HOME ASSIGNMENT

1) A motor car 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 4s by an unbalanced external force. Calculate the acceleration & change in momentum. Also calculate the magnitude of the force required.

Given:-
Mass of the motor car, $m = 1200\,kg$.
Initial velocity of the motor car, $u = 90\,km/h = 25\,m/s$
Final velocity of the motor car, $v = 18\,km/h = 5\,m/s$.
Time taken, $t = 4s$.

Solution:-

$\Delta P = mv - mu$

$\Delta P = 1200 \times 5 - 1200 \times 25 = -24000\,kg\,m/s$.

$v = u + at$

$5 = 25 + a \times 4$

$\Rightarrow a = -5\,m/s^2$.

(-ve shows retardation)

$|F| = m|a| = 1200 \times 5 = 6000\,N$

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 & (iii) the magnitude of the force.

Mass, $m = 100\,Kg$.
Time interval, $\Delta t = 10s$.

i) Distance travelled in next 5 seconds, $d = 100m$.
Thus, velocity acquired by body, $v = \frac{d}{t} = \frac{100}{5} = 20m/s$

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

$= \frac{20}{10} = 2m/s^2$.

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

3) Derive the relation b/w force & acceleration using Newton's second law of motion.

$F_{net} \propto \frac{mv-u}{t}$

$\Rightarrow F_{net} = K\left[\frac{m(v-u)}{t}\right]$ — ①

m → mass of the body.
v → final velocity
u → initial velocity.
t → time
Fnet → Net value.

$$v = u + at$$

$$a = \frac{v-u}{t} \quad \text{——} (12)$$

from (1) & (12), we have

$$f_{net} = m \times a.$$

H) How the first law of motion can be mathematically stated from the mathematical expression for the second laws of motion?

Newton's second law of motion can be started as the acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, & inversely proportional to the mass of the object.

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. Here 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,

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

HOME ASSIGNMENT (2)

1) Name & state the action & reaction in the following cases:

a) firing of a bullet from a gun
Action: Force exerted on the bullet.
Reaction: Recoil experienced by the gun

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

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

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

a) a person moving on the floor, and
Action : Force exerted by the feet on the ground in backward direction.
Reaction : Force exerted by the ground on feet in forward direction.

b) a moving train colliding with a stationary train.
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.
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.
Hence, it is difficult for him to remain stable while holding the hose.

b) Why action & reaction do not cancel each other?
Action & reaction do not cancel each other because they act on different objects. Forces can cancel of only if the act on the same object.

3) a) If some one jumps to the shore from a boat the boat moves in the opposite direction. Explain.
According to Newton's third law, to every action, there is an equal & opposite reaction. When we jump on the shore from the boat, we are applying force on the boat in the opposite direction in order to move forward & hence the boat moves in the opposite direction.

b) When air from an inflated ballon is allowed to be released, the balloon moves in a direction opposite to that of air. Explain
If a ballon filled with compressed air & 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 & opposite reaction of downward going air pushes the balloon upwards.

Numerical

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 acceleration of magnitude a_0.

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

Opposite direction

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

Yes, opposite to acceleration of expelled gas

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?

$2a_0$

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.

$2a_0$

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e) Suppose that twice as large a mass of gas is expelled with an acceleration twice as large as the original one. what the 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)?

4 ap, 4 times larger.