Momentum Challenge

Challenge 1

A particle P has mass 5 kg. It is moving along a straight line with speed 4 m s^{-1}, when it collides directly with another particle Q which is at rest. The mass of Q is m kg.

5 kg $\quad\quad\quad\quad\quad\quad\quad\quad$ m kg

P $\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad$ Q

$\longrightarrow$

4 m s^{-1}

After the collision P moves with a speed of 1.2 m s^{-1} and Q moves with a speed of 1.4 m s^{-1}.

(a) If P and Q both move in the same direction after the collision, show that $m = 10$.

(3 marks)

(b) If P and Q move in opposite directions after the collision, find m. *(3 marks)*

Challenge 2

A trolley, of mass 10 kg, is placed at rest on a set of straight horizontal rails. Large pellets, each of mass 0.5 kg, are fired at the trolley. When each pellet hits the trolley, the pellet is travelling horizontally and parallel to the rails at a speed of $20\,\mathrm{m\,s^{-1}}$. When the pellets hit the trolley, they stick to it and continue to move with the trolley. Assume that there is no resistance to the motion of the trolley.

$20\,\mathrm{m\,s^{-1}}$
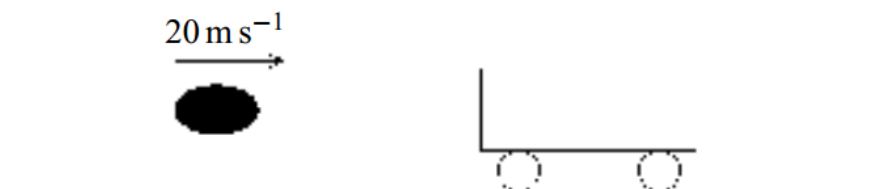
(a) Show that the speed of the trolley after it has been hit by the first pellet is $\frac{20}{21}\,\mathrm{m\,s^{-1}}$.

(2 marks)

(b) Find the speed of the trolley after it has been hit by the second pellet. *(4 marks)*

Challenge 3

Two particles, A and B, are moving with constant speeds in the same direction along a straight horizontal line. The velocity of A is $5\,\mathrm{m\,s^{-1}}$ and its mass is $0.1\,\mathrm{kg}$. The velocity of B is $3\,\mathrm{m\,s^{-1}}$ and its mass is $0.4\,\mathrm{kg}$. The two particles collide. The diagram shows the velocities before the collision.

A B

$5\,\mathrm{m\,s^{-1}}$ $3\,\mathrm{m\,s^{-1}}$
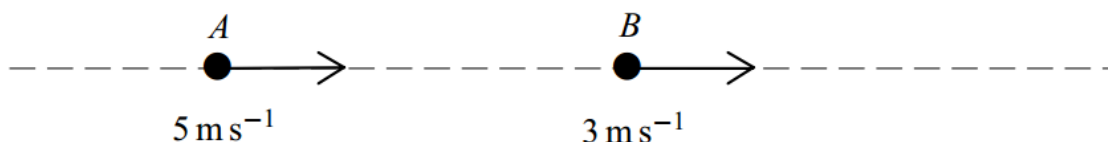
(a) If the particles coalesce during the collision, find the velocity of the combined particle after the collision.   *(3 marks)*

(b) If the particles do **not** coalesce during the collision, and the velocity of B increases to $3.5\,\mathrm{m\,s^{-1}}$, find the velocity of A after the collision.   *(4 marks)*

Final Challenge

A particle of mass m has velocity $\begin{bmatrix} 4 \\ 2 \end{bmatrix}$ m s^{-1}. It then collides with a particle of mass 3 kg which

has velocity $\begin{bmatrix} -1 \\ -1 \end{bmatrix}$ m s^{-1}. During the collision the particles coalesce and move with velocity

$\begin{bmatrix} 1 \\ V \end{bmatrix}$ m s^{-1}.

(a) Show that $m = 2$.   *(4 marks)*

(b) Find V.   *(3 marks)*