Homework →

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.

Ans → Mass of car = 1200 kg.

Initial velocity = u = 90 km/h = 25 m/s

Final velocity of car = v = 18 km/h

= 5 m/s

t = 4s

Change in momentum = ΔP

$\Delta P = mv - mu$

$\Delta P = 1200 \times 5 - 1200 \times 25 = -24000$ kgm/s

$v = u + at$

$5 = 25 + a \times 4$

$a = -5$ m/s²

Retardation = -5 m/s²

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

② A force act for 10s on a stationary body of mass 10 kg after which the force ceases to act. The body moves through a distance of 10 m in the next 5 sec. Calculate (i) the velocity acquired by the body

(ii) accⁿ produced by the force and

(iii) the magnitude of the force.

Ans → Mass, m = 100 kg.

Time travel, Δt = 10 sec.

(i) Distance traveled in next 5 seconds,

d = 100 m

Velocity = $v = \frac{d}{t} = \frac{100}{5}$ = 20 m/s

(ii) Acceleration produced by force,

$a = \frac{V}{\Delta t} = \frac{20}{10} = 2 m/s^2$

(iii) Magnitude of force, $F = ma$

= 100 kg × $2 m/s^2$ = 200 N

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

Ans → Rate of change of momentum ∝ force applied

If a body is moving with initial velocity 'u' and after applying a force 'F' on it its velocity becomes 'v' in time 't'.

Initial momentum of body P_1 = mu

Final momentum of body P_2 = mv

Change in momentum in time 't' is

mv − mu

Rate of change of momentum = $\frac{mv - mu}{t}$

According to Newton's second law

$$\frac{mv - mu}{t} \propto F$$

$$F \propto \frac{m(v-u)}{t} \qquad \left[\frac{v-u}{t} = a\right]$$

So, $F \propto kma$

$$F = kma$$

$$\boxed{F = ma} \quad [k = 1]$$

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

(4) How the 1st law of motion can be mathematically started from the mathematical expression for the second law of motion?

try → $F = ma$; where net external force is zero

if, $F = 0$

$$a = \frac{F}{m} = 0$$

therefore v = constant, as the first law states.

→ Home Assignment →

(1) Name and state the action & reaction in the following cases →

(a) Firing of a Bullet from a gun.

→ Action → Firing bullet.

→ Reaction → Recoiling of gun.

(b) Hammering a nail, Action ⇒ Hitting hammer on nail.
Reaction → the nail exerts equal force on hammer

(c) A book lying on table,
Action → book exerts force on table due to gravity.
Reaction → the table exerts equal force on the book.

(d) Moving rocket, Action → the fuel burns & releases large amount of force in opposite direction of the movement of rocket.
Reaction → the burnt fuel exerts equal pressure on the rocket & rocket move in upward direction.

(e) A person moving on the floor.
Action → the person exerts force on the floor
Reaction → the floor exerts equal force on the legs of person due to which he move forward.

(f) A moving train colliding with a stationary train; Action → the train collides to stationary train by applying large amount of force due to its large momentum.

Reaction → the stationary train also exerts equal force on the moving train which opposes the motion of the moving train

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

Ans → When a firemen 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. Therefore it is difficult to hold a horse.

(b) Why action and reaction don't cancel each other?

Ans → Force ~~ent~~ exerted by two objects on each other are often called as action-reaction force pair. However, action and reaction force ~~pulls~~ pairs don't cancel because they act on different objects. Forces can cancel only if they act on the same object.

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

Ans → According to Newton's third law, to every action, there is an equal and 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 opp. direction.

(b) When air from an inflated balloons 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.

→ Numerical → Q. 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 accln of magnitude a_0.

(a) How is the direction of the rocket's accln

related to the direction along which the gas is expelled?

Ans → The direction of the rocket accⁿ is opposite to the direction along which the gas is expelled i.e, if the direction of the rocket accⁿ is upward then the direction of the gas expelled will be in downward.

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

Ans → Yes, in the downward direction.

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

Ans → Rocket's accⁿ will also be twice i.e, 2a.

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

Ans → ~~2a~~ Twice more ~~larger than~~

~~(e) Suppose that~~

→ let the original accⁿ = a

mass of gas = 2m [let 'm' be mass]

$F_g = 2ma$

Rocket's accⁿ = $\frac{F_g}{2m}$ m/s².

(c) Suppose that twice as large a mass of gas is ~~ejected~~ expelled with an accelⁿ twice as large as the original one. What then would be the magnitude of the rocket's accelⁿ? How much larger would be the force exerted on the rocket by the gas?

Ans → Mass of gas = m

twice of it = 2m

Original accelⁿ be 'a'

twice of it = 2a

⇒ ~~$F_g = F_r$~~

⇒ $F_g = F_r$

= $F_g = 2m \times 2a = F_r$

~~$F_g = 4ma$~~

→ $\frac{F_g}{2m} = 2a$

= $\boxed{\frac{F_g}{4m} = a}$

Accelⁿ of rocket = $\frac{F_g}{4m}$ m/s^2

Original force exerted on Rocket by gas = 2ma Newton

Now, the force exerted on rocket by gas
$= 4ma$ Newton

How much larger $= (4ma - 2ma)$ Newton
$= \boxed{2ma}$ Newton

~~$\therefore 2ma$ N larger force~~

$\therefore$ $2ma$ Newton large force was exerted on rocket by gas.