Homework

(3) Given, distance covered by the truck (s) = 400m.
Time taken to cover the distance (t) = 20 secs
Initial velocity of the truck (u) = 0 (since it starts from a state of rest).
From the eqns. of motion, $s = ut + \frac{1}{2}at^2$.
Therefore, $400 = 0(20s) + \frac{1}{2}(a)(400s^2) = 2ms^{-2}$
The acceleration of the truck is equal to $2ms^{-2}$
As per the 2nd law of motion,

Force = Mass × Acceleration
Mass of the truck = 7 tonnes = 7000kg.
Force acting on the truck = $7000kg \times 2ms^{-2}$ = $14000 kg.ms^{-2} = 14000N$.
Therefore, a force of 14000N is acting on the truck.

(6) Given, Mass of the stone (m) = 1kg.
Initial velocity (u) = 20m/s.
Terminal velocity (v) = 0m/s (the stone reaches a position of rest)
Distance travelled by the stone (s) = 50m.
As per the 3rd motion eqn., $(v^2-u^2) = 2as$.
The acceleration of the stone is given by :
$\frac{(v^2-u^2)}{2s}$.
Therefore, acceleration of the stone (a) = $\frac{0-400}{100}$ ms^{-2}
$= -4ms^{-2}$
As per the 2nd law of motion, F = ma.
Therefore, force acting on the stone, F = $1kg \times -4ms^{-2} = -4N$.
The frictional force acting on the stone has a magnitude of 4N & it acts on the direction opposite to that of stone's motion.

(7) (a) Given, force exerted by the train (F) = 40,000N
Force of friction = -5000N (the -ve sign indicates that the force is applied in the opposite direction)
Therefore, the net accelerating force = sum of all forces.
40,000N + (-5000N) = 35,000N.

(b) Total mass of the train = mass of engine + mass of each wagon = 8000kg + 5 × 2000kg.
The total mass of the train is 18000 kg.

Acceleration = $\frac{\text{Net accelerating force}}{\text{Total mass of the train}} = \frac{35,000}{18,000}$

$= 1.94 ms^{-2}$.

The acceleration of the train is $1.94 m \cdot s^{-2}$.

(8) Given, mass of the vehicle (m) = 1500kg.
Acceleration (a) = $-1.7 ms^{-2}$.
As per the 2nd law of motion, F = ma
F = 1500 kg × $(-1.7 ms^{-2})$ = -2550N.
Therefore, a force of 2550N must act on the vehicle in a direction opposite to that of its motion.

(12) Since, the truck has a very high mass, the static friction between the road & the truck is high. When pushing the truck with a small force, the frictional force cancels out the applied force & the

truck doesn't move. This implies that the 2 forces are equal in magnitude but opposite in direction (since the person pushing the truck isn't displaced when the truck doesn't move). Therefore, the student's logic is correct.

(13) Given, mass of the ball (m) = 200g.
Initial velocity of the ball (u) = 10m/s.
Final velocity of the ball (v) = -5m/s.
Initial momentum of the ball = mu = 200g × 10ms^{-1} = 2000g·m·s^{-1}
Final momentum of the ball = mv = 200g × -5ms^{-1} = -1000g·m·s^{-1}
Therefore, the change in momentum ($mv - mu$) = -1000g·m·s^{-1} - 2000gm·s^{-1} = -3000g·m·s^{-1}
This implies that the momentum of the ball reduces by 1000 g·m·s^{-1} after being struck by the hockey stick.

(14) Given, mass of the bullet (m) = 10g (or 0.01kg)
Initial velocity of the bullet (u) = 150m/s
Terminal velocity of the bullet (v) = 0m/s.
t = 0.03s.
To find the distance of penetration, the acceleration of the bullet must be calculated.
As per the 1st motion equation, $v = u + at$
Therefore, $a = \frac{v-u}{t} = \frac{0-150}{0.03}$ ms^{-2}

Acceleration of the bullet after striking the wooden block is -5000 ms^{-2}.
Now, from the motion equation ($v^2 - u^2$) = 2as, the distance of penetration (s) can be calculated as follows:

$s = \frac{v^2 - u^2}{2a} = \frac{0^2 - (150)^2}{2(-5000)} m = 2.25 m$

Therefore, force exerted by the wooden block on the bullet (F) =
$0.01 kg \times (-5000 ms^{-2}) = -50 N$.
This implies that the wooden block exerts a force of magnitude 50N on the bullet in the direction that is opposite to the trajectory of the bullet.

(15) $m_1 = 1 kg$
$m_2 = 5 kg$
$u_1 = 10 m/s$
$u_2 = 0$
$m_1 + m_2 = 6 kg$
$m_1 u_1 + m_2 u_2 = (1 kg) \times (10 m/s) + 0 = 10 kg \cdot m \cdot s^{-1}$
$(m_1 + m_2) \times v = 10 kg \cdot m \cdot s^{-1}$
$v = \frac{10 kg \cdot m \cdot s^{-1}}{6 kg} = 1.66 ms^{-1}$.
The resulting object moves with a velocity of 1.66 m/s.