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Surname

Other names

**Pearson Edexcel**  
**Level 3 GCE**

Centre Number

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Candidate Number

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# Mathematics

**Advanced**

**Paper 3: Statistics and Mechanics**

Sample Assessment Material for first teaching September 2017

**Time: 2 hours**

Paper Reference

**9MA0/03**

**You must have:**

Mathematical Formulae and Statistical Tables, calculator

Total Marks

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**Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for algebraic manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.**

## Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- There are **two** sections in this question paper. Answer **all** the questions in Section A and **all** the questions in Section B.
- Answer the questions in the spaces provided  
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Answers should be given to three significant figures unless otherwise stated.

## Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 10 questions in this question paper. The total mark for this paper is 100.
- The marks for **each** question are shown in brackets  
– *use this as a guide as to how much time to spend on each question.*

## Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer cross it out and put your new answer and any working out underneath.

Turn over ►

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## SECTION A: STATISTICS

**Answer ALL questions. Write your answers in the spaces provided.**

1. The number of hours of sunshine each day,  $y$ , for the month of July at Heathrow are summarised in the table below.

<b>Hours</b>	$0 \leq y < 5$	$5 \leq y < 8$	$8 \leq y < 11$	$11 \leq y < 12$	$12 \leq y < 14$
<b>Frequency</b>	12	6	8	3	2

A histogram was drawn to represent these data. The  $8 \leq y < 11$  group was represented by a bar of width 1.5 cm and height 8 cm.

- (a) Find the width and the height of the  $0 \leq y < 5$  group. (3)

- (b) Use your calculator to estimate the mean and the standard deviation of the number of hours of sunshine each day, for the month of July at Heathrow.  
Give your answers to 3 significant figures. (3)

The mean and standard deviation for the number of hours of daily sunshine for the same month in Hurn are 5.98 hours and 4.12 hours respectively.  
Thomas believes that the further south you are the more consistent should be the number of hours of daily sunshine.

- (c) State, giving a reason, whether or not the calculations in part (b) support Thomas' belief. (2)

- (d) Estimate the number of days in July at Heathrow where the number of hours of sunshine is more than 1 standard deviation above the mean. (2)

Helen models the number of hours of sunshine each day, for the month of July at Heathrow by  $N(6.6, 3.7^2)$ .

- (e) Use Helen's model to predict the number of days in July at Heathrow when the number of hours of sunshine is more than 1 standard deviation above the mean. (2)

- (f) Use your answers to part (d) and part (e) to comment on the suitability of Helen's model. (1)

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2. A meteorologist believes that there is a relationship between the daily mean windspeed,  $w$  kn, and the daily mean temperature,  $t$  °C. A random sample of 9 consecutive days is taken from past records from a town in the UK in July and the relevant data is given in the table below.

$t$	13.3	16.2	15.7	16.6	16.3	16.4	19.3	17.1	13.2
$w$	7	11	8	11	13	8	15	10	11

The meteorologist calculated the product moment correlation coefficient for the 9 days and obtained  $r = 0.609$

- (a) Explain why a linear regression model based on these data is unreliable on a day when the mean temperature is 24 °C (1)
- (b) State what is measured by the product moment correlation coefficient. (1)
- (c) Stating your hypotheses clearly test, at the 5% significance level, whether or not the product moment correlation coefficient for the population is greater than zero. (3)
- Using the same 9 days a location from the large data set gave  $\bar{t} = 27.2$  and  $\bar{w} = 3.5$
- (d) Using your knowledge of the large data set, suggest, giving your reason, the location that gave rise to these statistics. (1)

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**Question 2 continued**

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(Total for Question 2 is 6 marks)

3. A machine cuts strips of metal to length  $L$  cm, where  $L$  is normally distributed with standard deviation 0.5 cm.

Strips with length either less than 49 cm or greater than 50.75 cm **cannot** be used.

Given that 2.5% of the cut lengths exceed 50.98 cm,

(a) find the probability that a randomly chosen strip of metal **can** be used. (5)

Ten strips of metal are selected at random.

(b) Find the probability fewer than 4 of these strips **cannot** be used. (2)

A second machine cuts strips of metal of length  $X$  cm, where  $X$  is normally distributed with standard deviation 0.6 cm

A random sample of 15 strips cut by this second machine was found to have a mean length of 50.4 cm

(c) Stating your hypotheses clearly and using a 1% level of significance, test whether or not the mean length of all the strips, cut by the second machine, is greater than 50.1 cm (5)

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**(Total for Question 3 is 12 marks)**

4. Given that

$$P(A) = 0.35 \quad P(B) = 0.45 \quad \text{and} \quad P(A \cap B) = 0.13$$

find

(a)  $P(A' | B')$  (2)

(b) Explain why the events  $A$  and  $B$  are not independent. (1)

The event  $C$  has  $P(C) = 0.20$

The events  $A$  and  $C$  are mutually exclusive and the events  $B$  and  $C$  are statistically independent.

(c) Draw a Venn diagram to illustrate the events  $A$ ,  $B$  and  $C$ , giving the probabilities for each region. (5)

(d) Find  $P([B \cup C]')$  (2)









## SECTION B: MECHANICS

Answer ALL questions. Write your answers in the spaces provided.

Unless otherwise indicated, whenever a numerical value of  $g$  is required, take  $g = 9.8 \text{ m s}^{-2}$  and give your answer to either 2 significant figures or 3 significant figures.

6. At time  $t$  seconds, where  $t \geq 0$ , a particle  $P$  moves so that its acceleration  $\mathbf{a} \text{ m s}^{-2}$  is given by

$$\mathbf{a} = 5t\mathbf{i} - 15t^{\frac{1}{2}}\mathbf{j}$$

When  $t = 0$ , the velocity of  $P$  is  $20\mathbf{i} \text{ m s}^{-1}$

Find the speed of  $P$  when  $t = 4$

(6)

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8. [In this question  $\mathbf{i}$  and  $\mathbf{j}$  are horizontal unit vectors due east and due north respectively]

A radio controlled model boat is placed on the surface of a large pond.

The boat is modelled as a particle.

At time  $t = 0$ , the boat is at the fixed point  $O$  and is moving due north with speed  $0.6 \text{ m s}^{-1}$ .

Relative to  $O$ , the position vector of the boat at time  $t$  seconds is  $\mathbf{r}$  metres.

At time  $t = 15$ , the velocity of the boat is  $(10.5\mathbf{i} - 0.9\mathbf{j}) \text{ m s}^{-1}$ .

The acceleration of the boat is constant.

- (a) Show that the acceleration of the boat is  $(0.7\mathbf{i} - 0.1\mathbf{j}) \text{ m s}^{-2}$ . (2)
- (b) Find  $\mathbf{r}$  in terms of  $t$ . (2)
- (c) Find the value of  $t$  when the boat is north-east of  $O$ . (3)
- (d) Find the value of  $t$  when the boat is moving in a north-east direction. (3)













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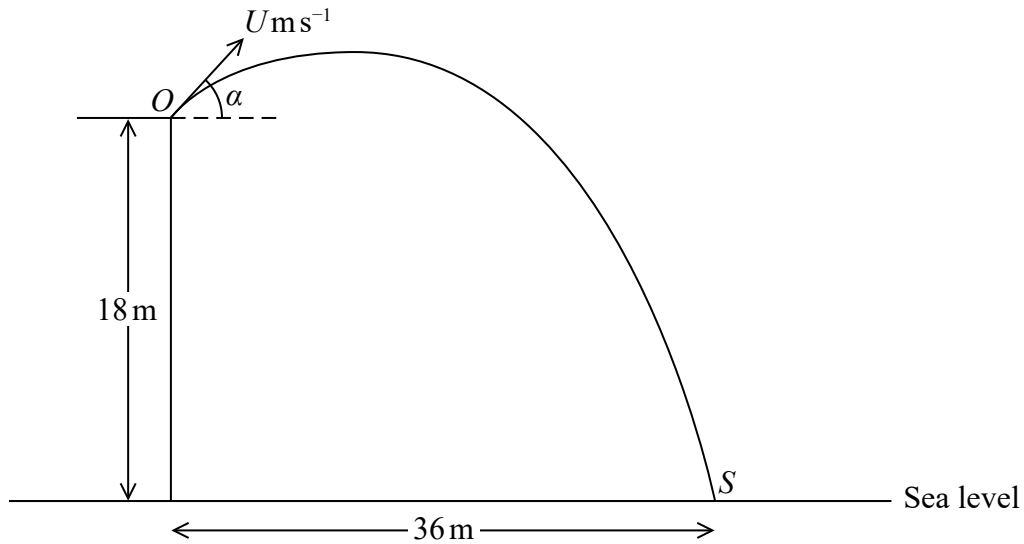


Figure 2

A boy throws a stone with speed  $U \text{ ms}^{-1}$  from a point  $O$  at the top of a vertical cliff. The point  $O$  is 18 m above sea level.

The stone is thrown at an angle  $\alpha$  above the horizontal, where  $\tan \alpha = \frac{3}{4}$ .

The stone hits the sea at the point  $S$  which is at a horizontal distance of 36 m from the foot of the cliff, as shown in Figure 2.

The stone is modelled as a particle moving freely under gravity with  $g = 10 \text{ m s}^{-2}$

Find

- (a) the value of  $U$ , (6)
- (b) the speed of the stone when it is 10.8 m above sea level, giving your answer to 2 significant figures. (5)
- (c) Suggest two improvements that could be made to the model. (2)

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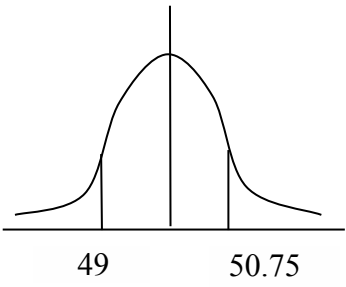


### Paper 3: Statistics and Mechanics Mark Scheme

Question	Scheme	Marks	AOs
<b>1(a)</b>	<b>Area</b> = $8 \times 1.5 = 12 \text{ cm}^2$ <b>Frequency</b> = 8 so $1 \text{ cm}^2 = \frac{2}{3} \text{ hour (o.e.)}$	M1	3.1a
	Frequency of 12 corresponds to area of 18 so height = $18 \div 2.5 = 7.2 \text{ (cm)}$	A1	1.1b
	<b>Width</b> = $5 \times 0.5 = 2.5 \text{ (cm)}$	B1cao	1.1b
		<b>(3)</b>	
<b>(b)</b>	$[\bar{y} =] \frac{205.5}{31} = \text{awrt } 6.63$	B1cao	1.1b
	$[\sigma_y =] \sqrt{\frac{1785.25}{31} - \bar{y}^2} = \sqrt{13.644641} = \text{awrt } 3.69$	M1	1.1a
	allow $[s =] \sqrt{\frac{1785.25 - 31\bar{y}^2}{30}} = \text{awrt } 3.75$	A1	1.1b
		<b>(3)</b>	
<b>(c)</b>	Mean of Heathrow is higher than Hurn and standard deviation smaller suggesting Heathrow is more reliable	M1	2.4
	Hurn is South of Heathrow so does <u>not</u> support his belief	A1	2.2b
		<b>(2)</b>	
<b>(d)</b>	$\bar{x} + \sigma \approx 10.3$ so number of days is e.g. $\frac{(11 - "10.3")}{3} \times 8 (+5)$	M1	1.1b
	= 6.86 so <b>7 days</b>	A1	1.1b
		<b>(2)</b>	
<b>(e)</b>	$[H = \text{no. of hours}] \quad P(H > 10.3) \text{ or } P(Z > 1) = [0.15865\dots]$	M1	3.4
	Predict $31 \times 0.15865\dots = \underline{\underline{4.9 \text{ or } 5 \text{ days}}}$	A1	1.1b
		<b>(2)</b>	
<b>(f)</b>	(5 or ) 4.9 days < (7 or ) 6.9 days so model may <b>not</b> be suitable	B1	3.5a
		<b>(1)</b>	
<b>(13 marks)</b>			

**Question 1 continued****Notes:****(a)****M1:** for clear attempt to relate the area to frequency. Can also award if their height  $\times$  their width = 18**A1:** for height = 7.2 (cm)**(b)****M1:** for a correct expression for  $\sigma$  or  $s$ , can ft their value for mean**A1:** awrt 3.69 (allow  $s = 3.75$ )**(c)****M1:** for a suitable comparison of standard deviations to comment on reliability.**A1:** for stating Hurn is south of Heathrow and a correct conclusion**(d)****M1:** for a correct expression – ft their  $\bar{x} + \sigma \approx 10.3$ **A1:** for 7 days but accept 6 (rounding down) following a correct expression**(e)****M1:** for a correct probability attempted**A1:** for a correct prediction**(f)****B1:** for a suitable comparison and a compatible conclusion

Question	Scheme	Marks	AOs
<b>2(a)</b>	e.g. It requires extrapolation so will be unreliable (o.e.)	B1	1.2
		(1)	
<b>(b)</b>	e.g. Linear association between $w$ and $t$	B1	1.2
		(1)	
<b>(c)</b>	$H_0: \rho = 0$ $H_1: \rho > 0$	B1	2.5
	Critical value 0.5822	M1	1.1a
	Reject $H_0$		
	There is evidence that the product moment correlation coefficient is greater than 0	A1	2.2b
		(3)	
<b>(d)</b>	Higher $\bar{t}$ suggests overseas and not Perth...lower wind speed so perhaps not close to the sea so suggest <b>Beijing</b>	B1	2.4
		(1)	
<b>(6 marks)</b>			
<b>Notes:</b>			
<b>(a)</b>	<b>B1:</b> for a correct statement (unreliable) with a suitable reason		
<b>(b)</b>	<b>B1:</b> for a correct statement		
<b>(c)</b>	<b>B1:</b> for both hypotheses in terms of $\rho$		
	<b>M1:</b> for selecting a suitable 5% critical value compatible with their $H_1$		
	<b>A1:</b> for a correct conclusion stated		
<b>(d)</b>	<b>B1:</b> for suggesting Beijing with some supporting reason based on $t$ or $w$		
	Allow Jacksonville with a reason based just on higher $\bar{t}$		

Question	Scheme	Marks	AOs
<b>Q3(a)</b>			
	$P(L > 50.98) = 0.025$	B1cao	3.4
	$\therefore \frac{50.98 - \mu}{0.5} = 1.96$	M1	1.1b
	$\therefore \mu = 50$	A1cao	1.1b
	$P(49 < L < 50.75)$	M1	3.4
	$= 0.9104\dots$ awrt <b>0.910</b>	A1ft	1.1b
		<b>(5)</b>	
<b>(b)</b>	$S =$ number of strips that cannot be used so $S \sim B(10, 0.090)$	M1	3.3
	$= P(S \leq 3) = 0.991166\dots$ awrt 0.991	A1	1.1b
		<b>(2)</b>	
<b>(c)</b>	$H_0 : \mu = 50.1$ $H_1 : \mu > 50.1$	B1	2.5
	$\bar{X} \sim N\left(50.1, \frac{0.6^2}{15}\right)$ and $\bar{X} > 50.4$	M1	3.3
	$P(\bar{X} > 50.4) = 0.0264$	A1	3.4
	$p = 0.0264 > 0.01$ or $z = 1.936\dots < 2.3263$ and not significant	A1	1.1b
	There is insufficient evidence that the <b>mean length</b> of strips is <b>greater than 50.1</b>	A1	2.2b
		<b>(5)</b>	
<b>(12 marks)</b>			

**Question 3 continued****Notes:****(a)****1<sup>st</sup> M1:** for standardizing with  $\mu$  and 0.5 and setting equal to a  $z$  value ( $|z| > 1$ )**2<sup>nd</sup> M1:** for attempting the correct probability for strips that can be used**2<sup>nd</sup> A1ft:** awrt 0.910 (allow ft of their  $\mu$ )**(b)****M1:** for identifying a suitable binomial distribution**A1:** awrt 0.991 (from calculator)**(c)****B1:** hypotheses stated correctly**M1:** for selecting a correct model (stated or implied)**1<sup>st</sup> A1:** for use of the correct model to find  $p =$  awrt 0.0264 (allow  $z =$  awrt 1.94)**2<sup>nd</sup> A1:** for a correct calculation, comparison and correct statement**3<sup>rd</sup> A1:** for a correct conclusion in context mentioning “mean length” and 50.1

Question	Scheme	Marks	AOs
<b>4(a)</b>	$P(A'   B') = \frac{P(A' \cap B')}{P(B')} \text{ or } \frac{0.33}{0.55}$	M1	3.1a
	$= \frac{3}{5} \text{ or } 0.6$	A1	1.1b
		<b>(2)</b>	
<b>(b)</b>	e.g. $P(A) \times P(B) = \frac{7}{20} \times \frac{9}{20} = \frac{63}{400} \neq P(A \cap B) = 0.13 = \frac{52}{400}$ or $P(A'   B') = 0.6 \neq P(A') = 0.65$	B1	2.4
		<b>(1)</b>	
<b>(c)</b>		B1	2.5
		M1	3.1a
		A1	1.1b
		M1	1.1b
		A1	1.1b
	<b>(5)</b>		
<b>(d)</b>	$P(B \cup C)' = 0.22 + 0.22 \text{ or } 1 - [0.56]$ or $1 - [0.13 + 0.23 + 0.09 + 0.11]$	M1	1.1b
	$= 0.44$	A1	1.1b
		<b>(2)</b>	
<b>(10 marks)</b>			
<b>Notes:</b>			
<b>(a)</b> <b>M1:</b> for a correct ratio of probabilities formula and at least one correct value. <b>A1:</b> a correct answer			
<b>(b)</b> for a fully correct explanation: correct probabilities and correct comparisons.			
<b>(c)</b> <b>B1:</b> for box with $B$ intersecting $A$ and $C$ but $C$ not intersecting $A$ . (Or accept three intersecting circles, but with zeros entered for $A \cap C$ and $A \cap B \cap C$ ) No box is $B_0$ <b>M1:</b> for method for finding $P(B \cap C)$ <b>A1:</b> for 0.09 <b>M1:</b> for 0.13 and their 0.09 in correct places and method for their 0.23 <b>A1:</b> fully correct			
<b>(d)</b> <b>M1:</b> for a correct expression – fit their probabilities from their Venn diagram. <b>A1:</b> cao			



Question	Scheme	Marks	AOs
<b>5 (a)</b>	The seeds would be destroyed in the process so they would have none to sell	B1	2.4
		(1)	
<b>(b)</b>	[ $S = \text{no. of seeds out of 24 that germinate, } S \sim B(24, 0.55)$ ]		
	$T = \text{no. of trays with at least 15 germinating. } T \sim B(10, p)$	M1	3.3
	$p = P(S \geq 15) = 0.299126\dots$	A1	1.1b
	So $P(T \geq 5) = 0.1487\dots$ awrt <b>0.149</b>	A1	1.1b
		(3)	
<b>(c)</b>	$n$ is large and $p$ close to 0.5	B1	1.2
		(1)	
<b>(d)</b>	$X \sim N(132, 59.4)$	B1	3.4
	$P(X \geq 149.5) = P\left(Z \geq \frac{149.5 - 132}{\sqrt{59.4}}\right)$	M1	1.1b
	$= 0.01158\dots$ awrt <b>0.0116</b>	A1cso	1.1b
		(3)	
<b>(e)</b>	e.g The probability is very small therefore there is evidence that the company's claim is incorrect.	B1	2.2b
		(1)	
<b>(9 marks)</b>			
<b>Notes:</b>			
<b>(a)</b> B1: cao			
<b>(b)</b> M1: for selection of an appropriate model for $T$ 1 <sup>st</sup> A1: for a correct value of the parameter $p$ (accept 0.3 or better) 2 <sup>nd</sup> A1: for awrt 0.149			
<b>(c)</b> B1: both correct conditions			
<b>(d)</b> B1: for correct normal distribution M1: for correct use of continuity correction A1: cso			
<b>(e)</b> B1: correct statement			

Question	Scheme	Marks	AOs
6	Integrate $\mathbf{a}$ w.r.t. time	M1	1.1a
	$\mathbf{v} = \frac{5t^2}{2}\mathbf{i} - 10t^{\frac{3}{2}}\mathbf{j} + \mathbf{C}$ (allow omission of $\mathbf{C}$ )	A1	1.1b
	$\mathbf{v} = \frac{5t^2}{2}\mathbf{i} - 10t^{\frac{3}{2}}\mathbf{j} + 20\mathbf{i}$	A1	1.1b
	When $t = 4$ , $\mathbf{v} = 60\mathbf{i} - 80\mathbf{j}$	M1	1.1b
	Attempt to find magnitude: $\sqrt{(60^2 + 80^2)}$	M1	3.1a
	Speed = $100 \text{ m s}^{-1}$	A1ft	1.1b
			<b>(6 marks)</b>
<b>Notes:</b>			
<p><b>1<sup>st</sup> M1:</b> for integrating <math>\mathbf{a}</math> w.r.t. time (powers of <math>t</math> increasing by 1)</p> <p><b>1<sup>st</sup> A1:</b> for a correct <math>\mathbf{v}</math> expression without <math>\mathbf{C}</math></p> <p><b>2<sup>nd</sup> A1:</b> for a correct <math>\mathbf{v}</math> expression including <math>\mathbf{C}</math></p> <p><b>2<sup>nd</sup> M1:</b> for putting <math>t = 4</math> into their <math>\mathbf{v}</math> expression</p> <p><b>3<sup>rd</sup> M1:</b> for finding magnitude of their <math>\mathbf{v}</math></p> <p><b>3<sup>rd</sup> A1:</b> ft for <math>100 \text{ m s}^{-1}</math>, follow through on an incorrect <math>\mathbf{v}</math></p>			

Question	Scheme	Marks	AOs
<b>7(a)</b>	$R = mg\cos\alpha$	B1	3.1b
	Resolve parallel to the plane	M1	3.1b
	$-F - mg\sin\alpha = -0.8mg$	A1	1.1b
	$F = \mu R$	M1	1.2
	Produce an equation in $\mu$ only and solve for $\mu$	M1	2.2a
	$\mu = \frac{1}{4}$	A1	1.1b
		<b>(6)</b>	
<b>(b)</b>	Compare $\mu mg\cos\alpha$ with $mg\sin\alpha$	M1	3.1b
	Deduce an appropriate conclusion	A1 ft	2.2a
		<b>(2)</b>	
			<b>(8 marks)</b>
<b>Notes:</b>			
<b>(a)</b>			
<b>B1:</b> for $R = mg\cos\alpha$			
<b>1<sup>st</sup> M1:</b> for resolving parallel to the plane			
<b>1<sup>st</sup> A1:</b> for a correct equation			
<b>2<sup>nd</sup> M1:</b> for use of $F = \mu R$			
<b>3<sup>rd</sup> M1:</b> for eliminating $F$ and $R$ to give a value for $\mu$			
<b>2<sup>nd</sup> A1:</b> for $\mu = \frac{1}{4}$			
<b>(b)</b>			
<b>M1:</b> comparing size of limiting friction with weight component down the plane			
<b>A1ft:</b> for an appropriate conclusion from their values			

Question	Scheme	Marks	AOs
<b>8(a)</b>	Use of $\mathbf{v} = \mathbf{u} + \mathbf{at}$ : $(10.5\mathbf{i} - 0.9\mathbf{j}) = 0.6\mathbf{j} + 15\mathbf{a}$	M1	3.1b
	$\mathbf{a} = (0.7\mathbf{i} - 0.1\mathbf{j}) \text{ m s}^{-2}$ Given answer	A1	1.1b
		<b>(2)</b>	
<b>(b)</b>	Use of $\mathbf{r} = \mathbf{ut} + \frac{1}{2} \mathbf{at}^2$	M1	3.1b
	$\mathbf{r} = 0.6\mathbf{j}t + \frac{1}{2}(0.7\mathbf{i} - 0.1\mathbf{j})t^2$	A1	1.1b
		<b>(2)</b>	
<b>(c)</b>	Equating the <b>i</b> and <b>j</b> components of <b>r</b>	M1	3.1b
	$\frac{1}{2} \leftarrow 0.7t^2 = 0.6t - \frac{1}{2} \leftarrow 0.1t^2$	A1ft	1.1b
	$t = 1.5$	A1	1.1b
		<b>(3)</b>	
<b>(d)</b>	Use of $\mathbf{v} = \mathbf{u} + \mathbf{at}$ : $\mathbf{v} = 0.6\mathbf{j} + (0.7\mathbf{i} - 0.1\mathbf{j})t$	M1	3.1b
	Equating the <b>i</b> and <b>j</b> components of <b>v</b>	M1	3.1b
	$t = 0.75$	A1 ft	1.1b
		<b>(3)</b>	
			<b>(10 marks)</b>
<b>Notes:</b>			
<b>(a)</b>			
<b>M1:</b> for use of $\mathbf{v} = \mathbf{u} + \mathbf{at}$			
<b>A1:</b> for given answer correctly obtained			
<b>(b)</b>			
<b>M1:</b> for use of $\mathbf{r} = \mathbf{ut} + \frac{1}{2} \mathbf{at}^2$			
<b>A1:</b> for a correct expression for <b>r</b> in terms of $t$			
<b>(c)</b>			
<b>M1:</b> for equating the <b>i</b> and <b>j</b> components of their <b>r</b>			
<b>A1ft:</b> for a correct equation following their <b>r</b>			
<b>A1:</b> for $t = 1.5$			
<b>(d)</b>			
<b>M1:</b> for use of $\mathbf{v} = \mathbf{u} + \mathbf{at}$ for a general $t$			
<b>M1:</b> for equating the <b>i</b> and <b>j</b> components of their <b>v</b>			
<b>A1ft:</b> for $t = 0.75$ , or a correct follow through answer from an incorrect equation			

Question	Scheme	Marks	AOs
<b>9(a)</b>	Take moments about $A$ (or any other complete method to produce an equation in $S$ , $W$ and $\alpha$ only)	M1	3.3
	$W \cos \alpha + 7W \cos \alpha = S \sin \alpha$	A1 A1	1.1b 1.1b
	Use of $\tan \alpha = \frac{5}{2}$ to obtain $S$	M1	2.1
	$S = 3W$ *	A1*	2.2a
		<b>(5)</b>	
<b>(b)</b>	$R = 8W$	B1	3.4
	$F = \frac{1}{4} R (= 2W)$	M1	3.4
	$P_{\text{MAX}} = 3W + F$ or $P_{\text{MIN}} = 3W - F$	M1	3.4
	$P_{\text{MAX}} = 5W$ or $P_{\text{MIN}} = W$	A1	1.1b
	$W \leq P \leq 5W$	A1	2.5
		<b>(5)</b>	
<b>(c)</b>	M(A) shows that the reaction on the ladder at $B$ is unchanged	M1	2.4
	also $R$ increases (resolving vertically)	M1	2.4
	which increases max $F$ available	M1	2.4
		<b>(3)</b>	
			<b>(13 marks)</b>

**Question 9 continued****Notes:****(a)****1<sup>st</sup> M1:** for producing an equation in  $S$ ,  $W$  and  $\alpha$  only**1<sup>st</sup> A1:** for an equation that is correct, or which has one error or omission**2<sup>nd</sup> A1:** for a fully correct equation**2<sup>nd</sup> M1:** for use of  $\tan \alpha = \frac{5}{2}$  to obtain  $S$  in terms of  $W$  only**3<sup>rd</sup> A1\*:** for given answer  $S = 3W$  correctly obtained**(b)****B1:** for  $R = 8W$ **1<sup>st</sup> M1:** for use of  $F = \frac{1}{4} R$ **2<sup>nd</sup> M1:** for either  $P = (3W + \text{their } F)$  or  $P = (3W - \text{their } F)$ **1<sup>st</sup> A1:** for a correct max or min value for a correct range for  $P$ **2<sup>nd</sup> A1:** for a correct range for  $P$ **(c)****1<sup>st</sup> M1:** for showing, by taking moments about  $A$ , that the reaction at  $B$  is unchanged by the builder's assistant standing on the bottom of the ladder**2<sup>nd</sup> M1:** for showing, by resolving vertically, that  $R$  increases as a result of the builder's assistant standing on the bottom of the ladder**3<sup>rd</sup> M1:** for concluding that this increases the limiting friction at  $A$

Question	Scheme	Marks	AOs
<b>10(a)</b>	Using the model and horizontal motion: $s = ut$	M1	3.4
	$36 = U t \cos \alpha$	A1	1.1b
	Using the model and vertical motion: $s = ut + \frac{1}{2}at^2$	M1	3.4
	$-18 = U t \sin \alpha - \frac{1}{2}gt^2$	A1	1.1b
	Correct strategy for solving the problem by setting up two equations in $t$ and $U$ and solving for $U$	M1	3.1b
	$U = 15$	A1	1.1b
		<b>(6)</b>	
<b>(b)</b>	Using the model and horizontal motion: $U \cos \alpha$ (12)	B1	3.4
	Using the model and vertical motion: $v^2 = (U \sin \alpha)^2 + 2(-10)(-7.2)$	M1	3.4
	$v = 15$	A1	1.1b
	Correct strategy for solving the problem by finding the horizontal and vertical components of velocity and combining using Pythagoras: Speed = $\sqrt{(12^2 + 15^2)}$	M1	3.1b
	$\sqrt{369} = 19 \text{ m s}^{-1}$ (2sf)	A1 ft	1.1b
		<b>(5)</b>	
<b>(c)</b>	Possible improvement (see below in notes)	B1	3.5c
	Possible improvement (see below in notes)	B1	3.5c
		<b>(2)</b>	
			<b>(13 marks)</b>

**Question 10 continued****Notes:****(a)****1<sup>st</sup> M1:** for use of  $s = ut$  horizontally**1<sup>st</sup> A1:** for a correct equation**2<sup>nd</sup> M1:** for use of  $s = ut + \frac{1}{2}at^2$  vertically**2<sup>nd</sup> A1:** for a correct equation**3<sup>rd</sup> M1:** for correct strategy (need both equations)**2<sup>nd</sup> A1:** for  $U = 15$ **(b)****B1:** for  $U\cos\alpha$  used as horizontal velocity component**1<sup>st</sup> M1:** for attempt to find vertical component**1<sup>st</sup> A1:** for 15**2<sup>nd</sup> M1:** for correct strategy (need both components)**2<sup>nd</sup> A1ft:** for  $19 \text{ m s}^{-1}$  (2sf) following through on incorrect component(s)**(c)****B1, B1:** for any two of

e.g. Include air resistance in the model of the motion

e.g. Use a more accurate value for  $g$  in the model of the motion

e.g. Include wind effects in the model of the motion

e.g. Include the dimensions of the stone in the model of the motion