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Chapter – 9 Force and Laws of Motion

Multiple Choice Questions

Q1. Which of the following statement is not correct for an object moving along a straight path in accelerated motion?

a) **Its speed keeps changing**
b) **Its velocity always changes**
c) **It always goes away from the earth**
d) **A force is always acting on it**

Answer: Option c) It always goes away from the earth

For any object in a straight path of an accelerated motion, always move away from the earth.

Q2. According to the third law of motion, action and reaction

a) **Always act on the same body**
b) **Always act on different bodies in opposite directions**
c) **Have same magnitude and direction**
d) **Act on either body at normal to each other**

Answer: Option b) Always act on different bodies in opposite directions

Third law of motion states that action and reaction always act on different bodies in opposite directions.

Q3. A goalkeeper in a game of football pulls his backwards after holding the ball shot at the goal. This enables the goalkeeper to

a) **Exert larger force on the ball**
b) **Reduce the force exerted by the ball on hands**
c) **Increase the rate of change of momentum**
d) **Decrease the rate of change of momentum**

Answer: Option d) Decrease the rate of change of momentum

To decrease the rate of change of momentum with time, the goalkeeper pulled his hands backwards after holding the ball. So, the force is exerted on his hands, as the force is directly proportional to the rate of change of momentum.

Q4. The inertia of an object tends to cause the object

a) **To increase its speed**
b) **To decrease its speed**
c) **To resist any change in its state of motion**
d) **To decelerate due to friction**

Answer: Option c) To resist any change in its state of motion

Inertia of any object resist any change in its state of rest of motion.

Q5. 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) **Retarded**
d) **Along circular tracks**

Answer: Option a) Accelerated

When the coin falls behind the passenger, when the train accelerate. When the coin is tossed it has same velocity as that of train, during the time coin is in the air its velocity becomes less than that of train and the train is in acceleration, so it falls behind the passenger.

Q6. An object of mass 2 kg is sliding with a constant velocity of $4\,ms^{-1}$ on a frictionless horizontal table. The force required to keep the object moving with the same velocity is

a) **32 N**
b) **0 N**
c) **2 N**
d) **8 N**

Answer: Option b) 0 N

mass, $m = 2\,kg$

Velocity, $v = 4\,ms^{-1}$

Acceleration of the object is zero, as object is moving with a constant velocity.

$$a = 0$$

By property of inertia, if there is no external force on the body, then the body will remain at rest and if in motion remains in motion.

Q7. Rocket works on the principle of conservation of

a) **Mass**
b) **Energy**
c) **Momentum**
d) **Velocity**

Answer: Option c) Momentum

Rocket is based on the principle of conservation of momentum. In a rocket, the fuel burns and produces gas at high temperatures, then these gases are expelled from a nozzle which exert a forward force on the rocket which is used for accelerating.

As escaping tendancy of gases every second is small and their momentum is very large due to high velocity. Due to equal and opposite momentum to the rocket, despite of having a large mass built-up of rocket it gets higher velocity.

Q8. A water tanker filled up to $2/3rd$ of its height is moving with a uniform speed. On sudden application of the brake, the water in the tank would

a) **Move backward**
b) **Move forward**
c) **Be unaffected**
d) **Rise upwards**

Answer: Option b) Move forward

When the sudden brakes are applied, the tanker come in the state of rest but the water remains in the state of motion, so water move forward.

Short Answer Type Question

Q9. There are three solids, made up of aluminium, steel and wood of the same shape and same volume. Which of them would have highest inertia?

Answer:

The mass is a measure of inertia. The ball of same shape and size, having more mass than other balls have highest inertia. As, the steel has greater density and mass so, it has highest inertia.

Q10. Two balls of the same size but of different materials, rubber and iron, are kept on the smooth floor of a moving train. The brakes are applied suddenly to stop the train. Will the balls start rolling? If so, in which direction? Will they move with the same speed? Give reasons for your answer.

Answer:

As the train is stop suddenly, it is in the state of rest but the balls is in the state of motion. Because of inertia of motion, the ball travel in forward direction. Since, the balls are of same size but different materials so their mass will be different. Thus, both the balls travel with different speed.

Q11. Two identical bullets are fired one by one by a light rifle and another by a heavy rifle with the same force, which rifle will hurt the shoulder more and why?

Answer:

Both the bullets are identical and are fired with the equal force. So, to reduce recoil velocity, a heavy rifle is used as its heavy mass is compensated with large momentum, but for a lighter rifle, recoil velocity is large because of small mass thus lighter rifle hurt more to the shoulder.

Q12. A horse continues to apply a force in order to move the cart with a constant speed. Explain why?

Answer:

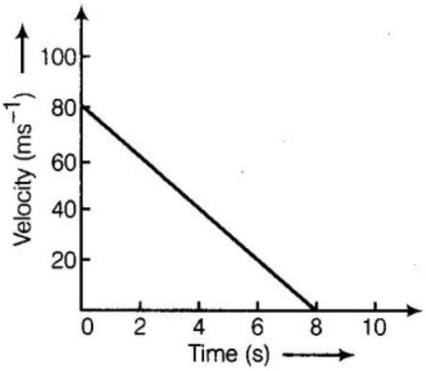
As the cart starts moving, frictional force start working on the wheel of cart in opposite to the motion. So, the horse apply force in forward direction to maintain the constant speed.

Q13. Suppose a ball of mass m is thrown vertically upward with an initial speed v, its speed decrease continuously till it becomes zero. Thereafter, the ball begins to fall downwards and attain the speed v again before striking the ground. It implies that the magnitude of initial and final momentums of the ball are same. Yet, it is not an example of conservation of momentum. Explain why?

Answer:

Momentum of a system remains conserved when there is no external force acting on the system. In the above example, the gravitational force acting on the ball which is an external force, so it is not an example of conservation of momentum.

Q14. Velocity versus time graph of a ball of mass 50 g rolling on a concrete floor is shown in figure. Calculate the acceleration and frictional force of the floor on the ball.



Answer:

mass, $m = 50\ g = 0.05\ kg$

Initial velocity, $u = 80\ ms^{-1}$

Final velocity, $v = 0\ ms^{-1}$

Time taken, $t = 8\ sec$

first equation of motion,

$$v = u + at$$

$$at = v - u$$

Acceleration,

$$a = \frac{v - u}{t} = \frac{0 - 80}{8}$$

$$a = \frac{-80}{8} =$$

$$a = -10ma^{-2}$$

So, the frictional force of the floor on the ball,

$$F = m \times a$$

$$F = 0.05 \times -10$$

$$F = -0.5\ N$$

Q15. A truck of mass m is moved under a force F. If the truck is then loaded with an object equal to the mass of the truck and the driving force is halved, then how does the acceleration change?

Answer:

Initial mass, $m_1 = M$

Initial force, $F_1 = F$

The new mass, $m_2 = M + M = 2M$

And the new force,

$$F_2 = \frac{F}{2}$$

From Newton's second law,

$$F = m \times a$$

$$a = \frac{F}{m}$$

Change in acceleration

$$\frac{a_1}{a_2} = \frac{F_1}{F_2} \times \frac{m_2}{m_1}$$

$$= \frac{F}{F/2} \times \frac{2M}{M}$$

$$= \frac{2F}{F} \times \frac{2m}{m} = 4$$

$$\frac{a_1}{a_2} = 4 \implies 4a_2 = a_1$$

$\implies$ $$a_2 = \frac{a_1}{4}$$

$$a_2 = \frac{1}{4} \times a_1$$

So, the final acceleration is one-fourth of initial acceleration.

Q16. Two friends on roller skates are standing 5 m apart facing each other. One of them throws a ball of 2 kg towards the other, who catches it. How will this activity affect the position of the two? Explain your answer.

Answer:

Momentum of both of them are zero as they are at rest. To conserve the momentum the one who throws the ball move backwards.

The other one will experience a net force after catching the ball and it will move backward, in the direction of the force.

Q17. Water sprinkler used for grass lawn begins to rotate as soon as the water is supplied. Explain the principle on which it works.

Answer:

Newton's third law of motion, is used by the water sprinkler. As the water is supplied so, the force is applied on the sprinkler due to which it rotates.

Long Answer Type Questions

Q18. Using second law of motion, derive the relation between force and acceleration. A bullet of 10 g strikes a sand-bag at speed of $10^3\ ms^{-1}$ and gets embedded after travelling 5 cm. Calculate

i) The resistive force exerted by the sand on the bullet.
ii) The time taken by the bullet to come to rest.

Answer:

When a body of mass, m, moving with a velocity, u accelerates uniformly at, a for time t, its velocity changes to v, then

$$initial\ momentum\ p_1 = mu$$

$$final\ momentum\ p_2 = mv$$

Change in momentum= $p_2 - p_1 = mv - mu = m(v - u)$

the second law of motion,

$$force, F \propto \frac{Change\ in\ momentum}{Time}$$

$$F \propto \frac{p_2 - p_1}{t}$$

$$F \propto \frac{m(v - u)}{t}$$

$$F \propto ma$$

$$F = kma$$

Where, $k = 1$

$$F = ma$$

$$m = 10\ g = 0.01\ g$$

$$u = 10^3\ m/s$$

$$v = 0$$

$$s = 5\ cm = 0.05\ m$$

i) third equation of motion,

$$v^2 = u^2 + 2as$$

$$v^2 - u^2 = 2as$$

$$a = \frac{v^2 - u^2}{2\ s} = \frac{(0)^2 - (10^3)^2}{2 \times 0.05}$$

$$a = \frac{-10^6}{0.1} = -10^7\ m/s^2$$

$So, the\ force\ applied\ by\ the\ bullet,$

$$F = ma$$
$$F = 0.01 \times -10^7 = -10^5\ N$$

The resistive force exerted by the sand on the bullet $= 10^5\ N$

ii) first equation of motion,

$$t = \frac{v - u}{a}$$
$$t = \frac{0 - 10^3}{-10^7}$$
$$t = \frac{-10^3}{-10^7} = 10^3 \times 10^{-7}$$
$$t -= 10^{-4}\ s$$

So, the force F= $10^5\ N$ and time $t = 10^{-4}\ s$

Q19. Derive the unit of force using the second law of motion. A force of 5 N produces an acceleration of 8 ms^{-2} on a mass m_1 and an acceleration of 24 ms^{-2} on a mass m_2. What acceleration would the same provide, if both the masses are tired together?

Answer:

The S.I unit of mass, $m = 1\ kg$

The S.I unit of acceleration, $a = 1\ ms^{-2}$

Newton's second law,

$$F = mma2$$

the S.I unit of force,

$$F = 1\ kg \times 1\ ms^{-2}$$
$$= 1\ kg - ms^{-2}$$

$1\ kg - ms^{-2}$ is called 1 newton (N)

$$1\ newton\ (N) = 1kg - ms^{-2}$$

Case-1:

$$F_1 = 5\ N, a_1 = \ 8\ ms^{-2}\ and\ m_1 = mass\ of\ 1st\ body$$
$$F_2 = 5\ N, a_2 = 24\ ms^{-2}\ and\ m_2 = mass\ of\ 2nd\ body$$

Newton's second law,

$$F = ma$$

$$5 = m_1 \times 8$$

$$m_1 = \frac{5}{8}\ kg$$

Case-2:

second Newton's law,

$$F = ma$$

$$5 = m_2 \times 24$$

$$m_2 = \frac{5}{24}\ kg$$

The sum of 2 masses, $m_1 + m_2$

$$= \frac{5}{8} + \frac{5}{24}$$

$$= \frac{15+5}{24} = \frac{20}{24}$$

$$= \frac{10}{12} = \frac{5}{6}$$

If both the masses are tied together, then the acceleration is

$$F = same$$

$$M = m_1 + m_2, M\ is\ the\ combined\ masses$$

$$a = \frac{F}{(m_1 + m_2)}$$

$$= \frac{5}{5/6} = \frac{5 \times 6}{5} = 6\ ms^{-2}$$

So, the acceleration is $6\ ms^{-2}$

Q20. What is momentum? Write its S.I unit. Interpret force in terms of momentum. Represent the following graphically

i) Momentum versus velocity when mass is fixed.
ii) Momentum versus mass when velocity is constant.

Answer:

Momentum is the quantity of motion of a moving body.

Momentum of any object of mass m moving with a velocity v is the product of it.

It is denoted by p.

$$p = mv$$

S.I unit is $kg - ms^{-1}$

The force,

$$F = ma\frac{\Delta p}{\Delta t}$$

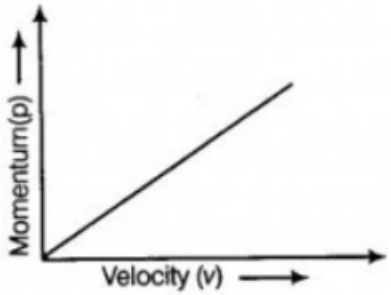
$$= m\frac{\Delta v}{\Delta t} = ma$$

i) Momentum versus velocity when mass is fixed.

$$p = mv$$

As m, is fixed, then $p \propto v$

the graph will be a straight line passing through the origin, if $v = 0$, then $p = 0$.



ii) Momentum versus mass graph when velocity is constant for different body

$$p = mv$$

If the velocity of different masses is constant, then

$$p \propto m$$

Hence, the graph is a straight line passing through the origin, if $m = 0$, then $p = 0$