



Mark Scheme (Results)

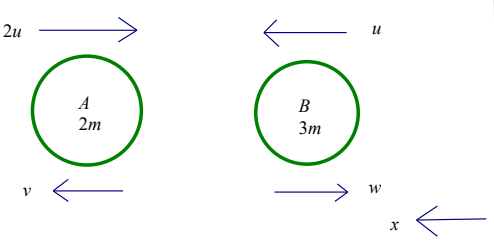
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Pearson Edexcel International A Level
In Mechanics M2 (WME02) Paper 01

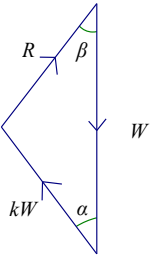
1a	Use of $\mathbf{I} = m\mathbf{v} - m\mathbf{u}$	M1	Condone subtraction in the wrong order.
	$\begin{pmatrix} -4 \\ 6 \end{pmatrix} = \frac{1}{2} \begin{pmatrix} x-2 \\ y-4 \end{pmatrix}$	A1	Correct unsimplified equation Any equivalent form. Allow with $\mathbf{v}$
	$\mathbf{v} = -6\mathbf{i} + 16\mathbf{j} \text{ (ms}^{-1}\text{)}$	A1	Correct only. Seen or implied SR: Allow 3/3 if stop at $\mathbf{v} = 6\mathbf{i} - 16\mathbf{j} \text{ (ms}^{-1}\text{)}$
	$ \mathbf{v} = \sqrt{(-6)^2 + 16^2}$	M1	Correct use of Pythagoras with their $\mathbf{v}$
	$= \sqrt{292} \text{ (} = 2\sqrt{73} \text{)} \text{ (ms}^{-1}\text{)}$	A1	Correct simplified value. 17 or better (17.088.....)
			Allow 5/5 if working from the negative of the velocity.
		[5]	
1b	Correct use of trigonometry to find 2 relevant angles - as values or in inverse tangent form	M1	For their $\mathbf{v}$ e.g. $\pm 69.44..^\circ, 63.43..^\circ$ or $\pm 1.212..., 0.4636..$
	$\theta = \left(180^\circ - \tan^{-1} \frac{16}{6} \right) - \tan^{-1} \frac{4}{2}$	A1ft	Correct unsimplified expression for θ Any equivalent form
	$= 47^\circ$	A1	47° or better (47.121..) 312.9° Accept radians (0.8224..)
		[3]	
1b alt	Use of scalar product with two relevant vectors	M1	For their $\mathbf{v}$
	$\theta = \cos^{-1} \left(\frac{-12 + 64}{\sqrt{20}\sqrt{292}} \right)$	A1ft	Correct unsimplified expression for $\cos \theta$ or equivalent
	$= 47^\circ$	A1	47° or better (47.121..) 312.9° Accept radians (0.8224..)
		[3]	
		(8)	

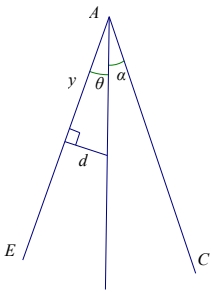
2.a	Equation of motion for car and trailer	M1	Need all terms. Dimensionally correct. Condone sin/cos confusion and sign errors.
	$F - 300 - 150 - \frac{200g}{20} - \frac{600g}{20} = 0$ $(F - 842 = 0)$	A1 A1	Unsimplified equation in P or F with at most one error Correct unsimplified equation in P or F Missing g is one accuracy error
	$\frac{1000P}{15}(-450 - 98 - 294 = 0)$	M1	Use of $P = Fv$ Allow with P or $1000P$
	$P = 12.6$ or $P = 13$	A1	3 s.f. or 2 s.f. only A final answer of 12600 (13000) scores 4/5 Condone $12600 = 12.6$ (correct thinking without stating the units)
		[5]	
2b	KE lost = gain in GPE + WD against resistance	M1	Must be using work-energy principle for trailer only. Dimensionally correct. Correct terms and no extras. Condone sign errors and sin / cos confusion.
	$\frac{1}{2} \times 200 \times 400 = \frac{200}{20}gd + 300d (= 398d)$	A1 A1	Correct unsimplified equation in one variable with at most one error Correct unsimplified equation in one variable.
	$XY = d = 101 (100) \text{ (m)}$	A1	3 s.f. or 2 s.f. only
		[4]	
		(9)	

[illegible]

4a			
	Use of CLM	M1	Need all terms, dimensionally correct. Condone sign errors.
	$4mu - 3mu = 3mw - 2mv$ $(u = 3w - 2v)$	A1	Correct unsimplified equation
	Use of impact law	M1	Used correctly. Condone sign errors
	$v + w = 3eu$	A1	Correct unsimplified equation. Signs consistent with their CLM equation
	$\begin{cases} u = 3w - 2v \\ 6eu = 2w + 2v \end{cases}$	DM1	Dependent on both preceding M marks. Solve to find speed of B.
	$\Rightarrow 5w = u + 6eu, \quad w = \frac{1}{5}u(1 + 6e) \quad *$	A1*	Obtain given answer from correct working
		[6]	
4b	$v = 3eu - w = \frac{u}{5}(9e - 1)$	B1	Check their diagram / directions and allow $v = \frac{u}{5}(1 - 9e)$ if correct for their working. Any equivalent form. Must be seen or used in (b)
	$x = \frac{u}{7}(1 + 6e)$	B1	Seen or implied. Accept $\pm$
	Second collision if $\frac{u}{7}(1 + 6e) > \frac{u}{5}(9e - 1)$	M1	Correct inequality to find the upper limit for e , using their v and x
	$(0 <) e < \frac{4}{11}$	A1	Final answer. Or equivalent. Do not need to mention the lower limit, but if they do it must be stated correctly (strict inequality).
		[4]	

5a			
	Angle ACO is a right angle or state that AB is a tangent hence triangle is $5a$, $12a$, $13a$ *	B1*	Or equivalent explanation of given answer . They need to say why it is a 5, 12, 13 triangle. If they say nothing, check the diagram to see if there is a right angle marked.
		[1]	
5b	Moments about A :	M1	Dimensionally correct equation Condone sin / cos confusion
	$W \times 8a \cos \alpha = kW \times 12a$ $\left(W \times 8a \times \frac{12}{13} = kW \times 12a \right)$	A1	Correct unsimplified equation
	$k = \frac{8}{13}$ *	A1*	Obtain given answer from correct working. Need to see correct substitution for $\cos \alpha$ and correct final statement.
		[3]	
5c	$\leftrightarrow R_H = kW \sin \alpha$	M1	First equation e.g. resolve horizontally. Condone sin/cos confusion
	$= \frac{8W}{13} \times \frac{5}{13} = \frac{40W}{169}$	A1	Correct unsimplified expression for R_H
	$\uparrow R_V + kW \cos \alpha = W$	M1	Second equation e.g. resolve vertically. Condone sin/cos confusion and sign errors.
	$R_V = W - \frac{8W}{13} \times \frac{12}{13} = \frac{73W}{169}$	A1	Correct unsimplified expression for R_V
	$ R ^2 = (R_V)^2 + (R_H)^2$	DM1	Dependent on the two preceding M marks. Method to obtain the magnitude, e.g. correct use of Pythagoras
	$ R = \frac{W}{169} \sqrt{40^2 + 73^2}$ $= \frac{\sqrt{6929}}{169} W = \frac{\sqrt{41}}{13} W$	A1	Accept $0.49W$ or better Allow $\sqrt{\frac{41W^2}{169}}$ or correct unsimplified form. ISW
	$\tan \theta^\circ = \frac{73}{40} \quad (=1.825)$	DM1	Dependent on the first 2 M marks. Method to obtain the angle, e.g. correct use of trigonometry to find a relevant angle (θ or $90 - \theta$)
	$\theta = 61 \quad (61.3)$	A1	61 or better (61.2796...)
		[8]	
	See overleaf for alternatives		
5c Alt 1	$P = W \sin \alpha$	M1	First equation e.g. resolve parallel to the rod. Condone sin/cos confusion.

	$= \frac{5W}{13}$	A1	Correct unsimplified expression for parallel component
	$Q + kW = W \cos \alpha$	M1	Second equation e.g. resolve perpendicular to the rod. Condone sin/cos confusion and sign errors.
	$Q = \frac{12}{13}W - \frac{8}{13}W = \frac{4W}{13}$	A1	Correct unsimplified expression for perpendicular component
	$ R = \sqrt{P^2 + Q^2}$	DM1	Dependent on the first 2 M marks. Correct use of Pythagoras
	$ R = \frac{W}{13} \sqrt{4^2 + 5^2} = \frac{\sqrt{41}}{13}W$	A1	Accept $0.49W$ or better Allow correct unsimplified form
	$\theta^\circ = \tan^{-1} \frac{5}{12} + \tan^{-1} \frac{4}{5}$	DM1	Dependent on the first 2 M marks. Correct use of trig to find the required angle
	$\theta = 61 \quad (61.3)$	A1	61 or better (61.2796...)
		[8]	
5c Alt2		M1 A1	Vector diagram showing the three forces acting Correctly configured
	Use of Cosine Rule:	M1	Correct use of cosine rule for their triangle
	$R^2 = W^2 + (kW)^2 - 2W(kW) \cos \alpha$	A1	Correct unsimplified equation.
	$R^2 = W^2 + \frac{64}{169}W^2 - \frac{16}{13} \times \frac{12}{13}W^2 \left(= \frac{41}{169}W^2 \right)$	DM1	Solve for R . Dependent on the first 2 M marks
	$ R = \frac{\sqrt{41}}{13}W$	A1	Accept $0.49W$ or better
	$\frac{R}{\sin \alpha} = \frac{kW}{\sin \beta} \quad \left(\sin \beta = \frac{8}{13} \times \frac{\sqrt{41}}{13} \times \frac{5}{13} \right)$	DM1	Dependent on the first M mark. Correct method to find a relevant angle e.g. by use of sine rule
	$\theta = 90 - 28.7 = 61.3$	A1	61 or better (61.2796...)
		[8]	
		(12)	

6a	Mass ratio $24a : 25a : 7\pi a : 7a(7 + \pi)$	B1	Correct ratio seen or implied
	Moments about AE	M1	Need all terms, with their masses and horizontal distances Allow use of a parallel axis.
	$25a \times \frac{7}{2}a + 7\pi a \times \frac{14a}{\pi}$ $= 7a(7 + \pi)d$	A1	Correct unsimplified equation
	$\frac{371}{2}a^2 = 7a(7 + \pi)d$ $\Rightarrow d = \frac{53}{2(7 + \pi)}a$ *	A1*	Obtain given answer from correct working Condone if they call it $\bar{x}$
		[4]	
6b	Centre of mass of semicircle lies $7a$ “vertically below” A	B1	Seen or implied e.g. $17a$ above E
	Moments about “horizontal” axis through A :	M1	Or a parallel axis. Need all terms, with their masses and distances.
	$24a \times 12a + 25a \times 12a + 7\pi a \times 7a$ $= 7a(7 + \pi)y$	A1	Correct unsimplified equation
	$y = \frac{49a(12 + \pi)}{7(7 + \pi)} \left(= \frac{7a(12 + \pi)}{7 + \pi} \right)$	A1	Any equivalent form. Accept $\frac{84 + 17\pi}{7 + \pi}a$ from E
	NB: A candidate might have a vector equation in (a) which provides evidence for some or all or the first 4 marks in (b).		
			
	$\theta^\circ = \tan^{-1} \frac{d}{y} = \tan^{-1} \frac{53}{14(12 + \pi)} (= 14.037...^\circ)$	DM1	Use trig to find relevant angle (θ or $90 - \theta$) in a triangle with d and A (must now be working with vertical distance of C of M from A) Dependent on first M
	$\alpha^\circ = \tan^{-1} \frac{7}{24} - \theta^\circ$	DM1	Dependent on the previous M1. Complete method for the required angle
	$\alpha = 2.2$	A1	2.2 or better (2.22...)
		[7]	
		(11)	

7a	Horizontal distance	M1	Correct use of <i>suvat</i>
	$x = u \cos \alpha t$	A1	Correct equation
	Vertical distance	M1	Correct use of <i>suvat</i>
	$y = u \sin \alpha t - \frac{1}{2} g t^2$	A1	Correct equation. Correct signs. Condone if not using “y”
	$t = \frac{x}{u \cos \alpha} \Rightarrow$ $y = u \sin \alpha \cdot \frac{x}{u \cos \alpha} - \frac{g}{2} \left(\frac{x}{u \cos \alpha} \right)^2$ $\left(= x \tan \alpha - \frac{g x^2}{2 u^2} \sec^2 \alpha \right)$	DM1	Dependent on the first 2 M marks. Substitute for t to obtain y in terms of x and α
	$y = x \tan \alpha - \frac{g x^2}{2 u^2} (1 + \tan^2 \alpha) \quad *$	A1*	Obtain given answer from correct working (final step needs to be explained). Allow if $\sec^2 \alpha$ seen. Must be “y” here
		[6]	
7b	$u = 20, x = 10, y > 2 \Rightarrow$ $2 = 10 \tan \theta - \frac{100g}{800} (1 + \tan^2 \theta)$ $\left(\frac{g}{8} \tan^2 \theta - 10 \tan \theta + \left(2 + \frac{g}{8} \right) = 0 \right)$	M1	Use given values to form quadratic in $\tan \theta$ or equivalent equation in one trig function. Allow working with $=, < \text{ or } > 2$
	Critical values: $\theta^\circ = 18.6^\circ$ or $\theta^\circ = 82.7^\circ$	A1	One correct value to 2 sf or better
	Range: $18.6 < \theta < 82.7$	A1	Accept $< \text{ or } \leq$ $(19 \leq \theta \leq 82 \text{ or } 83)$ max 3 sf
		[3]	
7c	$y = 10 \tan 40^\circ - \frac{9.8 \times 100}{2 \times 400} (1 + \tan^2 40^\circ)$	M1	Use given formula to find vertical height
	$y = 6.3(03...) \text{ (m)}$	A1	Can be implied by correctly substituted formula
	Conservation of energy	DM1	Dependent on the first M1. Need all 3 terms. Dimensionally correct. Condone sign errors.
	$\frac{1}{2} m v^2 = \frac{1}{2} m \times 400 - mgy$	A1ft	Correct unsimplified equation in y or their y
	$v = 17 \quad (16.6) \text{ (ms}^{-1}\text{)}$	A1	2sf or 3sf only
		[5]	
7c alt	$20 \cos 40^\circ t = 10, t = \frac{1}{2 \cos 40^\circ} = 0.653....$ $\Downarrow v_v = 20 \sin 40^\circ - gt$	M1	Complete method using <i>suvat</i> to vertical component of speed e.g. by finding time taken then use of $v = u - gt$ or finding vertical distance and using <i>suvat</i>
	$= 6.5 \quad (6.459...)$	A1	6.5 or better (not final answer so allow $> 3\text{sf}$ or a correct unsimplified expression)
	$v^2 = (v_H)^2 + (v_V)^2$	DM1	Correct use of Pythagoras

			Dependent on preceding M mark
	$\leftrightarrow v_H = 20 \cos 40^\circ (= 15.3....)$	A1	Horizontal component of speed seen or implied
	$v = 17 \quad (16.6) \text{ (ms}^{-1}\text{)}$	A1	2sf or 3sf only
		[5]	
7d	$0 = x \tan 40^\circ - \frac{9.8x^2}{800} (1 + \tan^2 40^\circ)$	M1	Complete method to solve for x.
	$x = 40 \text{ (40.2) (m)}$	A1	2sf or 3sf only
		[2]	
7d Alt1	$y = 0 \Rightarrow t = \frac{40 \sin 40^\circ}{g} (= 2.623...)$ $x = 20 \cos 40^\circ \times t$	M1	Complete method to solve for x.
	$x = 40 \text{ (40.2) (m)}$	A1	2sf or 3sf only
		[2]	
7d Alt2	Range = $\frac{20^2 \sin 80^\circ}{g}$	M1	Complete method to solve for x.
	$= 40 \text{ (40.2) (m)}$	A1	2sf or 3sf only
		[2]	
		(16)	