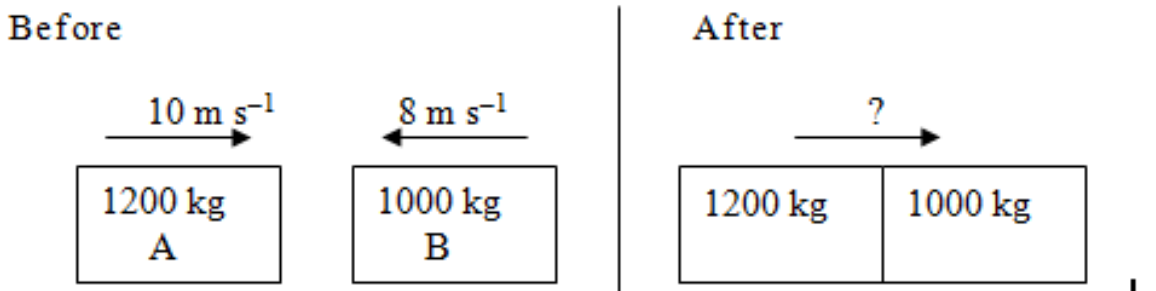
PQ 8

Questions & Answers

Q1

- Two cars are travelling towards each other as shown below. They collide, lock together and move forwards (ie to the right) after the collision.
- Find the speed of the cars immediately after the collision.



Take motion → as +

$m_1u_1 = 1200 \times 10 = 12{,}000$

$m_2u_2 = 1000 \times -8 = -8000$

$(m_1 + m_2)v = (1200 + 1000)v$

$= 2200v$

total momentum before = total momentum after

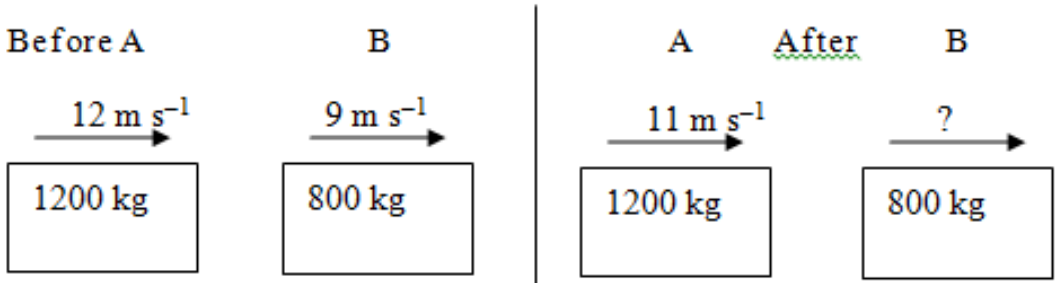
$12{,}000 - 8000 = 2200v$

$v = \frac{4000}{2200} = 1.8$

ie $= 1.8$ m s^{-1} to the right

Q2

- One vehicle (vehicle A) approaches another (vehicle B) from behind as shown below. The vehicles are moving with the speeds shown. After the collision the front vehicle is travelling at 11 m s^{-1}. Calculate the speed of vehicle B after the collision.



Take motion → as +

$m_1u_1 = 1200 \times 12 = 14{,}400$

$m_2u_2 = 800 \times 9 = 7200$

$m_1v_1 = 1200 \times v_1 11$

$m_2v_2 = 800 \times v_2$

total momentum before = total momentum after

$$14{,}400 + 7200 = 1320 + 800v_2$$

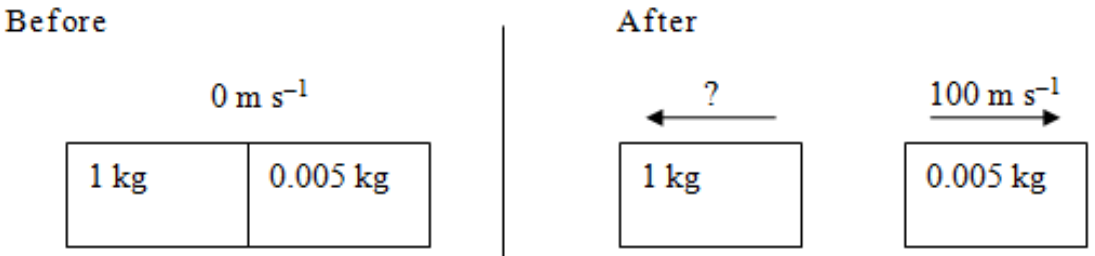
$$21{,}600 = 1320 + 800v_2$$

$$v_2 = \frac{20{,}280}{800} = 25.35$$

ie $v_2 = 25.4\ \text{ms}^{-1}$ to the right

Q3

- A gun of mass 1 kg fires a bullet of mass 5 g at a speed of 100 m s^{-1}. Calculate the recoil velocity of the gun.



Take motion → as +

momentum = 0

$m_1v_1 = 1 \times v_1$

$m_2v_2 = 0.005 \times -100$

$= -0.5$

total momentum before = total momentum after

$0 = (1 \times v_1) - 0.5$

$v_1 = 0.5$

ie $v_1 = 0.5$ m s^{-1} in the opposite direction to the bullet

Q4

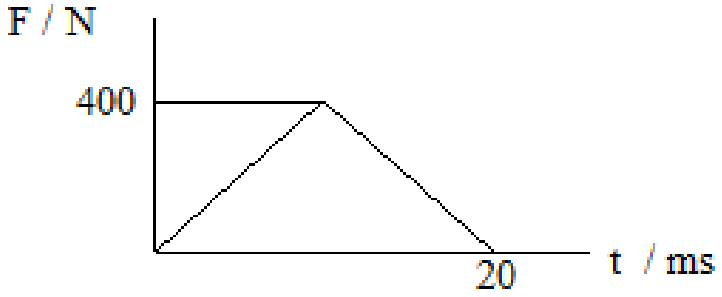
- In a snooker game, the cue ball, of mass 0.2 kg, is accelerated from the rest to a velocity of 2 m s^{-1} by a force from the cue which lasts 50 ms. what size of force is exerted by the cue?

$$u = 0,\ v = 2\ \text{m s}^{-1},\ t = 50\ \text{ms} = 0.05\ \text{s},\ m = 0.2\ \text{kg},\ F = ?$$

$$Ft = mv - mu$$
$$F \times 0.05 = (0.2 \times 2) - (0.2 \times 0)$$
$$F \times 0.05 = 0.4$$
$$F = 8\ \text{N}$$

Q5

- A tennis ball of mass 100 g, initially at rest, is hit by a racquet. The racquet is in contact with the ball for 20 ms and the force of contact varies over this period, as shown in the graph. Determine the speed of the ball as it leaves the racquet.



impulse = area under graph

$= \frac{1}{2} \times 20 \times 10^{-3} \times 400 = 4 \text{ N s}$

$u = 0$

$m = 100 \text{ g} = 0.1 \text{ kg}$

$v = ?$

$Ft = mv - mu$

$4 = 0.1v - (0.1 \times 0)$

$4 = 0.1v$

$v = 40 \text{ m s}^{-1}$

Q6

- A tennis ball of mass 0.1 kg travelling horizontally at 10 m s^{-1} is struck in the opposite direction by a tennis racket. The tennis ball rebounds horizontally at 15 m s^{-1} and is in contact with the racket for 50 ms. Calculate the force exerted on the ball by the racket

$m = 0.1$ kg
$u = 10$ m s^{-1}
$v = -15$ m s^{-1} (opposite direction to u)
$t = 50$ ms $= 0.05$ s

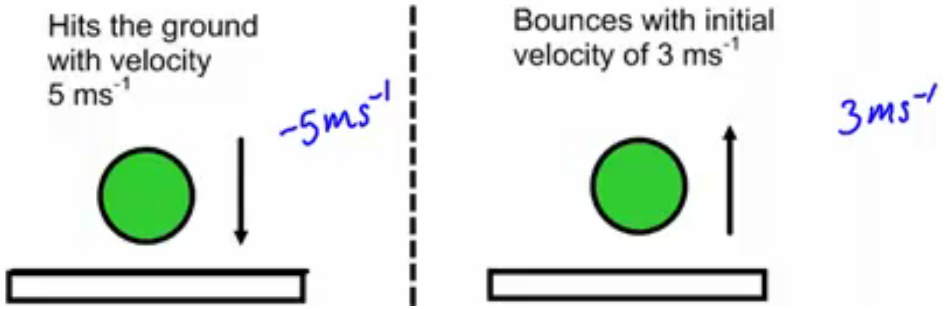
$$Ft = mv - mu$$
$$0.05F = (0.1 \times (-15)) - (0.1 \times 10)$$
$$= -1.5 - 1$$
$$= -2.5$$

$F = -50$ N (the negative sign indicates force in opposite direction to the initial velocity)

Q7

Find the average force experienced by the ball during the bounce

Mass of ball = 2 kg bounce lasted for 0.4 seconds



Change of momentum = impulse

$16 = F.t$

$16 = F \times 0.4$

$\frac{16}{0.4} = F$

$F = 40N \uparrow$

$p = mu$

$= (2 \times -5)$

$= -10\ kgms^{-1}$

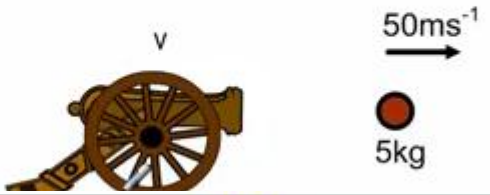
$p = mv$

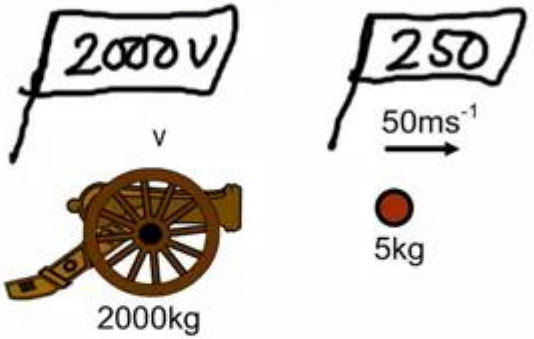
$= (2 \times 3)$

$= 6\ kgms^{-1}$

C.O.M $= 6 - (-10) = 16\ kgms^{-1}$

Q8

Before	After
	

Before	After
$P = mv$ 	
$TMB = TMA$	

$$0 = 2000v + 250$$

$$-2000v = 250$$

$$v = 250/-2000 = -0.125 m/s$$

Q9

- A car of mass 500 kg is moving at 8m/s when it hits another car. The first car stops moving after which the second car starts moving at a speed of 15m/s. What is the mass of the second car?

Using the formula above we can easily solve for the mass of the second car:

Momentum Before Collision = Momentum After Collision

$$M1 \times U1 + M2 \times U2 = M1 \times V1 + M2 \times V2$$

- M1 & M2 is the mass of the first and second car respectively.
- U1 & U2 is the velocity before collision for the first and second car respectively.
- V1 & V2 is the velocity after collision for the first and second car respectively.

$$M1 \times U1 + M2 \times U2 = M1 \times V1 + M2 \times V2$$
$$500 \times 8 + M2 \times 0 = 500 \times 0 + M2 \times 15$$
$$4000 + 0 = 0 + M2 \times 15$$
$$4000 / 15 = M2$$
$$266.7kg = M2$$

Q10

- A bullet of mass 0.25kg travelling at 150km/s strikes a stationary block of mass 3kg. What is the common velocity of the bullet and block after collision?
- The first step to solving the problem is to try and find out exactly what they are asking for. The question stated that you need to find the common velocity of the bullet and the block after collision. This simply means that the objects remain together after collision and so have a common velocity. This is known as an inelastic collision, when given problems involving inelastic collisions use the formula below to solve instead of the general formula given above:

  $M1 \times U1 + M2 \times U2 = (M1 + M2)\ V$

  Where V is the common velocity.

  In this case M1 would be the mass of the bullet.
- U1 is velocity of the bullet
- M2 is mass of block
- U2 is velocity of Block (would be zero since it is stationary)

Q10 continued

- The next step would be to plug in the values for both objects into the formula and then solve:

$$M1 \times U1 + M2 \times U2 = (M1 + M2)\ V$$
$$0.25 \times 150 + 3 \times 0 = (0.25 + 3)\ V$$
$$37.5 + 0 = 3.25 \times V$$

Transpose for V

$$37.5 + 0 = 3.25 \times V$$
$$37.5/3.25 = (3.25 \times V) / 3.25$$
$$V = 11.54 m/s$$