

# A-level FURTHER MATHS

Momentum and Collisions

Mark scheme v1.0

Specification content coverage: MB1, MB2, MB3

Question	Solutions	Mark
1	$750 \times 1.5 = 11250 \text{ Ns}$	1
	<b>Total</b>	<b>1</b>
2	$\mathbf{I} = m\mathbf{v} - m\mathbf{u}$ $\mathbf{I} = 2 \begin{bmatrix} 5 \\ -2 \end{bmatrix} - 2 \begin{bmatrix} 2 \\ 3 \end{bmatrix}$ $\mathbf{I} = \begin{bmatrix} 6 \\ -10 \end{bmatrix} \text{ Ns}$	<p>1 use of formula in 2D</p> <p>1</p>
	<b>Total</b>	<b>2</b>
3	$0.4(3) + 0.1(0) = 0.5v$ $v = 2.4 \text{ m s}^{-1}$	<p>1 use of conservation of momentum</p> <p>1</p>
	<b>Total</b>	<b>2</b>
4	<p>Momentum before = <math>4 \begin{bmatrix} 1.5 \\ 2 \end{bmatrix} + 6 \begin{bmatrix} -1 \\ -4 \end{bmatrix} = \begin{bmatrix} 0 \\ 16 \end{bmatrix}</math></p> <p>Momentum after = <math>4 \begin{bmatrix} -3 \\ -1 \end{bmatrix} + 6\mathbf{v} =</math></p> $= 4 \begin{bmatrix} -3 \\ -1 \end{bmatrix} + 6\mathbf{v} = \begin{bmatrix} 0 \\ -16 \end{bmatrix}$ $\mathbf{v} = \begin{bmatrix} 2 \\ -2 \end{bmatrix} \text{ m s}^{-1}$	<p>1 for either momentum before or after</p> <p>1 forming equation</p> <p>1</p>
	<b>Total</b>	<b>3</b>

<b>5</b>	Speed of $P$ after = $v$ Speed of $Q$ after = $w$ Conservation of momentum $2(4) - 3(1) = 2v + 3w$  Restitution $w - v = 1.5$  Solving gives $v = 0.1 \text{ m s}^{-1}$ and $w = 1.6 \text{ m s}^{-1}$	2 (1 for each side)  1  1 (both)
	<b>Total</b>	<b>4</b>
<b>6 (a)</b>	$v = \frac{3}{5} \times 10 = 6 \text{ m s}^{-1}$	1
	<b>Total</b>	<b>1</b>
<b>6 (b)</b>	$I = mv - mu$  $I = 0.25(6) - 0.25(-10)$  $I = 4 \text{ Ns}$	1 evidence of substituting in correct formula 1 correct signs (6, -10) 1 must be positive
	<b>Total</b>	<b>3</b>
<b>7(a)</b>	Let speed of $A$ after = $w$ in opposite direction to $2u$ Let speed of $B$ after = $v$ in opposite direction to $2u$  Conservation of momentum: $m(-2u) + 2m(4u) = mw + 2mv$ Simplified gives $6u = w + 2v$  Restitution $w - v = 6ue$  Subtract equations $3v = 6u - 6ue$  Giving $v = 2u(1 - e)$  Eliminating $v$ from equations gives  $v = 2u(1 + 2e)$	2 (1 each side)  1  1  1
	<b>Total</b>	<b>5</b>
<b>7(b)</b>	Elastic $e = 1$  Speed of $B = 0$ , speed of $A = 6u$  Impulse = $8mu$	1 clearly stated  1 stated and/or used  1
	<b>Total</b>	<b>3</b>

<b>8 (a)</b>	<p>Let velocity after = <math>a\mathbf{i} + b\mathbf{j}</math></p> <p>Parallel to cushion – velocity remains the same <math>b = 8</math></p> <p>Speed after = <math>\sqrt{a^2 + 8^2}</math></p> <p><math>= \sqrt{a^2 + 8^2} = 4\sqrt{5}</math></p> <p><math>a = 4</math></p> <p><math>6e = 4</math></p> <p><math>e = \frac{2}{3}</math></p>	<p>1 stated</p> <p>1 use of vector magnitude</p> <p>1 forming equation</p> <p>1 solving for a</p> <p>1 finding e</p>
	<b>Total</b>	<b>5</b>
<b>8 (b)</b>	<p><math>I = mv - mu</math></p> <p><math>I = 0.2(4) - 0.2(-6)</math></p> <p><math>I = 2 \text{ Ns}</math></p>	<p>1 impulse formula applied perpendicular to edge only</p> <p>1 correct signs 4, -6</p> <p>1</p>
	<b>Total</b>	<b>3</b>
	<b>TOTAL</b>	<b>32</b>