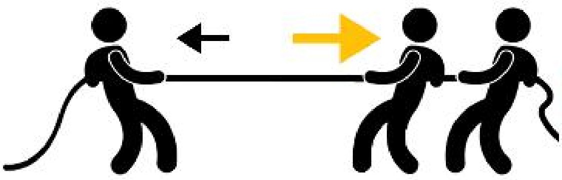
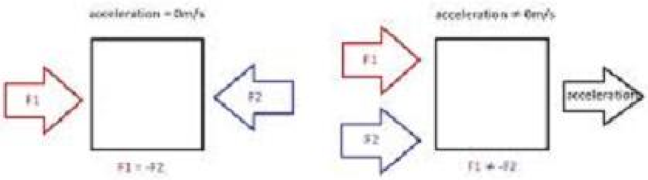
- Forces that cause a change in the motion of an object are **unbalanced forces**. Unbalanced forces are not equal and opposite.

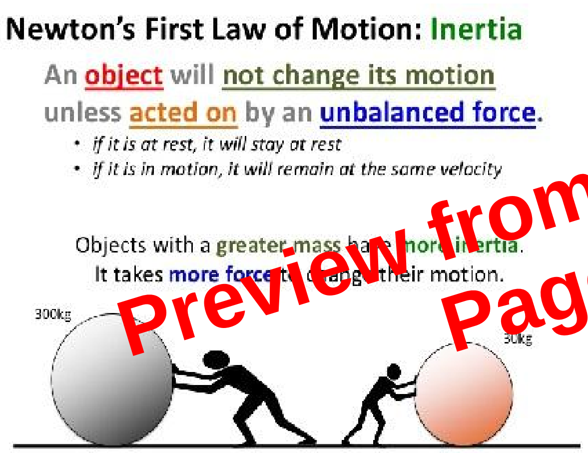




LAWS OF MOTION

❖ 1ST LAW OF MOTION

A object at rest remains at rest , and a object in motion remains in motion unless its stopped by external force(unbalanced force).



INERTIAL :- a property of matter by which it continues in its existing state of rest or uniform motion in a straight line, unless that state is changed by an external force. Its SI unit is kilogram (kg).

❖ 2ND LAW OF MOTION

The second law states that the acceleration of an object is dependent upon two variables - the net force acting upon the object and the mass of the object.

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:

$$\text{Mass of dumb-bell} = 10\text{ kg}$$

$$\text{Height, } h = 80\text{ cm} = 0.8\text{ m}$$

$$a = 10\text{ m/s}^2$$

$$u = 0$$

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

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

$$v^2 = 16$$

$$\therefore \quad v = 4\text{ m/s}$$

$$\text{Momentum } p = mv = 10 \times 4 = 40\text{ kgm/s}$$

When three persons push the car, they apply a total force 3F on the car.
Now net unbalanced force' on the car = force applied by three persons – frictional force

$$= 3F - 2F = F$$

As now acceleration $a = 0.2 \text{ ms}^{-2}$, hence

$$F = ma = 1200 \times 0.2 = 240 \text{ N}$$

Hence each person pushes the car with a force of 240 N.

Question 3. A hammer of mass 500 g, moving at 50 ms^{-1}, strikes a nail. The nail stops the hammer in a very short time of 0.01 s. What is the force of the nail on the hammer?
Answer:

Mass of hammer m = 500 g = 0.5 kg
Initial velocity of hammer u = 50 ms^{-1}
Final velocity of hammer v = 0 and time t = 0.01 s

$\therefore$ Acceleration of the hammer, $a = \frac{v-u}{t} = \frac{0-50}{0.01} = -5000 \text{ ms}^{-2}$

$\therefore$ Force applied by the nail on hammer

$$F = ma = (0.5) \times (-5000)$$
$$= -2500 \text{ N}$$

$-ve$ sign of force suggests that the force is opposing the motion of hammer.

Question 4. A motorcar of mass 1200 kg is moving along a straight line with a uniform velocity of 90 km/h. Its velocity is slowed down to 18 km/h in 4 s by an unbalanced external force. Calculate the acceleration and change in momentum. Also calculate the magnitude of the force required.
Answer:

Initial velocity of car $u = 90 \text{ km/h} = 90 \times \frac{5}{18} \text{ ms}^{-1} = 25 \text{ ms}^{-1}$

Final velocity of car $= 18 \text{ kmh}^{-1} = 18 \times \frac{5}{18} = 5 \text{ ms}^{-1}$

and time $t = 4 s$

Acceleration $a = \frac{v-u}{t} = \frac{5-25}{4} = -5 \text{ ms}^{-2}$

Change in momentum of car

$$mv - mu = m(v-u)$$
$$= 1200(5-25) = -24000 \text{ kg ms}^{-1}$$

Magnitude of force $F = ma = 1200 \times (-5) = -600 \text{ N}$