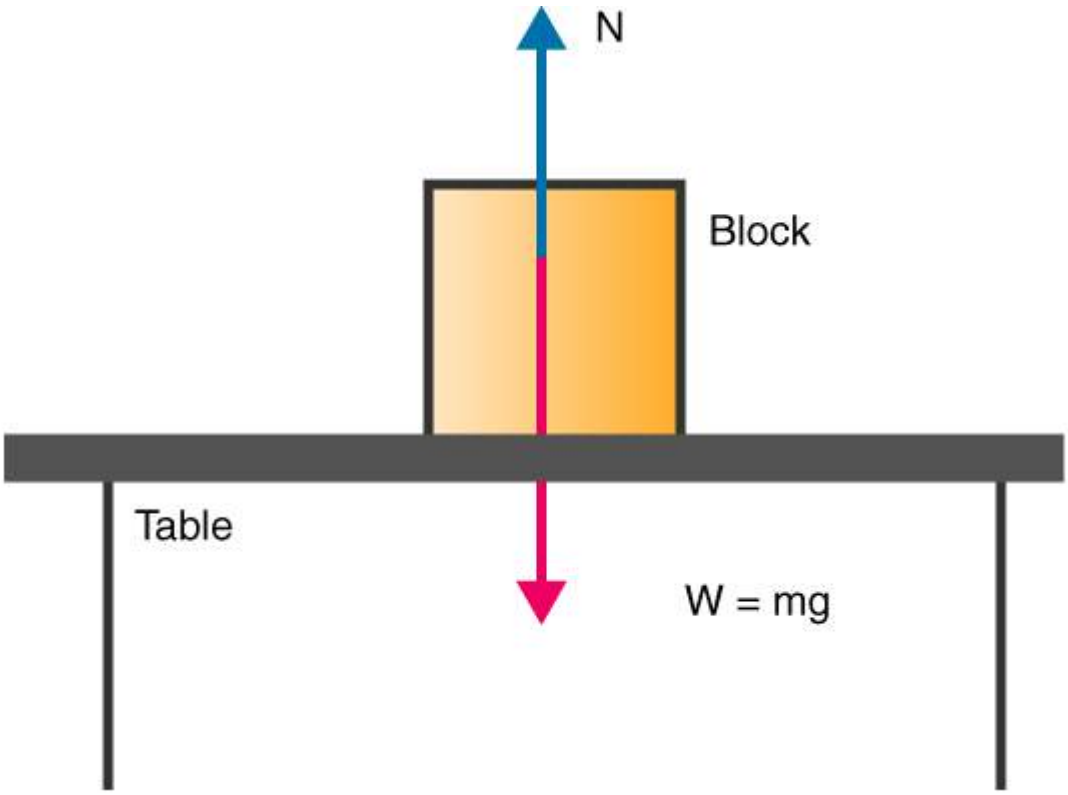
(a) The diagram shows the forces acting on the ball and the string



(b) The diagram shows the forces acting on the spring



(c) The diagram shows the point of application and the direction of these forces



The following are the forces that act on the block

- Reaction force from the table in the upward direction
- Weight of the block in the downward direction

5. **State one factor on which the magnitude of a non-contact force depends. How does it depend on the factor stated by you?**

Solution:

The magnitude of non-contact force depends on the distance. Distance and magnitude of force are inversely related. The magnitude of force decreases as the distance increases.

6. **The separation between two masses is reduced to half. How is the magnitude of gravitational force between them affected?**

Solution:

The magnitude of gravitational force is four times between two masses as gravitational force is inversely proportional to the square of the distance of separation.

7. **State the effects of a force applied on (i) a non-rigid, and (ii) a rigid body. How does the effect of the force differ in the two cases?**

Solution:

(i) Non-rigid force – When a non-rigid force is applied on a body, it changes the inter-spacing amongst its constituent particles and hence induces a modification in its dimension and hence can also generate motion in it.

(ii) Rigid-force – When a rigid force is applied on a body, it does not change the inter-spacing

amongst its constituent particles and consequently it does not change its dimensions but motion is induced.

8. **Give one example in each of the following cases where a force:**
   (a) Stops a moving body
   (b) Moves a stationary body
   (c) Changes the size of a body
   (d) Changes the shape of a body

   Solution:

   Listed below are the examples for the following cases:

   (a) In the game of cricket, a fielder, by applying force with his hands stops a moving ball.
   (b) Moving of a cart when a pull is exerted by a horse
   (c) When the piston is lowered in a cycle pump, the air is compressed to cover less volume
   (d) Rubber changes its shape on pressing a piece of it

Multiple Choice Type

1. **Which of the following is a contact force:**
   (a) Electrostatic force
   (b) Gravitational force
   (c) Frictional force
   (d) Magnetic force

   Solution:

   (c) Frictional force

   These are the forces that act upon bodies when they are in physical contact with each other.

2. **The non-contact force is:**
   (a) Force of reaction
   (b) Force due to gravity
   (c) Tension in string
   (d) Force of the friction

   Solution:

   (b) Force due to gravity

   These are the forces that are experienced by the bodies without any physical contact with each other.

Exercise -3(B) Page: 63

1. **Name the physical quantity which cause motion in a body.**
   Solution:
   The physical quantity that causes motion in a body is force.

2. **Is force needed to keep a moving body in motion?**
   Solution:
   No, force is not required to be applied to a moving body unless the direction or the speed is required to be changed.

3. **A ball moving on a table top eventually stops. Explain the reason.**
   Solution:
   A ball moving on a table top is restricted by the force of friction between the ball and the table top as it opposes the motion.

4. **A ball is moving on a perfectly smooth horizontal surface. If no force us applied on it, will its speed decrease, increase or remain unchanged?**
   Solution:
   When no force is applied on a ball moving on a perfectly smooth and horizontal surface, its speed remains unchanged.

5. **What is Galileo's law of inertia?**
   Solution:
   Galileo's law of inertia is as stated below:
   "An object, if once set in motion, moves with uniform velocity if no force acts on it."

6. **State Newton's first law of motion.**
   Solution:
   Newton's first law states that – if a body is in a state of rest, it will remain in the state of rest and if it is in the state of motion, it will remain moving in the same direction with the same speed unless an external force is applied on it.

7. **State and explain the law of inertia (or Newton's first law of motion).**
   Solution:
   The law of inertia is as stated below:
   "if a body is in a state of rest, it will remain in the state of rest and if it is in the state of motion, it will remain moving in the same direction with the same speed unless an external force is applied on it"
   The first part of the law gives the definition of inertia as per which an object cannot change its state by itself. If an object is in the state of rest, it will remain in the state of rest and if it is moving in some direction, it will continue to move with the same speed in the same direction unless an external force is applied on it.

8. What is meant by the term inertia?

Solution:

The property of an object by virtue of which it tends to retain its state of rest or of uniform is called inertia.

9. Give qualitative definition of force on the basis of Newton's first law of motion.

Solution:

The qualitative definition of force on the basis of Newton's first law of motion is as follows: "force is that external cause which can move a stationary object or which can change the state of motion of a moving object".

10. Name the factor on which inertia of a body depends and state how it depends on the factor stated by you.

Solution:

One factor on which inertia of a body depends is mass. Mass and inertia are directly proportional to each other. Greater the mass, greater is the inertia.

11. Give two examples to show that greater the mass, greater is the inertia of the body.

Solution:

Listed below are the examples:

- Compared to a tennis ball, a cricket ball is massive. The cricket ball acquires much smaller velocity than a tennis ball when both the balls are pushed with equal force for the same duration.
- It is difficult to set a loaded trolley(has more mass) in motion than an unloaded trolley(which has lesser mass)

12. 'More the mass, more difficult it is to move the body from rest'. Explain this statement by giving an example.

Solution:

Mass of a body is directly related to inertia, the more the mass of an object, the more the inertia. Compared to an unloaded trolley, it is difficult to set a loaded trolley in motion as a larger force is required to set it to motion.

13. Name the two kinds of inertia.

Solution:

The two kinds of inertia are:

- Inertia of rest
- Inertia of motion

14. Give one example of each of the following:
(a) Inertia of rest, and (b) inertia of motion.

Solution:

Listed below are the examples:

(a) Inertia of rest – The passenger standing in the compartment tends to fall backwards when a train suddenly starts moving forward.

(b) Inertia of motion – A cyclist riding along a level road does not come to rest immediately after

he stops pedaling.

15. Two equal and opposite forces act on a stationary body. Will the body move? Give reason to your answer.

Solution:

When two equal and opposite forces are acting on a stationary body, the body will not move as the net force on the body is zero, hence the body will remain stationary. It will be in a state of rest due to inertia.

16. Two equal and opposite forces act on a moving object. How is its motion affected? Give reason.

Solution:

When two equal and opposite forces are acting on a moving body, the motion of the body is not affected, it remains unchanged. It is because the net force acting on the object is zero.

17. An aero plane is moving uniformly at a constant height under the action of two forces (i) upward force (lift) and (ii) downward force (weight). What is the net force on the aero plane.

Solution:

The net force acting on the aero plane is zero as it is acted upon by two opposing forces and hence remains unchanged.

18. Why does a person fall when he jumps out from a moving train?

Solution:

It is because inside the train, his whole body was in a state of motion with the train. On jumping out of the moving train, as soon as his feet touch the ground, the lower part of his body comes to rest, while the upper part still remains in motion due to inertia of motion.

19. Why does a coin placed on a card, drop into the tumbler when the card is rapidly flicked with the finger?

Solution:

A momentary force acts on the card when it is flicked with fingers which causes it to move away. But the coin placed on it is not does not share the motion at once and continues to stay at rest which is attributed to inertia of rest. Eventually, the coin falls down into the tumbler due to the gravitational pull.

20. Why does a ball thrown vertically upwards in a moving train, come back to the thrower's hand?

Solution:

Inside the train, the ball and the person both are in motion. Due to inertia of motion, as long as the ball stays in air, both the person and the ball move in the same direction which causes the ball to fall back to the thrower's hand.

21. Explain the following:

(a) When a train suddenly moves forward, the passenger standing in the compartment tends to fall backwards.

(b) When a corridor train suddenly starts, the sliding doors of some compartments may open.
(c) People often shake branches of a tree for getting down its fruits.
(d) After alighting from a moving bus, one has to run for some distance in the direction of bus in order to avoid falling.
(e) Dust particles are removed from a carpet by beating it.
(f) It is advantageous to run before taking a long jump.

Solution:

(a) It is because the lower part of the passenger's body is in close contact with the train. When the train starts moving, the lower part shares the motion at once, but the upper part cannot share the motion at the same time due to inertia of rest and hence remains at the same place.
(b) It is because the frame of sliding door is in contact with the floor of the train also comes in motion when the train starts but due to inertia, the sliding door remains in its position.
(c) It is because when the branches are shaken they are in motion but the fruits remain in the state of rest due to inertia. Hence the fruits that are weakly attached to the branches, detach and fall due to the pull of gravity.
(d) It is because if they were to halt at once, their feet would suddenly come to rest but their upper body would still continue to stay in its state of motion and hence they tend to fall forward.
(e) The section of the carpet which comes in contact with the carpet comes in motion at once, but the dust particles present on it, due to inertia of rest, stay in the state of rest. Consequently, the section of the carpet moves along the stick leaving dust particles behind which tend to fall down to the pull of gravity.
(f) It is advantageous to run before taking a long jump as the athlete sets his body in the state of motion hence it becomes easier to take the jump.

Multiple Choice Type:

1. **The property of inertia is more in:**
   (a) A car
   (b) A truck
   (c) A horse cart
   (d) A toy car

   Solution:

   (b) A truck

   The property of inertia is directly proportional to the mass of the object.

2. **A tennis ball and a cricket ball, both are stationary. To start motion in them:**
   (a) A less force is required for the cricket ball than for the tennis ball
   (b) A less force is required for the tennis ball than for the cricket ball
   (c) Same force is required for both the balls
   (d) Nothing can be said

   Solution:

   (b) A less force is required for the tennis ball than for the cricket ball

   Cricket ball is more massive than tennis ball hence cricket ball acquires much smaller velocity

than a tennis ball when the two balls are pushed with equal force for the same duration.

3. **A force is needed to:**
   (a) Change the state of motion or state of rest of the body
   (b) Keep the body in motion
   (c) Keep the body stationary
   (d) Keep the velocity of body constant

   Solution:

   (a)Change the state of motion or state of rest of the body

   A body cannot change its state itself until acted upon by an external force.

Exercise -3(C) Page: 69

1. **Name the two factors on which the force needed to stop a moving body in a given time, depends.**
   Solution:
   Velocity and mass are the two factors on which the force needed to stop a moving body is dependent upon in a given time.

2. **Define linear momentum and state its S.I. unit.**
   Solution:
   Linear momentum of a body can be defined as the product of its mass and velocity. The S.I. unit of linear momentum is $kgms^{-1}$

3. **A body of mass m moving with a velocity v is acted upon by a force. Write expression for change in momentum in each of the following cases: (i) when v <<c, (ii) when v→c, and (iii) when v<<c but m does not remain constant. Here c is the speed of light.**
   Solution:
   Let Δp is the change in momentum;
   (i) When v << c ;
   Δp = m Δv
   (ii) when v→c;
   Δp = Δ(mv)
   (iii) when v<<c;
   Δp = Δ(mv)

4. **Show that the rate of change of momentum = mass x acceleration. Under what condition does this relation hold?**
   Solution:
   Let force 'F' be applied on a body having mass 'm' for 't' period of time because of which the velocity of the body changes from u to v.
   Hence, the initial velocity of the body is 'mu' and final velocity of the body is 'mv'

   The difference in the momentum of the body in 't' seconds is given as mv-mu=m(v-u)

   Rate of change of momentum = change in momentum/time
   = [m(v-u)] /t - equation 1

   As we know, acceleration 'a'=(v-u)/t
   Substituting this in the above equation 1, we get;
   Rate of change of momentum = mass x acceleration = ma

   The condition for this relation to hold true is that mass of the body remains constant.

5. Two bodies A and B of same mass are moving with velocities v and 2v respectively. Compare their (i) inertia (ii) momentum.

Solution:

(i) If 'm' is the mass of two bodies A and B,
Comparing inertia of both the bodies;
Inertia of A: Inertia of B :: m:m or 1:1

(ii) To compare momentum of bodies A and B
Momentum of A = m(v)
Momentum of B = m(2v) =2mv
Comparing momentum of bodies A and B
Momentum of A: Momentum of B :: mv:2mv or 1:2

6. Two balls A and B of masses m and 2m are in motion with velocities 2v and v respectively. Compare (i) their inertia, (ii) their momentum, and (iii) the force needed to stop them in same time.

Solution:

(i) Comparing inertia of two bodies A and B;
Inertia of body A: Inertia of body B :: m:2m or 1:2

(ii) Comparing momentum of both bodies
Momentum of body A = m(2v) = 2mv
Momentum of body B = (2m)v= 2mv
Momentum of body A: Momentum of body B :: 2mv:2mv or 1:1

(iii) Comparing the force needed to stop both the bodies at the same time
Rate of momentum change is directly proportional to the force applied on a body as per Newton's second law of motion. Hence;
Force required to stop A: Force required to stop B:: 1:1

7. State Newton's second law of motion. What information do you get from it?

Solution:

Newton's second law of motion states that:
The rate of change of momentum of a body is directly proportional to the force applied on it and the change in momentum takes place in the direction in which the force is applied.
Newton's second law of motion provides the quantitative value of force. We could relate the physical quantity force to the other measurable quantities such as mass and acceleration.

8. How does Newton's second law of motion differ from first law of motion?

Solution:

The differences are as given below:

Newton's First law of motion	Newton's second law of motion
The first law provides qualitative definition of force	The second law provides quantitative value of force
It demonstrates the force as cause of acceleration	It presents force as product of mass and acceleration, thereby relating force to measureable quantities such as mass and acceleration

9. Write the mathematical form of Newton's second law of motion. State condition if any.

Solution:

Newton's second law of motion can be expressed mathematically as follows:

$$F=ma$$

where 'F' is the force applied on a body having mass 'm' and acceleration 'a'. The force produces acceleration in the body due to which the velocity and hence the momentum of the body changes.

For the relation to hold well, two conditions are needed:

- Velocities must be much smaller than the velocity of light
- Mass of the body remains constant.

10. State Newton's second law of motion. Under what condition does it take the form F=ma?

Solution:

Newton's second law of motion states that:

The rate of change of momentum of a body is directly proportional to the force applied on it and the change in momentum takes place in the direction in which the force is applied.

For the relation to hold well, two conditions are needed:

- Velocities must be much smaller than the velocity of light
- Mass of the body remains constant.

11. How can Newton's first law of motion be obtained from the second law of motion?

Solution:

To obtain Newton's first law of motion from second law of motion:

From Newton's second law, $F=ma$

If $F=0$, then $a=0$;

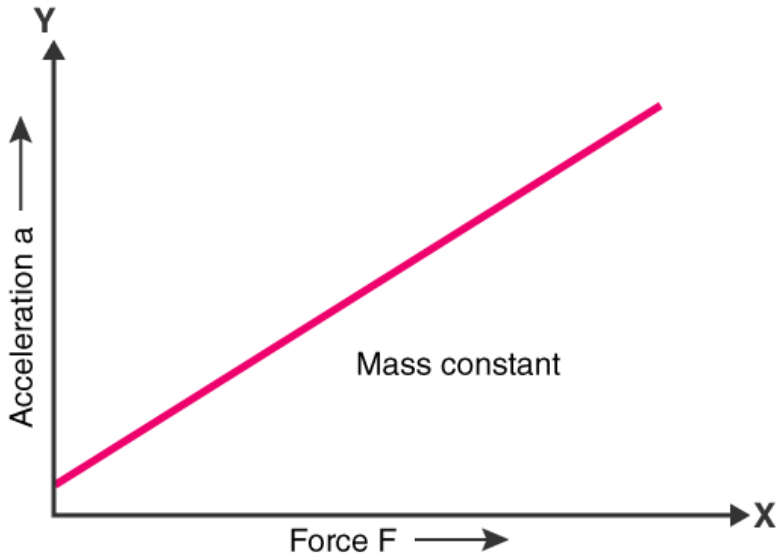
This implies that when force is not applied on a body, the acceleration will be zero. If the body is at rest, it will continue to stay at rest, when it is moving, it will continue to move in the same direction with the same speed.

Hence, a body not acted upon by an external force, does not change its state of rest or motion which is the statement of Newton's first law of motion.

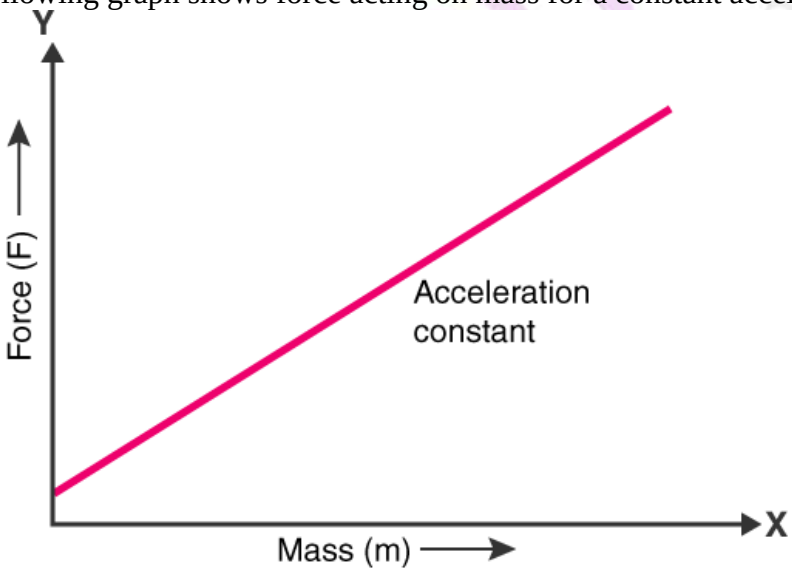
12. Draw graphs to show the dependence of (i) acceleration on force for a constant mass, and (ii) force on mass for a constant acceleration.

Solution:

(i) The following graph shows the acceleration on force for a constant mass



(ii) The following graph shows force acting on mass for a constant acceleration

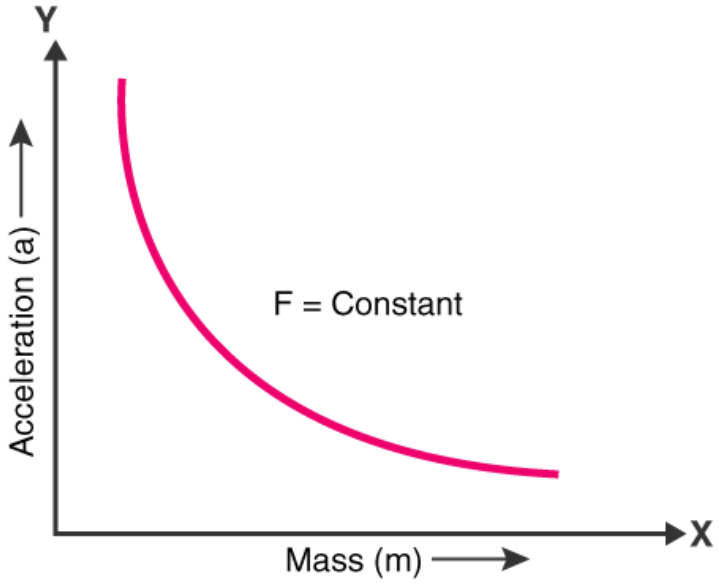


13. How does the acceleration produced by a given force depend on mass of the body? Draw a graph to show it.

Solution:

If a force is applied on two bodies that have different masses, then the acceleration that is produced by them varies inversely to their individual masses.

When a graph for mass against acceleration is sketched, a hyperbola is obtained.



14. Name the S.I. unit of force and define it.

Solution:

The S.I unit of force is newton.

One newton is the force which when acts on a body of mass 1kg, produces an acceleration of $1m/s^2$. i.e., 1 newton=1 kg x $1m/s^2$

15. What is the C.G.S unit of force? How is it defined?

Solution:

The C.G.S unit of force is dyne. One dyne is the force which when acts on a body of mass 1g, produces an acceleration of $1cm/s^2$. i.e., 1 dyne=1gx$1cm/s^2$

16. Name the S.I. and C.G.S units of force. How are they related?

Solution:

S.I. unit of force is newton, C.G.S. unit of force is dyne.

Relationship between newton and dyne:

1 newton = 1 kg x $1m/s^2$

= 1000g x $100cm/s^2$ = 10^5 g x cm/s^2

= 10^5 dyne

17. Why does a glass vessel break when it falls on a hard floor, but it does not break when it falls on a carpet?

Solution:

The glass vessel comes to rest almost immediately when it falls from a height on a hard floor. Hence the floor applies a huge force on the vessel causing it to break. But, if the glass vessel falls on a carpet, the time period at which the vessel comes to rest escalates hence the carpet applies lesser force in the vessel and hence it does not break.

18. Use Newton's second law of motion to explain the following:

(a) A cricketer pulls his hands back while catching a fast moving cricket ball.

(b) An athlete prefers to land on sand instead of hard floor while taking a high jump.

Solution:

(a) It is because while doing so, time of catching the ball can be increased. In other words, to increase the time to bring about a given change in momentum consequently rate of change of momentum decreases. Hence the ball exerts a small amount of force on our hands.

(b) When an athlete is landing from a height on a hard floor, his feet immediately come to rest which causes a very large force to be exerted on his feet by the floor. In case he lands on sand, for some distance, his feet pushes the sand hence the time period in which the feet comes to halt increases. Consequently, he is saved from getting hurt as the force exerted on his feet decreases.

Multiple choice type

1. The linear momentum of a body of mass m moving with velocity v is:

(a) v/m

(b) m/v

(c) mv

(d) 1/mv

Solution:

(c) mv

Linear momentum can be defined as the product of mass and velocity of an object.

2. The unit of linear momentum is:

(a) Ns

(b) kg ms^{-2}

(c) Ns^{-1}

(d) kg^2 ms^{-1}

Solution:

(a) Ns

3. The correct form of Newton's second law is:

(a) $F = \frac{\Delta p}{\Delta t}$

(b) $F = m\frac{\Delta v}{\Delta t}$

(c) $F = v\frac{\Delta m}{\Delta t}$

(d) F = mv

Solution:

(a) $F = \frac{\Delta p}{\Delta t}$

Where motion or momentum changes either due to change in velocity or change in mass or both.

4. The acceleration produced in a body by a force of given magnitude depends on

(c) Size of the body
(d) Shape of the body
(e) Mass of the body
(f) None of these
Solution:
(c) Mass of the body
F=ma; Force applied on a body depends on the mass of the body.

Numericals:

1. **A body of mass 5kg is moving with velocity 2m/s. Calculate its linear momentum.**
   Solution:
   Given: velocity=2m/s; mass=5kg
   Linear momentum = mv = 5x2 =10kg m/s

2. **The linear momentum of a ball of mass 50g is 0.5kg m/s. Find its velocity.**
   Solution:
   Given: mass=50g or 0.05kg; linear momentum =0.5 kg m/s, v=?
   Linear momentum = mv
   0.5=0.05 x v
   v=0.5/0.05
   v=10m/s

3. **A force of 15N acts on a body of mass 2kg. Calculate the acceleration produced.**
   Solution:
   Given: F=15N, m=2kg, a=?
   F=ma => a = F/m
   = 15/2 = 7.5m/s^2

4. **A force of 10N acts on a body of mass 5kg. Find the acceleration produced.**
   Solution:
   Given: F=10N, m=5kg, a=?
   F=ma => a=F/m
   =10/5=2 m/s^2

5. **Calculate the magnitude of force which when applied on a body of mass 0.5kg produces an acceleration of 5m/s^2.**
   Solution:
   Given: F=? m=0.5kg, a=5m/s^2
   F=ma
   = 0.5 x 5
   = 2.5N

6. **A force of 10N acts on a body of mass 2kg for 3s, initially at rest. Calculate: (i) the velocity acquired by the body, and (ii) change in momentum of the body.**
   Solution:

Given: F=10N, m=2kg, t=3s; initial velocity u=0m/s

(i) To find final velocity v;
F=ma
$a=F/m = 10/2=5m/s^2$
We know the 1st equation of motion;
v=u+at
=0+(5x3)
v=15m/s

(ii) To find change in momentum
Momentum change = final momentum – initial momentum
$\Delta p=m(v-u)$
=2(15-0) = 30 kg m/s

7. A force acts for 10s on a stationary body of mass 100kg after which the force ceases to act. The body moves through a distance of 100m in the next 5s. Calculate: (i) the velocity acquired by the body, (ii) the acceleration produced by the force, and (iii) the magnitude of the force.

Solution:

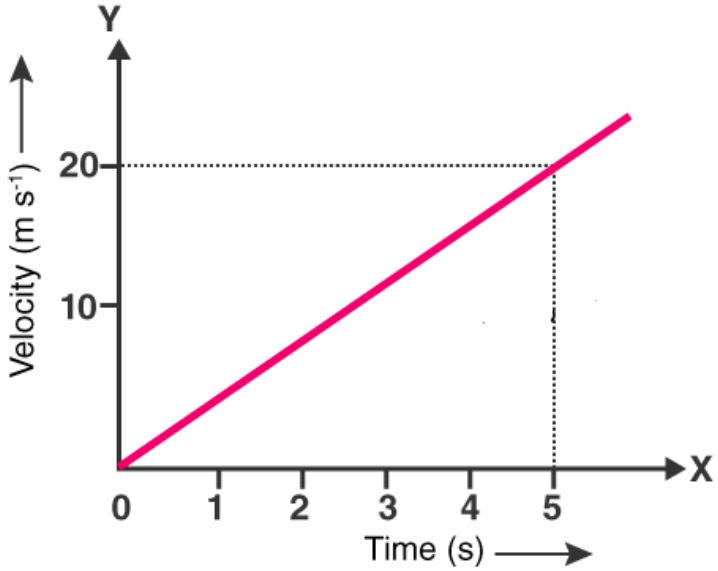
Given: m=100kg, initial velocity u =0, distance covered s=100m;

(i) Velocity of the body= distance covered/time
= 100/5 = 20m/s

(ii) Acceleration can be found using the equation of motion,
$v^2-u^2=2as$
$a=(v^2-u^2)/2s$
$= (20^2 – 0^2)/ 2 \times 100$
$a= 2m/s^2$

(iii) Force = ma
= 100 x 2
= 200N

8. Figure shows the velocity-time graph of a particle of mass 100g moving in a straight line. Calculate the force acting on the particle.



(Hint: acceleration = slope of v-t graph)

Solution:
Given: m=100g or 0.1kg
Value of acceleration can be obtained by the slope of velocity-time graph.
Acceleration = Slope = 20/5 = $4ms^{-2}$
Force = ma
= 0.1 x 4 = 0.4N

9. A force causes an acceleration of $10m/s^2$ in a body of mass 500g. What acceleration will be caused by the same force in a body of mass 5kg?

Solution:
Given: $a=10m/s^2$, m=500g or 0.5kg
We know that; F=ma
= 0.5 x 10
= 5N
To find acceleration caused by 5N force on a body having mass=5kg
a=F/m
=>5/5 = $1m/s^2$

10. A force acts for 0.1s on a body of mass 2kg initially at rest. The force is then withdrawn and the body moves with a velocity of 2m/s. Find the magnitude of force.

Solution:
Given: u=0, t=0.1s, m=2kg, final velocity v = 2m/s; F=?
We know that acceleration is the rate of change of velocity
Acceleration = (v-u)/t
= (2-0)/0.1
= $20m/s^2$
Force = ma
= 2 x 20

= 40N

11. A body of mass 500g, initially at rest, is acted upon by a force which causes it to move a distance of 4m in 2s, Calculate the force applied.

Solution:

Given: m=500g or 0.5kg, u=0; s=4m; t=2s, F=?

We know that, $S=ut+1/2\ at^2$

$4=(0)(2)+1/2(a)(2)^2$

$4=0+2a$

$a=2m/s^2$

Force = mass x acceleration

=0.5 x 2

= 1N

12. A car of mass 480kg moving at a speed of 54km/h is stopped by applying brakes in 10s. Calculate the force applied by the brakes.

Solution:

Given: m=480kg, initial velocity, u=54km/h or 15m/s, final velocity, v=0m/s, t=10s, F=?

We know that acceleration is the rate of change of velocity

$\therefore \text{acceleration} = (v-u)/t$

$= (0-15)/10$

$= -1.5m/s^2$

The negative sign shows that it is retardation.

Force = m x a

= 480 (-1.5)

= 780N

13. A car is moving with a uniform velocity of 30m/s. It is stopped in 2s by applying a force of 1500N through its brakes. Calculate: (a) the change in momentum of car, (b) the retardation produced in car, and (c) the mass of the car.

Solution:

Given: t=2s, F=1500N, u=30m/s, v=0m/s,

$\text{acceleration} = (v-u)/t$

$= (0-30)/2 = -15m/s^2$

The negative acceleration just indicates retardation.

Force = mass x acceleration

⇨ Mass = force/acceleration

⇨ = 1500/(15)

= 100kg

(a) To find change in momentum

Change in momentum = final velocity – initial velocity or $\Delta p = m(v-u)$

$\Delta p = 100(0-30)$

= 3000 kg m/s

(b) Retardation produced in car

We know that retardation is negative acceleration

∴acceleration = (v-u)/t
= (0-30)/2 = -15m/s^2
Retardation is 15m/s^2

(c) Mass of the car
As per newton's second law of motion,
Force = mass x acceleration
⇨ Mass = Force/acceleration
⇨ = 1500/15
⇨ = 100kg

14. A bullet of mass 50g moving with an initial velocity of 100m/s , strikes a wooden block and comes to rest after penetrating a distance 2cm in it. Calculate : (i) initial momentum of the bullet (ii) final momentum of the bullet, (iii) retardation caused by the wooden block, and (iv) resistive force exerted by the wooden block

Solution:

Given: m=50g or 0.05kg, u=100m/s, v=0m/s, s=2cm or 0.02m

(i) Initial momentum of the bullet = mu
= 0.05 x 100 = 5m/s

(ii) Final momentum of the bullet = mv
= 0.05 x 0 = 0 m/s

(iii) Retardation caused by the wooden block
Retardation is negative acceleration.
We know from the equation of motion that,
$v^2-u^2=2as$
$0^2 – (100)^2 = 2a(0.02)$
$(100 \times 100)/0.04= 0.04a$
$a = -2.5 \times 10^5$ m/s^2

(iv) Force = mass x acceleration
$= 0.05 \times (2.5 \times 10^5)$
= 12500N

Exercise -3(D) Page: 73

1. **State the usefulness of Newton's third law of motion.**
   Solution:
   Newton's third law unlike the first and second law of motion, explains how the force acts on the object.

2. **State Newton's third law of motion.**
   Solution:
   Newton's third law of motion states that:
   "To every action there is always an equal and opposite reaction".

3. **State and explain the law of action and reaction, by giving two examples.**
   Solution:
   The law of action and reaction is the Newton's third law of motion which states that to every action there is always an equal and opposite reaction. This can be explained with the help of the following examples:
   (a) A book on a table – a book exerts a force equal to its weight W when it is placed on a table top which is the action in downwards direction. The table balances it by exerting an equal force known as reaction that acts in an upward direction on the book.
   (b) Pushing a wall – when you apply a force on a wall by pushing your palm against it, that becomes an action and the force which you experience in turn from the wall, forms the reaction that is applied by the wall on your palm.

4. **Name and state the action and reaction in the following cases:**
   (a) Firing a bullet from a gun,
   (b) Hammering a nail,
   (c) A book lying on a table,
   (d) A moving rocket,
   (e) A person walking on the floor,
   (f) A moving train colliding with a stationary train
   Solution:
   The names and action, reactions in each of the cases are as follows:

Cases	Action	Reaction
Firing a bullet from a gun	Force exerted on the bullet	Gun experiences an equal recoil
Hammering a nail	Force exerted on the nail by the hammer	Force exerted by the nail on the hammer
A book lying on a table,	Force exerted by the book on the table	Force experienced by the book from the table in the upwards direction
A moving rocket	Force exerted by the rocket backwards on the gases	Force exerted by the gases on the rocket causing it to propel forward
A person walking on the floor	Force exerted by the	Force experienced by the

	person's feet in backward direction on the ground	ground on the person's feet in the forward direction
A moving train colliding with a stationary train	Force applied by a moving train on a train at rest	Force experienced by the train at rest on a moving train

5. Explain the motion of a rocket with the help of Newton's third law

Solution:

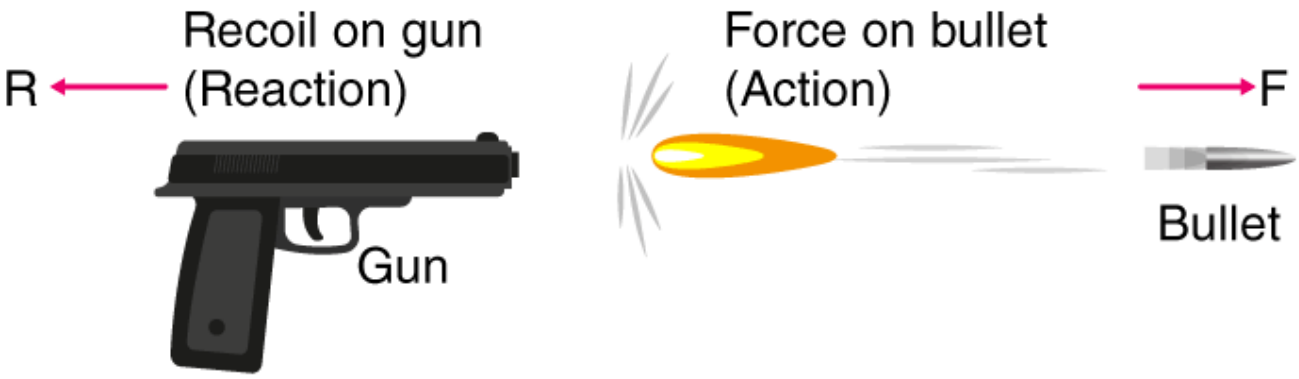
Newton's third law states that for every action there is always an equal and opposite reaction. The motion of a rocket can be explained with the help of this law. In a rocket, fuel burning inside is expelled as burning gases. The gases are expelled at a higher temperature and pressure through the nozzle of the rocket causing the rocket to exert a force F on the gases to expel them through a nozzle in the backwards direction.

The outgoing gases put forth an equal and opposite force R (reaction) on the rocket because of which it propels forward.

6. When a shot is fired from a gun, the gun gets recoiled. Explain.

Solution:

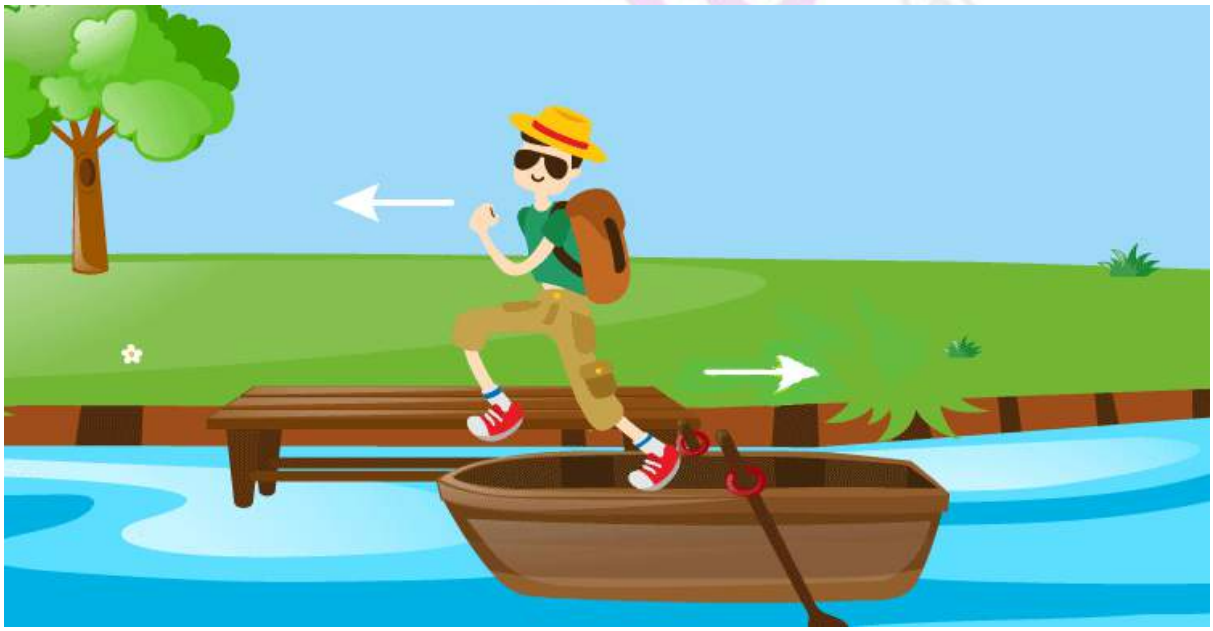
When a bullet is fired from a gun, force F is exerted on the bullet which forms the action. The gun in turn experiences an equal recoil R which forms the reaction.



7. **When you step ashore from a stationary boat, it tends to leave the shore. Explain.**

Solution:

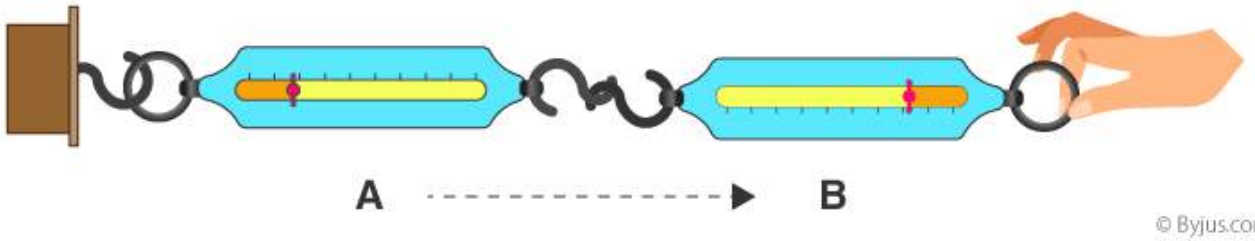
By stepping into a boat, when a man exerts a force (action), the force of reaction causes him to step of the boat and the boat is inclined to leave the shore because of the force applied by the man.



8. **When two spring balances joined at their free ends, are pulled apart, both show the same reading. Explain.**

Solution:

The figure shows two spring balances A and B that are coupled. When the balance B is pulled, both the balances tend to indicate the same reading depicting that both the forces of reaction and action are opposite and equal in nature. In such a condition, the pull of either of the two spring balances can be considered as action and other balance as the reaction.



9. **To move a boat ahead in water, the boatman has to push the water backwards by his oar. Explain.**
   Solution:
   The boatman pushes the water in the backward direction (action) to move a boat with his oar. The water in turn exerts an equal and opposite force (reaction) in the forward direction on the boat because of which the boat moves forward.

10. **A person pushing a wall hard is liable to fall back. Give reason.**
    Solution:
    A person experiences a force (reaction) by the wall on his palm in the opposite direction when he pushes the wall hard (action) by his palm. This is why he is liable to fall back.

11. **"The action and reaction both act simultaneously." Is this statement true?**
    Solution:
    Yes, the statement is true.

12. **"The action and reaction are equal in magnitude". Is this statement true?**
    Solution:
    Yes, the statement is true.

13. **A light ball falling on ground, after striking the ground rises upwards. Explain the reason.**
    Solution:
    A ball exerts a force when it strikes the ground. The ground in turn exerts a force on the ball in an opposite direction. Hence the ball rises in the upward direction.

14. **Comment on the statement 'the sum of action and reaction on a body is zero'.**
    [Hint: The statement is wrong]
    Solution:
    The statement is wrong.
    As per the Newton's third law of motion, action and reaction act at the same time on different objects. Consequently, they do not negate each other.

Multiple choice type:

1. **Newton's third law:**
   (a) Defines the force qualitatively

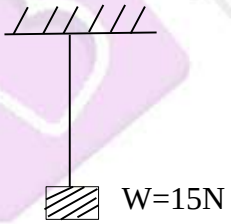
(b) Defines the force quantitatively
(c) Explains the way a force acts on a body
(d) Gives the direction of force.
Solution:
(c) Explains the way a force acts on a body
It states that to every action there is always an equal and opposite reaction.

2. **Action and reaction act on the:**
(a) Same body in opposite directions
(b) Different bodies in opposite direction
(c) Different bodies, but in same direction
(d) Same body in same direction.
Solution:
(b) Different bodies in opposite direction
As per Newton's third law, action and reaction are equal and opposite.

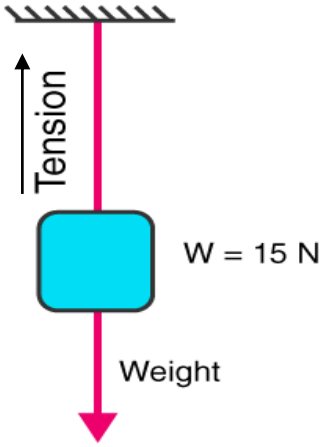
Numericals:

1. **A boy pushes a wall with a force of 10N towards east. What force is exerted by the wall on the boy?**
Solution:
The boy experiences an equal force of 10N exerted by the wall in the opposite direction, i.e., the west.

2. **In figure, a block of weight 15N is hanging from a rigid support by a string. What force is exerted by**



(a) Block on the string
(b) String on the block
Name them and show them in the diagram.
Solution:
(a) The force exerted by the block on the string is 15N acting downwards because of the weight of the block
(b) The force exerted by the string on the block is 15N acting upwards because of the tension generated.


Tension
W = 15 N
Weight

Exercise -3(E) Page: 79

1. **State Newton's law of gravitation.**
   Solution:
   Newton's law of gravitation states that – The force of attraction acting between two bodies is (i) directly proportional to the product of their masses and (ii) inversely proportional to the square of the distance between them. The force acts along the line joining the two particles.

2. **State whether the gravitational force between two masses is attractive or repulsive?**
   Solution:
   The gravitational force between two masses is always attractive.

3. **Write an expression for the gravitational force of attraction between two bodies of masses m_1 and m_2 separated by a distance r.**
   Solution:
   The gravitational force 'F' between two bodies having masses m_1 and m_2, separated by a distance r is given by:

   $$F = G \frac{m1\, m2}{r^2}$$

   where G is the constant of proportionality known as the gravitational constant.

4. **How does the gravitational force of attraction between two masses depend on the distance between them?**
   Solution:
   The gravitational force of attraction between two masses is inversely proportional to the square of the distance between the masses.

5. **How is the gravitational force between two masses affected if the separation between them is doubled?**
   Solution:
   The gravitational force reduces to one-fourth if the distance between two masses is doubled.

6. **Define gravitational constant G.**
   Solution:
   The gravitational constant G can be defined as the force of attraction between two masses having unit mass separated by a unit distance.

7. **Write the numerical value of gravitational constant G with its S.I unit.**
   Solution:
   The numerical value of gravitational constant G is 6.67×10^{-11} Nm^2kg^{-2}
   The S.I unit of G is Nm^2kg^{-2}

8. **What is the importance of the law of gravitation?**
   Solution:
   Newton used the law of gravitation to explain:

- the motion of planets around the sun
- the motion of the moon(satellite) around the earth
- the motion of a freely falling body.

9. What do you understand by the term force due to gravity?

Solution:

As per the law of gravitation, the earth attracts each object around it, towards its center. The force with which the earth attracts a body is called the force due to gravity.

10. Write an expression for the force due to gravity on a body of mass m and explain the meaning of the symbols used in it.

Solution:

The force due to gravity 'F' acting on a body of mass placed on the earth's surface having mass 'm' and radius 'r' is equivalent to the force of attraction between the body and the earth.

$$F = \frac{GMm}{R^2}$$

11. Define the term acceleration due to gravity? Write its S.I. unit.

Solution:

Acceleration due to gravity can be defined as the rate at which the velocity of a freely falling body increases. The S.I. unit of acceleration due to gravity is m/s^2.

12. Write down the average value of g on the earth's surface.

Solution:

The average value of g on the surface of the earth is 9.8 m/s^2.

13. How is the acceleration due to gravity on the surface of the earth related to its mass and radius?

Solution:

The acceleration due to gravity 'g' on the surface of earth, where mass is 'm' and radius is 'r'.

Then, $g = \frac{GM}{R^2}$

14. How are g and G related?

Solution:

The universal gravitational constant (G) and the acceleration due to gravity (g) are directly proportional to each other.

15. A body falls freely under gravity from rest and reaches the ground in time t. Write an expression for the height fallen by the body.

Solution:

Given: acceleration due to gravity='g', initial velocity, u=0, time=t.

Let 'h' be the height fallen by the body

$h = ut + ½ gt^2$

u = 0 m/s, therefore the equation becomes;

$h = ½ gt^2$

16. A body is thrown vertically upwards with an initial velocity u. Write an expression for the maximum height attained by the body.

Solution:

There will be retardation when a body is thrown vertically upwards having an initial velocity 'u' to reach a height 'h'. The final velocity 'v' at the highest point is 0m/s

We know from the equation of motion that,

$v^2 = u^2 - 2gh$

$h_{max} = \frac{u^2}{2g}$

17. Define the terms mass and weight.

Solution:

Mass: mass of a body is the quantity of matter it contains. It is a scalar quantity.

Weight: Weight of a body is the force with which the earth attracts it. It is the force of gravity on it. Weight is a vector quantity.

18. Distinguish between mass and weight.

Solution:

Mass	Weight
It is the quantity of matter it contains	It is the force with which earth attracts a body
Mass is a scalar quantity	Weight is a vector quantity
Mass of a body is always constant	Weight of a body varies from place to place
S.I. unit of mass is kg	S.I. unit of weight is newton

19. State the S.I. units of (a) mass and (b) weight.

Solution:

The S.I. unit of mass is kilogram and symbol is kg

The S.I. unit of weight is newton and symbol is N

20. The value of g at the center of the earth is zero. What will be the weight of a body of mass m kg at the center of the earth?

Solution:

Weight of a body of mass m kg

W =mg

At the center of the earth, acceleration due to gravity 'g' = 0, substituting this value,

W = 0

21. Which of the following quantity does not change by change of place of a body: mass or weight?

Solution:

Mass of a body is constant and does not change whereas weight varies from place to place.

22. Explain the meaning of the following statement '1kgf=9.8N'.

Solution:

The gravitational unit of force in M.K.S system is kilogram force (kgf)

One kilogram force is the force due to gravity on a mass of 1kg.
1kg = force due to gravity on a mass of 1kg
= mass of 1kg x acceleration due to gravity g m/s^2
= g newton
Since the average value of g is 9.8 m/s^2,
1kgf = 9.8 newton or 9.8N

Multiple choice type:

1. **The gravitational force between two bodies is:**
   (a) Always repulsive
   (b) Always attractive
   (c) Attractive only at large distances
   (d) Repulsive only at large distances
   Solution:
   (c) Always attractive
   Gravitational force between two masses is always attractive

2. **The value of G is**
   (a) 9.8N m^2 kg^{-2}
   (b) 6.7 x 10^{-11} Nm^2kg^{-2}
   (c) 6.7 x 10^{-11} ms^{-2}
   (d) 6.7 Nkg^{-1}
   Solution:
   (b) 6.7 x 10^{-11} Nm^2kg^{-2}
   Universal gravitational constant is represented as 'G'

3. **The force of attraction between two masses each of 1kg kept at a separation of 1m is:**
   (a) 9.8N
   (b) 6.7N
   (c) 980N
   (d) 6.7 x 10^{-11} N
   Solution:
   (d) 6.7 x 10^{-11} N
   The force of attraction is the gravitational force between two bodies.

4. **A body is projected vertically upward with an initial velocity u. If acceleration due to gravity is g, the time for which it remains in air, is:**
   (a) u/g
   (b) ug
   (c) 2u/g
   (d) u/2g
   Solution:
   (c)2u/g
   Time taken 't'= u/g, time taken to travel upwards and remain in air is 2t= 2u/g

5. **An object falling freely from rest reaches ground in 2s. if acceleration due to gravity is 9.8 m/s^2, the velocity of the object on reaching the ground will be:**
   (a) 9.8m/s
   (b) 4.9 m/s
   (c)19.6m/s
   (d) Zero
   Solution:
   (c)19.6 m/s
   Value of g=9.8m/s^2, t=2s, v=?
   Velocity of the object = g x t
   = 9.8m/s x 2s = 19.6 m/s

Numericals:

1. **The force of attraction between two bodies at a certain separation is 10N. What will be the force of attraction between them if the separation is reduced to half?**
   Solution:
   Given: F=10N;
   $F = G\frac{Mm}{R^2}$
   Let the new distance be R1 acting between two bodies with force F1, then:

   R1 = R/2
   $F1 = G\frac{Mm}{\left(\frac{R}{2}\right)^2} = 4G\frac{Mm}{(R)^2}$
   F1 = 4 F
   = 4 x 10
   F1 = 40N

2. **Write the approximate weight of a body of mass 5kg. What assumption have you made?**
   Solution:
   Given: mass = 5kg,
   Assumption made is value of acceleration due to gravity is 10m/s^2
   Weight = mg
   = 5 x 10 = 50N

3. **Calculate the weight of a body of mass 10kg in (a) kgf and (b) newton. Take g=9.8m/s^2**
   Solution:
   Given: mass =10kg
   (i)Weight of the body in kgf = 10 x 1 kgf = 10kgf
   (ii)Weight of the body in newton = 10 x 9.8 = 98N

4. **State the magnitude and direction of the force of gravity acting on a body of mass 5kg. Take g=9.8m/s^2**
   Solution:

Given: m=5kg, g=9.8m/s^2, F=?
If F is the force of gravity,
F=mg
= 5 x 9.8
= 49N
The force of gravity =49N acting vertically downwards.

5. **The weight of a body is 2.0N. What is the mass of the body? (g=10 m/s^2)**
Solution:
Given: w=2N, g=10m/s^2;
Let 'm' be the mass of the body,
We know that, W=mg
⇨ m = W/g = 2/9.8 = 0.2kg

6. **The weight of a body on earth is 98N where the acceleration due to gravity is 9.8ms^{-2}. What will be its (a) mass and (b) weight on moon where the acceleration due to gravity is 1.6m/s^2?**
Solution:
Given: weight=98N, g=9.8m/s^2
If 'm' is the mass of the body,
m = W/g
= 98/9.8 = 10kg
Mass remains constant
(a) Mass on the moon is the same as the mass on earth = 10kg
(b) If weight on the moon is W1,
W1 = mass x g on earth = 10 x 1.6 = 16N

7. **A man weighs 600N on earth. What would be his approximate weight on moon? Give reason for your answer?**
Solution:
Given: weight of man on earth = 600N
Weight of the man on moon = 1/6 weight of man on earth;
It is because the acceleration due to gravity on the moon is 1/6th of earth,
w=mg
∴ Weight of the man on the moon = 600/6 = 100N

8. **What is the (a) force of gravity and (b) weight of a block of mass 10.5kg? Take g=10 m/s^2**
Solution:
Given: m=10.5kg, G=10m/s^2
(a) Force of gravity, F=mg
= 10.5 x 10 = 105N
(b) Weight of a block mass, w=mg
w = 10.5 x 10 = 105N

9. **A ball is released from a height and it reaches the ground in 3s. If g=9.8m/s^2, find:**
(a) The height from which the ball was released,
(b) The velocity with which the ball will strike the ground.

Solution:

Given: t=3s, g = 9.8m/s^2, initial velocity u=0m/s

Assume 's' to be the height the ball is released;

(a)We know from the equation of motion;

$S = ut + ½ at^2$

$= 0 + ½ (9.8) (3)^2$

$= 44.1m$

(b) Assume 'v' to be the velocity with which the ball strikes the ground,

We know from the equation of motion,

$v^2 – u^2 = 2gs$

$v^2 – 0^2 = 2 (9.8)(44.1)$

$v^2 = 864.36$

$v = 29.4$ m/s

10. What force, in newton, your muscles need to apply to hold a mass of 5kg in your hand? State the assumption.

Solution:

Given: m=5kg,

$F=mg$

$= (5) (9.8)$

$= 49N$

The value of acceleration due to gravity assumed is 9.8m/s^2

11. A ball is thrown vertically upwards. It goes to a height 20m and then returns to the ground. Taking acceleration due to gravity g to be 10m/s^2, find:

(a) The initial velocity of the ball

(b) The final velocity of the ball on reaching the ground and

(c) The total time of journey of the ball.

Solution:

Given: maximum height, s= 20m, g=10m/s^2

(a)If 'u' is the initial velocity, velocity is zero at the highest point

We know that $v^2 – u^2 = 2gs$

$0 - u^2 = 2 (10)(20)$

$u^2 = - 400$m/s

$u = 20$ m/s

Here, the negative sign indicates that the motion is against gravity.

(b) If v1 is the final velocity of the ball when it strikes the ground,

Velocity at the maximum height reached is zero which is equivalent to the initial velocity for the journey of the ball towards the ground.

Distance covered, s=20m;

We know from the equation of motion;

$v^2 – u^2 = 2gs$

$v^2 – 0 = 2(10)(20)$ m/s

$v^2 = 400$ m/s or $v = 20$ m/s

(c)Time for which the ball stays in air, t=2u/g

t=2 (20)/10

= 4s

12. A body is dropped from the top of a tower. It acquires a velocity 20m/s on reaching the ground. Calculate the height of the tower. (Take g=10m/s^2)

Solution:

Given: u=0m/s, v=20 m/s, g=10m/s^2;

Assume 'h' to be the height of the tower

We know from the equation of motion;

$v^2 – u^2 = 2gs$

$(20)^2 – 0 = 2\ (10)(h)$

h=400/20 => 20m

13. A ball is thrown vertically upwards. It returns 6s later. Calculate: (i) the greatest height reached by the ball, and (ii) the initial velocity of the ball. (Take g=10m/s^2)

Solution:

Given: time=6s, g=10 m/s^2;

(i) To calculate the greatest height reached by the ball.

Assume 'h' to be the greatest height reached. Ascent

Time for the rise of the ball = 6/2 =3s

Initial velocity for the rise is zero

As per the equation of motion;

$h=ut + ½\ gt^2$

$= 0(3) + ½\ (10)(3)^2$

$= 0 + 45$

⇨ 45m

(ii) To calculate the initial velocity of the ball

Assume u1 to be the initial velocity

We know from the equation of motion

$v^2 – u^2 = 2gh$

⇨ $v^2 – 0 = 2(10)(45)$

⇨ v = 30m/s

14. A pebble is thrown vertically upwards with a speed of 20m/s. How high will it be after 2s? (Take g=10m/s^2)

Solution:

Given: initial velocity u = 20 m/s, t=2s, g=10m/s^2

The greatest height reached by the pebble can be obtained by the equation of motion

$H=ut + ½\ gt^2$

$=0(2) + ½\ (10)(2)^2$

= 20m

15. (a) How long will a stone take a fall to the ground from the top of a building 80m high and (b) what will be the velocity of the stone on reaching the ground? (Take g=10 m/s^2)

Solution:

Given: height=80m, g=10 m/s^2;

(a)From the equation of motion;

$H=ut + ½ gt^2$

⇨ $80 = 0(t) + ½ (10)t^2$

⇨ $160 = 10t^2$

⇨ $t=4s$

(b) To find the velocity of the stone, assume 'v' to be the velocity

From the equation of motion;

$v^2 – u^2 = 2gh$

$v^2 – 0 = 2(10)(80)$

$v^2 = 1600$

$v = 40m/s$

16. A body falls from the top of a building and reaches the ground 2.5s later. How high is the building? (Take $g=9.8m/s^2$)

Solution:

Given: $g=9.8m/s^2$, $t=2.5s$

Assume 'h' to be the height of the building

We know from the equation of motion,

$H=ut + ½ gt^2$

⇨ $H= ½ gt^2$

⇨ $H=1/2 (9.8)(2.5)^2$

⇨ $30.6m$

17. A ball is thrown vertically upwards with an initial velocity of 49m/s. Calculate: (i) the maximum height attained, (ii) the time taken by it before it reaches the ground again. (Take $g=9.8m/s^2$)

Solution:

Given: initial velocity $u=49m/s$, $g=9.8m/s^2$

(i) Assume 'h' to be the height, velocity = 0m/s at the greatest height

We know from the equation of motion,

$v^2 – u^2 = 2gh$

⇨ $0-(49)^2 = 2(-9.8)(h)$

⇨ $h=(49)^2/19.6$

⇨ $h=122.5m$

(ii) Time taken before the ball reaches the ground is given by $t=2u/g$

$t=2(49)/9.8$

$= 10s$

18. A stone is dropped freely from the top of a tower and it reaches the ground in 4s. Taking $g=10m/s^2$, calculate the height of the tower.

Solution:

Given: initial velocity $u=0m/s$, $t=4s$, $g=10\ m/s^2$

Assume 'h' to be the height of the tower.

From the equation of motion,

$H=ut + ½ at^2$

$= 0 + ½ (10)(4)^2$

$= 80m$

19. A pebble is dropped freely in a well from its top. It takes 20s for the pebble to reach the water surface in the well. Taking g=10m/s^2 and speed of sound=330m/s, find: (i) the depth of water surface, and (ii) the time when echo is heard after the pebble is dropped.

Solution:

Given: t=20s, g=10m/s^2

(i) Assume 'h' to be the depth of the well,

We know from the equation of motion,

$H=ut + ½ gt^2$

$= 0 + ½ (10)(20)^2$

$= 2000m$

(ii) To find the time when the echo is heard after the pebble is dropped

Given: speed of sound = 330 m/s

Time taken = depth/speed

= 2000/330

=6.1s

For the pebble to reach the water surface, it takes 20s,

Hence the total time taken when the echo is heard after the pebble is dropped

= 20 + 6.1 = 21.6s

20. A ball is thrown vertically upwards from the top of a tower with an initial velocity of 19.6m/s. the ball reaches the ground after 5s. Calculate: (i) the height of the tower, (ii) the velocity of ball on reaching the ground. Take g=9.8m/s^2

Solution:

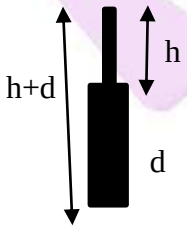
Given:

Initial velocity=19.6m/s, t=5s;

Velocity at the highest point is zero

(i) To calculate the height of the tower

Assume'd' to be height of the tower and 'h' to be the distance from the top of the tower to the maximum height as shown in the figure



We know from the equation of motion,

$v^2 – u^2 = 2gh$

⇨ $0 – (19.6)^2 = 2(9.8)(h)$

⇨ $h=19.6m$

(ii)

Let t1 be the time taken by the ball to reach the greatest point from the top of the tower

To calculate the time for which the ball remains in air;

We know the from the equation of motion,

$v=u-gt$

$0 = 19.6 – (9.8)(t1)$

$t1 = 2s$

Assume motion for (h+d) part;

Time taken for the ball to reach from the highest point of the tower to the ground is

$t-t1 = 5-2 = 3s$

From the equation of motion,

$s = ut+ ½ gt^2$

's' here is the distance from the top of the tower to the highest point, i.e., h+d

⇨ $h+d = 0 + ½ (9.8)(3)^2$

⇨ $d+19.6 = 44.1m$

⇨ $d=24.5m$

⇨ The height of the tower is 24.5m

(iii) Assume 'v' be the velocity of the ball when it strikes the ground

We know from the relation;

$v = u +gt$

$v = 0 + (9.8)(3)$

$= 29.4m/s$