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Force and Laws of Motion

In the Chapter

- First law of motion: An object continues to be in a state of rest or of uniform motion along a straight line unless acted upon by an unbalanced force.
- The natural tendency of objects to resist a change in their state of rest or of uniform motion is known as inertia.
- The mass of an object is a measure of its inertia. Its SI unit is kilogram (kg).
- Force of friction always opposes motion of objects.
- Second law of motion: The rate of change of momentum of an object is proportional to the applied unbalanced force in the direction of the force.
- The SI unit of force is kg m s^{-2}. This is also called newton and denoted by the symbol N. A force of one newton produces an acceleration of 1 m s^{-2} on an object of mass 1 kg.
- The momentum of an object is the product of its mass and velocity and has the same direction as that of the velocity. Its SI unit is kg m s^{-1}.
- Third law of motion: To every action, there is an equal and opposite reaction and they act on two different bodies.
- In an isolated system, the total momentum remains conserved.

Intext Exercises

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1. Which of the following has more inertia :
(a) a rubber ball and a stone of the same size ?
(b) a bicycle and a train ?
(c) a five rupee coin and a one rupee coin ?

Ans. (a) A stone
(b) A train
(c) A five rupee coin.

2. In the following example, try to identify the number of times the velocity of ball

changes :

"A football player kicks a football to another player of his team who kicks the football towards the goal. The goalkeeper of the opposite team collects the football and kicks it towards a players of his own team."

Also identify the agent supplying the force in each case.

Ans. Action

(i) A football player kicks a football to another player of his team.

(ii) The second football player kicks the football to make a goal.

(iii) The goalkeeper of the opposite team collects the football and kicks it towards the player of his own team.

Change in velocity

Change in velocity takes place. (From zero initial velocity the ball gains some velocity).

Change in velocity takes place again.

Change in velocity takes place for the third time.

Agent supplying the force

The first football player supplies the force.

The second football player supplies the force.

The goalkeeper supplies the force.

3. Explain why some of the leaves may get detached from a tree if we vigorously shake its branch.

Ans. When we vigorously shake the branch of a tree the branch is set in motion. Due to inertia of rest, the leaves tend to remain at rest and get detached.

4. Why do you fall in the forward direction when a moving bus breakes to a stop and fall backwards when it accelerates from rest ?

Ans. A passenger sitting in a running bus is also in motion in the same direction. When the running bus stops suddenly, the lower part of the passenger's body comes to rest, while the upper portion continues to remain in motion. As a result, the passenger is thrown in the forward direction.

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1. If action is always equal to the reaction, explain how a horse can pull a cart.

Ans. The force on the cart determines whether the cart will move or not. The force exerted by the cart on the horse affects only the horse. Hence, if the horse is able to apply enough force to overcome the frictional force, the cart will move. Thus, in order to make the cart move, the horse bends forward and pushes the ground with its feet. When the forward reaction to the backward push of the horse is greater than the opposing frictional force of the wheels, the cart moves.

2. Explain, why is it difficult for a fireman to hold a hose, which ejects large amounts of water at a high velocity.

Ans. This is because the hose pipe has a tendency to go backward. Ejection of water at a high velocity is the action which causes the hose pipe to move backward (the reaction). This is in accordance to Newton's third law of motion.

3. From a rifle of mass 4 kg, a bullet of mass 50g is fired with an initial velocity of $35 ms^{-1}$ .Calculate the initial recoil velocity of the rifle.

Ans. Mass of the bullet, m_1

$$= 50 g = \frac{50}{1000} kg = 0.05 kg$$

Mass of the rifle, $m_2 = 4$ kg
Initial velocity of the bullet, $u_1 = 0\ ms^{-1}$
Initial velocity of the rifle, $u_2 = 0\ ms^{-1}$
Final velocity of bullet, $v1 = 35\ m^{s-1}$
Final velocity of rifle = v_2
According to law of conservation of momentum,
Total momentum before the fire
= Total momentum after the fire

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$= 0.05\ kg \times 0\ ms^{-1} + 4\ kg \times 0\ ms^{-1} = 0.05\ kg \times 35\ ms^{-1} + 4\ kg \times v_2$$

$$0 = 1.75\ kgms^{-1} + 4\ kg\ v_2$$

$$\Rightarrow \quad v_2 = \frac{-1.75 kgms^{-1}}{4kg}$$

$$= 0.4375\ ms^{-1}$$

4. Two objects of masses 100 g and 200 g are moving along the same line and direction with velocities of 2 ms^{-1} and 1 ms^{-1} respectively. They collide and after the collision, the first object moves at a velocity of 1.67 ms^{-1}. Determine the velocity of the second object.

Ans. Mass of the first object,

$$m_1 = 100g = \frac{100}{1000} kg = 0.1 kg$$

Mass of the second object,

$$m_2 = 200g = \frac{200}{1000} kg = 0.2 kg$$

Initial velocity of the first object,
$u_1 = 2\ ms^{-1}$
Initial velocity of the second object,
$u_2 = 1\ ms^{-1}$
Final velocity of the first object,
$v_1 = 1.67\ ms^{-1}$
Final velocity of the second object $= v_2$
According to the law of conservation momentum,
Total momentum after collision

$$\Rightarrow \quad m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow \quad 0.1\ kg \times 2\ ms^{-1} + 0.2\ kg \times 1\ ms^{-1}$$

$$= 0.1\ kg \times 1.67\ ms^{-1} + 0.2\ kg \times v_2$$

$$\Rightarrow \quad 0.4\ kgms^{-1}$$

$$= 0.167\ kgms^{-1} + 0.2\ kgv_2$$

$$\Rightarrow \quad 0.233\ kgms^{-1} = 0.2\ kg\ v_2$$

$$\Rightarrow \quad v_2 = \frac{0.233}{0.2} = 1.165\ ms^{-1}$$

Exercise

1. An object experiences a net zero external unbalanced force. Is it possible for the object to be travelling with a non zero velocity? If yes, state the conditions that must be placed on the magnitude and direction of velocity . If no, provide a reason.

Ans. No, the object will not travel with non-zero velocity. This is because by Newton's first law of motion, an object at rest will remain at rest unless an unbalanced force acts upon it.

2. When a carpet is beaten with a stick, dust comes out of it. Explain.

Ans. When the carpet is shaken, or beaten with a stick the carpet is set in motion. Due to inertia of rest, the dust particles tend to remain at rest and fall off.

3. Why is it advised to tie and luggage kept on the roof of a bus with a rope ?

Ans. When the luggage is placed on the bus roof, it is not fixed to the bus. When the bus starts suddenly, the luggage due to inertia of rest tends to remain in the state of rest and as a result, some of the luggage might fall towards the backside of the bus. When the moving bus suddenly stops, due to the inertia of motion, the luggage might slide past the bus and fall in the front. To avoid it, luggage is tied up with a rope, so that the luggage becomes a part of the bus.

4. A batsman hits a cricket ball which then rolls on a level ground. After covering a short distance, the ball comes to rest. The ball slows to a stop because
(a) the batsman did not hit the ball hard enough.
(b) velocity is proportional to the force exerted on the ball.
(c) there is a force on the ball opposing the motion.
(d) there is no unbalanced force on the ball, so the ball would want to come to rest.

Ans. (c)

5. A truck starts from rest and rolls down a hill with a constant acceleration. It travels a distance of 400 m in 20 s. Find its accerleration. Find the force action on its mass is 7 metric tones.
[Hint : 1 metric tone = 1000 kg]

Ans. Initial velocity, $u = 0\ \text{ms}^{-1}$
Distance, $s = 400\ \text{m}$
Time, $t = 20\ \text{s}$
Mass, $m = 7$ metric tonnes $= 7000\ \text{kg}$
By second equation of motion,

$$s = ut + \frac{1}{2}\ \text{at}^2$$

$$\Rightarrow \quad 400\ \text{m} = 0\text{ms}^{-1} \times 20\ \text{s} + \frac{1}{2} \times \alpha \times (20\ \text{s})^2$$

$$\Rightarrow \quad 400\ \text{m} = \frac{1}{2} \times \alpha \times 400\ \text{s}^2$$

$$\Rightarrow \quad v = \frac{400\text{m}}{200\text{s}^2} = 2\ \text{ms}^{-2}$$

By Newton's second law of motion
$F = m \times a$
$F = 7000\ \text{kg} \times 2\ \text{ms}^{-2}$
$= 14{,}000\ \text{N}$

6. A stone of 1 kg is thrown with a velocity of 20 ms^{-1} across the frozen surface of lake and comes to rest after travelling a distance of 50 m. What is the force of friction between the stone and the ice ?

Ans. Mass, $m = 1$ kg
Initial velocity, $u = 20\ ms^{-1}$
Final velocity, $v = 0\ ms^{-1}$
Distance, $s = 50$ m
By third equation of motion,
$v^2 - u^2 = 2as$
$\Rightarrow$ $(0\ ms^{-1})^2 - 20\ ms^{-1})^2$
$= 2 \times a \times 50$ m
$\Rightarrow$ $-400 m^2 s^{-2} = 100a$ m
$\Rightarrow$ $= \frac{-400 m^2 s^2}{100 m} = a$
$\Rightarrow$ $-4\ ms^{-2} = a$
By Newton's second law of motion,
$F = m \times a$
$F = 1\ kg \times (-4\ ms^{-2}) = -4$ N

7. A 8000 kg engine pulls a train of 5 wagons each of 2000 kg, along a horizontal track. If the engine exerts a force of 40,000 N and the track offers a friction force of 5000 N, then calculate :
(a) the net accelerating force;
(b) the acceleration of the train; and
(c) the force of wagon 1 on wagon 2.

Ans. Mass of engine, $m^1 = 8000$ kg
Mass of each wagon, $m^2 = 2000$ kg
Number of wagons, $n = 5$
Total mass of 5 wagons, m
$= 2000\ kg \times 5 = 10{,}000$ kg
Force exerted by engine, $F^1 = 40{,}000$ N
Friction force of the track, $F^2 = 5000$ N
(a) Net accelerating force, $F = F^1 - F^2$
$= (40{,}0000 - 5000)$ N
$= 35{,}000$ N
(b) Acceleration of the train, $a = \frac{F}{m}$
$a = \frac{35{,}000 N}{10{,}000\ kg} = 3.5\ ms^{-1}$

8. An automobile vehicle has a mass of 1500 kg. What must be the force between the vehicle and road if the vehicle is to be stopped with a negative acceleration of 1.7 ms^{-2}?

Ans. Mass of vehicle, $m = 1500$ kg
Acceleration, $a = 1.7\ ms^{-2}$
By second law of motion,
$F = m \times a$
$F = 1500 \times 1.7 = -2550$ N

9. What is the momentum of an object of mass m, moving with velocity v?

(a) $(mv)^2$ **(b)** mv^2 **(c)** $\frac{1}{2}\ mv^2$ **(d)** mv

Ans. (d)

10. Using a horizontal force of 200 N, we intend to move wooden cabinet across a floor a constant velocity. What is the force of friction that will be exerted on the cabinet?

Ans. The friction force will also be 200 N

11. Two objects, each of mass 1.5 kg, are moving in the same straight line but in opposite directions. The velocity of each object is 2.5 ms-1 before the collision during which they stick together. What will be the velocity of the combined objects after collision?

Ans. Mass of the first object, m_1
$= 1.5\ kg$
Initial velocity of the first object, u_1
$= 2.5\ ms^{-1}$
Mass of the second object, m_2
$= 1.5\ kg^{-1}$
Initial velocity of the combined object , u_2
$= -2.5\ ms^{-1}$
Let velocity of the combined object be
$= v\ ms^{-1}$
By law of conservation of momentum,
Momentum before collision = Momentum after collision

$\Rightarrow \quad m_1u_1 + m_2u_2 = (m_1 + m_2)\ v$

$\Rightarrow \quad 1.5\ kg \times 2.5\ ms^{-1} + 1.5\ kg \times (-2.5\ ms^{-1})$
$= (1.5\ kg + 1.5\ kg) \times v$

$\Rightarrow \quad 0 = 3\ v$

$\Rightarrow \quad v = 0\ ms^{-1}$

12. According to the third law of motion, when we push on an object, the object pushes back on us with an equal and opposite force. If the object is a massive truck parked along the roadside, it will probably not move. A student justifies this by answering that the two opposite and equal forces cancel each other. Comment on this logic and explain why the truck does not move.

Ans. A massive truck has a high mass. As a result, it has a high inertia. (Mass is a measure of its inertia.) Due to high inertia, it remains at rest. By first law of motion, an object at rest remain at rest unless an unbalanced force acts upon it. The force created by our push is not strong enough to overcome the inertia of the truck.

13. A hockey ball of mass 200 g travelling at 10 ms^{-1} is struck by a hockey stick so as to return it along its original path with a velocity at 5 ms^{-1}. Calculate the change of momentum occurred in the motion of the hockey ball by the force applied by the hockey stick.

Ans. Mass of hockey ball, m = 200 g

$$= \frac{200}{1000} = 0.2\ kg$$

Initial velocity of the ball, $u = 10\ ms^{-1}$
Final velocity of the ball, $v = -5\ ms^{-1}$
Initial momentum of the ball = $m \times u$

$= 0.2\,\text{kg} \times 10\,\text{ms}^{-1}$
$= 2\,\text{kgms}^{-1}$
Final momentum of the ball $= m \times v$
$= 0.2\,\text{kg} \times (-5\,\text{ms}^{-1})$
$= -1\,\text{kgms}^{-1}$
Change of momentum $= mv - mu$
$= (-1-2)\,\text{kgms}^{-1}$
$= -3\,\text{kgms}^{-1}$

14. A bullet of mass 10 g travelling horizontally with a velocity of 150 ms-1 strikes a stationary wooden block and comes to rest in 0.03 s. Calculate the distance of penetration of the bullet into the black. Also calculate the magnitude of the force exerted by the wooden block on the bullet.

Ans. Mass, $m = 10\,\text{g} = \frac{10}{1000}\,\text{kg}$

$= 0.01\,\text{kg}$
Initial velocity, $u = 150\,\text{m}^{-1}$
Final velocity, $v = 0\,\text{ms}^{-1}$
Time, $t = 0.03\,\text{s}$

Acceleration, $a = \frac{v-u}{t}$

$a = \frac{(0-150)\text{ms}^{-1}}{0.03\text{s}}$
$a = -5000\,\text{ms}^{-2}$
By second equation of motion,

$s = ut + \frac{1}{2}\,\text{at}^2$
$\text{s} = 150\,\text{ms}^{-1} \times 0.03\,\text{s} + \frac{1}{2} \times (-5000\,\text{ms}^{-2}) \times (0.03\,\text{s})2$
$s = 4.50\,\text{m} - 25000\,\text{ms}^{-2} \times 0.0009\,\text{s}^2$
$s = 4.50\,\text{m} - 2.25\,\text{m}$
$s = 2.25\,\text{m}$
By second law of motion,
$\text{F} = m \times a$
$\text{F} = 0.01\,\text{kg} \times (-5000\,\text{ms}^{-2})$
F = -50 N.

15. An object of mass 1 kg travelling in a straight line with a velocity of 10 ms-1 collides with and sticks to a stationary wooden block of mass 5 kg. Then they both move off together in the same straight line. Calculate the total momentum just before the impact and just after the impact. Also calculate the velocity of the combined object.

Ans. Mass of the object, $\text{m}^1 = 1\,\text{kg}$
Initial velocity $u = 10\,\text{ms}^{-1}$
Mass of stationary wooden block,

$M_2 = 5\ kg$
Let velocity of the combined object $= v$
Total momentum just before impact
$= m_1 \times u$
$= 1\ kg \times 10\ ms^{-1}$
$= 10\ kgms^{-1}$
By law of conservation of momentum,
Total momentum just before impact
=Total momentum just after impact
Total momentum just after impact
$= 10\ kgms^{-1}$
Total momentum of the combined object
$= (m_1 + m_2) \times v$
$= (1\ kg + 5\ kg) \times v$
$\therefore \quad 10 = 6v$
or $v = \frac{10}{6} = \frac{5}{3} ms^{-1}$

16. An object of mass 100 kg is accelerated uniformly from a velocity of 5 ms^{-1} to 8 ms^{-1} in 6 s. Calculate the initial and final momentum of the object. Also find the magnitude of the force exerted on the object.

Ans. Mass of the object, $m = 100\ kg$
Initial velocity, $u = 5\ ms^{-1}$
Final velocity, $v = 8\ ms^{-1}$
Time, $t = 6\ s$
Initial momentum $= m \times u$
$= 100\ kg \times 5\ ms^{-1}$
$= 500\ kgms^{-1}$
Final momentum $= m \times v$
$= 100\ kg \times 8\ ms^{-1}$
$= 800\ kgms^{-1}$

Force, $F = \frac{mv - mu}{t}$

$F = \frac{(800 - 500)\ kgms^{-1}}{6s}$

$F = 50\ N$

17. Akhter, Kiran and Rahul were riding in a motorcar that was moving with a high velocity on an expressway when an insect hit the windshield and got stuck on the windscreen. Akhtar and Kiran started pondering over the situation. Kiran suggested that the insect suffered a greater change in momentum as compared to the change in the velocity of the insect was much more than that of the motorcar. Akhtar said that since the motorcar was moving with a larger velocity, it exerted a larger force on the insect. As a result, the insect died. Rahul, while putting an entirely new explanation, said that both the motorcar and insect experienced the same force and a change in their momentum. Comment on these suggestions.

Ans. Rahul gave the correct explanation. This is because due to the law of conservation of momentum, during a collision momentum of the system is conserved. Both the bodies

suffer the same momentum change. However, the bug having smaller mass will suffer greater change velocity. The bus having much larger mass does not the any noticeable change in velocity.

18. How much momentum will a dumb-bell of mass 10 transfer to the floor if it falls from a height of 80 cm? Take its downward acceleration to be 10 ms-2.

Ans. Mass, $m = 10$ kg
Height or Distance, $s = 80$ cm
$= 80 / 100 = 0.8$ m
Acceleration, $a = 10\ ms^{-2}$
Initial velocity, $u = 0\ ms^{-1}$
By third equation of motion,
$v^2 - u^2 = 2as$
$v^2 - (0\ ms^{-1})^2$
$= 2 \times 10\ ms^{-2} \times 0.5$ m
$v^2 = 16\ ms^{-1}$
$v = 4\ ms^{-1}$
Momentum transferred to the floor
$= m \times v$
$= 10\ kg \times 4\ ms^{-1}$
$= 40\ kgms^{-1}$

Additional Questions

1. An object experiences a net zero external unbalanced force. Is it possible for the object to be travelling with a non=zero velocity? If yes, state the conditions that must be placed on the magnitude and direction of the velocity. If no, provide a reason.

Ans. No, the object will not be able to travel with non-zero velocity because there is net zero external unbalanced force. However, this will apply only on the surface of the earth where forces of gravity and friction always act on the object.
If the object is in deep space and is completely free from the forces of friction and gravitation, such that it is moving with non-zero velocity, then it will continue moving with the same velocity and in the same direction.

2. Define the term 'force'.

Ans. The physical quantity which changes or tends to change the state of rest or of uniform motion of a body is called force.

3. A horse continues to apply a force in order to move a cart with a constant speed. Why?

Ans. The force applied by the horse balances the force of friction.

4. When a force acts on an objet, it accelerates. What do you observe, when two equal and opposite forces act on an object?

Ans. When two equal and opposite forces act on an object, then the net force acting on it is zero. Therefore, the object will remain at rest, if it were at rest before the application of two equal and opposite forces. However, the object will continue to move with constant velocity if it were moving with constant velocity before the application of the forces.

5. Define momentum. What is the SI unit of momentum?

Ans. Momentum is the product of mass and velocity. Its S.I. unit is $kg\ ms^{-1}$.

6. State Newton's first law of motion.

Ans. A body continues in its state of rest or of uniform motion in a straight line unless an external force acts on it.

7. Which will have more inertia a body of mass 10 kg or a body of mass 20 kg.

Ans. A body of mass 20 kg will have more inertia.

8. Two similar vehicles are moving with same velocity on the road, such that one of them is loaded and the other one is empty. Which of the two vehicles will require larger force to stop it ?

Ans. A large force is required to stop the loaded vehicle. It is because loaded vehicle has greater momentum than the empty vehicle as the mass of loaded vehicle is more than that of the empty vehicle. Thus, it requires a greater force to stop.

9. Why is it difficult to drive a nail into a wooden block without supporting it?

Ans. If the wooden block is not properly supported, then it will be unable to offer suitable reaction.

10. In a tug of war, the team that pushes harder against the ground wins. Explain.

Ans. The team that pushes harder against ground gets greater reactional force and this leads them to win.

11. A fast moving truck loses momentum equal to 2 kg ms $^{-1}$ after colloiding with a stationary car. Will the car lose or gain momentum? How much momentum is lost or gained by the car if the truck comes to the rest after collision ?

Ans. The car will gain momentum. Momentum gained by the car = 2 kg ms^{-1}.

12. If a body is in motion, it is necessary that it is being acted upon by a force?

Ans. Force is required for accelerated motion. If a body possesses uniform motion, no force is required for it.

13. What do you mean by recoil velocity of a gun?

Ans. The velocity with which a gun moves backward after firing a bullet is called the recoil of the gun.

14. Why is the foot of a man injured when he hits a stone?

Ans. When a person hits a stone, the stone exerts equal force on his foot. Due to this force, his foot gets injured.

15. Why are the passengers thrown outwards when a car in which they are travelling suddenly takes a circular turn ?

Ans. This is because the passengers tend to maintain their direction of motion (inertia of direction) while the direction of car changes when it takes the turn.

16. A bird is sitting on the floor of a wire cage and the cage is in the hand of a boy the bird stars flying in the cage. Is there any change in the weight of the cage?

Ans. When the bird starts flying in the air (inside the cage) the weight of the bird is not experienced. As a result, the cage will appear lighter than before.

17. Why do we pull the rope downwards for clamping up ?

Ans. When we pull the rope downwards, an upward reaction helps us to rise up.

18. How does Newton's third law of motion help us in walking?

Ans. When we push the ground with our foot, the reaction of the ground pushes us forward.

19. What is meant by inertia ?

Ans. Inertia is that property of a body due to which it resists a change in its state of rest or of uniform motion.

20. Which law of motion defines the force?

Ans. Newton's second law of motion.

21. An athlete always runs some distance before taking a jump. Why?

Ans. An athlete always runs for some distance before taking a jump because inertia of motion helps him to take a longer jump.

22. Define one newton.

Ans. One newton is the force which when acting on a body of mass 1 kg produces an acceleration of 1 ms^{-2} in the direction of force.

23. Which has highest inertia: Solids made of aluminium, steel or wood of same shape and same volume?

Ans. Solid made of steel.

24. State Newton's third law motion.

Ans. Newton's third law of motion states that to every action there is an equal and opposite reaction.

25. Name the unbalanced force which slows down a moving bicycle when we stop pedalling it.

Ans. An unbalanced force of friction.

26. State the meaning of balanced forces.

Ans. If the resultant of all the forces acting on a body is zero, the forces are called balanced forces.

27. According to Newton's third law, every force is accompanied by equal and opposite forces how then can anything move?

Ans. Action and reaction are two equal and opposite forces but they act on different bodies. This makes the motion of a body possible.

28. Name the force which arises between two surfaces in contact.

Ans. Frictional force.

29. Name the physical quantity whose SI unit is 'newton'.

Ans. Force.

30. Name the physical quantity which corresponds to rate of change of momentum.

Ans. Force.

31. State Newton's third law of motion.

Ans. According to Newton's third law of motion, whenever one body exerts a force on another body, the second body exerts an equal and opposite force on the first body.

32. Which one has greater inertia: a stone of mass 1 kg or a stone of mass 5 kg?

Ans. A stone of mass 5 kg has greater inertia.

33. You are applying force on the pan of single pan weighing balance and the pointer points to 100g. What is the force in newtons applied by you?

Ans. One newton

34. A ball on the ground when given a small hit does not move forever. What does this observation suggest?

Ans. This observation suggests that rest is the natural state of an object.

35. Why are shockers used in cars, scooters and motorcycles ?

Ans. Due to the shockers, time interval of the jerk increases. As the rate of change of momentum will be smaller, comparatively lesser force acts on the passengers during the jerks.

36. Why are buffers provided between the bogies of a railway train ?

Ans. The buffers increase the time intervals of jerks during shunting. This reduces the force with which bogies push or pull each other and hence severe jerks get avoided.

37. Explain why it is dangerous to jump out of a moving bus?

Ans. When a passenger jumps out of a fast moving bus, his feet on touching the ground come to rest, whereas the upper part of his body continues to move forward due to inertia of motion. As a result, if he does not run forward he falls with his face downwards.

38. What can we do to an object to change its state of motion?

Ans. We can push or hit or pull an object to change its state of motion.

39. Why are passengers thrown in the forward direction when a running bus stops suddenly?

Ans. The passengers in a running bus are also moving with the same speed in the same direction. When the running bus stops suddenly, the lower part of the passenger's body comes to rest, while the upper body portion continues to remain in motion. As a result, the passengers are thrown in the forward direction when a running bus stops suddenly.

40. Two similar buses are moving with same velocity. One of them is empty and the other is loaded with passengers. Which of the two will be stopped by the application of less force? Explain.

Ans. Momentum = mv. Loaded bus has greater mass than the empty bus. So loaded bus has greater momentum than the empty bus. The rate of change of momentum is change proportional to the force applied. Therefore, the empty bus will be stopped by applying less force.

41. What is force? What is the SI Unit of force?

Ans. (i) Force is something that changes or tends to change the state of rest, or the state of uniform motion of a body.
(ii) The SI unit of force is Newton (N).

42. Explain why is it difficult for a fireman to hold a hose, which ejects large amounts of water at a high speed.

Ans. It is based on the law of conservation of momentum. When water comes out of the hose, with certain momentum in the forward direction, the hose, in order to conserve momentum moves backward. This makes it difficult for the fireman to hold the hose.

43. Write the effects of force.

Ans. Force can produce three effects :
(i) It can change the shape or size of the object.
(ii) It can change the magnitude of velocity of an object. (i.e., to make the object move faster or slower.)
(iii) It can change the direction of motion of the object.

Multiple Choice Questions

1. Which of the following statement is not correct for an object moving along a straight path in an accelerated motion?
(a) Its speed keeps changing.
(b) A force is always acting on it.
(c) It always goes away from the earth.
(d) Its velocity always changes.

Ans. (c) It always goes away from the earth.

2. A passenger in a moving train tosses a coin which falls behind him. It means that motion of the train is :
(a) accelerated.
(b) uniform
(c) along circular tracks.
(d) retarded.

Ans. (a) accelerated.

3. The change in the momentum of a body in 0.01 s is 10kgms^{-1}. The force acting on the body is
(a) 10N (b) 0.1 N
(c) 100 N (d) 1000 N

Ans. (d) 1000 N

4. A force of 100 N applied on an object accelerates it with an acceleration of 2 ms^{-2}. How much force is required to produce the same acceleration when identical object of same mass is tied with the first object ?

(a) 50N (b) 100 N

(c) 200 N (d) 300 N

Ans. (c) 200 N

5. An object of mass 1 kg is moving with an acceleration of 1 ms^{-2}. Force acting on the object is

(a) 10 N (b) 0.1N

(c) 0.001 N (d) 1 N

Ans. (d) 1 N

6. An object A is at rest even when number of forces act on it. Another object B if moving with constant velocity even when number of forces act on it.

(a) Balanced force acts only on object A.

(b) Balanced force acts only on object B.

(c) Unbalanced force acts on object B and balanced force acts on object A.

(d) Balanced forces act on both the objects A and B.

Ans. (d) Balanced forces act on both the objects A and B.

7. A wooden cabinet moves with a constant velocity of 5 ms^{-1} over the surface of a floor, when 200 N horizontal force acts on it. The force of friction acting on the cabinet is

(a) 1000 N (b) 500 N

(c) 100 N (d) 200 N

Ans. (d) 200 N

8. Momentum of a body of mass m moving with velocity *v* is

(a) m/v (b) m/v^2

(c) mv (d) mv^2

Ans. (c) mv

9. S1 unit of linear momentum is

(a) g cm S^{-1} (b) g ms^{-1}

(c) kg cm S^{-1} (d) kg ms^{-1}

Ans. (d) kg ms^{-1}

10. Four iron balls A, B, C and D have mass 1 kg, 8 kg, 2 kg and 4 kg, respectively. Which of the balls has the highest inertia ?

(a) A (b) B

(c) C (d) D

Ans. (d) D

11. A father has mass 60 kg and the mass of his son is 80 kg. The ratio of the inertia of the father to the inertia of the son is

(a) 1: 1 (b) 1 : 2

(c) 2 : 1 (d) 1 : 3

Ans. (c) 2 : 1

12. A gun recoils after firing to conserve

(a) force (b) speed

(c) velocity (d) momentum

Ans. (d) momentum.