HW
7/9/21.

Force And Laws Of Motion

Exercises

5) A truck starts from rest & rolls down a hill with a constant acceleration. It travels a distance of 400m in 20s. Find its accln. Find the force acting on it if its mass is 7 tonnes. (Hint: 1 tonne = 1000 kg).

$u = 0$

Distance travelled (s) = 400m

time (t) = 20s.

According to 2nd equation of motion,

$$s = ut + \frac{1}{2}at^2$$

$$\Rightarrow 400 = 0 \times 20 + \frac{1}{2} \times a (20)^2$$

$$\Rightarrow 400 = \frac{1}{2} \times a \times 400$$

$$\Rightarrow 400 = 200a$$

$$\Rightarrow a = \frac{400}{200} \Rightarrow a = 2 m/s^2$$

7 tonnes = $7 \times 1000 = 7000$ kg

$f = ma$.

$= 7000 kg \times 2 m/s^2$

$= 14000 kg\, m/s^2$

$= 14000 N$.

6) A stone of 1 kg is thrown with a velocity of 20 m/s across the frozen surface of a lake & comes to rest after travelling a distance of 50m. What is the force of friction between the stone & ice?

$u = 20$, $v = 0$, $s = 50\,m$.

According to the third law of motion :-

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

$\Rightarrow (0)^2 = (20)^2 + 2a \times 50$

$\Rightarrow -400 = 100a$

$\Rightarrow a = \frac{-400}{100} \Rightarrow a = -4\,m/s^2$.

$f = ma$

$= 1kg \times -4m/s^2 = -4\,kgm/s^2 = -4N$.

7) A 8000 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 & the track offers a friction force of 5000 N, then calculate :

a) the net accelerating force

b) the accelerating of the train

c) the force of wagon 1 on wagon 2.

a) Force exerted by the engine (F) = 40000 N

Frictional force affected by the track (F_f) = 5000 N.

Net accelerating force, $F_n = F - F_f = 40000 - 5000 = 35000N$

b) Mass of the wagons (m) = 2000 × 5 = 10000 kg

Total mass of the train (M) = m + mass of engine

= 10000 kg + 8000 kg = 18000 kg.

$F_a = Ma$

$a = \frac{F_a}{M}$

$= \frac{35000}{18000} = 1.944 \text{ m/s}^2$.

c) Let the accel of the wagons is a_w.

$35000 = 5m \times a_w$

$\Rightarrow a_w = 35000/5m$

$\Rightarrow a_w = 35000/(5 \times 2000)$

$\Rightarrow a_w = 3.5$.

Then mass of last 4 wagons can be considered as m_w

$m_w = 2000 \times 4$

$m_w = 8000$ kg.

Net force on the last four wagons :-

$F' = m_w \times a_w$

$= 8000 \times 3.5 = 28000$ N.

8) An automobile vehicle has a mass of 1500 kg. what must be the force between the vehicle & road if the vehicle is to be stopped with a negative accel^n of 1.7 m/s^2 ?

$F = m \times a$

$= 1500 \text{ kg} \times -1.7 \text{ m/s}^2$

$= -2550 \text{ kg m/s}^2$

$= -2550$ N

9) What is the momentum of an object of mass m moving with a velocity v?

a) $(mv)^2$

b) mv^2

c) $\frac{1}{2}mv^2$

d) mv.

10) Using a horizontal force of 200N, 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?

A force of 200N is applied in the forward direction. Thus, from Newton's third law of motion, an equal amount of force will act in the opposite direction. This opposite force is the frictional force exerted on the cabinet. Hence a frictional force of 200N is exerted on the cabinet.

11) Two objects, each of mass 1.5kg are moving in the same straight line but in opposite directions. The velocity of each object is 2.5 m/s before the collision during which they stick together. What will be the velocity of the combined object after collision?

Mass of one of the objects, $m_1 = 1.5$ kg.
Mass of the other object, $m_2 = 1.5$ kg.
Velocity of m_1 before collision, $v_1 = 2.5$ m/s
Velocity of m_2 moving in opposite dir^n before collision, v_2
$= -2.5$ m/s.

Total mass of the combined object $= m_1 + m_2$
Velocity of the combined object $= v$.

According to the law of conservation of momentum:

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v$$
$$\Rightarrow 1.5 \times 2.5 + 1.5 \times -2.5 = (1.5 + 1.5) v$$
$$\Rightarrow 3.75 - 3.75 = 3v$$
$$\Rightarrow v = 0 \text{ m/s}.$$

12) According to the third law of motion when we push an object, the object pushes back on us with an equal & 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 & equal forces cancel each other. Comment on this logic & explain why the truck does not move.

The logic is that Action & Reaction always act on different bodies, so they cannot cancel each other when we push a massive truck, the force of friction between its tyres & the road is very large & so the truck does not move. The force of friction cancel the force applied by person push. So student's justification is correct.

13) A hockey ball of mass 200g travelling at 10 m/s is struck by a hockey stick so as to return it along its original path with a velocity at 5m/s. Calculate the change of momentum occured in the motion of the hockey ball by the force applied by the hockey stick.

Mass of the hockey ball, $m = 200g = 0.2kg$.

Hockey ball travels with velocity $V_1 = 10 m/s$.

Initial momentum $= mV_1$

Hockey ball travels in the opposite direction with velocity, $V_2 = -5 m/s$.

final momentum $= mv_2$.

change in momentum $= mV_1 - m_2 = (0.2 \times 10) - (-5) = 0.2$

$15 = 3 kgm/s$.

Hence, the magnitude of change of momentum of the hockey ball is $3 kgm/s$.

14) A bullet of mass 10g travelling horizontally with a velocity of 150 m/s strikes a stationary wooden block & comes to rest in 0.03s. Calculate the distance of penetration of the bullet into block. Also calculate the magnitude of the force exerted by the wooden block on the bullet.

$u = 150 m/s$

$v = 0$.

$t = 0.03s$

According to the first eqn of motion,

$v = u + at$

$\Rightarrow 0 = 150 + (a \times 0.03)$

$\Rightarrow 0.0 = 150 + 0.03a$

$\Rightarrow -150 = 0.03a$

$\Rightarrow a = \frac{-150}{0.03}$

$\Rightarrow a = 5000 \text{ m/s}^2$.

According to the third eqn of motion,

$v^2 = u^2 + 2as$

$\Rightarrow 0 = 150^2 + 2 \times -5000 s$.

$\Rightarrow s = \frac{(-150)^2}{-2(5000)} = 2.25$

From Newton's second law of motion;

$F = m \times a$

$= 0.01 \times 5000 = 50 \text{ N}$.

Hence the magnitude of force exerted by the wooden block on the bullet is 50 N.

15 An object of mass 1kg travelling in a straight line with a velocity of 10 m/s collides with & sticks to, a stationary wooden block of mass 5kg. Then they both move off together in the same straight line. Calculate the total momentum just before the impact & just after the impact. Also, calculate the velocity of the combined object

$m_1 = 1\,kg$, $v_1 = 10\,m/s$.
$m_2 = 5\,kg$, $v_2 = 0\,m/s$.

Total momentum before collision $= m_1v_1 + m_2v_2$
$= 1 \times 10 + 5 \times 0 = 10\,kg\,m/s$.

Total mass of the combined system $= m_1 + m_2$.
Velocity of the combined system $= v$.

Total momentum before collision = Total momentum after collision
$m_1v_1 + m_2v_2 = (m_1 + m_2)v$
$\Rightarrow 1 \times 10 + 5 \times 0 = (1+5)v$
$\Rightarrow 10 = 6v$.
$\Rightarrow v = 10/6 = 5/3$

$\Rightarrow v = 5/3\ m/s$.