Further Maths A-Level Starter Activity

Topic: Momentum and Impulse (1)

Chapter Reference: Further Mechanics 1, Chapter 1

8 minutes

Don't risk it, draw a diagram!

1. A particle P of mass 3 kg is moving with a speed of 8 ms^{-1} in a straight horizontal line when it collides with particle Q, of mass 4 kg, which is moving in the opposite direction with speed 1.5 ms^{-1}. After the collision, the direction of motion of P is unchanged and it moves with a speed of 2 ms^{-1}. The direction of motion of Q is reversed. Find the speed of Q after the collision. **(3)**

2. An ice hockey puck, of mass 0.2 kg, is moving along smooth horizontal ice with a speed of 10 m s–1 when it receives a direct hit from a stick which reverses its direction and increases its speed to 15 m s–1. Calculate the magnitude of the impulse exerted by the stick on the puck. **(2)**

Solutions

1.

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$	**M1**
$3 \times 8 + 4 \times -1.5 = 3 \times 2 + 4v$	**M1**
$v = 3$ ms^{-1}	**A1**

2.

$I = m(v - u)$	**M1**
$I = 0.2(15 - (-10) = 5$ Ns	**A1**

Further Maths A-Level Starter Activity

Topic: Momentum and Impulse (2)

Chapter Reference: Further Mechanics 1, Chapter 1

8 minutes

1. A particle A of mass 4 kg is moving with velocity $(3\mathbf{i} + 5\mathbf{j})$ m s^{-1} on horizontal ground when it collides with a second particle B, with mass 2 kg, which is moving with velocity $(-2\mathbf{i} + 4\mathbf{j})$ m s^{-1}. As a result of the collision, B is brought to rest. Find the speed and direction of A after the collision. **(6)**

Solution

1.

Using conservation of linear momentum	**M1**
$4(3\mathbf{i} + 5\mathbf{j}) + 2(-2\mathbf{i} + 4\mathbf{j}) = 4v$ $12\mathbf{i} + 20\mathbf{j} - 4\mathbf{i} + 8\mathbf{j} = 4v$	**A1**
$v = \frac{8i+28j}{4} = 2\boldsymbol{i} + 7\boldsymbol{j}$	**A1**
Speed of $A = \sqrt{2^2 + 7^2} = \sqrt{53} = 7.23\ ms^{-1}$	**A1**
The direction: $\theta = \tan^{-1}(\frac{7}{2})$	**M1**
$\theta = 74.1^o$ So A makes an angle of 74.1^o with the unit vector **i**	**A1**

Further Maths A-Level Starter Activity

Jahwa Maths

Topic: Momentum and Impulse (3)

Chapter Reference: Further Mechanics 1, Chapter 1

8 minutes

1. Particle P has mass 3 kg and particle Q has mass m kg.
The particles are moving in opposite directions along a smooth horizontal plane when they collide directly. Immediately before the collision, the speed of P is 4 ms^{-1} and the speed of Q is 3 ms^{-1}.
In the collision the direction of motion of P is unchanged and the direction of motion is Q is reversed. Immediately after the collision, the speed of P is 1 ms^{-1} and the speed of Q is 1.5 ms^{-1}.

a. Find the magnitude of the impulse exerted on P in the collision. **(3)**

b. Find the value of m. **(3)**

Jahwa Maths

Solutions

1a.

Consider P and use $I = mv - mu$ Take $\leftarrow = +$	**M1**
$I = 3(-1) - 3(-4)$	**M1**
$I = 9$ Ns	**A1**

1b.

Consider Q and use $I = mv - mu$ Take $\rightarrow = +$	**M1**
$9 = m(1.5) - m(-3)$ $9 = 1.5m + 3m$ $9 = 4.5m$	**M1**
$m = 2$	**A1**

Further Maths A-Level Starter Activity

Jahwa Maths

Topic: Momentum and Impulse (4)

Chapter Reference: Further Mechanics 1, Chapter 1

8 minutes

1. Two particles P and Q have masses $4m$ and m respectively. The particles are moving towards each other on a smooth horizontal plane and collide directly.
The speeds of P and Q immediately before the collision are $2u$ and $5u$ respectively. Immediately after the collision, the speed of P is $\frac{1}{2}u$ and its direction of motion is reversed.

a. Find the speed and direction of Q after the collision **(4)**

b. Find the magnitude of the impulse exerted on P by Q in the collision. **(3)**

Jahwa Maths

Solutions

1a.

$4m(2u) - m(5u) = -4m(\frac{1}{2}u) + mv$	**M1**
$3mu = -2mu + mv$	**M1**
$v = 5u$	**A1**
Opposite direction	**A1**

1b.

Use of $I = mv - mu$	**M1**
$I = 4m(\frac{1}{2}u - -2u)$ or $I = m(5u - -5u)$	**M1**
$= 10\ mu$	**A1**

Further Maths A-Level Starter Activity

Jahwa Maths

Topic: Momentum and Impulse (5)

Chapter Reference: Further Mechanics 1, Chapter 1

6 minutes

1. A tennis ball of mass 0.1 kg is hit by a racquet.
Immediately before being hit, the ball has a velocity 30 I ms^{-1}. The racquet exerts an impulse of (-2**i** – 4**j**) Ns on the ball.
By modelling the ball as a particle, find the velocity of the ball immediately after being hit. **(4)**

Jahwa Maths

Solutions

1.

Use of $m(v - u) = I$	**M1**
$0.1 \times (v - 30\mathbf{i}) = -2\mathbf{i} - 4\mathbf{j}$	**M1**
Solve for v: $0.1v = 3\mathbf{i} - 2\mathbf{i} - 4\mathbf{j} = \mathbf{i} - 4\mathbf{j}$	**M1**
$v = 10\mathbf{i} - 40\mathbf{j}$	**A1**