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Mark Scheme (Results)

Summer 2024

Pearson Edexcel International Advanced Level In Mechanics (WME01) Paper 01

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Summer 2024
Question Paper Log Number P75718A
Publications Code WME01_01_2406_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.
- 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.

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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.

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 $\sqrt{}$ 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 Right hand side
LHS Left hand side.

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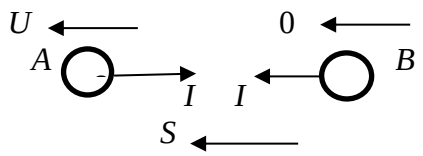
Question Number	Scheme	Marks
1.		
(a)	CLM: oe $mU = mS + 3mS$ **OR** $A: -I = m(S-U)$ and $B: I = 3mS$ AND eliminate I to give $-3mS = m(S-U)$ oe	M1
	$S = \frac{1}{4}U$ or 0.25 U	A1 (2)
(b)	For A: $\pm m(\frac{1}{4}U - U)$	M1A1**ft**
	$\frac{3}{4}mU$	A1 (3)
Alternative	For B: $\pm 3m\frac{1}{4}U$	M1A1**ft**
	$\frac{3}{4}mU$	A1 (3)
		(5)
	Notes	
1(a)	M1: CLM equation with correct terms, condone sign errors and cancelled m's or consistent extra g's **N.B.** If they use 2 impulse-momentum equations, each equation must have the correct terms but condone sign errors.They must then eliminate the impulse to produce an equation in m, U and S only. **N.B.** Allow the use of v or similar for S in the working but must use S for their answer.
	A1: cao (A0 if m's not cancelled)
1(b)	M1: Impulse-momentum for A or B, with correct terms, condone sign errors and allow S for final speed but M0 if m omitted or extra g
	A1**ft**: Correct expression in terms of m and U, ft on the **magnitude** of their S.
	A1 cao (must be positive and a multiple of mU)

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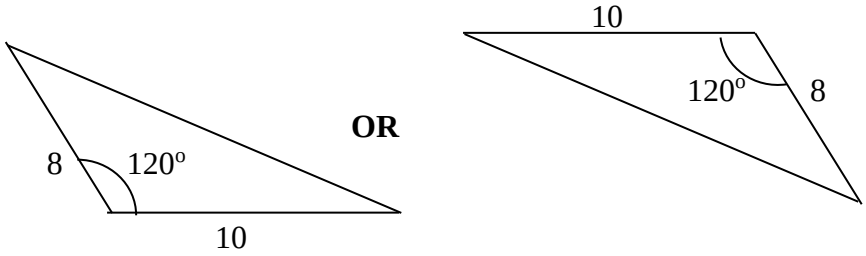
Question Number	Scheme	Marks
2.	 Correct triangle	M1
	$(F^2) = 8^2 + 10^2 - 2 \times 8 \times 10\cos\theta$ where $\theta < 180^o$	M1
	$(F^2) = 8^2 + 10^2 - 2 \times 8 \times 10\cos 120^o$	A1
	$F = \sqrt{244} = 2\sqrt{61}$ or 16 (N) or better (15.620499..)	A1 (4)
	OR:	
	$\pm(10 + 8\cos 60^o)$ **and** $\pm 8\sin 60^o$	M1
	Use of Pythagoras on their **combined** components	M1
	$F^2 = (10 + 8\cos 60^o)^2 + (8\sin 60^o)^2$	A1
	$F = \sqrt{244} = 2\sqrt{61}$ or 16 (N) or better (15.620499..)	A1 (4)
		(4)
	Notes	
2.	M1: **Correct** triangle with lengths and the angle (arrows not needed), seen or implied.	
	M1:Use of cosine rule with correct structure but any angle < 180°	
	A1: Correct expression with or without root	
	A1: cao	
	OR:	
	M1: Two **correct** components (allow inclusion of **i** and **j**)	
	M1:Use of Pythagoras using their combined **i** cpts and **j** cpts	
	A1: Correct expression with or without root	
	A1: cao	
	N.B. A scale drawing can score Max M1M0A0A0	

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Question Number	Scheme	Marks
3.	For P: $4mg - 3mg = 4ma$ For both: $4mg + 2mg - T = (4+2)ma = 6ma$ **Any two of these** For Q: $2mg + 3mg - T = 2ma$	M1A1 M1A1
	Solve for T	DM1
	$\frac{9mg}{2}$, $4.5mg$ oe	A1 (6)
		(6)
	Notes	
	N.B. Use the mass in the 'ma' term in each equation of motion to determine to which part of the system the equation refers. Allow a replaced by $-a$ in both equations. Enter marks on ePEN in the order in which equations appear.	
	M1: Equation of motion with correct terms, condone sign errors	
	A1: Correct equation	
	M1: Equation of motion with correct terms, condone sign errors	
	A1: Correct equation	
	DM1: Dependent on both M's, for solving for T (must be in terms of mg)	
	A1: Any equivalent expression of the form kmg.	
	N.B. For the P and Q equations, allow M1 if they have T instead of $3mg$ and it's VERY **clear** that T is the tension in the connecting string and not the tension they are trying to find.	

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Question Number	Scheme	Marks
4(a)	$M(C),\ Mg\times 4.5+1.2g\times 2=4g\times 1.5$	M1A1
	$M = 0.8$ oe	A1 (3)
	Other possible equations: $(\uparrow),\ Y=4g+1.2g+Mg$ $M(A),\ 5Y=1.2g\times 3+4g\times 6.5+Mg\times 0.5$ $M(B),\ 1.5Y=1.2g\times 3.5+Mg\times 6$ $M(G),\ 2Y+Mg\times 2.5=4g\times 3.5$ from which Y would need to be eliminated.	
4(b)	$M(E),\ R_C\times 0.6=1.2g\times 2.6$	M1A1
	$R_C=5.2g$ isw	A1 (3)
	Other possible equations: $(\uparrow),\ Xg+1.2g=R_C$ $M(C),\ Xg\times 0.6=1.2g\times 2$ $M(A),\ 1.2g\times 3+Xg\times 5.6=R_C\times 5$ $M(B),\ 1.2g\times 3.5+Xg\times 0.9=R_C\times 1.5$ $M(G),\ Xg\times 2.6=R_C\times 2$ from which Xg would need to be eliminated. (Note that $X = 4$) Xg may appear as a single letter.	
		(6)
	Notes	
4(a)	M1: For an equation in M only, with correct number of terms, condone sign errors and missing g's	
	A1: Correct equation	
	A1: cao	
4(b)	M1: For an equation in R_C only, with correct number of terms, condone sign errors and missing g's	
	A1: Correct equation	
	A1: $\frac{26g}{5}$, 51 or 51.0	

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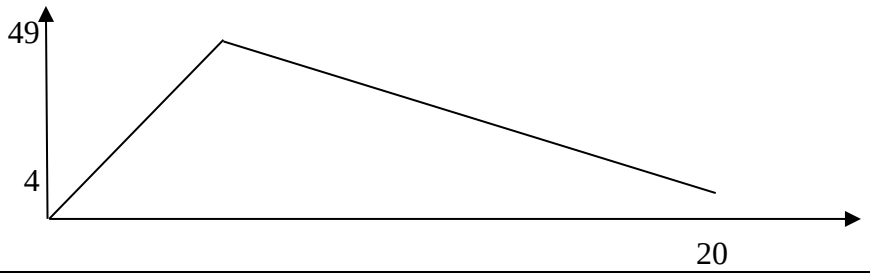
Question Number	Scheme	Marks
5(a)	$s = \frac{1}{2}\times 9.8\times 5^2$	M1
	= 123 or 120 (m)	A1 (2)
5(b)	$v = 9.8\times 5 = 49$ **OR** $v = \sqrt{2\times 9.8\times 122.5} = 49$ **OR** $122.5 = 5v - \frac{1}{2}\times 9.8\times 5^2 \Rightarrow v = 49$	B1
	$250g - 3200 = \pm 250a$	M1A1
	Correct value for their a (3 or -3)	A1
	$v^2 = 49^2 - 2\times 3\times (520 - 122.5)$	M1 A1**ft**
	v = 4 (m s^{-1})	A1 (7)
	N.B. They may do (c) first and then use their t value to obtain v: $v = 49 + (-3\times 15)$ **OR** $(520 - 122.5) = 15v - \frac{1}{2}\times(-3)\times 15^2$ M1A1**ft** v = 4 (m s^{-1}) A1	
5(c)	$4 = 49 - 3t$ **OR** $(520 - 122.5) = \frac{(49+4)}{2}t$ **OR** $(520 - 122.5) = 49t - \frac{1}{2}\times 3t^2$ **OR** $(520 - 122.5) = 4t + \frac{1}{2}\times 3t^2$	M1
	t = 15 (other root of quadratic is $\frac{53}{3}$ which leads to $v < 0$)	A1
	Total time = 5 + 15 = 20 (s)	A1**ft** (3)
5(d)		B1 shape B1 **ft** figs (2)
		(14)
	Notes	
5(a)	M1: Complete method to find the distance	
	A1: cao	
(b)	B1: 49 or -49. Allow 5g or -5g or 49^2 (2401) seen.	
	M1: Equation of motion, correct terms, condone sign errors	
	A1: Correct equation (allow + or $-$)	
	A1: cao	
	M1: Complete method to find speed at ground (must have found a new a) M0 if they use u = 0 either explicitly in (b) or implicitly, by using it in (c) to get the time, which is then used in (b).	
	A1**ft**: Correct equation, ft on their s, v and a . **N.B.** This mark can be awarded even if it leads to a negative value for v^2	
	A1: cao	

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(c)	M1: Complete method to find time from when the parachute opens to when *P* lands on the ground (must have found and use a new *a*) M0 if they use $s = 520$ and/or $u = 0$
	A1:cao.
	A1**ft**: Their $t + 5$ **N.B.** The final answer should be rounded to 2 or 3 sf, if they haven't already been penalised following use of $g = 9.8$ earlier in the question.
(d)	B1: Correct shape (B0 if continuous vertical line at the end or graph ends on the *t*-axis)
	B1**ft**:Correct figs, ft on their 49, 4 and 20, but B0ft if they just assume it stops as it reaches the ground. The ft is only available if the graph has just 2 straight lines, one starting at the origin with positive gradient and the second line has negative gradient with second line not meeting the *t*-axis. This B1ft is available if the graph has a vertical line at the end but is otherwise correct.

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Question Number	Scheme	Marks
6(a)	$R + T\sin\theta = mg$	M1A1
	$T\cos\theta - F = 0$	M1A1
	$F = \frac{1}{3}R$	B1
	Solve for T, in terms of mg	DM1
	$(T) = \frac{1}{3}mg$	A1 (7)
(b)	$F = \frac{1}{3}mg$	B1
	$F = \pm ma$ **OR** W.D. = $\pm Fd$	B1
	$\left(\frac{1}{2}u\right)^2 = u^2 - 2(\frac{1}{3}g)d$ $\quad\quad$ $\frac{1}{2}m\left(\frac{1}{2}u\right)^2 = \frac{1}{2}mu^2 - \frac{1}{3}mgd$	DM1A1
	$d = \frac{9u^2}{8g}$ oe $\quad\quad$ $d = \frac{9u^2}{8g}$ oe	A1 (5)
		(12)
	Notes	
6(a)	M1: Vertical resolution, with correct terms, condone sign errors and sin/cos confusion. Allow if they use $\sin(\frac{3}{5})$ or similar.	
	A1: Correct equation	
	M1: Horizontal resolution, with correct terms, condone sign errors and sin/cos confusion. Allow if they use $\cos(\frac{4}{5})$ or similar.	
	A1: Correct equation	
	B1: Seen anywhere, including on a diagram	
	DM1: Dependent on both M's	
	A1:cao. Accept 0.33 *mg* or better.	
6(b)	B1: Seen anywhere, including on a diagram	
	B1: $F = \pm ma$ where F is friction, (allow + or $-$) **OR** Fd	
	DM1: Complete method, dependent on the previous B mark, using a new dimensionally correct acceleration, to produce an equation, with correct no. of terms, in d, u and g, condone sign errors. **OR**, using work-energy principle using Fd , where F is friction, to produce an equation, with correct no. of terms, in d, u and g, condone sign errors	
	A1: Correct equation	
	A1: cao (must be d = , seen or implied, **but allow *s* in the working**)	

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Question Number	Scheme	Marks
	N.B. Answers to (a) and (b) should be in terms of **i** and **j**, but only penalise once. Column vectors can be used in working.	
7(a)	$\mathbf{v}_B = (20\sin\alpha)\mathbf{i} + (20\cos\alpha)\mathbf{j}$ oe e.g. use of Pythagoras but must get to an answer	M1
	$= 16\mathbf{i} + 12\mathbf{j}$ (km h^{-1})	A1 (2)
7(b)	(**s** =) (10**i** + 5**j**) + t(16**i** + 12**j**) or $(10+16t)\mathbf{i} + (5+12t)\mathbf{j}$	M1 A1 **ft** (2)
7(c)	$\overrightarrow{AB} = \mathbf{s} - \mathbf{r} = (10\mathbf{i} + 5\mathbf{j}) + t(16\mathbf{i} + 12\mathbf{j}) - [20\mathbf{j} + 40t\mathbf{i}]$	M1
	$\overrightarrow{AB} = [(10 - 24t)\mathbf{i} + (12t - 15)\mathbf{j}]$ km *	A1* (2)
7(d)	$10 - 24t = 0$ and $12t - 15 = 0$ **OR** $40t = 10 + 16t$ and $20 = 5 + 12t$	M1
	$t = \frac{5}{12}$ and $\frac{5}{4}$ or one correct t value which is then used in the other equation **correctly** to show that the equation is not true.	A1
	Different *t* values oe so never collide*	A1* (3)
	ALT 1:	
	$(10 - 24t)^2 + (12t - 15)^2 = 0$ (i.e. $720t^2 - 840t + 325 = 0$) M1	
	$(-840)^2 - 4 \times 720 \times 325$ $(= -230,400)$ < 0 A1 Or roots $\frac{7 \pm 4i}{12}$ (calculator)	
	No real roots oe so never collide* A1* **N.B.** Must see justification for 'no real roots' to score either of the A marks.	
	ALT 2:	
	Finds minimum value of $720t^2 - 840t + 325$ or its square root using derivative or completing the square or calculator M1	
	80 or $\sqrt{80}$ or $\overrightarrow{AB} = -4\mathbf{i} - 8\mathbf{j}$ (at $t = \frac{7}{12}$) A1	
	so never collide* A1*	
7(e)	$10 - 24t = 12t - 15$ oe	M1
	$t = \frac{25}{36}$ or 0.69 or better	A1
	$\overrightarrow{AB} = \left[(10 - 24 \times \frac{25}{36})\mathbf{i} + (12 \times \frac{25}{36} - 15)\mathbf{j} \right]$ (km)	M1
	$AB = 20\frac{\sqrt{2}}{3}$, 9.4 or better (km)	A1 (4)
		(13)

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	Notes	
7(a)	M1: Condone sign errors and sin/cos confusion but both components must be resolved. Allow if they use $\cos(\frac{3}{5})$ or similar. If $12\mathbf{i}+16\mathbf{j}$ appears without working, award M1A0.	
	A1: cao	
7(b)	M1: Correct structure, condone slips	
	A1**ft**: ft on their answer to (a)	
7(c)	M1: Allow $\mathbf{r}-\mathbf{s}$. $\mathbf{r}$ and $\mathbf{s}$ must be substituted.	
	A1*: Correct given answer, correctly obtained **N.B.** Need to see $\overrightarrow{AB}$ at the start or finish for the A1* and answer must be **exactly** as printed, ignoring [] and km.	
7(d)	M1: They may use $\mathbf{r}=\mathbf{s}$ with both **i** and **j** cpts equated.	
	A1: Need both *t* values. Accept 0.42 or better and 1.25.	
	A1*: Correct conclusion	
7(e)	M1: Correct method	
	A1: cao	
	M1: Sub their calculated *t* value into $\overrightarrow{AB}$ or $\overrightarrow{BA}$, seen or implied, oe. Note that this is an independent M mark.	
	A1: cao	

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Question Number	Scheme	Marks
8.	**N.B.** In parts (a) and (c), $g = 9.8$ could appear in the working but final answers must be using g. In (b), $g = 9.8$ could be used in their answer. In (d), $g = 9.8$ could appear throughout in the working. **N.B.** For any equation of motion, if they use an incorrect mass in the 'ma' term, award M0 for the equation. However, if the correct mass has been used in (c), treat an error in the 'ma' term in (d) as a slip.	
8(a)	$R = 2mg\cos\alpha$	M1A1
	$F = \frac{11}{36} \times 2mg \times \frac{12}{13} = \frac{22mg}{39}$ *	A1* (3)
8(b)	$3mg - T = 3ma$	M1A1 (2)
8(c)	$T - \frac{22mg}{39} - 2mg\sin\alpha = 2ma$ $\quad (T - \frac{4mg}{3} = 2ma)$ **OR:** $3mg - \frac{22mg}{39} - 2mg\sin\alpha = 5ma$	M1A1
	Solve for a in terms of g **N.B.** Must reach $a = kg$ from **their** equations	M1
	$a = \frac{1}{3}g$ *	A1* (4)
8(d)	$v^2 = \frac{2gh}{3}$	B1
	$-\frac{22mg}{39} - 2mg\sin\alpha = \pm 2ma$ **OR** PE Gain = $2mgd\sin\alpha$	M1
	$\pm\frac{2g}{3} = a$ $\quad =$ $\frac{10mgd}{13}$	A1
	$0 = \frac{2gh}{3} - 2 \times \frac{2g}{3} \times d$ $\frac{22mgd}{39} = \frac{1}{2} \times 2m \times \frac{2gh}{3} - \frac{10mgd}{13}$	M1
	$d = \frac{1}{2}h$ $\quad d = \frac{1}{2}h$	A1
	Total distance = $\frac{1}{2}h + h = \frac{3}{2}h$	A1 ft (6)
		(15)

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	Notes	
	N.B. For (a) and (c), if fractions for the trig ratios are not seen or implied, only penalise once.	
8(a)	M1: Resolve perp to the plane, correct terms, condone cos/sin confusion and sign errors. Allow if they use $\cos(\frac{12}{13})$ or similar.	
	A1: Correct equation	
	A1*: Correct given answer correctly obtained, must see $\frac{12}{13}$	
8(b)	M1:Equation of motion for *B*, correct terms, condone sign errors	
	A1: Correct equation	
8(c)	M1:Equation of motion for *A* **OR** whole system, correct terms but allow *F*, condone sign errors and sin/cos confusion. Allow if they use $\sin(\frac{5}{13})$ or similar.	
	A1: Correct equation	
	M1: Solve for *a* in terms of *g*, need to see trig substituted and must be solving 2 equations in *T* and *a* **OR** using a whole system equation with correct terms.	
	A1*: Correct given answer correctly obtained, must see $\frac{5}{13}$	
	N.B. Allow a full verification, using the equations of motion for *A* and *B* **OR** the whole system equation.	
8(d)	B1: seen or implied	
	M1:Equation of motion for *A*, correct terms, condone sign errors and sin/cos confusion	
	A1: Correct acceleration or deceleration of *A*	
	M1: Complete method to find an equation in *d*, *g* and *h* only, using a new calculated *a*	
	A1: cao	
	A1ft: Their *d* (which must be a multiple of *h*) + *h*. **N.B.** This mark is only dependent on the previous M.	
	OR: Using Work-energy	
	B1: cao	
	M1: PE gain of *A*, condone sign errors and sin/cos confusion	
	A1: Correct PE gain	
	M1: Use of work-energy principle to obtain an equation in *m*, *d*, *g* and *h* only, using their PE expression	
	A1: cao	
	A1ft: Their *d* (which must be a multiple of *h*) + *h*, with the final answer of the form *kh*.	

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