



Mark Scheme (Results)

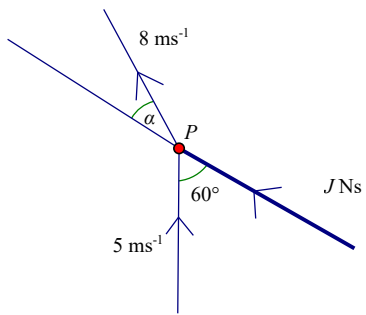
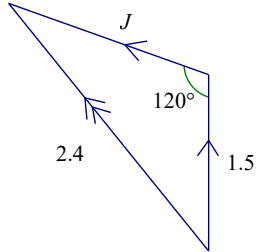
Summer 2021

Pearson Edexcel International Advanced
Level In Mechanics M2 (WME02/01)

Q	Solution	Mark	Notes
1	Driving force $(F) = \frac{3500}{V}$	B1	Use of $P = Fv$
	Equation of motion: $F - 20V + 480g \sin \theta = 0$	M1	Need all terms. Dimensionally correct. Condone sign errors and sin/cos confusion
	$\frac{3500}{V} - 20V + 40g = 0$	A1	Correct unsimplified equation in V .
	$20V^2 - 392V - 3500 = 0$	M1	Form a 3 term quadratic equation ($= 0$) in V
	$V = 26.3 \quad (26)$	A1	3 sf or 2 sf Not $\frac{49 + 22\sqrt{14}}{5}$ (follows use of 9.8)
		(5)	
		[5]	

[illegible]

[illegible]

4 Alt 1			Resolving parallel and perpendicular to the direction of the impulse.
	Use of $J = m(v - u)$	M1	Use of $J = m(v - u)$ in any direction
	$J = 0.3(8 \cos \alpha - 5 \cos 60^\circ)$ Or $5 \sin 60^\circ = 8 \sin \alpha$	A1	Correct unsimplified equation $\left(\begin{array}{l} 2.4 \cos \alpha = J + 1.5 \cos 60^\circ \\ 2.4 \sin \alpha = 1.5 \sin 60^\circ \end{array} \right)$
	Use of $J = m(v - u)$	M1	Use of $J = m(v - u)$ in perpendicular direction
		A1	Correct unsimplified equation
	$2.4^2 = \left(J + \frac{3}{4}\right)^2 + \left(\frac{3}{2}\right)^2 \times \frac{3}{4}$ $(J^2 + 1.5J - 3.51 = 0)$	DM 1	Form an equation in J only Dependent on previous two M1 marks
	$J = 1.3$	A1	1.3 or better (1.268....)
Could have a mixture of the first 2 alternatives. M1A1M1A1 for 2 independent equations. DM1A1 for solving			
		(6)	
4 Alt 2			Using vector triangle.
	Impulse momentum triangle	M1	Form dimensionally correct vector triangle (for impulse or momentum)
	Use of cosine rule	M1	Use of cosine rule in momentum or velocity triangle
	$2.4^2 = J^2 + 1.5^2 - 3J \cos 120^\circ$	A1	unsimplified equation in v or mv with at most one error
		A1	Correct unsimplified equation
	$J^2 + 1.5J - 3.51 = 0$	DM 1	Form a simplified equation in J Dependent on previous two M1 marks
	$J = 1.3$	A1	1.3 or better (1.268....)
		(6)	
		[6]	

5a			
	Moments about A :	M1	Need all terms and dimensionally correct. Condone sign errors, incorrect angles and sin/cos confusion Or complete method to form equation in T (and M).
	$5a \times T \sin 55^\circ = 4a \cos 20^\circ \times Mg$	A1	Correct unsimplified equation in T (and M).
	$T = \frac{4 \cos 20^\circ}{5 \sin 55^\circ} Mg (= 0.918Mg)$	A1	Or equivalent (Exact or $0.92Mg$ or better)
		(3)	
5b	Resolve vertically	M1	Need all terms. Condone sign errors, incorrect angle and sin/cos confusion
	$\uparrow: Mg = V + T \cos 55^\circ$ ($V = 0.47...Mg$)	A1	Correct unsimplified equation in T or their T
	Resolve horizontally	M1	Condone consistent sin/cos confusion
	$H = T \sin 55^\circ$ ($H = 0.75...Mg$)	A1	Correct unsimplified equation in T or their T
	Resultant $\lambda = \sqrt{(0.4736..)^2 + (0.7517..)^2}$	M1	Substitute for T and use Pythagoras
	$= 0.89$	A1	The Q asks for 2 sf
		(6)	
			See over for further alternative

5b alt	Moments about B	M1	Dimensionally correct. Need all terms. Condone sign errors and sin/cos confusion
	$Mga \cos 20^\circ + 5aH \cos 70^\circ = 5aV \cos 20^\circ$	A1	Correct unsimplified equation
	Moments about C	M1	Dimensionally correct. Condone sign errors and sin/cos confusion
	$5aH = 4aMg \cos 20^\circ$	A1	Correct unsimplified equation
	Resultant $\lambda = \sqrt{(0.4736..)^2 + (0.7517..)^2}$	M1	Use Pythagoras
	$= 0.89$	A1	The Q asks for 2 sf
	M1A1M1A1 for 2 independent equations M1A1 to solve for λ		

6a	GPE lost	M1	Need all terms. Condone sign errors and sin/cos confusion
	$= 3g \times 2 - 2g \times 2 \sin \theta$ $(= 6g - 4g \times \frac{5}{13})$	A1	Correct unsimplified. Accept $\pm$
	$= \frac{58}{13}g = 43.7(44)(J)$	A1	Must be positive. Exact multiple of g or 3 sf or 2 sf
		(3)	
6b	Normal reaction $= 2g \cos \theta \left(= \frac{24}{13}g \right)$	B1	Condone $\frac{1176}{65}$
	$F_{\max} = \frac{3}{8} \times R \left(= \frac{9g}{13} \right)$	M1	Use $F = \mu R$ with their R $\left(\frac{441}{65} \right)$
	Work done $= 2 \times F_{\max}$	M1	Their $F_{\max}$
	$\left(= \frac{18g}{13} \right) = 13.6(J) \quad 14(J)$	A1	Exact multiple of g or 3 sf or 2 sf. Not $\frac{882}{65}$
		(4)	
6c	Total KE gained = GPE lost - total WD against friction	M1	Must be using work-energy. Dimensionally correct. Required terms and no extras. Condone sign errors.
	$\frac{1}{2}(2+3)v^2 = (their(a)) - (their(b))$ $\left(\frac{5}{2}v^2 = \frac{58}{13}g - \frac{18}{13}g = \frac{40}{13}g \right)$	A2ft	Follow their (a) and (b) -1 each error
	$v = \sqrt{\frac{16}{13}g} = 3.47(\text{ms}^{-1}) \text{ or } 3.5(\text{ms}^{-1})$	A1	3 sf or 2 sf (need to substitute for g)
		(4)	
6d	KE lost = GPE gained + WD against friction	M1	Must be using work-energy. Dimensionally correct. Required terms and no extras. Condone sign errors.
	$\frac{1}{2} \times 2 \times \frac{16}{13}g = 2g \times d \sin \theta + \frac{3}{8} \times 2g \times \frac{12}{13}d$ $\frac{1}{2} \times 2 \times v^2 = 2g \times d \sin \theta + d \times F_{\max}$ $\frac{16}{13}g = \left(\frac{10}{13}g + \frac{9}{13}g \right) d$	A2ft	Follow their (c) and their $F_{\max}$ -1 each error
	$d = \frac{16}{19}$	A1	g cancels. 0.84 or better (0.8421....)
		[15]	

7a	$-12 = 12 - gt$	M1	Use <i>suvat</i> to find time taken
	$t = \frac{24}{g} (= 2.45)$	A1	
	$AB = 6t$	M1	Horizontal distance
	$= 14.7 (15) \text{ (m)}$	A1	3 sf or 2 sf Not $\frac{720}{49}$ (follows use of 9.8) Not $\frac{144}{g}$ (do not accept g in the denominator)
		(4)	
7b	Vertical component of velocity $= (\pm)8$	B1	
	$v^2 = u^2 + 2as$	M1	Complete method using <i>suvat</i> to find h
	$\Rightarrow 8^2 = 12^2 - 2gh$	A1	Correct unsimplified equation
	$h = 4.08 \text{ (4.1)}$	A1	3 sf or 2 sf Not $\frac{200}{49}$ (follows use of 9.8) Not $\frac{40}{g}$ (do not accept g in the denominator)
		(4)	
7b alt	$\mathbf{v} = \begin{pmatrix} 6 \\ 12 \end{pmatrix} - \begin{pmatrix} 0 \\ g \end{pmatrix} t \Rightarrow 12 - gt = (\pm)8$	B1	Correct expression for critical value(s) of t
	$h = 12t - \frac{1}{2}gt^2$	M1	Complete method using <i>suvat</i> to find h
	$= \frac{48}{g} - \frac{8}{g} \text{ or } = \frac{240}{g} - \frac{200}{g}$	A1	Correct unsimplified equation
	$h = 4.08 \text{ (4.1)}$	A1	3 sf or 2 sf
		(4)	
7b alt	Conservation of energy	M1	Need all terms and dimensionally correct
	$mgh + \frac{1}{2}m \times 10^2 = \frac{1}{2}m(12^2 + 6^2)$	A(B)1	Unsimplified equation with at most one error
		A1	Correct unsimplified equation
	$h = 4.08 \text{ (4.1)}$	A1	3 sf or 2 sf
		(4)	
			See over for (c)

7c	$\begin{pmatrix} 6 \\ -12 \end{pmatrix} \cdot \begin{pmatrix} 6 \\ v \end{pmatrix} = 0$	M1	Complete method to find vertical component at C.
	$\Rightarrow v = 3$	A1	
	$\mathbf{v} = 6\mathbf{i} + 3\mathbf{j} \text{ (ms}^{-1}\text{)}$	A1	Must be a vector in terms of i and j
	If see $\begin{pmatrix} 6 \\ 12 \end{pmatrix} \cdot \begin{pmatrix} 6 \\ v \end{pmatrix} = 0$ leading to $\mathbf{v} = 6\mathbf{i} - 3\mathbf{j}$ mark as a misread: M1A0A0		
		(3)	
		[11]	
	Accept working in column vectors throughout apart from the final A1		

8a			
	Use CLM: $4mu = 2mv + mw$	M1	Need all terms. Condone sign errors. Dimensionally correct but allow with m cancelled
	$(4u = 2v + w)$	A1	Correct unsimplified. Signs correct for their v, w
	Use Impact law	M1	Used the right way round. Condone sign errors.
	$w - v = 2ue$	A1	Correct unsimplified. Signs consistent with CLM equation.
	$\Rightarrow 4u = 2(w - 2ue) + w$	DM1	Solve for v or w . Dependent on previous 2 M marks
	$3w = 4u + 4ue, \quad w = \frac{4}{3}u(1 + e) \quad *$	A1*	Obtain given result from correct working
	$v = \frac{2}{3}u(2 - e)$	A1	Or equivalent. Must be positive
		(7)	
8b	$2 > e$ so A moving towards centre	B1	Correct statement about direction of travel for A
	$mw - 3mu = mx + 3my$ $y - x = e\left(u + \frac{4u}{3} + \frac{4eu}{3}\right)$	M1	Use CLM and impact law correctly to form simultaneous equations in x and y .
	$\frac{4}{3}eu - \frac{5}{3}u = x + 3y$ $3y - 3x = e(7u + 4ue)$	A1	Both equations correct unsimplified in u, e, x and y
	$4x = \frac{4}{3}ue - \frac{5}{3}u - 7ue - 4ue^2$	DM1	Solve for x
	$x = -\frac{5}{12}u - \frac{17}{12}ue - ue^2$	A1	Allow for a correct constant multiple of x
	$e > 0, u > 0$ so B moving towards centre from opposite direction, hence they collide.*	A1*	Obtain given answer from correct working
		(6)	
	Alternative for last 3 marks;		
	C moving towards centre implies B moving towards centre, so collision. C moving away from centre, so $y > 0$, $x = w - 3u - 3y = -\frac{8u}{3} + \frac{4eu}{3} - 3y$	DM1	Consider direction of C

	$= -\frac{u}{3}(8-4e) - 3y$	A1	
	< 0 because $e \leq 1$ and $y > 0$ hence B moving towards centre from opposite direction, and they will collide.*	A1*	Obtain given answer from correct working
		[13]	