HOME ASSIGNMENT

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

Ans) Given,

Mass of the motor car = 1000kg

Initial velocity = u = 90km/h

Final velocity = v = 18km/h

Time taken = t = 4s

Let's first convert initial and final velocity in m/s

Initial velocity = u = 90km/h

$= 90 \times \frac{5}{18}$ m/s

$= 25$ m/s

Final velocity = v = 18km/h $= 18 \times \frac{5}{18}$ m/s $= 5$ m/s

Finding acceleration,

We know v, u and t

So, we can find the acceleration using 1st law of motion,

$v = u + at$

$5 = 25 + a(4)$

$5 - 25 = 4a$

$-20 = 4a$

$\frac{-20}{4} = a$

$-5 = a$

$a = -5 m/s^2$

Finding change in momentum

Change in momentum

= Final momentum - initial momentum

= mv - mu

= m(v - u)

= 1200(5 - 25)

= 1200(-20)

= -24000 kgm/s

Finding force,

Force = Mass x Acceleration

= ma = 1200 x -5 = -6000 N

Magnitude of force = 6000 N

2. 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) Acceleration produced by the force and

(iii) the magnitude of the force.

Ans) mass, m = 100kg

Time interval, $\Delta t = 10s$

(i) Distance travelled in next 5 seconds, d = 100m.

Thus, velocity acquired by body, $v = \frac{d}{t} = \frac{100}{5} = 20 m/s$

(ii) Acceleration produced by the force, $a = \frac{v}{\Delta t} = \frac{20}{10}$

$= 2 m/s^2$

(iii) Magnitude of force, $F = ma = 100kg \times 2 m/s^2 = 200N$.

3. Derive the relation between force and acceleration using Newton's second law of motion.

Ans) m = mass of an object, u = initial velocity, v = final velocity, t = time interval, F = constant force.

$P_1 = mu$ = initial momentum of the object

$P_2 = mv$ = Final momentum of the object

The change in momentum = $P_2 - P_1 = mv - mu = m(v-u)$

the rate of change of momentum = $\frac{m(v-u)}{t}$

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

$F = \frac{Km(v-u)}{t}$

$F = Kma$

The unit of force is so chosen that the value of the constant K becomes one.

So, $F = ma$

4. How the first law of motion can be mathematically stated from the Mathematical expression for the second law of motion?

Ans) Let us consider an object of mass m, moving along a straight line with an initial velocity u. Let us say, after a certain time t, with a constant acceleration the final velocity becomes v. Hence we see that, the initial momentum.

$P_1 = m \times u$

the final momentum

$P_2 = m \times v$

The change in momentum is

$P_2 - P_1 = (m \times v) - (m \times u)$

$P_2 - P_1 = m(v-u)$

The rate of change of momentum with respect to time is proportional to the applied force. The applied force is

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

or

$F \propto m \times a$

a = Rate of change of velocity / Time

$F = K \times m \times a$

K = Proportionality Constant.

Hence, from the second law of motion, we get force is the product of mass and acceleration. i.e. $F = ma$

HOME ASSIGNMENT

1. Name and State the action and reaction in the following cases:

(a) Firing of a bullet from a gun

(b) hammering a nail

(c) a book lying on a table

(d) moving rocket

(e) a person moving on the floor, and

(f) a moving train colliding with a stationary train.

(a) Action: Force exerted on the bullet.
Reaction: Recoil experienced by the gun.

(b) Action: The force exerted by the hammer on the nail.
Reaction: The force applied by the nail on the hammer.

(c) Action: Weight of the book acting downwards.
Reaction: Force acted by the table upwards.

(d) Action: Force exerted by the rocket on the gases backward.
Reaction: Force exerted by outgoing gases on the rocket in forward direction.

(e) Action: Force exerted by the feet on the ground in backward direction.
Reaction: Force exerted by the ground on feet in forward direction.

(f) Action: Force exerted by a moving train on a stationary train.
Reaction: Force exerted by a stationary train on a moving train.

2. (a) Explain why is it difficult to hold a hose, which ejects a large amount of water at a high velocity.

Ans) When a fireman holds a hose, which is ejecting large amounts of water at a high velocity, then a reaction force is exerted on him by the ejecting water in the backward direction. This is because of Newton's third law of motion. As a result of the backward forces, the stability of the fireman decreases. Hence, it is difficult for him to remain stable while holding the hose.

(b) Why action and reaction do not cancel each other?

Ans) Newton's third law of motion states that every action has an equal and opposite reaction. This indicates that forces always act in pairs. Reaction forces are equal and opposite, but they are not balanced forces because they act on different objects so they don't cancel each other out.

3. (a) If some one jumps to the shore from a boat the boat moves in the opposite direction. Explain.

Ans) According to Newton's third law, to each and every action there is equal and opposite reaction. When a person jumps to the shore from a boat, then he pushes the boat in the backward direction. The boat, in turns, provides a reaction force on the person which helps him get to the shore. On the other hands

the force exerted by the person on the boat makes the boat move on the opposite direction. This can be prevented by tying the boat to a fixed support on the store.

(b) When air from an inflated balloon is allowed to be released, the balloon moves in a direction opposite to that of air. Explain.

Ans) If a balloon filled with compressed air and its mouth untied is released with its mouth in the downward direction, the balloon moves in the upward direction because the air present in the balloon rushes out in the downward direction. The equal and opposite reaction of downward going air pushes the balloon upwards.

HOME ASSIGNMENT

To propel a rocket, some mass of fuel in the rocket is burned. The resultant gas is then expelled from the rear of the rocket at some high speed (much larger than that of the rocket). Hence the rocket itself is accelerated with an deceleration of magnitude a_0.

(a) How is the direction of the rocket's acceleration related to the direction along which the gas is expelled?

Ans) Opposite

(b) Does the expelled gas exert a force on the rocket? If so, in which direction is this force?

Ans) Yes, opposite direction (downwards)

(c) Suppose that the same mass of gas is expelled with larger speed so that its acceleration is twice as large. What then would be the magnitude of the rocket's acceleration?

Ans) 2 times of original ($2a_0$)

(d) Suppose that more fuel is burned per second so that twice as large a mass of gas is expelled with the original acceleration. What then would be the magnitude of the rocket's acceleration?

Ans) 2 times of original ($2a_0$)

(e) Suppose that twice as large a mass of gas is expelled with an acceleration twice as large as the original one. What then would be the magnitude of the rocket's acceleration? How much larger would be the force exerted on the rocket by the gas (compared to the force exerted on it in the original situation)?

Ans) 4 times magnitude of the rocket's acceleration ($4a_0$) and force also 4 times.