



Mark Scheme (Results)

Summer 2026

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

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

General Principles for Mechanics Marking

(**N.B.** specific mark schemes may sometimes override these general principles)

- Rules for M marks:
 - correct number of terms
 - dimensionally correct
 - all terms that need resolving (i.e. *multiplied* by cos or sin) are resolved
 - only terms that need resolving are resolved
 - +/- errors are condoned
 - sin/cos confusion is condoned
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark, i.e. one that can only be awarded if a previous specified method mark(s) has been awarded.
- Any numerical answer which comes from use of $g = 9.8$ should be given as a decimal to 2 or 3 SF.
- Use of $g = 9.81$ should be penalised once per (complete) question.
 - N.B. Over-accuracy or under-accuracy of correct answers should only be penalised once per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c)...then that working can only score marks for that part of the question.
- Accept column vectors in all cases.

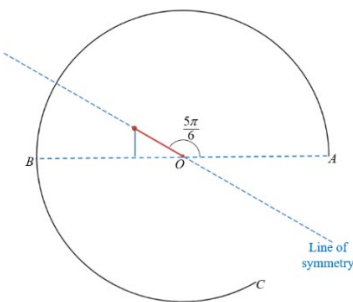
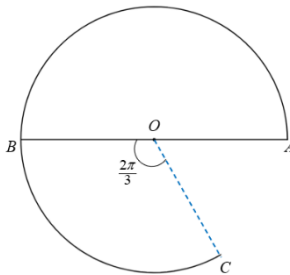
Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

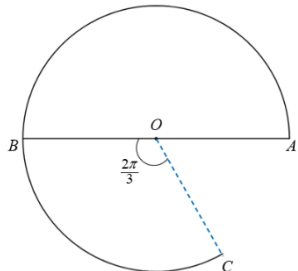
Question Number	Answer	Mark
1(a)	Moments equation	M1
	$2m(4\lambda) + 3m(2) + 7m(4) = 12m\bar{x}$	A1
	$\bar{x} = \frac{4\lambda + 17}{6} *$	A1*
		(3)
1(b)	Moments equation to find $\bar{y}$	M1
	$2m\lambda + 3m(4) + 7m(-3) = 12m\bar{y}$	A1
	Use of straight line equation to form an equation in λ only: $\frac{4\lambda + 17}{6} - 6 \times \frac{(2\lambda - 9)}{12} = 6$	M1
	$(\lambda =)4$	A1
		(4)
		(7)
	Notes for question	
(a)		
M1	Moments about y-axis (or a parallel axis). All terms required. Dimensionally consistent. Condone sign errors.	
A1	Correct equation	
A1*	Obtain given answer from complete and correct working. Allow terms reversed. N.B. Must see $\bar{x} = ..$ somewhere.	
(b)		
M1	Moments about x-axis (or a parallel axis). All terms required. Dimensionally consistent. Condone sign errors.	
A1	Correct equation	
M1	Use of straight line equation to form an equation in λ only N.B. Must use the given answer for $\bar{x}$ and have found a $\bar{y}$	
A1	Correct answer.	

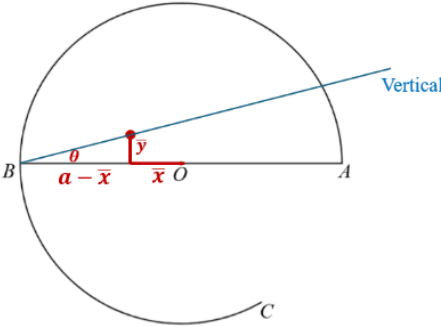
Question Number	Answer	Mark
	N.B. Accept column vectors throughout the question	
2(a)	Integrate both components of v	M1
	$\mathbf{r} = \left(\frac{t^2}{2} - \cos t \right) \mathbf{i} + (\sin t - 3t) \mathbf{j} \quad (+\mathbf{c})$	A1
	Complete method using $t = 0$ and $\mathbf{r} = 2\mathbf{i}$ to find $\mathbf{r}$ when $t = \pi$:	M1
	$\mathbf{r} = \left(\frac{\pi^2}{2} + 4 \right) \mathbf{i} - 3\pi \mathbf{j}$	A1
		(4)
2(b)	Differentiates both components of v	M1
	$\mathbf{a} = (1 + \cos t) \mathbf{i} + (-\sin t) \mathbf{j}$	A1
	Use of $\mathbf{F} = m \mathbf{a}$ or $F = ma$ and Pythagoras	M1
	$ \mathbf{F} = 0.5 \sqrt{(1 + \cos t)^2 + (-\sin t)^2}$	A1
	Expand and use trig identity to reach given answer $ \mathbf{F} = \sqrt{\frac{1 + \cos t}{2}} *$	A1*
		(5)
		(9)
	Notes for question	
(a)		
M1	Integrates both components of v . At least one power of t must increase by 1 and at least one trig term must change (sint/cost) overall, rather than in each component.	
A1	Correct unsimplified expression. Allow with no constant of integration.	
M1	N.B. Must have attempted to integrate. Complete method using $t = 0$ and $\mathbf{r} = 2\mathbf{i}$ to find $\mathbf{r}$ when $t = \pi$ Constant of integration is $3\mathbf{i}$	
A1	Correct answer. Trig values must be evaluated.	
(b)		
M1	Differentiates both components of v . At least one power of t must decrease by 1 and at least one trig term must change (sint/cost) overall, rather than in each component.	
A1	Correct expression for acceleration	
M1	Use $\mathbf{F} = m\mathbf{a}$ or $F = ma$ and Pythagoras with root. N.B. Must have attempted to differentiate v to find a M0 if only one component of a is multiplied by 0.5	
A1	Correct expression	
A1*	Expand and use trig identity to obtain the given answer. N.B. Must see $ \mathbf{F} = ..$ somewhere	

Question Number	Answer	Mark
3(a)	Use of $P = Fv$ at least once $\left((D =) \frac{P}{18} \text{ or } (D' =) \frac{6P}{12} \right)$	M1
	Equation for motion down road $D + 900g \sin \theta - R = 0$	M1 A1
	Equation for motion up road $D' - 900g \sin \theta - R = 0$	M1 A1
	$P = 2646$: possible answers are 2650 or 2600 or 270g $R = 735$ (exact) or 740 or 75g	A1 A1
		(7)
3(b)	GPE term = $900g(40 \sin \theta)$ (= 2400g)	B1
	WD against $R = 40R$	B1
	(Total work-done =) Increase in KE + GPE + WD against R $= \frac{1}{2}(900)16^2 - \frac{1}{2}(900)12^2 + 900g(40 \sin \theta) + 40R$	M1 A1
	=103,320 (exact) So possible answers are only: 103 000 or 100 000 (J) or 103 kJ or 1.03×10^5 (J)	A1
(b) ALT 1	$900g \sin \theta \times 40$, seen or implied	B1
	$40R$ seen or implied (R does not need to be substituted)	B1
	Equation of motion: $\frac{W}{40} - R - 900g \sin \theta = 900 \times \left(\frac{16^2 - 12^2}{2 \times 40} \right)$ OR: $\frac{W}{40} - \frac{6P}{12} = 900 \times \frac{(16^2 - 12^2)}{2 \times 40}$	M1A1
	(W =) 103,320 (exact) So possible answers are only: 103 000 or 100 000 (J) or 103 kJ or 1.03×10^5 (J)	A1
		(5)
		(12)
	Notes for question	
(a)		
M1	Use of $P = Fv$ at least once	
M1	Equation of motion down the road. Dimensionally correct, correct number of terms, condone sin/cos confusion and sign errors. Trig and D do not need to be replaced.	
A1	Correct unsimplified equation	
M1	Equation of motion up the road. Dimensionally correct, correct number of terms, condone sin/cos confusion and sign errors. Trig and D do not need to be replaced.	
A1	Correct unsimplified equation	
A1	One correct value (P or R) 2/3 sf.	

	$P = 2650 \text{ or } 2600 \text{ or } 270g$ $R = 735 \text{ or } 740 \text{ or } 75g$	
A1	Both correct values (P and R)	
(b)		
B1	GPE term seen	
B1	WD against R	
M1	Expression for total work-done by the engine. Dimensionally correct with all required terms present and no extras or double-counting. All terms of correct structure. Condone sign errors.	
A1	Correct unsimplified equation, R does NOT need to be substituted.	
A1	Correct answer 2 or 3 sf.	
(b) ALT 1	For the M mark, if no reference to 40 in the force term is seen or implied then M0: i.e. $F - R - 900g \sin \theta = 900 \times \left(\frac{16^2 - 12^2}{2 \times 40} \right)$ is M0 unless the F is then multiplied by 40.	

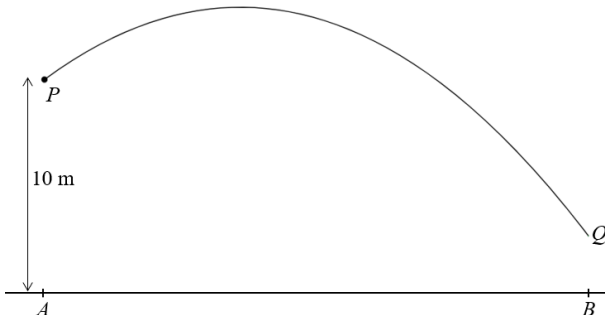
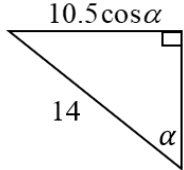
Question Number	Answer	Mark												
	N.B. If areas are involved there are no marks available.													
4(a)	Using arc $ABC + BA$													
	For arc ABC , distance of centre of mass from O  $d = \frac{a \sin\left(\frac{5\pi}{6}\right)}{\frac{5\pi}{6}} = \frac{3a}{5\pi}$	B1												
	<table><tr><td></td><td>Arc ABC</td><td>Line BA</td><td>Total</td></tr><tr><td>Mass ratio</td><td>$\frac{5\pi a}{3}$</td><td>$2a$</td><td>$a\left(\frac{5\pi}{3} + 2\right)$</td></tr><tr><td>Distance from BA</td><td>$\frac{3a}{10\pi}$</td><td>0</td><td>$\bar{y}$</td></tr></table>		Arc ABC	Line BA	Total	Mass ratio	$\frac{5\pi a}{3}$	$2a$	$a\left(\frac{5\pi}{3} + 2\right)$	Distance from BA	$\frac{3a}{10\pi}$	0	$\bar{y}$	B1 mass ratios B1 dist
	Arc ABC	Line BA	Total											
Mass ratio	$\frac{5\pi a}{3}$	$2a$	$a\left(\frac{5\pi}{3} + 2\right)$											
Distance from BA	$\frac{3a}{10\pi}$	0	$\bar{y}$											
	Moments about BA or a parallel axis	M1												
	$M(BA): \quad \frac{5\pi a}{3} \times \frac{3a}{10\pi} = a\left(\frac{5\pi}{3} + 2\right)\bar{y}$	A1												
	$\bar{y} = \frac{3a}{2(5\pi + 6)} *$	A1*												
		(6)												
(a) ALT1	Using arc $AB + BA + \text{arc } BC$													
	For arc BC , distance of centre of mass from O  $= \frac{a \sin\left(\frac{\pi}{3}\right)}{\frac{\pi}{3}} = \frac{3\sqrt{3}a}{2\pi}$ OR for arc AB , distance of centre of mass from O $= \frac{a \sin\left(\frac{\pi}{2}\right)}{\frac{\pi}{2}} = \frac{2a}{\pi}$	B1												

	<table><tr><td></td><td>Arc AB</td><td>Line BA</td><td>Arc BC</td><td>Total</td></tr><tr><td>Mass ratio</td><td>πa</td><td>$2a$</td><td>$\frac{2\pi a}{3}$</td><td>$a\left(\frac{5\pi}{3}+2\right)$</td></tr><tr><td>Distance From BA</td><td>$\frac{2a}{\pi}$</td><td>0</td><td>$\frac{9a}{4\pi}$</td><td>$\bar{y}$</td></tr></table>		Arc AB	Line BA	Arc BC	Total	Mass ratio	πa	$2a$	$\frac{2\pi a}{3}$	$a\left(\frac{5\pi}{3}+2\right)$	Distance From BA	$\frac{2a}{\pi}$	0	$\frac{9a}{4\pi}$	$\bar{y}$	B1 mass ratios B1 dist
	Arc AB	Line BA	Arc BC	Total													
Mass ratio	πa	$2a$	$\frac{2\pi a}{3}$	$a\left(\frac{5\pi}{3}+2\right)$													
Distance From BA	$\frac{2a}{\pi}$	0	$\frac{9a}{4\pi}$	$\bar{y}$													
	Moments about BA or a parallel axis	M1															
	M(BA): $\pi a \times \frac{2a}{\pi} - \frac{2\pi a}{3} \times \frac{9a}{4\pi} = a\left(\frac{5\pi}{3}+2\right)\bar{y}$	A1															
	$\bar{y} = \frac{3a}{2(5\pi+6)} *$	A1*															
		(6)															
(a) ALT 2	Using Circle + BA – arc AC																
	For arc AC , distance of centre of mass from O  $= \frac{a \sin\left(\frac{\pi}{6}\right)}{\frac{\pi}{6}} = \frac{3a}{\pi}$	B1															
	<table><tr><td></td><td>Circle</td><td>Line BA</td><td>Arc AC</td><td>Total</td></tr><tr><td>Mass ratio</td><td>$2\pi a$</td><td>$2a$</td><td>$\frac{\pi a}{3}$</td><td>$2\pi a + 2a - \frac{\pi a}{3}$</td></tr><tr><td>Distance from BA</td><td>0</td><td>0</td><td>$\frac{3a}{2\pi}$</td><td>$\bar{y}$</td></tr></table>		Circle	Line BA	Arc AC	Total	Mass ratio	$2\pi a$	$2a$	$\frac{\pi a}{3}$	$2\pi a + 2a - \frac{\pi a}{3}$	Distance from BA	0	0	$\frac{3a}{2\pi}$	$\bar{y}$	B1 mass ratios B1 dist
	Circle	Line BA	Arc AC	Total													
Mass ratio	$2\pi a$	$2a$	$\frac{\pi a}{3}$	$2\pi a + 2a - \frac{\pi a}{3}$													
Distance from BA	0	0	$\frac{3a}{2\pi}$	$\bar{y}$													
	Moments about BA or a parallel axis	M1															
	M(BA): $0 + 0 - \left(-\frac{\pi a}{3} \times \frac{3a}{2\pi}\right) = \left(2\pi a + 2a - \frac{\pi a}{3}\right)\bar{y}$	A1															
	$\bar{y} = \frac{3a}{2(5\pi+6)} *$	A1*															
	S.C. Moments about an axis through O , perpendicular to the line of symmetry and multiply $\bar{y}$ by $\sin\frac{\pi}{6}$ $0 + 0 - \left(-\frac{\pi a}{3} \times \frac{3a}{\pi}\right) = \left(2\pi a + 2a - \frac{\pi a}{3}\right)\bar{y}$	M1 A1															

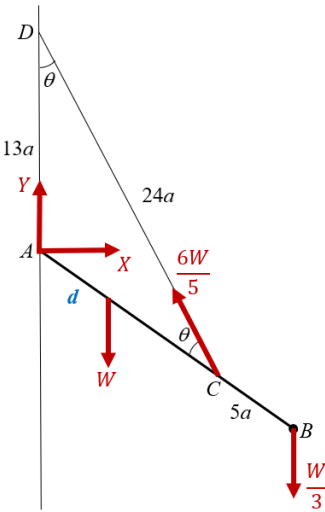
	$\bar{y} = \frac{3a}{2(5\pi + 6)} *$	A1*
		(6)
4(b)		
	M(axis through O): (using arc $ABC + BA$) $\frac{5\pi a}{3} \times \left(\frac{3a}{5\pi} \times \frac{\sqrt{3}}{2} \right) = a \left(\frac{5\pi}{3} + 2 \right) \bar{x}$ OR: M(axis through O): (using circle + $BA - AC$) $0 + 0 - \left(-\frac{\pi a}{3} \times \frac{3a\sqrt{3}}{2\pi} \right) = \left(2\pi a + 2a - \frac{\pi a}{3} \right) \bar{x}$ OR: M(axis through O): (arc $AB + BA +$ arc BC) $(\pi a \times 0) + (2a \times 0) + \frac{2\pi a}{3} \times \frac{3a\sqrt{3}}{4\pi} = \left(\pi a + 2a + \frac{2\pi a}{3} \right) \bar{x}$ OR: Using symmetry: $\bar{x} = \bar{y} \tan \frac{\pi}{3} = \frac{3a\sqrt{3}}{10\pi + 12}$	M1 A1 M1 A1 M1 A1 M1 A1
	Method to find a relevant angle  $\tan \theta = \frac{\bar{y}}{a - \bar{x}}$ $= \frac{\frac{3a}{2(5\pi + 6)}}{a - \left(\frac{3a\sqrt{3}}{10\pi + 12} \right)}$ $\left(= \frac{3}{10\pi + 12 - 3\sqrt{3}} \right)$	M1 A1
	$\theta = 4.5 \text{ 1 d.p.}$	A1
		(5)
4(b) ALT 1	M(axis through B) to find $\bar{x}$	M1
	(using arc $ABC + BA$): $\frac{5\pi a}{3} \times \left(a - \left(\frac{3a}{5\pi} \times \frac{\sqrt{3}}{2} \right) \right) + (2a \times a) = \left(\frac{5\pi a}{3} + 2a \right) \bar{x}$	

	OR: (using arc $AB + BA + \text{arc } BC$) $(\pi a \times a) + (2a \times a) + \frac{2\pi a}{3} \times \left(a - \frac{3a\sqrt{3}}{4\pi} \right) = \left(\frac{5\pi a}{3} + 2a \right) \bar{x}$ OR: (using circle + $BA - AC$) $(2\pi a \times a) + (2a \times a) - \frac{\pi a}{3} \times \left(a + \frac{3a\sqrt{3}}{2\pi} \right) = \left(\frac{5\pi a}{3} + 2a \right)$	A1
	$\tan \theta = \frac{\bar{y}}{\bar{x}}$ $= \frac{\frac{3a}{2(5\pi + 6)}}{a \left(\frac{10\pi + 12 - 3\sqrt{3}}{10\pi + 12} \right)}$ $= \frac{3}{10\pi + 12 - 3\sqrt{3}}$	M1 A1
	$\theta = 4.5 \text{ 1 d.p.}$	A1
		(5)
		(11)
	Notes for question	
(a)		
B1	Correct distance from O seen or implied for an arc, $\frac{r \sin \alpha}{\alpha}$ where $\alpha = \frac{\pi}{6}, \frac{\pi}{3}, \frac{\pi}{2}$ or $\frac{5\pi}{6}$	
B1	Correct mass ratios, including total mass.	
B1	Correct distances. Allow $\pm$.	
M1	Moments about BA or a parallel axis. Condone sin/cos confusion. Must be dimensionally consistent and distances must be resolved and correct no. of terms in the total mass	
A1	Correct unsimplified equation.	
A1*	Obtain given answer from complete and correct working. Must see at least one line of working or simplification before reaching the given answer.	
(a) ALT1		
B1	Correct distance from O seen or implied for an arc, $\frac{r \sin \alpha}{\alpha}$ where $\alpha = \frac{\pi}{6}, \frac{\pi}{3}, \frac{\pi}{2}$ or $\frac{5\pi}{6}$	
B1	Correct mass ratios	
B1	Correct distances	
M1	Moments about BA or a parallel axis. Condone sin/cos confusion. Must be dimensionally consistent.	
A1	Correct unsimplified equation.	

A1*	Obtain given answer from complete and correct working. Must see at least one line of working or simplification before reaching the given answer.	
(b)		
M1	Moments equation about axis perpendicular to BA to find $\bar{x}$ with correct structure. Must be dimensionally consistent. and distances must be resolved and correct no. of terms in the total mass.	
A1	Correct unsimplified equation.	
M1	Complete method using trig to find an equation in θ . allow $\tan \theta = \frac{-\bar{y}}{a - \bar{x}}$ or $\tan \theta = \frac{-\bar{y}}{\bar{x}}$ as appropriate for their $\bar{x}$ and $\bar{y}$ but must be dimensionally consistent. N.B. $\bar{x}$ and $\bar{y}$ do NOT need to be substituted for this mark.	
A1	Correct unsimplified equation	
A1	Correct answer to 1dp (N.B. 4.488138..is the unrounded value)	

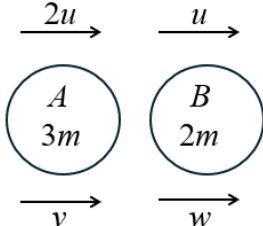
Question Number	Answer	Mark
5		
5(a)	Conservation of energy used to find relevant height	M1
	$\frac{1}{2}m(14)^2 - \frac{1}{2}m(10.5)^2 = mgh$ $\left(h = \frac{343}{8g} = \frac{35}{8}\right)$	A1
	(BQ) = 5.6 or 5.63 (m)	A1
		(3)
5(b)	Horizontal component of velocity = $10.5 \cos \alpha$ seen	B1
	Use direction of motion at Q with $10.5 \cos \alpha$ to form an equation in α only  e.g. $\sin \alpha = \frac{10.5 \cos \alpha}{14}$ OR $14^2 = (10.5 \cos \alpha)^2 + (14 \cos \alpha)^2$ OR $(14 \cos \alpha)^2 = (10.5 \sin \alpha)^2 + 2g \times 4.375$ OR $\left(\frac{10.5 \cos \alpha}{10.5 \sin \alpha}\right) \cdot \left(-\frac{10.5 \cos \alpha}{\sqrt{14^2 - (10.5 \cos \alpha)^2}}\right) = 0$ i.e. $(10.5 \cos \alpha)^2 - 10.5 \sin \alpha \sqrt{14^2 - (10.5 \cos \alpha)^2} = 0$ OR similarly: $(10.5 \cos \alpha)^2 - 10.5 \sin \alpha \sqrt{(10.5 \sin \alpha)^2 + 2g \times 4.375} = 0$ OR $(10.5 \cos \alpha)^2 - 10.5 \sin \alpha \times 14 \cos \alpha = 0$	M1
	$\tan \alpha = \frac{3}{4} *$	A1*
		(3)

5(c)	Complete method to find an equation in the time from P to Q only (t) using vertical motion e.g. $-14 \cos \alpha = 10.5 \sin \alpha - gt$ OR $10 - 5.625 = -10.5 \sin \alpha \times t + \frac{1}{2}gt^2$	M1A1
	Horizontal motion of ball: $AB = 10.5 \cos \alpha \times t$ ($AB = 15$)	M1
	Motion of car: $AB = \frac{1}{2}at^2$	M1
	$a = 9.4$ or $9.41 \text{ (m s}^{-2}\text{)}$	A1
		(5)
		(11)
	Notes for question	
	N.B. Allow use of a different angle for α throughout apart from in the answer to (b).	
(a)		
M1	Method using conservation of energy as directed in the question to find a relevant height. Dimensionally correct, all required terms. Condone sign errors. N.B. Award the mark if seen, even if not used. M0 if only <i>suvat</i> is used.	
A1	Correct unsimplified equation.	
A1	Correct answer for BQ to 2 or 3 sf ($45/8$ is A0)	
(b)		
B1	Horizontal component of velocity seen .	
M1	Use perpendicularity of velocities at P and Q to form a trig equation in α only. N.B. Must see any scalar product evaluated. N.B. $\tan \alpha = \frac{10.5}{14}$ is M0.	
A1*	Obtain given answer from complete and correct working. N.B. $\tan \theta = \frac{3}{4}$ is A0.	
(c)		
M1	Complete method to find an equation in time from P to Q only, condone sign errors and sin/cos confusion. N.B. M0 if they use $s = 10$ or -10 but allow their $\pm BQ$	
A1	Correct equation	
M1	Method using horizontal motion to form an equation in AB and t only (t does not need to be substituted)	
M1	Correct method to find an equation in AB , t and a (t does not need to be substituted)	
A1	Correct answer, 2/3 sf (exact is 9.408)	

Question Number	Answer	Mark
6		
6(a)	Method to form an equation in d (and a)	M1
	E.g. $M(A)$: $(W \times d \sin 2\theta) + \left(\frac{W}{3} \times 18a \sin 2\theta \right) = \left(\frac{6W}{5} \times 13a \sin \theta \right)$	A1 A1
	$d = \frac{49}{20}a = 2.45a$	A1
		(4)
6(b)	First relevant equation	M1
	E.g. Horiz: $\pm X = \frac{6W}{5} \sin \theta$	A1
	Second relevant equation	M1
	E.g. Vert: $\pm Y + \frac{6W}{5} \cos \theta = W + \frac{W}{3}$	A1
	Other possible equations: Parallel to the rod: $\pm P + \frac{6W}{5} \cos \theta = W \cos 2\theta + \frac{W}{3} \cos 2\theta$ Perp. to the rod: $\pm Q + \frac{6W}{5} \sin \theta = W \sin 2\theta + \frac{W}{3} \sin 2\theta$ $M(B)$: $\left(\frac{6W}{5} \times 5a \sin \theta \right) + (Y \times 18a \sin 2\theta) + (X \times 18a \cos 2\theta) = \left(W \times \frac{311a}{20} \sin \theta \right)$ $M(C)$: $\left(\frac{W}{3} \times 5a \sin 2\theta \right) + (Y \times 13a \sin 2\theta) + (X \times 13a \cos 2\theta) = W \times \frac{211a}{20} \sin \theta$ $M(D)$: $13aX = \left(W \times \frac{49a}{20} \sin 2\theta \right) + \left(\frac{1}{3} W \times 18a \sin 2\theta \right)$	

	Pythagoras using X and Y: $\sqrt{\left(\frac{6W \sin \theta}{5}\right)^2 + \left(\frac{4W}{3} - \frac{6W \cos \theta}{5}\right)^2}$ $\left(= \sqrt{\left(\frac{6W}{13}\right)^2 + \left(\frac{44W}{195}\right)^2} \right)$ Pythagoras using P and Q: $\sqrt{\left(W \cos 2\theta + \frac{W}{3} \cos 2\theta - \frac{6W}{5} \cos \theta\right)^2 + \left(W \sin 2\theta + \frac{W}{3} \sin 2\theta - \frac{6W}{5}\right)^2}$ $\left(= \sqrt{\left(\frac{82W}{169}\right)^2 + \left(\frac{428W}{2535}\right)^2} \right)$	dM1
	$= 0.51W$ or better $(0.51374\dots)W$ or $W\sqrt{\frac{772}{2925}}$ or any equivalent surd form.	A1
		(6)
		(10)
	Notes for question	
(a)		
M1	Complete method to find an equation in d only. Correct no. of terms with correct angle and force pairings. Dimensionally correct. Condone sin/cos confusion. Trig does not need to be replaced here. W's may be cancelled before the equation is formed. The distance d may be a different letter or written as a multiple of a e.g. ka N.B. Allow M1A0A0 if they use say α for 2θ Can score max M1A1A0A0 if they have T instead of $\frac{6W}{5}$ and never replace it. Allow the $\frac{6W}{5} \times 13a \sin \theta$ term to be cancelled down immediately to either $\frac{6W}{5} \times 5a$ or $6Wa$	
A1	Unsimplified equation with at most one error. N.B. Count each error on each term.	
A1	Correct unsimplified equation.	
A1	Any equivalent exact answer.	
(b)		
M1	First relevant equation. Dimensionally correct. Condone sin/cos confusion but must be using the correct angle. N.B. Trig does not need to be replaced here nor $T = \frac{6W}{5}$	

A1	Correct unsimplified equation with $T = \frac{6W}{5}$.	
M1	Second relevant equation. Dimensionally correct. Condone sin/cos confusion but must be using the correct angle. N.B. Trig does not need to be replaced here nor $T = \frac{6W}{5}$	
A1	Correct unsimplified equation with $T = \frac{6W}{5}$.	
dM1	Solve equations to find X and Y and use Pythagoras with square root to find magnitude of the force at A in terms of W and θ only, dependent on both M marks.	
A1	$(0.51374\dots)W$	

Question Number	Answer	Mark
7		
7(a)	Equation for CLM	M1
	$3m(2u) + 2mu = 3mv + 2mw$	A1
	Use of impact law	M1
	$eu = w - v$	A1
	Solve to reach given answer for speed of B $\frac{u}{5}(8 + 3e) *$	A1*
		(5)
7(b)	Speed of B after collision = $\frac{7u}{4}$	B1
	Speed of A after collision = $\frac{3u}{2}$	B1
	Difference in KE before and after in terms of m and u only	M1
	KE Loss = $\frac{1}{2}3m(2u)^2 + \frac{1}{2}2m(u)^2 - \frac{1}{2}3m\left(\frac{3u}{2}\right)^2 - \frac{1}{2}2m\left(\frac{7u}{4}\right)^2$	A1
	Percentage of KE lost = $\frac{9}{16}\frac{mu^2}{mu^2} \times 100 = \frac{225}{28}\% \text{ (8.03571...%)}$	A1
		(5)
7(c)	Time taken for B to reach wall = $\frac{d}{\left(\frac{7u}{4}\right)}$ oe	M1
	Rebound speed of B = $\frac{7uf}{4}$	B1
	Remaining time = $\frac{60d}{91u} - \frac{4d}{7u} \left(= \frac{8d}{91u} \right)$ (Time moved by B after hitting the wall)	M1
	Complete method to form an equation in f only: ALT 1: $d = \frac{7fu}{4} \left(\frac{8d}{91u} \right) + \frac{3u}{2} \left(\frac{60d}{91u} \right)$ ALT 2: $d - \left(\frac{3u}{2} \times \frac{4d}{7u} \right) = \frac{7fu}{4} \left(\frac{8d}{91u} \right) + \frac{3u}{2} \left(\frac{8d}{91u} \right)$	dM1

	$f = \frac{1}{14}$	A1
		(5)
		(15)
	Notes for question	
(a)		
M1	Equation for CLM. Dimensionally correct, all terms required, correct pairings of masses and velocities. Condone sign errors.	
A1	Correct unsimplified equation.	
M1	Use of impact law. Condone sign errors but must be used the right way round.	
A1	Correct unsimplified equation, signs consistent with CLM.	
A1*	Obtain given answer from correct working. Accept terms in bracket reversed and all over 5.	
(b)		
B1	Seen or implied	
B1	Seen or implied	
M1	Expression for difference in KE in terms of m and u only using their speeds . Must be dimensionally correct with all terms present and with the correct structures. Mass and velocity must be correctly paired. Must be $\pm$ (initial KE – final KE)	
A1	Correct unsimplified expression for the KE loss	
A1	Correct percentage, accept 8% or better (8.03571...%)	
(c)		
M1	Find, in terms of u and d , the time taken for B to reach wall using their speed of B , seen	
B1	Cao, seen or implied. Allow $-\frac{7uf}{4}$ N.B. Allow $f v_B$ if their v_B is correct.	
M1	Remaining time, in terms of u and d , seen or implied, either as an expression or in an equation. N.B. Accept unsimplified	
dM1	Complete method to form an equation in f only. Allow uncanceled d's and u's. Dependent on both previous M's.	
A1	Accept 0.071 or better (0.07142857.....)	