Solutionbank M1

Heinemann Modular Maths for Edexcel AS and A-level

8 Momentum

Exercise B, Question 12

Question:

A particle, P, moves with constant velocity.

(a) The particle passes through the points with position vectors $\begin{bmatrix} -1 \\ 2 \end{bmatrix}$ and $\begin{bmatrix} 2 \\ 8 \end{bmatrix}$ at times $t = 0$ and $t = 3$, respectively. The units of distance and time are metres and seconds, respectively. Show that the velocity of P is $\begin{bmatrix} 1 \\ 2 \end{bmatrix}$ m s^{-1}.

(b) When $t = 3$, the particle P, of mass 0.2 kg, collides with a particle Q. The particle Q has mass 0.1 kg and, immediately before the collision, it is moving with velocity $\begin{bmatrix} -5 \\ 5 \end{bmatrix}$ m s^{-1}. As a result of the collision, P and Q coalesce into a single particle, R. Find the velocity of R immediately after the collision.

(c) Assuming that the velocity of R remains constant, find the position vector of R three seconds after the collision. [A]

Solution:

(a) The particle moves from $\begin{bmatrix} -1 \\ 2 \end{bmatrix}$ to $\begin{bmatrix} 2 \\ 8 \end{bmatrix}$ which is a

displacement of $\begin{bmatrix} 2 \\ 8 \end{bmatrix} - \begin{bmatrix} -1 \\ 2 \end{bmatrix} = \begin{bmatrix} 3 \\ 6 \end{bmatrix}$

This takes 3 seconds;

$\therefore$ The velocity of P is $\frac{1}{3} \times \begin{bmatrix} 3 \\ 6 \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$ m s^{-1}

(b) Using conservation of momentum with **v** as the velocity of R immediately after the collision,

$0.2 \begin{bmatrix} 1 \\ 2 \end{bmatrix} + 0.1 \begin{bmatrix} -5 \\ 5 \end{bmatrix} = 0.3\mathbf{v}$

$\begin{bmatrix} -0.3 \\ 0.9 \end{bmatrix} = 0.3\mathbf{v}$

$\mathbf{v} = \begin{bmatrix} -1 \\ 3 \end{bmatrix}$

$\therefore$ Velocity of R immediately after the collision is $\begin{bmatrix} -1 \\ 3 \end{bmatrix}$ m s^{-1}

(c) Three seconds after the impact, R will have moved a displacement

$3 \begin{bmatrix} -1 \\ 3 \end{bmatrix} = \begin{bmatrix} -3 \\ 9 \end{bmatrix}$

It was, at impact, at $\begin{bmatrix} 2 \\ 8 \end{bmatrix}$

$\therefore$ Its position vector, three seconds after impact,

is $\begin{bmatrix} -3 \\ 9 \end{bmatrix} + \begin{bmatrix} 2 \\ 8 \end{bmatrix} = \begin{bmatrix} -1 \\ 17 \end{bmatrix}$