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

$m = 1\ kg$
$u = 20\ m/s$
$s = 50\ m$
$v = 0$
$F = ?$
$a = ?$

$v^2 - u^2 = 2as$
$(0)^2 - (20)^2 = 2a\,(50)$
$\therefore -400 = 100\,a$
$\therefore a = \frac{-400}{100} = -4\ m/s^2$

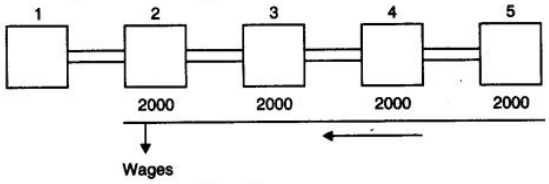
Force of friction, $F = m \times a$
$= 1\ kg \times -4\ m/s^2$
$= -4\ N$

Question 7. 40000 kg engine pulls a train of 5 wagons, each of 2000 kg, along a horizontal track. If the engine exerts a force of 40000 N and the track offers a friction force of 5000 N, then calculate:
Answer:

(a) The net accelerating force = Force exerted by the engine – friction force
= 40000 N – 5000 N
= 35000 N

(b) The acceleration of the train (a) = ?
F = 35000 N
Mass of 5 wagons pulled by engine = 5 × 2000
= 10000 kg
$\therefore F = ma$
$35000 = 10000 \times a$
$\therefore a = \frac{35000}{10000} = 3.5\ m/s^2$

(c) The force of wagon 1 on wagon 2



$F = ?$
Mass of wagon 2 → (2000 × 4)
$a = 3.5\ m/s^2$
$F = ma$
$= 8000 \times 3.5$
$= 28000\ N$

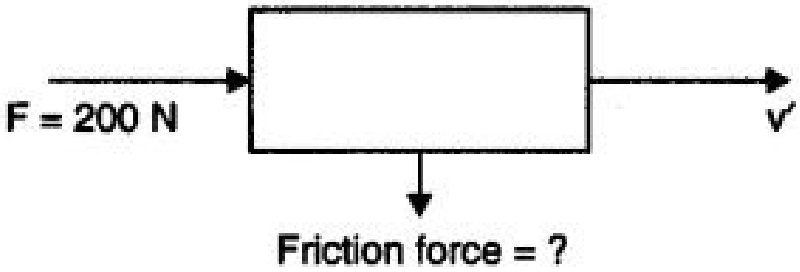
Question 8. An automobile vehicle has a mass of 1500 kg. What must be the force between the vehicle and road if the vehicle is to be stopped with a negative acceleration of 1.7 ms^{-2}?
Answer:

$$\text{mass} = 1500\ \text{kg}$$
$$a = -1.7\ \text{m/s}^2$$
$$F = ?$$
$$F = m \times a$$
$$= 1500 \times (-1.7)$$
$$= -2550\ \text{N}$$

The force between the vehicle and road is – 2550 N.

Question 9.What is the momentum of an object of mass m, moving with a velocity v?.
(a) $(mv)^2$
(b) mv^2
(c) $1/2\ mv^2$
(d) mv
Answer: (d) mv

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



As the wooden cabinet moves across the floor at a constant velocity and the force applied is 200 N. Hence the frictional force that will be exerted on the cabinet will be less than 200 N.

Question 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 object after collision?
Answer:

Mass of the objects $m_1 = m_2 = 1.5$ kg
Velocity of first object $v_1 = 2.5$ m/s
Velocity of second object $v_2 = -2.5$ m/s
Momentum before collision $= m_1v_1 + m_2v_2$
$= (1.5 \times 2.5) + (1.5 \times -2.5) = 0$
Momentum after collision $= m_1 + m_2 = 1.5 + 1.5 = 3.0$ kg
After collision $v = ?$
According to law of conservation of momentum
Momentum before collision = Momentum after collision
$0 = 3 \times v$
$\therefore \quad v = 0$

Question 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.
Answer: The mass of truck is too large and hence its inertia is too high. The small force exerted on the truck cannot move it and the truck remains at rest. For the truck to attain motion, an external large amount of unbalanced force need to be exerted on it.

Question 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.
Answer:

$$\text{Mass of ball } m = 200 \text{ g} = 0.2 \text{ kg}$$
$$\text{Initial speed of ball } u = 10 \text{ m/s}$$
$$\text{Final speed of ball } v = -5 \text{ m/s}$$
$$\text{Initial momentum of the ball} = mu$$
$$= 0.2 \text{ kg} \times 10 \text{ m/s}$$
$$= 2 \text{ kg m/s}$$
$$\text{Final momentum of the ball} = mv$$
$$= 0.2 \text{ kg} \times (-5 \text{ m/s})$$
$$= -1 \text{ kg m/s}$$
$$\text{Hence, change in momentum} = \text{Difference in the momentum}$$
$$= 2 - (-1)$$
$$= 2 + 1 = 3 \text{ kg m/s}$$

Question 14. A bullet of mass 10 p travelling horizontally with a velocity of 150 m^{-1} strikes a stationary wooden block and comes to rest in 0.03 s. Calculate the distance of penetration of the bullet into the block. Also calculate the magnitude of the force exerted by the wooden block on the bullet.
Answer:

$$m = 10 \text{ g} = \frac{10}{1000} = 0.01 \text{ kg}$$
$$u = 150 \text{ m/s}$$
$$v = 0 \text{ m/s}$$
$$t = 0.03 \text{ s}$$
$$v = u + at$$
$$0 = 150 + a\,(0.03)$$
$$a = \frac{-150}{0.03} = -5000 \text{ m/s}^2$$
$$s = ?$$
$$F = ?$$
$$v^2 - u^2 = 2as$$
$$\therefore \quad (0)^2 - (150)^2 = 2 \times 5000 \times s$$
$$\therefore \quad s = \frac{150 \times 150}{2 \times 5000}$$
$$s = \frac{22500}{10000}$$
$$s = 2.25 \text{ m.}$$

$\therefore$ The penetration distance of the bullet in the wooden block = 2.25 m.

$$\text{Magnitude of force } F = ma$$
$$= \frac{10}{1000} \times 5000$$
$$F = 50 \text{ N.}$$

Question 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 before the impact and just after the impact. Also, calculate the velocity of the combined object.
Answer:

$m_1 = 1\ \text{kg}$

$v_1 = 10\ \text{m/s}$

Mass of wooden block $= 5\ \text{kg}$

$m_2 = 5\ \text{kg} + 1\ \text{kg}$ (combined object) $= 6\ \text{kg}$

Velocity of combined object $= v_2 = ?$

ρ_1 and $\rho_2 = ?$

Momentum before impact $\rho = m_1 v_1$

$= 1 \times 10 = 10\ \text{kg m/s}$

$\therefore$ Momentum before impact = Momentum after impact

$m_1 v_1 = m_2 v_2$

$10\ \text{kg m/s} = 6\ v_2$

$\therefore \quad \frac{10}{6} = v_2$

$\therefore \quad v_2 = 1.67\ \text{m/s}$

Question 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.

Answer:

$m = 100\ \text{kg}$

$u = 5\ \text{m/s}$

$v = 8\ \text{m/s}$

$t = 6\ \text{s}$

$\rho_1 = ?$

$\rho_2 = ?$

$F = ?$

$\therefore$ Initial momentum $\rho_1 = mu$

$= 100 \times 5 = 500\ \text{kg m/s}$

Final momentum $\rho_2 = mv$

$= 100 \times 8 = 800\ \text{kg m/s}$

Force exerted on the object $F = ma$

$= 100 \left(\frac{u - v}{t}\right)$

$= 100 \left(\frac{8 - 5}{6}\right) = 100 \times \frac{3}{6}$

$F = 50\ \text{N}$

Question 17. Akhtar, 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 momentum of the motorcar (because the change in the velocity of 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. And as a result the insect died. Rahul while putting an entirely new explanation said that both the motorcar and the insect experienced the same force and a change in their momentum. Comment on these suggestions.

Answer: Rahul gave the correct reasoning and explanation that both the motorcar and the insect experienced the same force and a change in their momentum. As per the law of conservation of momentum.

When 2 bodies collide:

Initial momentum before collision = Final momentum after collision

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

The equal force is exerted on both the bodies but, because the mass of insect is very small it will suffer greater change in velocity.

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

Mass of dumb-bell = 10 kg

Height, h = 80 cm = 0.8 m

a = 10 m/s^2

u = 0

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

$v^2 - (0)^2 = 2 \times 10 \times 0.8$

$v^2 = 16$

$\therefore$ v = 4 m/s

Momentum $\rho = mv$

$= 10 \times 4$

= 40 kgm/s

********** END **********