Oxford Cambridge and RSA

GCE

Mathematics A

H240/03: Pure Mathematics and Mechanics

Advanced GCE

Mark Scheme for November 2020

Oxford Cambridge and RSA Examinations

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

Text Instructions

1. Annotations and abbreviations

Annotation in RM assessor	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	
Other abbreviations in mark scheme	**Meaning**
dep*	Mark dependent on a previous mark, indicated by *. The * may be omitted if only one previous M mark
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This question included the instruction: In this question you must show detailed reasoning.

2. Subject-specific Marking Instructions for A Level Mathematics A

a Annotations must be used during your marking. For a response awarded zero (or full) marks a single appropriate annotation (cross, tick, M0 or ^) is sufficient, but not required.

For responses that are not awarded either 0 or full marks, you must make it clear how you have arrived at the mark you have awarded and all responses must have enough annotation for a reviewer to decide if the mark awarded is correct without having to mark it independently.

It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

Award NR (No Response)

- if there is nothing written at all in the answer space and no attempt elsewhere in the script
- OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
- OR if there is a mark (e.g. a dash, a question mark, a picture) which isn't an attempt at the question.

Note: Award 0 marks only for an attempt that earns no credit (including copying out the question).

If a candidate uses the answer space for one question to answer another, for example using the space for 8(b) to answer 8(a), then give benefit of doubt unless it is ambiguous for which part it is intended.

b An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct solutions leading to correct answers are awarded full marks but work must not always be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly. Correct but unfamiliar or unexpected methods are often signalled by a correct result following an apparently incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.
If you are in any doubt whatsoever you should contact your Team Leader.

c The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.
A method mark may usually be implied by a correct answer unless the question includes the DR statement, the command words “Determine” or “Show that”, or some other indication that the method must be given explicitly.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d When a part of a question has two or more ‘method’ steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation ‘dep*’ is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e The abbreviation FT implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.
Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be ‘follow through’. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f We are usually quite flexible about the accuracy to which the final answer is expressed; over-specification is usually only penalised where the scheme explicitly says so.

- When a value **is given** in the paper only accept an answer correct to at least as many significant figures as the given value.

- When a value **is not given** in the paper accept any answer that agrees with the correct value to **3 s.f.** unless a different level of accuracy has been asked for in the question, or the mark scheme specifies an acceptable range.
  NB for Specification B (MEI) the rubric is not specific about the level of accuracy required, so this statement reads “2 s.f”.

Follow through should be used so that only one mark in any question is lost for each distinct accuracy error.
Candidates using a value of 9.80, 9.81 or 10 for *g* should usually be penalised for any final accuracy marks which do not agree to the value found with 9.8 which is given in the rubric.

g Rules for replaced work and multiple attempts:

- If one attempt is clearly indicated as the one to mark, or only one is left uncrossed out, then mark that attempt and ignore the others.
- If more than one attempt is left not crossed out, then mark the last attempt unless it only repeats part of the first attempt or is substantially less complete.
- if a candidate crosses out all of their attempts, the assessor should attempt to mark the crossed out answer(s) as above and award marks appropriately.

h For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate’s data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A or B mark in the question. Marks designated as cao may be awarded as long as there are no other errors.
If a candidate corrects the misread in a later part, do not continue to follow through. Note that a miscopy of the candidate’s own working is not a misread but an accuracy error.

i If a calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers, provided that there is nothing in the wording of the question specifying that analytical methods are required such as the bold “In this question you must show detailed reasoning”, or the command words “Show” or “Determine”. Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	AO	Guidance	
1			Area = $\frac{1}{2}(8.5)(6.2)\sin 35°$	**M1**	**1.1a**	Correct application of $\frac{1}{2}ab\sin C$	Or other complete method
			= 15.1 (cm^2)	**A1**	**1.1**	Answer given to at least 3 sf	15.1137391…
				[2]			

2			Refers to translation and stretch	**M1**	**1.1**	In either order; ignore details here; allow any equivalent wording (such as move or shift for translation) to describe geometrical transformations but not statements such as add –3 to *x* (do not accept 'enlargement' or 'shear' for stretch)	If M0 then award SC B1 for one correct transformation
			State translation $\begin{pmatrix}-3\\0\end{pmatrix}$	**A1**	**1.1**	Or state translation in *x*-direction by –3 (units); accept horizontal to indicate direction or parallel to the *x*-axis; term 'translate' or 'translation' needed for award of A1	Do not accept 'in/on/across/up/along the *x* axis' or 'to the left' only A0 for SF –3
			State stretch by scale factor 0.5 parallel to the *x*-axis	**A1** **[3]**	**1.1**	Or in the *x* direction or horizontally; term 'stretch' needed for award of A1; these two transformations must be in this order – if details correct for M1A1A1 but order wrong, award M1A1A0	Allow 'factor' or 'SF' for 'scale factor'. Do not accept 'in/on/across/up/ along the *x* axis', 'in the positive *x*-direction', 'SF 0.5 units'
			ALT 1 Or a stretch scale factor 0.5 parallel to the *x*-axis followed by translation $\begin{pmatrix}-1.5\\0\end{pmatrix}$			These transformations must be in this order for full marks	
			ALT 2 Or a stretch scale factor 0.5 parallel to the *x*-axis and a stretch scale factor e^3 parallel to the *y*-axis			These transformations can be in either order (must refer to two stretches for the M mark)	

3	(a)		$f(x)=2\left[x^2+3x\right]=2\left[(x+\frac{3}{2})^2-\left(\frac{3}{2}\right)^2\right]$	M1	3.1a	Attempt to complete the square – must have $2\left(x+\frac{3}{2}\right)^2 \pm ...$	Or $f'(x)=4x+6$ and solves equal to zero Or finds *x*-coordinate of vertex
			$f(x)=2\left(x+\frac{3}{2}\right)^2-\frac{9}{2} \Rightarrow -\frac{9}{2}$	A1	1.1	Correct completing the square and selection of $-\frac{9}{2}$	Or by differentiation
			Range of f(*x*): $f(x) \geq -\frac{9}{2}$	A1	1.2	cao – or equivalent notation e.g. set notation $\{f(x): f(x) \geq -\frac{9}{2}\}$ or $\left[-\frac{9}{2}, \infty\right)$	Allow in terms of f, *y* but not *x*
				[3]			
3	(b)		Function is not one-one	B1	2.4	Or different *x*-values give the same *y*-value (oe) e.g. function is many-one	
				[1]			
3	(c)		$g^{-1}(a)=\frac{1}{3}(a-2)$	B1	1.1	Or in terms of *x*	Or $a = gfg(-2)$ (or *x* = …)
			$fg(-2)=f(-4)\left[=2(-4)^2+6(-4)\right]$	M1*	1.2	Correct order of operations for fg so $f(-4)$ is sufficient	$a = gf('-4')$
			$8=\frac{1}{3}(a-2) \Rightarrow a = ...$	M1dep*	1.1	Sets their $fg(-2)$ equal to correct $g^{-1}(a)$ and solves for *a* or *x*	$a = g('8')$
			$a = 26$	A1	2.2a	Condone *x* = 26	
				[4]			
3	(d)		$2x^2+6x>3x+2 \Rightarrow 2x^2+3x-2>0$	M1	1.1	Sets f(*x*) > g(*x*) and rearranges correctly and solves equality (giving two c.v.)	Can be implied by both c.v. stated correctly
			Critical values $\frac{1}{2}$, -2	A1	1.1		
			$\{x: x>\frac{1}{2}\} \cup \{x: x<-2\}$	A1	2.5	Correct set notation e.g. $(-\infty,-2)\cup\left(\frac{1}{2},\infty\right)$ but not $x>\frac{1}{2}$ or $x<-2$	

				[3]			

4	(a)			M1*	2.1	Differentiates wrt x – answer of the form $c\left(k-3x\right)^{-1}+2x-3$ where $c\neq 0$	
			$\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{6}{3x-k}+2x-3$	A1	1.1	oe	
			$\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=-\frac{18}{(3x-k)^2}+2$	A1ft	1.1	Follow through their first derivative	
			$\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=0\Rightarrow\left(3(1)-k\right)^2=9$	M1dep*	1.1	Sets second derivative equal to zero and substitutes x = 1	
			$3-k=\pm3\Rightarrow k=6\left(\because k>0\right)$	A1 **[5]**	2.2a	**AG** – sufficient working must be shown $\left(\text{e.g. } k^2-6k=0\Rightarrow k=6\right)$	
4	(b)		Considers both f(0.5) and f(1.5) where $\mathrm{f}(x)=\pm[2\ln(6-3x)+x^2-3x]$	M1	1.1	Working or correct answer for one value is sufficient evidence of correct method but both 0.5 and 1.5 must be seen	
			$\mathrm{f}(0.5)=1.758...>0$ and $\mathrm{f}(1.5)=-1.439...<0$ change of sign indicates that the x-intersect lies between 0.5 and 1.5	A1 **[2]**	2.4	Correct values (to at least 2 sf rot) together with explanation (change of sign) and conclusion (as a minimum 'root')	
4	(c)		$x_{n+1}=x_n-\left\{\frac{2\ln(6-3x_n)+x_n^{\,2}-3x_n}{6(3x_n-6)^{-1}+2x_n-3}\right\}$	M1	2.1	Correct NR formula with their first derivative and k = 6	Allow x not x_n
			$x_0=1$, $x_1=1.0657415...$, $x_2=1.0656753...$	A1	1.1	Uses given starting value and states next two iterations to at least 6 d.p. rot	
			x coordinate is 1.06568	A1 **[3]**	2.2a	cao – stated to 5 decimal places only	Correct answer with no working scores 0/3

4	**(d)**		$f(1.065675) = 0.00000091... > 0$ $f(1.065685) = -0.000029... < 0$ – change of sign indicates that 1.06568 is correct to 5 decimal places.	**B1** **[1]**	**2.2a**	Must be evaluated to at least 1 sf (rot) – together with explanation and conclusion	

5	(a)		$\frac{dy}{dt} = 3t^2e^{-2t} + t^3\left(-2e^{-2t}\right)$	M1*	2.1	Attempts to differentiate y with respect to t using the product rule – answer of the form $\frac{dy}{dt} = \lambda t^2e^{-2t} + \mu t^3e^{-2t}$ or $y' = \alpha x^{-5}e^{-6x^{-1}}\left(\beta x + \gamma\right)$	Where $\lambda, \mu \neq 0$ Where $\alpha, \beta, \gamma \neq 0$
			$\frac{dy}{dt} = 0 \Rightarrow t^2e^{-2t}(3-2t) = 0 \Rightarrow t = \ldots$	M1dep*	1.1	Sets their derivative equal to zero and solves for t	Or their $\frac{dy}{dx}$ set = 0 and solve for x
			$t = \frac{3}{2}$	A1	1.1	From correct working only (or for x = 2)	
			$P\left(2, \frac{27}{8}e^{-3}\right)$	A1	2.2a	From correct working only y-coordinate must be exact but ISW	
				[4]			
5	(b)		$\frac{dx}{dt} = -3t^{-2}$ and $\int y\frac{dx}{dt}\,dt$	M1	2.1	Differentiates x with respect to t and attempts to set up integral for the required area	With $\frac{dx}{dt} = kt^{-2}$ with non-zero k
			$x = 6 \Rightarrow t = 0.5$ and $x = 1 \Rightarrow t = 3$	B1	1.1	Stating 0.5 and 3 is sufficient for this mark	If not attempted in **(b)** then this B mark can be awarded if seen in **(c)**
			Area $= \int_3^{0.5} t^3e^{-2t}\left(-\frac{3}{t^2}\right)dt = \int_3^{0.5} -3te^{-2t}\,dt = \int_{0.5}^3 3te^{-2t}\,dt$	A1	2.2a	Must be correctly shown	
				[3]			

5	(c)		$u = 3t$, and dv or $\frac{dv}{dt} = e^{-2t}$	M1*	1.1	Integrating by parts as far as $f(t) \pm \int g(t)\,dt$	Ignore limits for first three marks and allow those who consider $-\int 3te^{-2t}dt$ for possibly full marks
			$\int 3te^{-2t}\,dt = -\frac{3}{2}te^{-2t} + \frac{3}{2}\int e^{-2t}\,dt$	A1	1.1		
			$= ... - \frac{3}{4}e^{-2t}(+c)$	A1	1.1	Allow correct un-simplified for both A marks	
			$\left[-\frac{3}{2}te^{-2t} - \frac{3}{4}e^{-2t}\right]_{0.5}^{3} = \left(-\frac{3}{2}(3)e^{-6} - \frac{3}{4}e^{-6}\right)$ $-\left(-\frac{3}{2}(0.5)e^{-1} - \frac{3}{4}e^{-1}\right)$	M1dep*	1.1	Use of their t-limits (so not 1 and 6) in fully integrated expression (must subtract bottom limit from top limit)	
			Area $= -\frac{21}{4}e^{-6} + \frac{3}{2}e^{-1}$	A1	2.2a	ISW once correct exact answer seen	
				[5]			

6	(a)		**DR**			$4xy = 2(x^2+4y^2)-9x$	
				M1	1.1	For correct differentiation of either LHS or RHS, even if not in an equation	
			$4y+4x\frac{dy}{dx} = 4x+16y\frac{dy}{dx}-9$	A1	1.1		
			$4x\frac{dy}{dx}-16y\frac{dy}{dx} = 4x-4y-9 \Rightarrow \frac{dy}{dx} = \frac{4x-4y-9}{4x-16y}$	A1	2.1	**AG** (at least one line of working from correct differentiation to given answer)	
				[3]			
6	(b)		**DR**				
			(At P) $4x-16y=0$	M1*	3.1a		
			$x=4y \Rightarrow 16y^2 = 2(16y^2+4y^2)-36y$ $24y^2-36y=0$	M1dep*	2.1	Forms two-term quadratic equation in y or x (if correct $x^2-6x=0$)	
			$y(2y-3)=0 \Rightarrow y=\frac{3}{2}$ $P\left(6,\frac{3}{2}\right)$	A1	1.1		$y \neq 0$ not required
			(At Q) $4x-4y-9=0$	M1*	3.1a		
			$\Rightarrow 4x\left(x-\frac{9}{4}\right) = 2x^2+8\left(x-\frac{9}{4}\right)^2-9x$ $4x^2-24x+27=0$	M1dep*	2.1	Forms three-term quadratic equation in y or x (if correct $16y^2-24y-27=0$)	
			$Q\left(\frac{3}{2},-\frac{3}{4}\right)$ only	A1	3.2a		**A0** if $\left(\frac{9}{2},\frac{9}{4}\right)$ is given as possible coordinates for Q
			$PQ^2 = \left(6-\frac{3}{2}\right)^2+\left(\frac{3}{2}-\left(-\frac{3}{4}\right)\right)^2$	M1	1.1	Correct implies distance formula for their P and Q	Dependent on all previous **M** marks
			$PQ = \frac{9}{4}\sqrt{5}$	A1	2.2a	www	$k=\frac{9}{4}$
				[8]			

7	(a)		$\mathbf{v} = (7\mathbf{i} + 6\mathbf{j}) + 3(-4\mathbf{i} + 2\mathbf{j})$ $\mathbf{v} = -5\mathbf{i} + 12\mathbf{j}$ $\|\mathbf{v}\|^2 = \|-5\mathbf{i} + 12\mathbf{j}\|^2 = (-5)^2 + 12^2$ Speed = 13 (m s^{-1})	**M1*** **A1** **M1dep*** **A1** **[4]**	**3.3** **1.1** **1.1** **1.1**	Applies $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ Attempts speed or speed squared If both –5**i** + 12**j** and 13 stated as the answer, then A0	Or complete method via integration
7	(b)		$\mathbf{s} = 3(7\mathbf{i} + 6\mathbf{j}) + \frac{1}{2}(-4\mathbf{i} + 2\mathbf{j})(3)^2$ $= 3\mathbf{i} + 27\mathbf{j}$ (m)	**M1** **A1** **[2]**	**3.3** **1.1**	Applies $\mathbf{s} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ ISW (e.g. if finding modulus as well)	Or other complete *suvat*/integration method with their **v**

8	(a)		$t = 0, v = 8 \Rightarrow c = 8$	**B1** **[1]**	**1.1**	Correct value of *c*	
8	(b)		$\frac{\mathrm{d}v}{\mathrm{d}t} = 2at + b$ $10a + b = -0.12$ $a(18)^2 + 18b + 8 = 2.96$ $a = -0.02, \quad b = 0.08$	**B1** **M1** **M1** **A1** **[4]**	**3.1b** **1.1** **1.1** **3.1a**	Correct derivative Substitutes *t* = 5 into their derivative for *v* and sets equal to ± 0.12 Substitutes *t* = 18 into *v* and sets equal to 2.96 **BC** (oe e.g. $a = -\frac{1}{50}, b = \frac{2}{25}$)	Allow if still contains *c*
8	(c)		$\int_0^{18} (-0.02t^2 + 0.08t + 8)\,\mathrm{d}t$ $= 118$ (m)	**M1** **A1** **[2]**	**1.1a** **1.1**	Attempts integral between 0 and 18 for their *v* (with their values for *a*, *b* and *c*) **BC** Allow 118.08	At least two powers increased by 1 if shown

9	(a)		$1.2^2 = 0^2 + 2a(1.5) \Rightarrow a = 0.48$ (m s^{-2})	B1 [1]	2.1	**AG**	
9	(b)		 $2.5g - T = 2.5a$ $T = 2.5(9.8) - 2.5(0.48) = 23.3$ (N)	M1 A1 A1 [3]	3.3 1.1 1.1	N2L for particle B – correct number of terms – allow sign errors **AG** e.g. $2.5(9.8) - T = 2.5(0.48)$ $\Rightarrow T = 23.3$	M0 if mass only on lhs Value of a must be substituted for this mark
9	(c)		$R = 2g\cos\theta = 2g\left(\frac{4}{5}\right)$ $T - F - 2g\sin\theta = 2a$ or $T - \mu R - 2g\sin\theta = 2a$ $23.3 - F - 2g\left(\frac{3}{5}\right) = 2a$ or $23.3 - \mu R - 2g\left(\frac{3}{5}\right) = 2a$ $23.3 - \mu(2g)\left(\frac{4}{5}\right) - 2g\left(\frac{3}{5}\right) = 2(0.48)$ $\mu = 0.675$	B1 M1* A1 M1dep* A1 [5]	1.1 3.3 1.1 3.4 2.2a	Correctly resolves perpendicular to the plane and substitutes the correct value for cosine N2L for particle A – correct number of terms with weight component resolved Correct equation with T = 23.3 and a = 0.48 Use of $F = \mu R$ with their values for F and R – may be implied by N2L Correct to at least 3 sf (0.674744898…)	R = 15.68 Allow sign errors Equation in μ only R must be a component of $2g$ only Note that $\mu = \frac{529}{784}$
9	(d)		$-\mu R - 2g\sin\theta = 2a$ therefore $-\frac{529}{784}(15.68) - 2g\left(\frac{3}{5}\right) = 2a$ $a = -11.17$ $0^2 = 1.2^2 + 2(-11.17)s$ s = 0.065 (m) or 0.064 (m)	M1* A1 M1dep* A1 [4]	3.1b 1.1 3.4 1.1	N2L parallel to the plane with T = 0 to find new acceleration $a = -11.172$ if $\mu = 0.675$ used Applies $v^2 = u^2 + 2as$ with v = 0 and u = 1.2 Correct to at least 3 d.p.	Correct number of terms Accept positive a – may be implied by later working 0.06445837064… if μ exact used or 0.06444683… if 3 sf for μ used

10	**(a)**		$0.4(0.25g\sin 60)+0.8(0.5g\sin 60)=\ldots$ $\ldots=T(0.4\sin 30)$ Tension is 21.2 (N)	**M1** **B1** **B1** **A1** **[4]**	**3.3** **1.1** **1.1** **3.4**	Moments about *A* correct number of terms – condone sign errors and cos/sin confusion **B1** for lhs **B1** for rhs (21.2176…)	M0 if only using masses or if no sin/cos term with either weight or *T* term $T=1.25g\sqrt{3}=\frac{49}{4}\sqrt{3}$
10	**(b)**	**(i)**	$(X=)T\cos 60,\ (Y=)T\sin 60-0.25g-0.5g$ $\sqrt{(21.2\ldots\cos 60°)^2+(21.2\ldots\sin 60°-0.75g)^2}$ $=15.3\text{(N)}$	**M1*** **A1** **M1dep*** **A1** **[4]**	**3.3** **3.3** **3.1b** **2.2a**	Resolving horizontally and vertically – correct number of terms allow cos/sin confusion – award this mark if only one stated correctly (For reference only: *Y* = 11.025 and *X* = 10.6…) Correct method for finding the magnitude of the contact force (using their value of *T*) (15.283139… if *T* = 21.2 used)	Where *X* is the horizontal component of the reaction at *A* Where *Y* is the vertical component $\frac{49}{20}\sqrt{39}=15.3002...$
10	**(b)**	**(ii)**	$\tan\theta=\frac{Y}{X}$ 46.1° below the horizontal	**M1** **A1** **[2]**	**3.1b** **3.2a**	Correct method for finding the direction of the contact force at *A* oe (e.g. 43.9° to the downward vertical)	Dependent on first M mark in **(b)(i)** 46.1021137… or 46.086245… if *T* = 21.2 used
10	**(c)**		• Consider the dimensions of the lamp • Consider the weight of the chain • Model the rod as non-uniform • Friction at the hinge • More accurate value of g used	**B1** **[1]**	**3.5c**	Any valid improvement	

11	(a)		$(OC=)Ut$	B1	1.1	Applies $s=ut+0.5at^2$ horizontally correctly with a = 0	
			$0=Vt-\frac{1}{2}gt^2 \Rightarrow t=...$	M1	3.3	$s=ut+0.5at^2$ with s = 0 and a = -g and solves for t or $v = u + at$ vertically with v = 0, $u = V$ and time doubled	vertically – must be a complete method to find t
			$t=\frac{2V}{g}$	A1	1.1	Correct time	Ignore mention of t = 0
			$(OC=)\frac{2UV}{g}$	A1 [4]	2.2a		
11	(b)		Horizontal component is $(u_A=)U$	B1	3.4		
			Vertical component is $(v_A=)\sqrt{V^2-2gh}$	B1 [2]	3.4	oe Or $V-gt$ provided t defined as the time of flight from O to A	
11	(c)		From A to B the time of flight T is $\frac{d}{U}$	B1ft	1.1	Allow with their expression for the horizontal component	Or M1 for their $d=\frac{2u_A v_A}{g}$ from **(a)** with their u_A and v_A
			$0=v_AT-\frac{1}{2}gT^2 \Rightarrow v_A-\frac{1}{2}gT=0$ Therefore $\sqrt{V^2-2gh}-\frac{1}{2}gT=0$	M1	3.3	Applies $s=ut+0.5at^2$ vertically with s = 0 and uses vertical component from **(b)**	M1A1ft for $d=\frac{2u_A v_A}{g}$ with their values (or vice-versa)
			$\sqrt{V^2-2gh}-\frac{1}{2}g\left(\frac{d}{U}\right)=0 \Rightarrow d=\frac{2U}{g}\sqrt{V^2-2gh}$	A1 [3]	2.2a	oe	Full marks for correct answer with no working
11	(d)		$\frac{1}{2}=\frac{\left(\frac{gd}{2U}\right)}{U}$ or $\frac{1}{2}=\frac{\sqrt{V^2-2gh}}{U}$	M1*	3.1b	Uses $\tan\theta=\frac{v_A}{u_A}$ with their u_A and v_A	
			$U=\sqrt{gd}$ or $U=2\sqrt{V^2-2gh}$	A1	1.1	A correct expression for U or U^2	
			$\sqrt{gd}=2\sqrt{V^2-2gh}$	M1dep*	3.1a	Eliminate U and correct method to find V	
			$gd=4\left(V^2-2gh\right) \Rightarrow V=\frac{1}{2}\sqrt{g\left(8h+d\right)}$	A1 [4]	2.2a	oe	

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