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EDEXCEL INTERNATIONAL A LEVEL MATHS: QUESTIONS BY TOPIC

Statics of a Particle (M1.3)

International A Level Mathematics · M1: Mechanics 1 (WME01)

12 questions · 106 marks · Mark schemes included

Past papers January 2020 - June 2025 · 1 sub-topic

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HOW TO USE THIS BOOKLET

Questions are grouped by sub-topic and run from the lowest to the highest mark tariff, then oldest paper first.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme; < QUESTION brings you back.

A gold bar in the left margin marks exactly where the question sits on the original page.

Diagrams, graphs, grids and tables are printed exactly as they appear in the original papers.

Each question is filed under its main topic; longer questions may also test skills from other topics.

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QUESTIONS

12 questions · 106 marks · 1 sub-topic

SUB-TOPIC M1.3a

EQUILIBRIUM & RESOLVING FORCES

Sub-topic M1.3a · 12 questions · 106 marks · lowest tariff first



Question 1 continued

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Lined area for writing the answer to Question 1.

(Total 6 marks)

Q1



Question 1 continued

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(Total for Question 1 is 6 marks)

6.

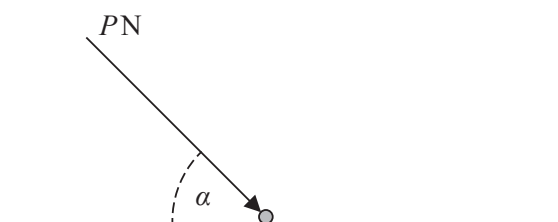


Figure 3

A particle of weight W newtons lies at rest on a rough horizontal surface, as shown in Figure 3.

A force of magnitude P newtons is applied to the particle.

The force acts at an angle α to the horizontal, where $\tan \alpha = \frac{4}{3}$

The coefficient of friction between the particle and the surface is $\frac{1}{4}$

Given that the particle does not move, show that

$$P \leq \frac{5W}{8}$$

(7)

Question 6 continued

Lined area for writing the answer to Question 6.

(Total for Question 6 is 7 marks)



4.

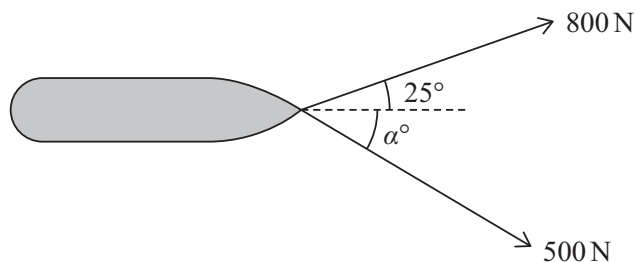


Figure 2

Two ropes are attached to a point on the front of a barge.

The barge is being pulled horizontally in a straight line along the centre of a long straight canal.

One rope makes an angle of 25° with the direction of motion of the barge and has a tension of 800 N.

The other rope makes an angle of α° with the direction of motion of the barge and has a tension of 500 N, as shown in Figure 2.

Both ropes are horizontal.

- (a) Find the value of α

(3)

The mass of the barge is 15 tonnes and the resistance to the motion of the barge is a constant force of magnitude 750 N.

- (b) Find the acceleration of the barge.

(4)

Question 4 continued

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Question 4 continued

Lined area for writing the answer to Question 4 continued.



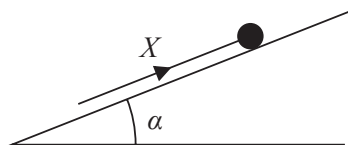
Question 4 continued

Lined area for writing the answer to Question 4.

(Total for Question 4 is 7 marks)



5.

**Figure 3**

A particle of mass m rests in equilibrium on a fixed rough plane under the action of a force of magnitude X . The force acts up a line of greatest slope of the plane, as shown in Figure 3.

The plane is inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$

The coefficient of friction between the particle and the plane is μ .

- When $X = 2P$, the particle is on the point of sliding up the plane.
- When $X = P$, the particle is on the point of sliding down the plane.

Find the value of μ .

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Question 5 continued

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Question 5 continued

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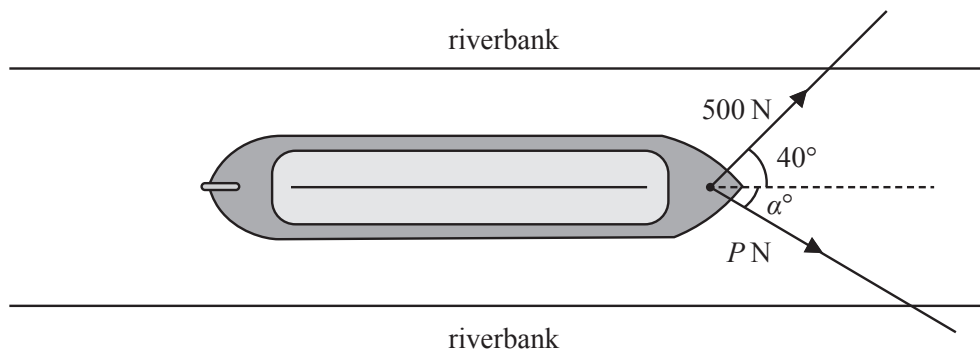
Lined area for writing the answer to Question 5.

(Total 8 marks)

Q5



6.

**Figure 3**

A boat is pulled along a river at a constant speed by two ropes.

The banks of the river are parallel and the boat travels horizontally in a straight line, parallel to the riverbanks.

- The tension in the first rope is 500 N acting at an angle of 40° to the direction of motion, as shown in Figure 3.
- The tension in the second rope is P newtons, acting at an angle of α° to the direction of motion, also shown in Figure 3.
- The resistance to motion of the boat as it moves through the water is a constant force of magnitude 900 N

The boat is modelled as a particle. The ropes are modelled as being light and lying in a horizontal plane.

Use the model to find

- the value of α
- the value of P

(8)

Question 6 continued



4.

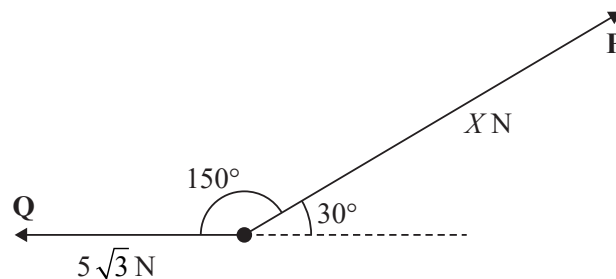
**Figure 3**

Figure 3 shows two horizontal forces **P** and **Q** acting on a particle.

The angle between the direction of **P** and the direction of **Q** is 150°

Force **P** has magnitude X newtons.

Force **Q** has magnitude $5\sqrt{3}$ N.

The resultant of **P** and **Q** has magnitude $\sqrt{129}$ N.

Find

(i) the value of X .

(ii) the angle between **Q** and the resultant, giving your answer to the nearest degree.

(8)



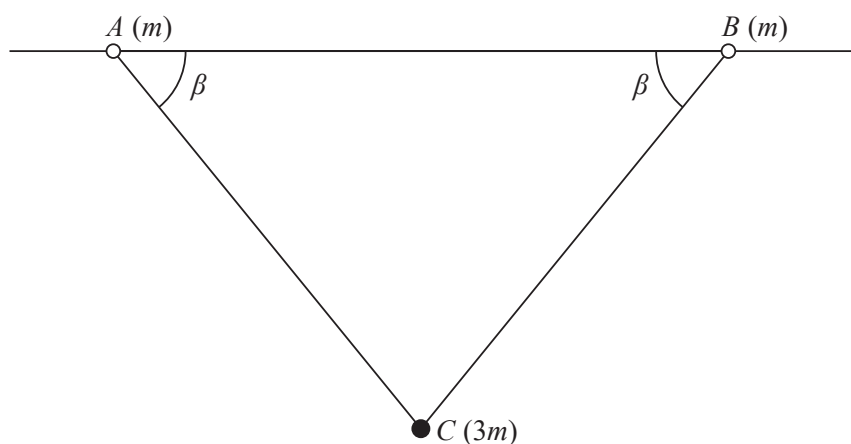


(Total for Question 4 is 6 marks)



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4.

**Figure 2**

Two identical small rings, A and B , each of mass m , are threaded onto a rough horizontal wire. The rings are connected by a light inextensible string. A particle C of mass $3m$ is attached to the midpoint of the string. The particle C hangs in equilibrium below the wire with angle $BAC = \beta$, as shown in Figure 2.

The tension in each of the parts, AC and BC , of the string is T

(a) By considering particle C , find T in terms of m , g and β (2)

(b) Find, in terms of m and g , the magnitude of the normal reaction between the wire and A . (3)

The coefficient of friction between each ring and the wire is $\frac{4}{5}$

The two rings, A and B , are on the point of sliding along the wire towards each other.

(c) Find the value of $\tan \beta$ (5)

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Question 4 continued

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(Total 10 marks)

Q4

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Question 5 continued

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Question 5 continued

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Question 5 continued

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(Total 10 marks)

Q5



5.

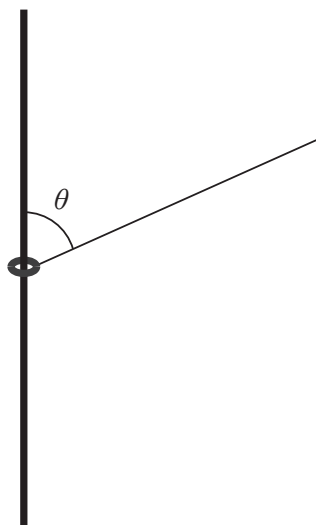


Figure 3

A small ring of mass 0.2 kg is attached to one end of a light inextensible string.

The ring is **threaded** onto a fixed rough vertical rod.

The string is taut and makes an angle θ with the rod, as shown in Figure 3,

where $\tan \theta = \frac{12}{5}$

Given that the ring is in equilibrium and that the tension in the string is 10 N ,

(a) find the magnitude of the frictional force acting on the ring,

(3)

(b) state the direction of the frictional force acting on the ring.

(1)

The coefficient of friction between the ring and the rod is $\frac{1}{4}$

Given that the ring is in equilibrium, and that the tension in the string, T newtons, can now vary,

(c) (i) find the minimum value of T

(ii) find the maximum value of T

(8)



Question 5 continued

Lined area for writing the answer to Question 5 continued.



(Total for Question 3 is 12 marks)



Question 6 continued

Lined area for writing the answer to Question 6 continued.



Question 6 continued

Lined area for writing the answer to Question 6 continued.



Question 6 continued

Lined area for writing the answer to Question 6.

(Total for Question 6 is 12 marks)



Question 6 continued

Lined area for writing the answer to Question 6 continued.



Question 6 continued

Lined area for writing the answer to Question 6 continued.



Question 6 continued

Lined area for writing the answer to Question 6.

(Total for Question 6 is 12 marks)



MARK SCHEMES

official mark schemes, in the same order as the questions



Question Number	Scheme	Marks
1(a)	$F = 5 \cos 30^\circ$ oe (Resolving perp to string or from triangle of forces or Lami's Theorem: $\frac{F}{\sin 120^\circ} = \frac{5}{\sin 90^\circ}$) OR $\frac{F \sin 30^\circ}{\sin 60^\circ} \cos 60^\circ + F \cos 30^\circ = 5$	M1 A1
	$F = \frac{5\sqrt{3}}{2}$ 4.3 or better	A1
	N.B. $F \sin 30^\circ = T \sin 60^\circ$	(3)
1(b)	$T = 5 \sin 30^\circ$ oe (Resolving along string or from triangle of forces or Lami's Theorem: $\frac{T}{\sin 150^\circ} = \frac{5}{\sin 90^\circ}$) OR $T \cos 60^\circ + \frac{T \sin 60^\circ}{\sin 30^\circ} \cos 30^\circ = 5$	M1 A1
	$T = \frac{5}{2}$ (N)	A1
	N.B. $F \sin 30^\circ = T \sin 60^\circ$	(3)
		(6)
	Notes for question 1	
1(a)	M1 Complete method to obtain equation in F only - correct no. of terms, condone sign errors and sin/cos confusion (If they resolve horizontally and vertically, they will need to eliminate T to obtain this M mark, with the usual rules applying to each equation they use) N.B. If they do (b) first and find an incorrect value for T and then use that value in (a), using an equation that would earn M1, with usual rules, to find F , give M1A0A0 in (a). M0 if using wrong angles e.g. 45°	
	A1 Correct equation	
	A1 cao (4.3301..)	
1(b)	M1 Complete method to obtain equation in T only - correct no. of terms, condone sign errors and sin/cos confusion (If they resolve horizontally and vertically, they will need to eliminate F to obtain this M mark, with the usual rules applying to each equation they use) N.B. If they find an incorrect value for F in (a) and then use that value in (b), using an equation that would earn M1, with usual rules, to find T , give M1A0A0 in (b). M0 if using wrong angles e.g. 45°	
	A1 Correct equation	
	A1 cao	

QUESTION NUMBER	SCHEME	MARKS
1		
(a)	Horiz: $2 = T \cos \theta$	M1 A1
	$T = 2.5$	A1
		(3)
(b)	Vert: $T + T \sin \theta = Mg$	M1 A1
	$M = 0.41$ or 0.408	A1
		(3)
		(6)
	Notes for question 1	
	N.B. If they have different tensions, they can score all the marks in (a) but nothing in (b). If they have $2 = T \cos(\frac{4}{5})$ or similar and never recover, allow M1A0.	
(a) M1 A1 A1	Horizontal equilibrium. Correct no. of terms, dimensionally correct, condone sin/cos confusion. Correct unsimplified equation. Correct answer. (ignore units)	
(b) M1 A1 A1	Vertical equilibrium. Correct no. of terms, dimensionally correct, condone sin/cos confusion and missing g , to give an equation which must include M . Correct unsimplified equation Correct answer. (ignore units)	

Question Number	Scheme	Marks
6	Vertical $R - P \sin \alpha = W$	M1 A1
	Horizontal $F = P \cos \alpha$ OR $F_{MAX} \geq P \cos \alpha$	M1 A1
	$F \leq \frac{1}{4}R$ or $F = \frac{1}{4}R$ seen or implied	M1
	Produce a dimensionally correct inequality or equation in P and W only, trig does not need to be substituted	M1
	Reach the given answer, with exact working. $P \leq \frac{5W}{8}^*$ or $\frac{5W}{8} \geq P$	A1* cso
		(7)
		(7)
Notes for Question 6		
M1	Equation for vertical equilibrium. Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion. M0 for an inequality	
A1	Correct unsimplified equation.	
M1	Equation for horizontal equilibrium. Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion. N.B. Allow $F \geq P \cos \alpha$	
A1	Either $F = P \cos \alpha$ or $F_{MAX} \geq P \cos \alpha$ where F_{MAX} may be implied by use of $\frac{1}{4}R$	
M1	M0 for $F < \frac{1}{4}R$ or $F > \frac{1}{4}R$ or $F \geq \frac{1}{4}R$	
M1	Eliminate F and R to form an inequality or equation in P and W only but allow trig to be unsubstituted. e.g. $\frac{1}{4}(W + P \sin \alpha) \geq P \cos \alpha$ or $\frac{1}{4}(W + P \sin \alpha) = P \cos \alpha$ M0 for use of $F < \frac{1}{4}R$ or $F > \frac{1}{4}R$ or $F \geq \frac{1}{4}R$ to form their inequality	
A1* cso	Reach the given answer with at least one line of working. Must come from exact working and correct use of the inequality	

4a	Resolve perpendicular to the direction of motion to form an equation in α only. OR sine rule on a vector triangle.	M1	Dimensionally correct. Both forces resolved. Condone sign errors. Condone sine / cosine confusion but M0 for $800 \cos 25^\circ + 500 \cos \alpha^\circ = 0$ if clearly resolving in the direction of motion.
	$800 \sin 25^\circ = 500 \sin \alpha^\circ$ oe	A1	Correct unsimplified equation
	43 or better (must be correctly rounded to however many figs they choose)	A1	$\alpha = 42.5465\dots$ is A0
		(3)	
4b	Use $F = ma$ parallel to the direction of the motion, to form an equation in α and a only. N.B. The resultant of the two tensions may be found using the sine rule or cosine rule on a vector triangle.	M1	Dimensionally correct. Both forces resolved. Condone sine / cosine confusion. Condone sign errors. All relevant terms. Condone 15 or incorrect zeros for the mass. N.B. An extra g in a resolution is counted as an A error not an M error.
	$800 \cos 25^\circ + 500 \cos \alpha^\circ - 750 = 15000a$ OR $\frac{500 \sin(180^\circ - 25^\circ - \alpha^\circ)}{\sin 25^\circ} - 750 = 15000a$ OR $\frac{800 \sin(180^\circ - 25^\circ - \alpha^\circ)}{\sin \alpha^\circ} - 750 = 15000a$ OR $F - 750 = 15000a$ where $F = \sqrt{800^2 + 500^2 - 2 \times 800 \times 500 \cos(180^\circ - 25^\circ - \alpha^\circ)}$	A1 A1	Unsimplified equation with at most one error. Correct unsimplified equation. α does not need to be substituted. N.B. If they haven't attempted part (a) and use a 'random' numerical value for α , can score max A1A0. N.B. Allow a replaced by $-a$
	Accept $0.023 \text{ (ms}^{-2}\text{)}$ or better, (must be correctly rounded to however many figs they choose)	A1	$a = 0.02289\dots$ is A0 N.B. Penalise the use of ... in their answer, ONCE for the question.
		(4)	
		(7)	

Question Number	Scheme	Marks
5.	Resolve perp to the plane: $R = mg \cos \alpha$	M1A1
	Resolve parallel to the plane:	M1
	$mg \sin \alpha + F = 2P$	A1
	$mg \sin \alpha - F = P$	A1
	Use of $F = \mu R$	M1
	Substitute correctly for trig, eliminate P and F and solve for μ	M1
	$\mu = 0.25$	A1
	N.B. If they consistently omit g and obtain the correct answer, max marks are: M1A0M1A0A0M1M1A1	(8)
		(8)
	Notes for question 5	
	M1 First resolution, correct no. of terms, condone sign errors and sin/cos confusion N.B. If they use cos (4/5) etc, treat as an A error but allow recovery.	
	A1 Correct equation	
	M1 Second (or third) resolution, correct no. of terms, condone sign errors and sin/cos confusion N.B. M0 if they don't substitute for X , but full marks is possible if they use X and $2X$ oe. If they use sin (3/5) etc, treat as an A error but allow recovery.	
	A1 Correct equation (A0 if they use different R 's or F 's)	
	A1 Correct equation (A0 if they use different R 's or F 's)	
	M1 Use of $F = \mu R$	
	M1 Substitute for trig, eliminate P and F and solve for μ	
	A1 cao	
	Other possible equations:	
	$(\rightarrow) 2P \cos \alpha = R \sin \alpha + F \cos \alpha \quad (1)$	
	$(\rightarrow) P \cos \alpha = R \sin \alpha - F \cos \alpha \quad (2)$	
	$(\uparrow) mg - 2P \sin \alpha = R \cos \alpha - F \sin \alpha \quad (3)$	
	$(\uparrow) mg - P \sin \alpha = R \cos \alpha + F \sin \alpha \quad (4)$	
	SC: (Only needs 2 equations)	
	Equation (1):	M1A1
	Equation (2):	M1A1
	(1) + (2): $3P \cos \alpha = 2R \sin \alpha$	
	(1) - (2): $P \cos \alpha = 2F \cos \alpha$	
	Divide $\frac{1}{3} = \frac{F}{R} \cot \alpha$.	A1
	Use of $F = \mu R$	M1
	Substitute for trig and solve for μ	M1
	$\mu = 0.25$	A1

Question Number	Scheme	Marks
6.	Perpendicular to direction of motion: $500 \sin 40^\circ = P \sin \alpha^\circ$	M1 A1
	Parallel to direction of motion: $500 \cos 40^\circ + P \cos \alpha^\circ = 900$	M1 A1
	(i) Form and solve an equation in α $\tan \alpha^\circ = \frac{500 \sin 40^\circ}{900 - 500 \cos 40^\circ}$	M1
	$\alpha = 32$ or better (31.8683...)	A1
	(ii) Form and solve an equation in P $P = \frac{500 \sin 40^\circ}{\sin 31.868...^\circ}$	M1
	$P = 610$ or better (608.736...)	A1
	N.B. Penalise over accurate answers only once for the question.	
	ALTERNATIVE USING A TRIANGLE OF FORCES: Cosine Rule: $P^2 = 500^2 + 900^2 - 2 \times 500 \times 900 \cos 40^\circ$ OR: $500^2 = P^2 + 900^2 - 2 \times P \times 900 \cos \alpha^\circ$ OR: $900^2 = P^2 + 500^2 - 2 \times P \times 500 \cos(140^\circ - \alpha^\circ)$	M1 A1
	Sine Rule /Lami's Theorem: $\frac{P}{\sin 40^\circ} = \frac{500}{\sin \alpha^\circ} = \frac{900}{\sin(140^\circ - \alpha^\circ)}$ (any two)	M1 A1
	(i) Solve for α $\alpha = 32$ or better (31.8683...)	M1 A1
	(ii) Solve for P $P = 610$ or better (608.736...)	M1 A1
(8)		
	NOTES	
M1	Form an equation perpendicular to the direction of motion. Correct number of terms, condone sign errors and sin/cos confusion.	
A1	Correct unsimplified equation	
M1	Form an equation parallel to the direction of motion. If using $F = ma$ then must have $a = 0$. Correct number of terms, condone sign errors and sin/cos confusion.	
A1	Correct unsimplified equation	
(i) M1	Form and solve an equation in α (This an M mark so do not penalise accuracy of manipulation)	
A1	Accept 32 or better (i.e 32, 31.9, 31.87,... as their final answer)	
(ii) M1		



A1	Form and solve an equation in P (This an M mark so do not penalise accuracy of manipulation) Accept 610 or better (i.e 610, 609, 608.7,... as their final answer)	
M1	ALTERNATIVE	
A1	Use cosine rule to give an equation in P (and α possibly) Correct equation	
M1		
A1	Use sine rule to give an equation in P and α Correct equation	
	N.B. They could use the Sine or the Cosine Rule twice to obtain their two equations.	
(i) M1		
A1	Form and solve an equation in α Accept 32 or better (i.e 32, 31.9, 31.87,... as their final answer)	
(ii) M1		
A1	Form and solve an equation in P Accept 610 or better (i.e 610, 609, 608.7,... as their final answer)	



QUESTION NUMBER	SCHEME	MARKS
N.B. They may do (ii) first using the OR method to find α (and possibly β) and then use either angle to do (i), using the Sine Rule or Cosine Rule.		
4		
4(i)	Complete method to find an equation in X only: - Using correct vector triangle with cosine rule: $129 = X^2 + (5\sqrt{3})^2 - 2X \times 5\sqrt{3} \cos 30^\circ$ - Using correct vector triangle with sine rule to find α : $\frac{\sqrt{129}}{\sin 30^\circ} = \frac{5\sqrt{3}}{\sin \alpha}$ $\alpha = 22.4109..^\circ \Rightarrow \beta = 180^\circ - 30^\circ - 22.4109..^\circ = 127.589..^\circ$ Then sine rule: $\frac{X}{\sin \beta} = \frac{\sqrt{129}}{\sin 30^\circ} = \frac{5\sqrt{3}}{\sin \alpha}$ or cosine rule: $(5\sqrt{3})^2 = X^2 + 129 - 2X \sqrt{129} \cos \alpha$ or $X^2 = (5\sqrt{3})^2 + 129 - 2 \times 5\sqrt{3} \times \sqrt{129} \cos \beta$ to find X. - Using components with magnitude: $\sqrt{129} = \sqrt{(X \cos 30^\circ - 5\sqrt{3})^2 + (X \sin 30^\circ)^2}$	M1 A1
	Solves their equation (if quadratic, must include an X term) to find an X value.	M1
	$X = 18$	A1

Question Number	Scheme	Marks
4(a)	$2T \sin \beta = 3mg$ OR $\frac{T}{\sin(90^\circ - \beta)} = \frac{3mg}{\sin 2\beta}$	M1
	$T = \frac{3mg}{2 \sin \beta}$ OR $T = \frac{3mg \cos \beta}{\sin 2\beta}$	A1
		(2)
(b)	For A or B : $(\uparrow) R = mg + T \sin \beta$ OR For whole system: $(\uparrow) 2R = 3mg + mg + mg$ OR For AC or BC : $(\uparrow) R + T \sin \beta = mg + 3mg$	M1 A1
	$R = 2.5mg$	A1
		(3)
(c)	$F = T \cos \beta$	M1A1
	$F = \frac{4}{5} \times 2.5mg$	B1 ft
	Eliminate T and solve for $\tan \beta$	M1
	$\tan \beta = \frac{3}{4}$	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 $\cos(90^\circ - \beta)$ for $\sin \beta$ or $\sin(90^\circ - \beta)$ 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 $F = \frac{4}{5} \times$ 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 $\frac{3}{4}$ oe	



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)	$60 \text{ (m s}^{-1}\text{)}$	B1
	$60 + T \text{ (m s}^{-1}\text{)}$	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 ' $\frac{1}{2}$ ' 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.	

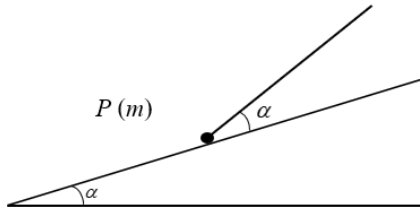


Question Number	Scheme	Marks
5(a)	($\uparrow$) $\pm F = 0.2g - 2.5 \cos \alpha$ Allow use of (μR) for F	M1 A1
	$F = 0.46$ (N) oe including fractions, upwards	A1
		(3)
5(b)	($\uparrow$) $F + 0.2g = 6.125 \cos \alpha$	M1A1
	($\rightarrow$) $R = 6.125 \sin \alpha$ (4.9)	M1A1
	$F = \mu R$	B1
	Solve for μ	DM1
	$\mu = 0.35$ oe including fractions.	A1
	N.B. If F and R are interchanged in their equations, max B1 can be scored.	(7)
		(10)
	Notes for question 5	
5(a)	M1 Correct no. of terms, condone sin/cos confusion and sign errors, allow if they have T instead of 2.5	
	A1 Correct equation. Allow $+F$ or $-F$	
	A1 Need both magnitude (must be positive) and direction	
5(b)	M1 Correct terms, condone sin/cos confusion and sign errors errors allow if they have T instead of 6.125 (but M0 if using $T = 2.5$)	
	A1 Correct equation	
	M1 Correct terms, condone sin/cos confusion and sign error allow if they have T instead of 6.125 (but M0 if using $T = 2.5$)	
	A1 Correct equation	
	B1 $F = \mu R$ seen but B0 if they use a value for R found in (a)	
	DM1 Dependent on both M's	
	A1 cao	

QUESTION NUMBER	SCHEME	MARKS
5		
5(a)	$F = 10 \cos \theta - 0.2g$ or $F = 0.2g - 10 \cos \theta$	M1 A1
	$ F = 1.9$ or 1.89 (N)	A1
		(3)
5(b)	Friction acts downwards or down.	A1
	A0 for anything else.	
		(1)
5(c)	$R = T \sin \theta$ $\left(R = \frac{12T}{13} \right)$	M1 A1
	$F = \frac{1}{4}R$	B1
	Resolve vertically For min value $T \cos \theta = 0.2g - F$ For max value $T \cos \theta = 0.2g + F$	M1 A1 A1
(i)	Min T 3.2 or 3.19 (N)	A1
(ii)	Max T 13 or 12.7 (N)	A1
	N.B. Penalise over accuracy once for the whole question and penalise the FIRST time it is seen.	
	N.B. If 2 instead of 0.2 is used throughout the WHOLE question, treat as a MR.	
		(8)
		(12)
	Notes for question 5	
(a) M1	Resolve vertically, dimensionally correct, condone sin/cos confusion and sign errors.	
A1	Correct unsimplified equation.	
A1	Correct value for Friction, must be positive	
	N.B. If they use μR as their notation for F and never separate μ and R , allow M1A1A1. If, however, they do separate them, give M1A1A0.	
(b) A1	Correct direction from a correct, but possibly unrounded, answer to part (a).	
(c) M1	Resolve perpendicular to the rod. Must be dimensionally correct and have correct no of terms. Condone sin/cos confusion.	
	N.B. M0 if they use $T = 10$	
A1	Correct unsimplified equation	
B1	$F = \frac{1}{4}R$ seen or implied	
M1	Resolve parallel to the rod for either case. Must be dimensionally correct and have correct no of terms. Condone sin/cos confusion.	
	N.B. M0 if they use $T = 10$ or if they use F from part (a).	
A1	Correct minimum case equation	
A1	Correct maximum case equation	
(i)A1	cao for min T . Allow 0.325g	
(ii)A1	cao for max T . Allow 1.3g	
	N.B. If only one found and no labels, allow the A mark for the equation but must state which one it is to score the A mark for the answer.	
	N.B. If both correctly found and no labels, allow all the marks.	
	N.B. If both correctly found but the answers are labelled wrongly, lose the final two A marks.	

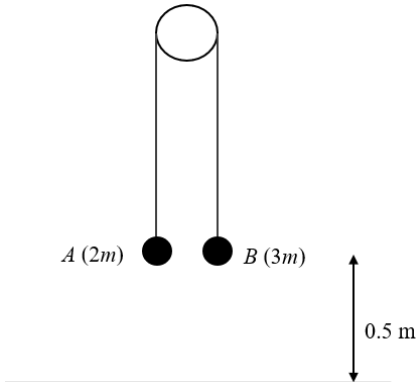


Question Number	Scheme	Marks
6(a)	$R + T \sin \theta = mg$	M1A1
	$T \cos \theta - F = 0$	M1A1
	$F = \frac{1}{3} R$	B1
	Solve for T , in terms of mg	DM1
	$(T) = \frac{1}{3} mg$	A1 (7)
(b)	$F = \frac{1}{3} mg$	B1
	$F = \pm ma$ OR W.D. = $\pm Fd$	B1
	$\left(\frac{1}{2}u\right)^2 = u^2 - 2\left(\frac{1}{3}g\right)d$ $\frac{1}{2}m\left(\frac{1}{2}u\right)^2 = \frac{1}{2}mu^2 - \frac{1}{3}mgd$	DM1A1
	$d = \frac{9u^2}{8g}$ oe $d = \frac{9u^2}{8g}$ 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)	

QUESTION NUMBER	SCHEME	MARKS
6		
6(a)	$(F =) 0.75mg \cos \alpha - mg \sin \alpha$ N.B. Accept $\frac{1}{2}(mg \cos \alpha - 0.75mg \sin \alpha)$	M1 A1 A1
		(3)
6(b)	$R = mg \cos \alpha - 0.75mg \sin \alpha$	M1 A1
	Use of (max) $F = \frac{1}{2}R$	B1
	$0.75mg \cos \alpha - mg \sin \alpha = \frac{1}{2}(mg \cos \alpha - 0.75mg \sin \alpha)$	M1 A1
	e.g. $(0.75mg - \frac{1}{2}mg) \cos \alpha = (mg - \frac{1}{2} \times 0.75mg) \sin \alpha$ $\tan \alpha = \frac{2}{5} \quad *$	A1*
		(6)
6(c)		
	(Finds max friction =) $\frac{1}{2}(mg \cos \alpha)$ (and weight component down the plane =) $mg \sin \alpha$	M1
	Sub for α AND compare: $(\text{max friction}) = \frac{1}{2}mg \times \frac{5}{\sqrt{29}} = \frac{5\sqrt{29}mg}{58} = 0.4642..mg$ $(\text{wt cpt}) = mg \times \frac{2}{\sqrt{29}} = \frac{4\sqrt{29}mg}{58} = 0.371..mg$ AND e.g. $0.464mg > 0.371mg$ N.B. Must see an inequality or a difference i.e words are not sufficient. OR: use $\tan \alpha = \frac{2}{5}$, e.g. $mg \sin \alpha = \frac{2}{5}mg \cos \alpha < \frac{1}{2}(mg \cos \alpha)$ OR: At rest if $\frac{1}{2}(mg \cos \alpha) > mg \sin \alpha$ oe	A1



	$\frac{1}{2} > \tan \alpha$	
	Conclusion: since $0.4642\ldots > 0.371\ldots$ the box remains at rest. OR: $\frac{1}{2} > \frac{2}{5}$ so the box remains at rest.	A1
		(3)
		(12)
	Notes for Question 6	
6(a)		
M1	Resolve parallel to the plane to give an expression in m , g and α only. Correct no. of terms, dimensionally correct, any forces that should be resolved must be resolved, condone sign errors and sin/cos confusion.	
A1	Unsimplified expression in m , g and α only, with at most one error (if both signs are wrong treat as one error) Sin/cos reversed is ONE error. Omission of g 's is ONE error.	
A1	Correct expression	
6(b)		
M1	Resolve perpendicular to the plane. Correct no. of terms, dimensionally correct, any forces that should be resolved must be resolved, condone sign errors and sin/cos confusion.	
A1	Correct unsimplified equation.	
B1	Use of $\max F = \frac{1}{2} R$	
M1	Eliminate F and R to form an equation in mg and α with correct no. of terms	
A1	Correct equation in mg and α	
A1*	cso Complete method to reach the given answer from sufficient working, must have collected the $\sin \alpha$ terms and the $\cos \alpha$ terms, before proceeding to the given answer OR collect $\tan \alpha$ terms if they divide through by $\cos \alpha$ first.	
6(c)		
M1	Finds new max friction and weight component down the plane. Condone sign errors and sin/cos confusion. M0 if no new R is used.	
A1	Correct expressions with α replaced AND compared or difference found (this could be done by writing down an equation of motion parallel to the plane) OR: if α not replaced, correct inequality in $\tan \alpha$ only.	
A1	Correct conclusion with valid reason.	

QUESTION NUMBER	SCHEME	MARKS
7		
7(a)	First equation of motion for either particle or whole system. For A : $T - 2mg = 2ma$ For B : $3mg - T = 3ma$ For system: $3mg - 2mg = 5ma$	M1 A1
	Second equation of motion for either particle or whole system.	M1 A1
	$T = \frac{12mg}{5}$ or $2.4mg$	A1
		(5)
7(b)	Acceleration = $\frac{g}{5}$ oe (must be used in (b))	B1
	$v^2 = 0^2 + 2 \times \text{their } a \times (0.5)$	M1
	$v^2 = 2 \times \frac{g}{5} \times 0.5$ (=1.96)	A1
	$v = 1.4$ (m s^{-1})	A1
		(4)
7(c)	Equation for time to travel the first 0.5m e.g. $0.5 = 0 + \frac{1}{2} \left(\frac{g}{5} \right) t^2$ OR $0.5 = \left(\frac{0 + 1.4}{2} \right) t$	M1 A1
	Equation for time for which A is moving under gravity $0.06 = 1.4t + \frac{1}{2}(-g)t^2$	M1 A1ft