



Pearson  
Edexcel

## Mark Scheme (Results)

October 2020

Pearson Edexcel GCE Advanced Level  
In Mathematics (9MA0)  
Paper 31 Statistics

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Autumn 2020

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## General Marking Guidance

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- 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.
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- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

## PEARSON EDEXCEL GCE MATHEMATICS

### General Instructions for Marking

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2. These mark schemes use the following types of marks:
  - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
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  - **B** marks are unconditional accuracy marks (independent of M marks)
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3. 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  $\checkmark$  will be used for correct ft
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  - **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
  - **o.e.** – or equivalent (and appropriate)
  - **d** or **dep** – dependent
  - **indep** – independent
  - **dp** decimal places
  - **sf** significant figures
  - \* The answer is printed on the paper or ag- answer given
4. All M marks are follow through.  
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 answers that don't logically make sense e.g. if an answer given for a probability is  $>1$  or  $<0$ , should never be awarded A marks.
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8. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used. If no such alternative answer is provided but the response is deemed to be valid, examiners must escalate the response for a senior examiner to review.

Qu 1	Scheme	Marks	AO
(a)	$A, C$ <u>or</u> $D, B$ <u>or</u> $D, C$	B1 <b>(1)</b>	1.2
(b)	$[p = 0.4 - 0.07 - 0.24 = ]$ <b><u>0.09</u></b>	B1 <b>(1)</b>	1.1b
(c)	$A$ and $B$ independent implies $P(A) \times 0.4 = 0.24$ <u>or</u> $(q + 0.16 + 0.24) \times 0.4 = 0.24$  so $P(A) = 0.6$ and $q =$ <b><u>0.20</u></b>	M1  A1cso <b>(2)</b>	1.1b
(d)(i)	$P(B'   C) = 0.64$ gives $\frac{r}{r+p} = 0.64$ <u>or</u> $\frac{r}{r+0.09} = 0.64$  $r = 0.64r + 0.64$ "p" so $0.36r = 0.0576$ so $r =$ <b><u>0.16</u></b>	M1  A1	3.1a  1.1b
(ii)	Using sum of probabilities = 1 e.g. "0.6" + 0.07 + "0.25" + $s = 1$  so $s =$ <b><u>0.08</u></b>	M1  A1 <b>(4)</b>	1.1b  1.1b
		<b>( 8 marks)</b>	
<b>Notes</b>			
(a)	B1 for one correct pair. If more than one pair they must all be correct. Condone in a correct probability statement such as $P(A \cap C) = 0$ or correct use of set notation e.g. $A \cap C = \emptyset$ BUT e.g. "P(A) and P(C) are mutually exclusive" alone is B0		
(b)	B1 for $p = 0.09$ (Maybe stated in Venn Diagram [VD]) [ If values in VD and text conflict, take text or a value <u>used</u> in a later part]		
(c)	M1 for a correct equation in one variable for $P(A)$ or $q$ using independence <u>or</u> for seeing <b>both</b> $P(A \cap B) = P(A) \times P(B)$ <u>and</u> $0.24 = 0.6 \times 0.4$ A1cso for $q = 0.20$ or exact equivalent (dep on correct use of independence) Use of $P(A) = 1 - P(B) = 0.6$ leading to $q = 0.2$ scores M0A0		
<b>Beware</b>			
(d)(i)	1 <sup>st</sup> M1 for use of $P(B'   C) = 0.64$ leading to a correct equation in $r$ and possibly $p$ . Can fit their $p$ provided $0 < p < 1$ 1 <sup>st</sup> A1 for $r = 0.16$ or exact equivalent		
(ii)	2 <sup>nd</sup> M1 for use of total probability = 1 to form a linear equation in $s$ . Allow $p, q, r$ etc Can follow through their values provided each of $p, q, r$ are in $[0, 1)$ 2 <sup>nd</sup> A1 for $s = 0.08$ or exact equivalent		

Qu 2	Scheme	Marks	AO
(a)	Negative	B1 (1)	1.2
(b)(i)	Rainfall	B1	2.2b
(ii)	mm   <u>or</u>   Pressure hPa or Pascals or hectopascals or mb or millibars	B1ft (2)	1.1b
(c)	$H_0 : \rho = 0$ $H_1 : \rho \neq 0$ Critical value: $-0.361(0)$ $r < -0.3610$ so significant result and there is evidence of a correlation between Daily Total <u>Sunshine</u> and Daily Maximum Relative <u>Humidity</u>	B1 M1 A1 (3)	2.5 1.1b 2.2b
(d)	Humidity is high and there is evidence of correlation and $r < 0$ So expect amount of sunshine to be <u>lower</u> than the <u>average</u> for Heathrow(oe)	B1 (1)	2.2b
		<b>( 7 marks)</b>	
<b>Notes</b>			
(a)	B1 for stating negative. “Negative skew” is B0 though		
(b)(i)	B1 for mentioning “rainfall” (allow “rain” <u>or</u> “precipitation”) <u>or</u> “pressure” (if more than 1 answer both must be correct) NB the other quantitative variable for Perth is: Daily Mean Wind Speed and scores B0 [Not allowed “wind speed” since $r = +0.15$ and in winter might expect wind to raise temp]		
(ii)	B1ft for giving the correct units. If Daily Mean Wind Speed (kn) or knots “Wind speed” and “knots” would score B0B1 but any other variable scores B0B0		
(c)	B1 for both hypotheses correct in terms of $\rho$ M1 for the correct critical value compatible with their $H_1$ : allow $\pm 0.361(0)$ If the hypotheses are 1-tail then allow cv of $\pm 0.3061$ e.g. Alternative hypothesis with $r < \pm 0.377$ implies a one-tail test <u>or</u> $H_0$ and $H_1$ in words saying “ $H_0$ : there is no correlation, $H_1$ : there is correlation” is two-tail If there are no hypotheses (or they are nonsensical) assume 2-tail so M1 for $\pm 0.361(0)$		
	A1 for a correct conclusion in context based on comparing $-0.377$ with their cv. Condone incorrect inequality e.g. $-0.3610 < -0.377$ as long as they reject $H_0$ Do not accept contradictory statements such as “accept $H_0$ so there is evidence of ...” Can say “support for Stav’s <u>belief</u> ”(o.e.e.g. “claim”) or “evidence of a correlation between <u>sunshine</u> and <u>humidity</u> ” condone “negative correlation” or comments such as “if humidity is high amount of sunshine will be low”		
(d)	B1 for stating <u>low</u> amount of sunshine (o. e.) <b>and</b> some reference to $r < 0$ or fog Check for the following 2 features: (i) <b>low</b> sunshine: allow $\leq 5$ hrs (LDS mean for 2015 is 5.3, humidity 97% is 4.1, $\geq 97\%$ is 3.1) (ii) <b>negative</b> correlation may be described in words e.g. “high humidity gives low sunshine” <u>or</u> <b>fog</b> (LDS says $>95\%$ humidity is foggy) so less sunshine		

Qu 3	Scheme	Marks	AO
(a)	$[68 - 7 = ]$ <b>61</b> (only)	B1 <b>(1)</b>	1.1b
(b)	$[25 - 14] =$ <b>11</b>	B1 <b>(1)</b>	1.1b
(c)	$\left[ \mu \text{ or } \bar{x} = \frac{607.5}{27} = \right] =$ <b>22.5</b>	B1 <b>(1)</b>	1.1b
(d)	$\sigma = \sqrt{\frac{17\,623.25}{27} - "22.5"{}^2}$ <u>or</u> $\sqrt{146.4629\dots}$ $= 12.10218\dots$ awrt <b>12.1</b>	M1 A1 <b>(2)</b>	1.1b 1.1b
(e)	$\mu + 3\sigma = "22.5" + 3 \times "12.1\dots" =$ awrt 59 so only <b>one</b> outlier	B1ft <b>(1)</b>	1.1b
(f)	Median increases implies that both values must be $> 20$ Mean is the same means that $a + b = 45$ So possible values are: e.g. $b = 21$ and $a = 24$ (o.e.)	M1 M1 A1 <b>(3)</b>	3.1b 1.1b 2.2b
(g)	Both values will be less than 1 standard deviation from the mean and so the standard deviation of all 29 values will be smaller	B1 <b>(1)</b>	2.4
		<b>( 10 marks)</b>	
<b>Notes</b>			
(a)	B1 for correctly interpreting the box plot to find the range (more than 1 answer is B0)		
(b)	B1 for correct understanding of IQR and answer of 11		
(c)	B1 for 22.5 only (or exact equivalent such as $\frac{45}{2}$ ). Allow 22 mins and 30 secs.		
(d)	M1 for a correct expression including square root. Allow $\sqrt{146}$ or better. Ft their mean A1 for awrt 12.1 NB Allow use of $s = 12.3327\dots$ or awrt 12.3		
(e)	B1ft for a correct calculation or value based on their $\mu$ and $\sigma$ and compatible conclusion		
(f)	1 <sup>st</sup> M1 Correct start to the problem and a correct statement about the values based on median Allow if their final two values are both $> 20$ 2 <sup>nd</sup> M1 for a correct explanation leading to equation $a + b = 45$ (o.e. e.g. equidistant from mean) Allow if their final two values sum to 45 A1 for a correct pair of values (both $> 20$ with a sum of 45) <b>and</b> at least some attempt to explain how their values satisfy at least one of the conditions (both $> 20$ <u>or</u> $a + b = 45$ ). Ignore $a =$ or $b =$ labels <b>NB</b> The values for $a$ and $b$ do not need to be integers.		
(g)	B1 for a correct explanation. Must mention that both values are less than 1 sd (ft their answer to (d)) from the mean		



Qu 4	Scheme	Marks	AO
(a)	$\frac{k}{10} + \frac{k}{20} + \frac{k}{30} + \frac{k}{40} + \frac{k}{50} = 1$ or $\frac{1}{600}(60k + 30k + 20k + 15k + 12k) = 1$ So $k = \frac{600}{137}$ (*)	M1	1.1b
		A1 cso	1.1b
(b)	(Cases are:) $D_1 = 30, D_2 = 50$ and $D_1 = 50, D_2 = 30$ and $D_1 = 40, D_2 = 40$ $P(D_1 + D_2 = 80) = \frac{k}{50} \times \frac{k}{30} \times 2 + \left(\frac{k}{40}\right)^2$ $= 0.0375619... \text{ awrt } \underline{\underline{0.0376}}$	(2) M1	2.1
		M1	3.4
		A1	1.1b
(c)	Angles are: $a, a + d, a + 2d, a + 3d$ $S_4 = a + (a + d) + (a + 2d) + (a + 3d) = 360$ $2a + 3d = 180$ (o.e.) Smallest angle is $a > 50$ consider cases: $d = 10$ so $a = 75$ <u>or</u> $d = 20$ so $a = 60$ [ $d = 30$ gives $a = 45$ no good] $P(D = 10 \text{ or } 20) = \frac{3k}{20} = \frac{90}{137}$	(3) M1	3.1a
		M1	2.1
		A1	2.2a
		M1	3.1b
		A1	1.1b
		(5)	
<b>( 10 marks )</b>			
<b>Notes</b>			
(a)	M1 for clear use of sum of probabilities = 1 (all terms seen) A1 cso (*) M1 scored and no incorrect working seen.		
Verify	(Assume $k = \frac{600}{137}$ ) to score the final A1 they must have a <u>final</u> comment " $\therefore k = \frac{600}{137}$ "		
(b)	1 <sup>st</sup> M1 for selecting at least 2 of the relevant cases (may be implied by their correct probs) e.g. allow 30, 50 and 50,30 i.e. $D_1$ and $D_2$ labels not required 2 <sup>nd</sup> M1 for using the model to obtain a correct expression for two different probabilities. May use letter $k$ or their value for $k$ . $\text{Allow for } \frac{k}{50} \times \frac{k}{30} + \left(\frac{k}{40}\right)^2 \text{ or } 2 \times \left(\frac{k}{50} \times \frac{k}{30} + \left(\frac{k}{40}\right)^2\right)$		
	A1 for awrt 0.0376 (exact fraction is $\frac{705}{18769}$ )		
(c)	1 <sup>st</sup> M1 for recognising the 4 angles and finding expressions in terms of $d$ and their $a$ 2 <sup>nd</sup> M1 for using property of quad with these 4 angles (equation can be un-simplified) Allow these two marks for use of a (possible) value of $d$ e.g. $a + a + 10 + a + 20 + a + 30 = 360$ (If at least 3 cases seen allow A1 for e.g. $4a = 300$ ) <u>or</u> allow M1M1 for a set of 4 angles with sum 360 and possible value of $d$ (3 cases for A1) e.g. (for $d = 20$ ) 60, 80, 100, 120 1 <sup>st</sup> A1 for $2a + 3d = 180$ condition (o.e.) [Must be in the form $pa + qd = N$ ] 3 <sup>rd</sup> M1 for examining cases and getting $d = 10$ and $d = 20$ only 2 <sup>nd</sup> A1 for $\frac{90}{137}$ or exact equivalent The correct answer and no obviously incorrect working will score 5/5 A final answer of awrt 0.657 (0.65693...) with no obviously incorrect working scores 4/5		

Qu 5	Scheme	Marks	AO
(a)	{Let $X$ = time spent, $P(X > 15) =$ } 0.105649... awrt <b>0.106</b>	B1 (1)	1.1b
(b)	$H_0 : \mu = 10$ $H_1 : \mu > 10$ $\bar{X} \sim N\left(10, \left(\frac{4}{\sqrt{20}}\right)^2\right)$ ; $P(\bar{X} > 11.5) = 0.046766...$ [Condone 0.9532...] [This is significant (< 5%) so ] there is evidence to support the complaint	B1 M1;A1 A1 (4)	2.5 3.3;3.4 2.2b
(c)(i)	[ $P(T < 2) =$ ] 0.1956... awrt <b>0.196</b>	B1 (1)	1.1b
(ii)	Require $\frac{P(0 < T < 2)}{P(T > 0)} = \frac{0.119119...}{0.923436...}$ ; = 0.1289955... awrt <b>0.129</b>	M1 A1;A1 (3)	3.4 1.1bx2
(iii)	The current model suggests <b>non-negligible</b> probability of $T$ values < 0 which is impossible	B1 (1)	3.5b
(d)	Require $t$ such that $P(T > t   T > 2) = 0.5$ <u>or</u> $P(T < t   T > 2) = 0.5$ e.g. $\frac{P(T > t)}{P(T > 2)} = 0.5$ ; so $P(T > t) = 0.5 \times [1 - (c)(i)]$ <u>or</u> $P(T > t) = 0.5 \times 0.8043..$ [i.e. $P(T > t) = 0.40...$ implies] $\frac{t-5}{3.5} = 0.2533$ <u>or</u> $P(T < t) = "0.5978.."$ $t = 5.886...$ <u>or</u> from calculator 5.867... so awrt <b>5.9</b>	M1 M1; A1ft M1 A1 (5)	3.1b 1.1b 3.4 1.1b 1.1b
<b>Notes</b>			
(a)	B1 for awrt 0.106 (from calculator) [Allow 10.6%]		
(b)	B1 for both hypotheses correct in terms of $\mu$ M1 for selection of a correct model (sight or use of correct normal- may not have label $\bar{X}$ ) 1 <sup>st</sup> A1 for use of this model to get probability allow 0.046~0.047 [Condone awrt 0.953]		
ALT	<b>OR</b> test statistic $z = 1.677...$ (awrt 1.68) <u>and</u> cv of 1.64 (or better) <b>or</b> CR $\bar{X} > 11.47..$		
	2 <sup>nd</sup> A1 (dep on 1 <sup>st</sup> A1 or at least $P(\bar{X} > 11.5) < 0.05$ (o.e.)) for a correct conclusion in context -must mention <b>complaint/claim</b> or <b>time/mins</b> is > 10		
SC	<b>(M0 for <math>\bar{X} \sim N(11.5, ...)</math></b> for correct probability <b>and</b> conclusion (score M0A0A1 on open)		
(c)(i)	B1 for awrt 0.196 (from calculator) [Allow 19.6%]		
(ii)	M1 for a correct probability ratio expression (may be implied by 1 <sup>st</sup> A1 scored) 1 <sup>st</sup> A1 for a correct ratio of probabilities (both correct or truncated to 2 dp) 2 <sup>nd</sup> A1 for awrt 0.129		
(iii)	B1 for a suitable explanation of why model is not suitable based on negative $T$ values Must say that a <b>significant</b> proportion of values < 0 (o.e.) e.g. $P(T > 0)$ should be <b>closer</b> to 1 <u>or</u> Difference between $P(T < 2   T > 0)$ and $P(T < 2)$ is <b>too big</b> (o.e.)		
(d)	1 <sup>st</sup> M1 for a correct conditional probability statement to start the problem <u>or</u> $0.5 \times P(T > 2)$ 2 <sup>nd</sup> M1 for correct ratio of probability expressions [Must have $P(T > t)$ or $P(2 < T < t)$ ] 1 <sup>st</sup> A1ft for a correct equation for $P(T > t)$ (o.e.) ft their answer to part (c)[May be in a diagram] 3 <sup>rd</sup> M1 for attempt to find $t$ (standardising and sight of 0.2533) or prepare to use calc (ft) Arriving at $P(T < \text{median}) = 1 - 0.5 \times$ "their 0.8043" will score 1 <sup>st</sup> 4 marks 2 <sup>nd</sup> A1 for awrt 5.9 Sight of awrt 5.9 and at least one M mark scores 5/5 [Answer only send to review]		

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In Mathematics (9MA0)  
Paper 32: Mechanics

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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.



Question	Scheme		Marks	AOs
1.(a)	Resolve perpendicular to the plane		M1	3.4
	$R = mg \cos \alpha = \frac{4}{5}mg$		A1	1.1b
			(2)	
1(b)	Resolve parallel to the plane or horizontally or vertically		M1	3.4
	$F = mg \sin \alpha$ or $R \sin \alpha = F \cos \alpha$		A1	1.1b
	Use $F = \mu R$ and solve for $\mu$		M1	2.1
	$\mu = \frac{3}{4}$ *		A1*	2.2a
			(4)	
1(c)	The forces acting on $Q$ will still balance as the $m$ 's cancel oe Other possibilities: e.g. the <u>friction</u> will increase <u>in the same proportion</u> as <u>the weight component or force down the plane</u> . The <u>force pulling the brick down the plane</u> increases <u>by the same amount</u> as the <u>friction</u> oe This mark can be scored if they do the calculation.		B1	2.4
			(1)	
1(d)	Brick $Q$ slides down the plane with <b>constant</b> speed.		B1	2.4
	No resultant force down the plane (so no acceleration) oe		B1	2.4
	These marks can be scored if they do the calculation.		(2)	
<b>(9 marks)</b>				
<b>Notes:</b>				
1a	M1	Correct no. of terms, condone sin/cos confusion		
	A1	cao with no wrong working seen. $mg \cos 36.86$ is A0		
1b	M1	Correct no. of terms, condone sin/cos confusion		
	A1	Correct equation		
	M1	Must use $F = \mu R$ (not merely state it) to obtain a numerical value for $\mu$ . This is an independent M mark.		
	A1*	Given answer correctly obtained		
1c	B1	Must have the 3 underlined phrases/word oe		
1d	B1	Must say <b>constant</b> speed.		
	B1	Any appropriate equivalent statement		

Question	Scheme	Marks	AOs
2(a)	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ or integrate to give: $\mathbf{v} = (-2\mathbf{i} + 2\mathbf{j}) + 2(4\mathbf{i} - 5\mathbf{j})$	M1	3.1a
	$(6\mathbf{i} - 8\mathbf{j}) (\text{m s}^{-1})$	A1	1.1b
		(2)	
2(b)	Solve problem through use of $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ or integration (M0 if $\mathbf{u} = \mathbf{0}$ ) Or any other complete method e.g use $\mathbf{v} = \mathbf{u} + \mathbf{a}T$ and $\mathbf{r} = \frac{(\mathbf{u} + \mathbf{v})T}{2}$ :	M1	3.1a
	$-4.5\mathbf{j} = 2t\mathbf{j} - \frac{1}{2}t^2 5\mathbf{j}$ ( $\mathbf{j}$ terms only)	A1	1.1b
	The first two marks could be implied if they go straight to an algebraic equation.		
	Attempt to equate $\mathbf{j}$ components to give equation in $T$ only $(-4.5 = 2T - \frac{5}{2}T^2)$	M1	2.1
	$T = 1.8$	A1	1.1b
		(4)	
2(c)	Solve problem by substituting <u>their</u> $T$ value (M0 if $T < 0$ ) into the $\mathbf{i}$ component equation to give an equation in $\lambda$ only: $\lambda = -2T + \frac{1}{2}T^2 \times 4$	M1	3.1a
	$\lambda = 2.9$ or $2.88$ or $\frac{72}{25}$ oe	A1	1.1b
		(2)	

**Notes: Accept column vectors throughout****(8 marks)**

2a	M1	For any complete method to give a $\mathbf{v}$ expression with correct no. of terms with $t = 2$ used, so if integrating, must see the initial velocity as the constant. Allow sign errors.
	A1	Caosw if they go on to find the speed.
2b	M1	For any complete method to give a vector expression for $\mathbf{j}$ component of displacement in $t$ (or $T$ ) only, using $\mathbf{a} = (4\mathbf{i} - 5\mathbf{j})$ , so if integrating, RHS of equation must have the correct structure. Allow sign errors.
	A1	Correct $\mathbf{j}$ vector equation in $t$ or $T$ . Ignore $\mathbf{i}$ terms.
	M1	Must have earned 1 <sup>st</sup> M mark.

		Equate $\mathbf{j}$ components to give equation in $T$ (allow $t$ ) only (no $\mathbf{j}$ 's) which has come from a displacement. Equation must be a 3 term quadratic in $T$ .
	A1	cao
<b>2c</b>	M1	Must have earned 1 <sup>st</sup> M mark in (b) Complete method - must have an equation in $\lambda$ only (no $\mathbf{i}$ 's) which has come from an appropriate displacement.. (e.g M0 if $\mathbf{a} = \mathbf{0}$ has been used) Expression for $\lambda$ must be a quadratic in $T$
	A1	cao

Question	Scheme		Marks	AOs
<b>3(i)(a)</b>	Integrate $\mathbf{a}$ wrt $t$ to obtain velocity		M1	3.4
	$\mathbf{v} = (t - 2t^2)\mathbf{i} + \left(3t - \frac{1}{3}t^3\right)\mathbf{j} (+C)$		A1	1.1b
	$8\mathbf{i} - \frac{28}{3}\mathbf{j} \text{ (m s}^{-1}\text{)}$		A1	1.1b
			<b>(3)</b>	
<b>3(i)(b)</b>	Equate $\mathbf{i}$ component of $\mathbf{v}$ to zero		M1	3.1a
	$t - 2t^2 + 36 = 0$		A1ft	1.1b
	$t = 4.5$ (ignore an incorrect second solution)		A1	1.1b
			<b>(3)</b>	
<b>3(ii)</b>	Differentiate $\mathbf{r}$ wrt to $t$ to obtain velocity		M1	3.4
	$\mathbf{v} = (2t - 1)\mathbf{i} + 3\mathbf{j}$		A1	1.1b
	Use magnitude to give an equation in $t$ only		M1	2.1
	$(2t - 1)^2 + 3^2 = 5^2$		A1	1.1b
	Solve problem by solving this equation for $t$		M1	3.1a
	$t = 2.5$		A1	1.1b
			<b>(6)</b>	
<b>(12 marks)</b>				
<b>Notes: Accept column vectors throughout</b>				
<b>3(i)(a)</b>	M1	At least 3 terms with powers increasing by 1 (but M0 if clearly just multiplying by $t$ )		
	A1	Correct expression		
	A1	Accept $8\mathbf{i} - 9.3\mathbf{j}$ or better. Isw if speed found.		
<b>3(i)(b)</b>	M1	Must have an equation in $t$ only (Must have integrated to find a velocity vector)		
	A1ft	Correct equation follow through on their $\mathbf{v}$ but must be a 3 term quadratic		
	A1	cao		
<b>3(ii)</b>	M1	At least 2 terms with powers decreasing by 1 (but M0 if clearly just dividing by $t$ )		
	A1	Correct expression		
	M1	Use magnitude to give an equation in $t$ only, must have differentiated to find a velocity (M0 if they use $\sqrt{x^2 - y^2}$ )		

	A1	Correct equation $\sqrt{(2t-1)^2 + 3^2} = 5$
	M1	Solve a 3 term quadratic for $t$ which has come from differentiating and using a magnitude. This M mark can be implied by a correct answer with no working.
	A1	2.5

Question	Scheme	Marks	AOs
4(a)	Take moments about $A$	M1	3.3
	$N \times \frac{4a}{\sin \alpha} = Mg \times 3a \cos \alpha$	A1	1.1b
	$\frac{9Mg}{25} *$	A1*	1.1b
		(3)	
4(b)	Resolve horizontally	M1	3.4
	$(\rightarrow) F = \frac{9Mg}{25} \sin \alpha$	A1	1.1b
	Resolve vertically	M1	3.4
	$(\uparrow) R + \frac{9Mg}{25} \cos \alpha = Mg$	A1	1.1b
	Other possible equations: $(\nwarrow), R \cos \alpha + \frac{9Mg}{25} = Mg \cos \alpha + F \sin \alpha$ $(\nearrow), Mg \sin \alpha = F \cos \alpha + R \sin \alpha$ $M(C), Mg \cdot 2a \cos \alpha + F \cdot 5a \sin \alpha = R \cdot 5a \cos \alpha$ $M(G), \frac{9Mg}{25} \cdot 2a + F \cdot 3a \sin \alpha = R \cdot 3a \cos \alpha$ $M(B), Mg \cdot 3a \cos \alpha + F \cdot 6a \sin \alpha = R \cdot 6a \cos \alpha + \frac{9Mg}{25} a$ $(F = \frac{36Mg}{125}, R = \frac{98Mg}{125})$		
	$F = \mu R \text{ used}$	M1	3.4
	Eliminate $R$ and $F$ and solve for $\mu$	M1	3.1b
	<b>Alternative equations</b> if they have at $A$ : $X$ horizontally and $Y$ perpendicular to the rod. $(\nwarrow), Y + \frac{9Mg}{25} = Mg \cos \alpha + X \sin \alpha$ $(\nearrow), Mg \sin \alpha = X \cos \alpha$ $(\uparrow), \frac{9Mg}{25} \cos \alpha + Y \cos \alpha = Mg$ $(\rightarrow), Y \sin \alpha + \frac{9Mg}{25} \sin \alpha = X$		

		$M(C), Mg.2a \cos \alpha + X.5a \sin \alpha = Y.5a$ $M(G), \frac{9Mg}{25}.2a + X.3a \sin \alpha = Y.3a$ M1A1 M1A1 $M(B), Mg.3a \cos \alpha + X.6a \sin \alpha = Y.6a + \frac{9Mg}{25}a$ $(X = \frac{4Mg}{3}, Y = \frac{98Mg}{75})$ Then $F = \mu R$ becomes: $X - Y \sin \alpha = \mu Y \cos \alpha$ M1 Eliminate $X$ and $Y$ and solve for $\mu$ M1		
		$\mu = \frac{18}{49}$ (0.3673.....accept 0.37 or better)	A1	2.2a
			(7)	
<b>(10 marks)</b>				
<b>Notes:</b>				
<b>4a</b>	M1	Correct no. of terms, dim correct, condone sin/cos confusion and sign errors for an equation in $N$ and $Mg$ only. For perp distance allow any of: $\frac{4a}{\sin \alpha}, \frac{4a}{\cos \alpha}, 5a$ but use of any of: $6a, 5a \sin \alpha, 4a \cos \alpha, \dots$ or anything involving $\tan \alpha$ is M0 Also M0 if no $a$ 's in their first equation.		
	A1	Correct equation, trig does not need to be substituted		
	A1*	Given answer correctly obtained.		
<b>4b</b>	M1	Correct no. of terms, dim correct, condone sin/cos confusion and sign errors		
	A1	Correct equation, trig does not need to be substituted but $N$ does.		
	M1	Correct no. of terms, dim correct, condone sin/cos confusion and sign errors		
	A1	Correct equation, trig does not need to be substituted but $N$ does.		
		<b>N.B.</b> The above 4 marks are for any two equations, either resolutions or moments or one of each. Mark best two equations. Equations may appear in part (a) but must be used in (b) to earn marks.		
	M1	Must be used, e.g. seen on the diagram. i.e. M0 if merely quoting it. (M0 if $F = \mu \times \frac{9Mg}{25}$ used)		
	M1	Must have 3 equations ( <u>and all 3 previous M marks</u> )		
	A1	Accept 0.37 or better		

Question	Scheme		Marks	AOs
<b>5(a)</b>	Using horizontal motion		M1	3.3
	$U \cos 45^\circ t = 100$		A1	1.1b
	Using vertical motion		M1	3.4
	$U \sin 45^\circ t - \frac{1}{2}gt^2 = -25$		A1	1.1b
	Solve problem by eliminating $t$ and solving for $U$		M1	3.1b
	$U = 28^*$		A1*	1.1b
			<b>(6)</b>	
<b>5(b)</b>	Using vertical motion		M1	3.4
	$0^2 = (28 \sin 45^\circ)^2 - 2gh$		A1	1.1b
	Greatest height = 45 m		A1	1.1b
			<b>(3)</b>	
<b>5(c)</b>	New value > 28		B1	3.5a
			<b>(1)</b>	
<b>5(d)</b>	e.g. wind effects, more accurate value of $g$ , spin of ball, include size of the ball, not model as a particle, shape of ball		B1	3.5c
			<b>(1)</b>	
<b>(11 marks)</b>				
<b>Notes:</b>				
<b>5a</b>	M1	Complete method to give equation in $U$ and $t$ only, condone sin/cos confusion and sign errors		
	A1	Correct equation		
	M1	Complete method to give equation in $U$ and $t$ only, condone sin/cos confusion and sign errors		
	A1	Correct equation ( $g$ does not need to be substituted)		
	M1	Must have earned the previous two M marks. Eliminate $t$ and solve for $U$ . <b>N.B.</b> They may solve for $t$ first ( $100 - \frac{1}{2}gt^2 = -25$ ) and then use it to find $U$ .		
	A1*	Exact given answer correctly obtained with no wrong working (e.g. $g = 9.81$ used) or approximation seen.		
<b>5b</b>	M1	Complete method to give equation in $h$ only (allow if $U$ not substituted), condone sin/cos confusion and sign errors		



	A1	Correct equation ( $g$ does not need to be substituted) (A0 if $U$ is used instead of 28)
	A1	cao
<b>5c</b>	B1	Clear statement
<b>5d</b>	B1	Penalise incorrect extras i.e. B0 if there are incorrect extras. The ground being horizontal, the cliff being vertical, .. are not part of the model so B0 Include weight/mass of the ball B0

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