5 A truck starts from rest and rolls down a hill with a constant acceleration. It travels a distance of 400 m in 20 s. Find its acceleration. Find the force acting on it if its mass is 7 tonnes.

Ans $u = 0$ m/s. $\quad m = 7$ tonnes

$s = 400$ m. $\quad 7 \times 1000 = 7000$ kg.

$t = 20$ s.

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

$\Rightarrow 400 = (0 \times 20) + \frac{1}{2}a(20)^2 = \frac{400 \times 2}{(20)^2} = \frac{800}{400} = 2$ m/s^2.

Force $(F) = ma = 7000 \times 2 = 14000$ N.

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

Ans $m = 1$ kg ; $u = 20$ m/s ; $s = 50$ m, $v = 0$

$v^2 - u^2 = 2as \Rightarrow (0)^2 - (20)^2 = 2a(50) \Rightarrow -400 = 100a$

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

Force of friction, $f = ma = 1$ kg $\times (-4$ m/s$^2) = -4$ N.

7a The net accelerating force = force exerted by engine - Friction
= 40000 - 5000
= 35000N.

b The acceleration of the train = F = 35000N.
Mass of 5 wagons pulled by engine = 5 × 2000 = 10000kg
$F = ma \Rightarrow 35000 = 10000 \times a \Rightarrow a = \frac{35000}{10000} = 3.5 m/s^2$.

8 An automobile vehicle has a mass of 1500kg. What must be the force between the vehicle and road if the vehicle is to be stopped with a negative acceleration of $1.7 m/s^2$?

Ans $m = 1500kg$, $a = 1.7 m/s^2$
$F = ma$
$= 1500 \times (-1.7) = -2550N$.

12 According to 3rd law of motion, when we push an object, it pushes us back with the same and opposite force. If object is a massive truck parked along roadside, it will probably not move. A student justifies this by answering that two opposite and equal forces cancel each other. Comment on this logic and explain why truck doesn't move.

Ans Mass of truck is too large and hence its inertia is too high. Small force exerted on truck can't move it and it remains at rest. For it to attain motion, an external large amount of unbalanced force need to be exerted on it.

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 of 5 m/s. Calculate change of momentum occured in motion of hockey ball by the force applied by the hockey stick.

Ans $m = 200g = 0.2kg$, $u = 10m/s$, $v = -5m/s$.

$mu = 0.2 \times 10 = 2kgm/s$.

$mv = 0.2 \times (-5) = -1kgm/s$.

Change in Momentum = Difference in momentum.

$= 2 - (-1)$

$= 3kgm/s$.

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

Ans $m = 10g = \frac{10}{1000} = 0.01kg$, $u = 150m/s$, $v = 0m/s$, $t = 0.03s$.

$v = u + at$

2) $0 = 150 + a(0.03)$

2) $a = \frac{-150}{0.03} = -5000 m/s^2$.

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

2) $(0)^2 - (150)^2 = 2 \times 5000 \times s$

2) $s = \frac{-150 \times -150}{2 \times 5000} = 2.25m$.

$F = ma$

$= \frac{10}{1000} \times 5000 = 50N$.

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

Ans $m_1 = 1kg$, $v_1 = 10m/s$, $m_2 = 5kg + 1kg = 6kg$ (Combined object)

Mass of wooden block = 5kg.

Momentum before impact $p = m_1 v_1 = 1 \times 10 = 10 kgm/s$.

$m_1 v_1 = m_2 v_2 \Rightarrow 10 kgm/s = 6v_2 \Rightarrow \frac{10}{6} = v_2 \Rightarrow v_2 = 1.67 m/s$.

16 An object of mass 100kg is accelerated uniformly from a velocity of 5m/s to 8m/s in 6s. Calculate initial and final momentum of the object. Also, find magnitude of force exerted on the object.

Ans $m = 100kg$, $u = 5m/s$, $v = 8m/s$, $t = 6s$.

Initial momentum $(p_1) = mu = 100 \times 5 = 500 kgm/s$.

$p_2 = mv = 100 \times 8 = 800 kgm/s$.

$F = ma = 100\left(\frac{v-u}{t}\right) = 100\left(\frac{8-5}{6}\right) = 100 \times \frac{3}{6} = 50N$.