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Mark Scheme (Results)

January 2020

Pearson Edexcel International GCE
in Mechanics M1 (WME01) Paper 01

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January 2020
Publications Code WME01_01_2001_MS
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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.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

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General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

'M' marks
These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
(ii) be dimensionally correct i.e. all the terms need to be dimensionally correct
e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.
For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.
e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

'A' marks
These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

'B' marks
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

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3. General Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

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General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- 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 has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given 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
- Mechanics Abbreviations

  M(A) Taking moments about A.

  N2L Newton's Second Law (Equation of Motion)

  NEL Newton's Experimental Law (Newton's Law of Impact)

  HL Hooke's Law

  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

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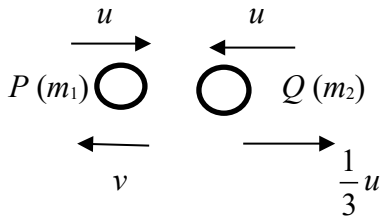
Jan 2020 WME01
Final

Question Number	Scheme	Marks
1(a)		
	$\pm m_2\left(\frac{1}{3}u--u\right)$	M1 A1
	$\frac{4m_2u}{3}$	A1 (3)
(b)	CLM: $m_1u-m_2u=-m_1v+m_2\frac{1}{3}u$ **OR** $\frac{4m_2u}{3}=m_1\left(v--u\right)$	M1 A1
	$\frac{u(4m_2-3m_1)}{3m_1}$ oe	A1
		(3)
(c)	$\frac{u(4m_2-3m_1)}{3m_1}>0$	M1
	$(4m_2-3m_1)>0 \Rightarrow 4m_2>3m_1 \Rightarrow m_2>\frac{3}{4}m_1$ * **Given answer**	A1*
	N.B. If they use $-v$ in (b), can score M1 for $-v<0$ and possibly A1.	(2) **(8)**
	Notes for question 1	
1(a)	M1 for impulse-momentum principle applied to Q ; condone sign errors but must be using m_2 for mass and subtracting momenta M0 if it's dimensionally incorrect e.g if g is included.	
	First A1 for $\pm m_2\left(\frac{1}{3}u--u\right)$	
	A1 Correct answer, must be positive and a single term (Allow fraction replaced by a decimal to at least 2 SF)	
(b)	M1 CLM , with usual rules (allow consistent extra g's), or impulse-momentum principle applied to P, using their answer from (a) which must be in terms of m_2 and u (but allow consistent extra g's)	
	A1 Correct equation (allow consistent use of $-v$ instead of v)	
	A1 Correct answer only. Any equivalent expression with m_2 terms collected (Allow fraction replaced by a decimal to at least 2 SF)	
(c)	M1 Correct inequality for their v, containing u . **N.B**. Their first statement must include u **and** >0 or <0 as appropriate	
	A1* Correct given answer correctly obtained. **N.B.** $\frac{3}{4}m_1<m_2$ is A0	

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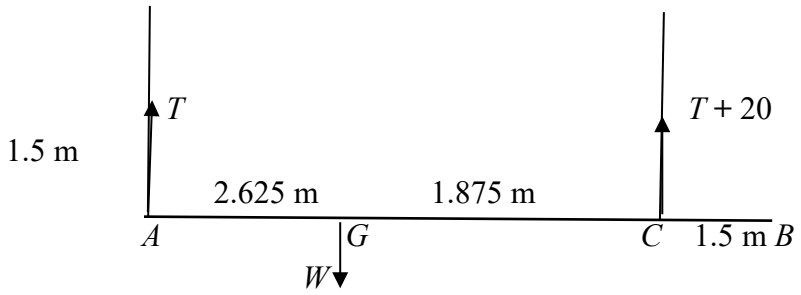
Question Number	Scheme	Marks
2.		
(a)	Any two of these $T+(T+20)=W$ $M(A),\ 4.5(T+20)=2.625W$ $M(G),\ 2.625T=1.875(T+20)$ $M(C),\ 4.5T=1.875W$ $M(B),\ 6T+1.5(T+20)=3.375W$ **N.B.** The A marks and the DM1 can **only** be scored if the candidate is using T **and** $T+20$ or T **and** $T-20$ in **both** equations. **N.B.** Can score M1A1 for a correct vertical resolution, even if T and $T+20$ are the wrong way round. **N.B.** If they just use T_A and T_C, can score max M1A0 M1A0DM0A0 If they assume that $T_A=T_C$, can score max M1A0 M1A0DM0A0 If they assume that the tensions are T and 20, can score max M1A0 M1A0 DM0A0 If they use T and $20T$, can score max M1A0 M1A0DM0A0 **N.B.** If it's not clear from their working which way round they have the two tensions, use their diagram to decide.	M1 A1 M1 A1
	Solve for W	DM1
	$W=120$	A1
		(6)
(b)	The beam remains straight,or rigid, or in a straight line or 1-dimensional or it doesn't bend	B1 (1)
		(7)
	Notes for question 2	
(a)	M1 First equation (vertical resolution or moments) with usual rules	
	A1 Correct equation (T may be replaced by $T-20$)	
	M1 Second equation (vertical resolution or moments) with usual rules	
	A1 Correct equation (T may be replaced by $T-20$)	
	DM1 Dependent on previous two M marks, for solving for W	
	A1 cao	
(b)	B1 any appropriate comment. **N.B.** Penalise incorrect extras.	

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Question Number	Scheme	Marks
3.	Allow a numerical value of g used anywhere apart from the final A marks in (a) and (b) but penalise use of $g = 9.81$ once for whole question	
(a)	$0^2 = U^2 - 2gH$	M1
	$H = \dfrac{U^2}{2g}$	A1
		(2)
(b)	$s_P = \dfrac{1}{2}gt^2$ **OR** $s_P = Ut - \dfrac{1}{2}gt^2$	M1A1
	$s_Q = \dfrac{1}{2}Ut - \dfrac{1}{2}gt^2$ $\quad$ $s_Q = \dfrac{1}{2}U(t - \dfrac{U}{g}) - \dfrac{1}{2}g(t - \dfrac{U}{g})^2$	M1A1
	$s_P + s_Q = H$ $\quad$ $s_P = s_Q$ $\Rightarrow \dfrac{1}{2}Ut = \dfrac{U^2}{2g}$ $\quad$ $\Rightarrow Ut - \dfrac{1}{2}gt^2 = \dfrac{1}{2}U(t - \dfrac{U}{g}) - \dfrac{1}{2}g(t - \dfrac{U}{g})^2$	M1
	$t = \dfrac{U}{g}$ $\quad$ Answer $= (t - \dfrac{U}{g}) = \dfrac{U}{g}$	A1
		(6)
(c)	$s_P = \dfrac{1}{2}g\left(\dfrac{U}{g}\right)^2$ **OR** $s_P = U(\dfrac{2U}{g}) - \dfrac{1}{2}g(\dfrac{2U}{g})^2$ or $s_Q = \dfrac{1}{2}U\left(\dfrac{U}{g}\right) - \dfrac{1}{2}g\left(\dfrac{U}{g}\right)^2$ $\quad$ or $s_Q = \dfrac{1}{2}U\left(\dfrac{U}{g}\right) - \dfrac{1}{2}g\left(\dfrac{U}{g}\right)^2$	M1 A1
	Collide at the point O or at the point of projection. (At the same level as O is A0)	A1
		(3)
		(11)
	Notes for question 3	
3(a)	M1 Complete method to find an equation in H, U and g *only* .Condone sign errors	
	A1 Correct expression for H in terms of U and g. (A0 if they use h or s in their answer but allow for the M mark)	
3(b)	**N.B.** When awarding marks, must use EITHER the LH column OR the RH column, **not** a mixture of both. Award as many marks as possible. M1 Complete method to find s_P in terms of t, where $t = 0$ is when Q is projected upwards. The alternative arises when $t = 0$ is taken to be when P is projected *upwards*. Condone sign errors.	
	A1 Correct equation (using their H where it is used) Allow: $s_P = \dfrac{1}{2}gt^2$ or $s_P = -\dfrac{1}{2}gt^2$ or $s_P = H - \dfrac{1}{2}gt^2$ or $s_P = -(H - \dfrac{1}{2}gt^2)$	

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Question Number	Scheme	Marks
	or $s_P = U(t + \frac{U}{g}) - \frac{1}{2}g(t + \frac{U}{g})^2$	
	M1 Complete method to find s_Q in terms of t. Condone sign errors.	
	A1 Correct equation (using their H where it is used) Allow: $s_Q = \frac{1}{2}Ut - \frac{1}{2}gt^2$ or $s_Q = -(\frac{1}{2}Ut - \frac{1}{2}gt^2)$ Or $s_Q = H - (\frac{1}{2}Ut - \frac{1}{2}gt^2)$ or $s_Q = -(H - (\frac{1}{2}Ut - \frac{1}{2}gt^2))$	
	M1 Use of $s_P + s_Q = H$ oe **OR** $s_P = s_Q$ oe to obtain a CORRECT equation in t, U and g *only*	
	A1 Correct expression for t in terms of U and g.	
3(c)	M1 Sub their t value, provided it's POSITIVE, into their equation for s_P or s_Q	
	A1 Correct unsimplified expression	
	A1 Correct conclusion	

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Question Number	Scheme	Marks
4(a)	$2T\sin\beta = 3mg$ OR $\dfrac{T}{\sin(90^o-\beta)} = \dfrac{3mg}{\sin 2\beta}$	M1
	$T = \dfrac{3mg}{2\sin\beta}$ OR $T = \dfrac{3mg\cos\beta}{\sin 2\beta}$	A1
		(2)
(b)	For A or B: $(\uparrow)\quad R = mg + T\sin\beta$ OR For whole system: $(\uparrow)\ 2R = 3mg + mg + mg$ OR For AC or BC: $(\uparrow)\quad R + T\sin\beta = mg + 3mg$	M1 A1
	$R = 2.5mg$	A1
		(3)
(c)	$F = T\cos\beta$	M1A1
	$F = \dfrac{4}{5}\times 2.5mg$	B1 **ft**
	Eliminate T and solve for $\tan\beta$	M1
	$\tan\beta = \dfrac{3}{4}$	A1
		(5)
		(10)
	Notes for question 4	
4(a)	M1 Resolve vertically for C with usual rules or use triangle of forces	
	A1 Answer. Allow $\cos(90^o-\beta)$ for $\sin\beta$ or $\sin(90^o-\beta)$ for $\cos\beta$	
4(b)	M1 Resolve vertically for A or B, for whole system or for AC or BC with usual rules	
	A1 Correct equation	
	A1 Correct answer	
4(c)	M1 Resolve horizontally for A with usual rules	
	A1 Correct equation	
	B1 **ft** for $F = \dfrac{4}{5}\times$ their R (allow magnitude if $R<0$) seen anywhere (B0 for just F =4/5 R)	
	M1 Eliminate T and solve for $\tan\beta$ *correctly*.	
	A1 $\dfrac{3}{4}$ oe	

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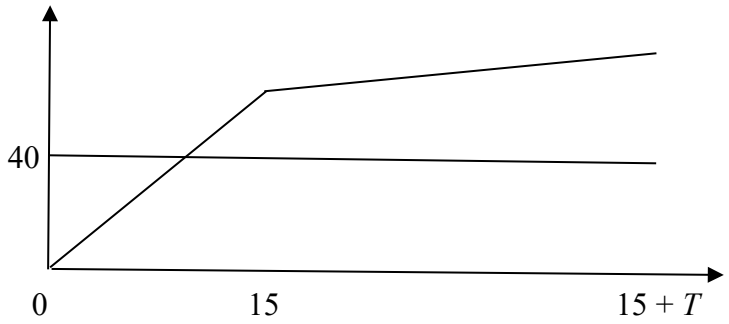
Question Number	Scheme	Marks
5(a)		B1 shape B1 40, 15, $15+T$ Correctly Placed (2)
5(b)	$40 = 4t_1 \Rightarrow t_1 = 10$	M1 A1 (2)
5(c)	60 (m s^{-1})	B1
	$60 + T$ (m s^{-1})	B1 **ft**
	$\frac{1}{2}\times 15\times 60+\frac{1}{2}T(60+60+T)=40(15+T)$ **OR** $\frac{1}{2}\times 15\times 60+60T+\frac{1}{2}T\times T=40(15+T)$ **OR** $\frac{1}{2}(T+T+15)\times 60+\frac{1}{2}T\times T=40(15+T)$	M1 A2
	$T^2+40T-300=0$; $(k=40)$	A1
		(6) **(10)**
	Notes for question 5	
5(a)	B1 Correct graph shapes on same axes with intersection, a horizontal line and 2 lines, both with positive gradient, the second less steep than the first and both ending at the same t-value. B0 for a solid vertical line at the end but allow intermediate solid vertical lines.	
	B1 Figs. correctly placed. Allow appropriate delineators.	
5(b)	M1 Complete method to give an equation in t_1 only	
	A1 $t_1 = 10$	
5(c)	B1 60 m s^{-1} seen	
	B1 **ft** $60 + T$ seen or <u>implied</u>; ft on their graph (i.e. on their interpretation of T) **N.B.** If they use $s = ut + \frac{1}{2}at^2$, $60 + T$ is not needed	
	M1 Equating distances to give an equation in T *only*, with correct structure (e.g. M0 if a '½' is omitted or a 'section' is omitted but give BOD where possible e.g. treat middle term below as an attempt at a trapezium, with 60 and T as the parallel sides $\frac{1}{2}\times 15\times 60+\frac{1}{2}T(60+T)=40(15+T)$ B1B0M1A1A0A0)	
	A2 Correct unsimplified equation -1 e.e.	
	A1 Correct quadratic with $k = 40$	
	N.B. If they take T to be the end of the time period (instead of $15 + T$), can score max: (a) B1B0 (b) M1A1 (c) B1B1ft M1A0A0A0 where T is replaced consistently by $(T-15)$ in the scheme above.	

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Question Number	Scheme	Marks
6(a)	Magnitude $= \sqrt{10^2+1^2} = \sqrt{101}$ (N)	M1A1
		(2)
6(b)	$\tan\alpha = \frac{1}{10}$	M1
	$45°$	B1
	Angle $= 45° - \alpha = 39.289\ldots$ Accept $39°$ or better	M1 A1 (4)
	ALTERNATIVE 1 Scalar Product	
	$(10\mathbf{i}+\mathbf{j}).(\mathbf{i}+\mathbf{j}) = \sqrt{10^2+1^2}.\sqrt{1^2+1^2}\cos\theta$	M1
	$(10\mathbf{i}+\mathbf{j}).(\mathbf{i}+\mathbf{j}) = 11$	B1
	$11 = \sqrt{10^2+1^2}.\sqrt{1^2+1^2}\cos\theta$	M1
	$\theta = 39^O$ *or better*	A1 (4)
	ALTERNATIVE 2 Cosine Rule	
	$(10^2+1^2)+(1^2+1^2)-2\sqrt{10^2+1^2}.\sqrt{1^2+1^2}\cos\theta$	M1
	$(10\mathbf{i}+\mathbf{j})-(\mathbf{i}+\mathbf{j}) = 9\mathbf{i}$ or $(\mathbf{i}+\mathbf{j})-(10\mathbf{i}+\mathbf{j}) = -9\mathbf{i}$	B1
	$9^2 = (10^2+1^2)+(1^2+1^2)-2\sqrt{10^2+1^2}.\sqrt{1^2+1^2}\cos\theta$	M1
	$\theta = 39^O$ *or better*	A1 (4)
6(c)	$(10\mathbf{i}+\mathbf{j})+(-15\mathbf{i}+a\mathbf{j}) = -5\mathbf{i}+(a+1)\mathbf{j}$	B1
	$\frac{a+1}{-5} = \frac{-3}{2}$	M1A1
	Solve for a	M1
	$a = 6.5$	A1
		(5)
		(11)
	Notes for question 6	
6(a)	M1 Use of Pythagoras	
	A0 if they *only* give a decimal	
6(b)	M1 For any relevant trig ratio for α or $(90°-\alpha)$	
	B1 $45°$ seen	
	M1 Finding the difference between $45°$ and α or $(90°-\alpha)$ and $45°$	
	A1 Accept $39°$ or better	
6(c)	B1 Adding the two forces **and** collecting **i**'s and **j**'s. Seen or implied.	
	M1 For producing an equation in a *only* e.g. using ratios from their resultant (M0 if no resultant attempted and M0 if equation comes from *equating* their resultant to $(2\mathbf{i} - 3\mathbf{j})$. Condone sign error but M0 if ratio is upside down.	
	A1 Correct equation in a only	
	M1 Solve for a . This is an independent M mark but their equation must have come from a ratio equation obtained from using their resultant	
	A1 $a = 6.5$	

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Question Number	Scheme	Marks
7(a)	$1.4 = \frac{1}{2}a \times 2^2$	M1
	$a = 0.7$ (m s^{-2}) * **GIVEN ANSWER**	A1*
		(2)
7(b)	Inextensibility of string	B1
		(1)
7(c)	$3g - T = 3 \times 0.7$ (for B)	M1 A1
	Resultant $= 2T\cos 45^o$ **OR** $= \sqrt{T^2 + T^2}$ **OR** $= \frac{T}{\cos 45^o}$	M1
	$= 39$ or 38.6 (N)	A1
		(4)
7(d)	$T - F = 4 \times 0.7$ (for A) **OR** $3g - F = 7 \times 0.7$ (whole system)	M1 A1
	$R = 4g$; $F = \mu \times R$	B1; B1
	$27.3 - \mu \times 4g = 4 \times 0.7$ **OR** $3g - \mu \times 4g = 7 \times 0.7$	**D**M1
	$\mu = 0.625$ or 0.63	A1
		(6)
7(e)	$v = 0.7 \times 2$ or $v = \sqrt{2 \times 0.7 \times 1.4}$	M1
	$-\mu \times 4g = 4a$	M1
	$0^2 = 1.4^2 - 2 \times \frac{5g}{8} s$	M1
	$s = 0.16$ or 0.159	A1
	$0.16 + 1.4 < 2 \Rightarrow$ Does not reach pulley	A1 **cso**
		(5)
	ALTERNATIVE for final 3 marks:	**(18)**
	$v^2 = 1.4^2 - 2 \times \frac{5g}{8} \times 0.6$	M1
	$= -5.39$ or -5.4488	A1
	Since v^2 must be ≥ 0, does not reach pulley	A1 **cso**
	Notes for question 7	
7(a)	M1 Complete method to obtain an equation in a only. *Allow verification*	
	A1* Given answer correctly obtained or *verification completed correctly.*	
7(b)	B1 B0 if any extras given.	
7(c)	M1 Equation of motion for B with usual rules	
	A1 Correct equation	
	M1 for correct expression in terms of T	
	A1 39 or 38.6 (N)	
7(d)	M1 Equation of motion for A or whole system, with usual rules	
	A1 Correct equation	
	B1 $R = 4g$	
	B1 $F = \mu R$	
	DM1 Solving to give equation in μ only. Dependent on first M1	

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Question Number	Scheme	Marks
	N.B. DM0 if they use $T = 3g$	
	A1 0.625 or 0.63 (5/8 is A0)	
7(e)	M1 Finding the speed or speed^2 of either particle when B hits the floor	
	M1 Equation of motion for A. Allow without the -ve sign.	
	M1 Complete method to find distance moved by A until it stops, condone sign error. **N.B.** This is an independent M mark but M0 if they have not found a new deceleration.	
	A1 Correct distance	
	A1 cso Correct conclusion correctly reached. Must see ' < 2' or use 2 in their working	
	ALTERNATIVE for final 3 marks:	
	M1 Complete method to find v^2 where v is speed with which it would hit the pulley, condone sign error. **N.B.** This is an independent M mark but M0 if they have not found a new deceleration	
	A1 Correct value for v^2	
	A1 cso	

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