A-LEVEL

Mathematics

Paper 2

Mark scheme

Specimen

Version 1.3

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Mark scheme instructions to examiners

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General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- marking instructions that indicate when marks should be awarded or withheld including the principle on which each mark is awarded. Information is included to help the examiner make his or her judgement and to delineate what is creditworthy from that not worthy of credit
- a typical solution. This response is one we expect to see frequently. However credit must be given on the basis of the marking instructions.

If a student uses a method which is not explicitly covered by the marking instructions the same principles of marking should be applied. Credit should be given to any valid methods. Examiners should seek advice from their senior examiner if in any doubt.

Key to mark types

M	mark is for method
dM	mark is dependent on one or more M marks and is for method
R	mark is for reasoning
A	mark is dependent on M or m marks and is for accuracy
B	mark is independent of M or m marks and is for method and accuracy
E	mark is for explanation
F	follow through from previous incorrect result

Key to mark scheme abbreviations

CAO	correct answer only
CSO	correct solution only
ft	follow through from previous incorrect result
‘their’	Indicates that credit can be given from previous incorrect result
AWFW	anything which falls within
AWRT	anything which rounds to
ACF	any correct form
AG	answer given
SC	special case
OE	or equivalent
NMS	no method shown
PI	possibly implied
SCA	substantially correct approach
sf	significant figure(s)
dp	decimal place(s)

Examiners should consistently apply the following general marking principles

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to students showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the student to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

Diagrams

Diagrams that have working on them should be treated like normal responses. If a diagram has been written on but the correct response is within the answer space, the work within the answer space should be marked. Working on diagrams that contradicts work within the answer space is not to be considered as choice but as working, and is not, therefore, penalised.

Work erased or crossed out

Erased or crossed out work that is still legible and has not been replaced should be marked. Erased or crossed out work that has been replaced can be ignored.

Choice

When a choice of answers and/or methods is given and the student has not clearly indicated which answer they want to be marked, only the last complete attempt should be awarded marks.

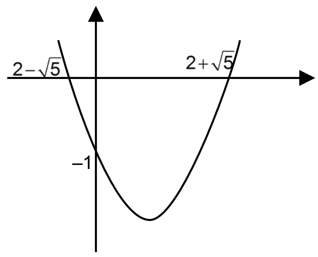
Q	Marking Instructions	AO	Marks	Typical Solution
1	Circles correct answer	AO1.1b	B1	$\lvert x \rvert < \frac{3}{2}$
	Total		**1**	
2	Circles correct answer	AO3.4	B1	20
	Total		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
3(a)	Uses a correct method for finding $\frac{dy}{dx}$ evidence for this includes sight of $\frac{dy}{dx}$ or $\frac{dx}{dt}$ and chain rule OR an attempt at implicit or explicit differentiation of a correct Cartesian equation or 'their' equation from part **(b)**	AO1.1a	M1	$\frac{dx}{dt} = 3t^2$ $\quad \frac{dy}{dt} = 2t$ $\frac{dy}{dx} = \frac{2t}{3t^2}$ When $t = -2$ $\frac{dy}{dx} = -\frac{1}{3}$ **ALT** $y = (x-2)^{\frac{2}{3}} - 1$ $\frac{dy}{dx} = \frac{2(x-2)^{-\frac{1}{3}}}{3}$ When $t = -2$, $x = -6$ $\frac{dy}{dx} = \frac{2(-6-2)^{-\frac{1}{3}}}{3} = -\frac{1}{3}$
	Obtains correct $\frac{dy}{dx}$	AO1.1b	A1	
	Substitutes $t = -2$ (or $x = -6$) into 'their' equation for $\frac{dy}{dx}$	AO1.1a	M1	
	Obtains correct simplified gradient of the curve FT 'their' equation for $\frac{dy}{dx}$	AO1.1b	A1F	
(b)	Eliminates t or makes t the subject in one expression (evidence for this includes one equation with t as the subject or two equations with equal powers of t.)	AO1.1a	M1	$t^3 = (x-2)$, $t^2 = (y+1)$ $t^6 = (x-2)^2$, $t^6 = (y+1)^3$ $(x-2)^2 = (y+1)^3$ **ALT** $t^3 = (x-2)$ $t = (x-2)^{\frac{1}{3}}$ $y = (x-2)^{\frac{2}{3}} - 1$
	Finds a correct Cartesian equation in any form	AO1.1b	A1	
	Total		**6**	

Q	Marking Instructions	AO	Marks	Typical Solution
4(a)	Starts an argument by showing that $\mathrm{f}(-2)<0$ and $\mathrm{f}(-1)>0$ Both attempted and at least one evaluated correctly f must be clearly defined or substitution of values must be explicit.	AO2.1	R1	$\mathrm{f}(x)=x^3-3x+1$ $\mathrm{f}(-2)=(-2)^3-3(-2)+1=-1<0$ $\mathrm{f}(-1)=(-1)^3-3(-1)+1=3>0$ Change of sign and $\mathrm{f}(x)$ is continuous so a root must lie between $x=$ –2 and $x=$ –1
	Explains reasoning fully to complete the argument Evaluations above need to be of opposite sign **and** 'change of sign' OE seen **and** reference to x-values –2 & –1 **and** reference to continuous function	AO2.4	E1	
(b)	Uses Newton–Raphson, must have $\mathrm{f}'(x)$ correct PI by correct substitution	AO1.1a	M1	$x_{n+1}=x_n-\dfrac{(x_n)^3-3x_n+1}{3(x_n)^2-3}$
	Substitutes $x_1=-2$ into 'their' Newton–Raphson formula (accept 'their' $\mathrm{f}(-2)$ from part **(a)**)	AO1.1a	M1	$x_2=-2-\dfrac{-1}{3(-2)^2-3}$
	Obtains correct value for x_2 $-\dfrac{17}{9}$ or $-1\dfrac{8}{9}$ or -1.89 or better	AO1.1b	A1	$=-\dfrac{17}{9}$
(c)	Explains why the method fails when $x_1=-1$ This must include a substitution of $x_1=-1$ and an explanation of what goes wrong eg division by zero | not possible gradient zero | method fails	AO2.4	E1	$x_1=-1$ $x_2=-2=\dfrac{3}{3(-1)^2-3}=-2-\dfrac{3}{0}$ causes division by zero (expression undefined) **ALT** $\mathrm{f}'(-1)=0$, function has zero gradient at this point, method will fail

	Total		**6**	

Q	Marking Instructions	AO	Marks	Typical Solution
5(a)	Compares with $R\cos(\theta \pm \alpha)$ or $R\sin(\theta \pm \alpha)$	AO3.1a	M1	$R\cos(\theta - \alpha)$ $\equiv R\sin\alpha\cos\theta + R\sin\theta\sin\alpha$
	Identifies version which will allow them to solve the problem	AO3.1a	A1	$\therefore R\cos\alpha = 3$ and $R\sin\alpha = 3$ $R = \sqrt{18}$
	Obtains correct R	AO1.1b	A1	$\alpha = \frac{\pi}{4}$
	Obtains correct α	AO1.1b	A1	$\therefore 3\cos\theta + 3\sin\theta \equiv \sqrt{18}\cos\left(\theta - \frac{\pi}{4}\right)$
	Interprets 'their' equation to identify first transformation	AO3.2a	E1	Which is a stretch in the y-direction scale factor $\sqrt{18}$ and a translation $\begin{pmatrix} \frac{\pi}{4} \\ 0 \end{pmatrix}$
	Interprets 'their' equation to identify second transformation	AO3.2a	E1	
(b)	Constructs a rigorous mathematical argument, to find either the least or greatest value Only award if they have a completely correct solution, which is clear, easy to follow and contains no slips (no FT for this mark)	AO2.1	R1	$4 + (3\cos\theta + 3\sin\theta)^2$ $4 + \left(\sqrt{18}\cos\left(\theta + \frac{\pi}{4}\right)\right)^2$ Least value occurs when $\cos^2\left(\theta + \frac{\pi}{4}\right) = 0$ $\therefore$ least value = 4
	Deduces the least value Using 'their' values of R and α	AO2.2a	A1F	Greatest value occurs when $\cos^2\left(\theta + \frac{\pi}{4}\right) = 1$
	Deduces the greatest value Using 'their' values of R and α	AO2.2a	A1F	greatest value $= 4 + 18$ $= 22$
	Total		**9**	

Q	Marking Instructions	AO	Marks	Typical Solution
6(a)	Uses either of the given coordinates in the given equation (accept product of the roots)	AO1.1a	M1	$k = 4(2+\sqrt{5}) - (2+\sqrt{5})^2 = -1$ **ALT** $k = 4(2-\sqrt{5}) - (2-\sqrt{5})^2 = -1$ **ALT** $k = (2-\sqrt{5})(2+\sqrt{5}) = -1$
	Obtains the correct value of k	AO1.1b	A1	
6(b)	Sketches a graph with the correct shape	AO1.2	B1	
	Deduces correct relative positioning of intersections with axes (must see labels)	AO2.2a	B1	
	Deduces minimum lies to right of y-axis in fourth quadrant	AO2.2a	B1	
	Total		**5**	

Q	Marking Instructions	AO	Marks	Typical Solution
7(a)	States any correct reason	AO2.3	B1	Just checking a few cases only proves it for those cases
(b)	Commences an argument, writing the sum of two consecutive odd numbers algebraically (at least two lines of argument)	AO2.1	R1	Two consecutive odd numbers can be written as $2n+1$ and $2n+3$ Their sum is $2n+1+2n+3 \equiv 4n+4$
	At some point in the argument correctly writes the difference of two appropriate square numbers algebraically	AO2.5	R1	n^2 and $(n+2)^2$ are two square numbers Their difference is $(n+2)^2 - n^2$
	Correctly deduces the result from correct working	AO2.2a	R1	$\equiv n^2+4n+4-n^2$ $\equiv 4n+4$ Therefore the sum of two consecutive odd numbers can always be written as the difference of two square numbers
	Total		**4**	

Q	Marking Instructions	AO	Marks	Typical Solution
8(a)	Uses the product rule for either term	AO1.1a	M1	$y = 2x\cos 3x + (3x^2 - 4)\sin 3x$
	Uses the product rule for both terms	AO1.1a	M1	$\frac{dy}{dx} = 2\cos 3x - 6x\sin 3x$ $+6x\sin 3x + 3(3x^2 - 4)\cos 3x$
	Differentiates both terms correctly	AO1.1b	A1	$= (9x^2 - 10)\cos 3x$
	Rearranges to correct form CAO	AO1.1b	A1	
(b)	Finds $\frac{d^2y}{dx^2}$ from 'their' first derivative and equates to zero	AO3.1a	M1	$\frac{d^2y}{dx^2} = 18x\cos 3x - 3(9x^2 - 10)\sin 3x$
	Applies product rule correctly on 'their' $\frac{dy}{dx}$ FT only applies if both M1 marks awarded in part **(a)**	AO1.1b	A1F	point of inflection $\Rightarrow \frac{d^2y}{dx^2} = 0 \Rightarrow$ $18x\cos 3x - 3(9x^2 - 10)\sin 3x = 0$ $\Rightarrow \frac{\cos 3x}{\sin 3x} = \frac{3(9x^2 - 10)}{18x}$
	Arrives at a result using 'their' second derivative through correct algebraic manipulation that is correct for 'their' second derivative FT only applies if both previous marks in **(b)** have been awarded.	AO1.1b	A1F	$\Rightarrow \cot 3x = \frac{9x^2 - 10}{6x}$ (**AG**)
	Constructs a clearly explained rigorous mathematical argument, to show the required result This must include a concluding statement or an explanation of reasoning at the start. **AG**	AO2.1	R1	
	Total		**8**	

Q	Marking Instructions	AO	Marks	Typical Solution
9(a)	Finds a difference between 2 terms	AO3.1a	M1	$3e^{p} - 5 = 5 - 3e^{-p}$ (*) $3e^{p} - 10 + 3e^{-p} = 0$ $3e^{2p} - 10e^{p} + 3 = 0$ $e^{p} = \frac{1}{3}, \quad 3$ $p = \ln\frac{1}{3}, \ln 3$ **ALT to (*)** $2(5 - 3e^{-p}) = 3e^{p} - 3e^{-p}$ **Or** $2(3e^{-p} - 5) = 3e^{p} - 3e^{-p}$
	Forms an equation using two differences	AO3.1a	M1	
	Forms a quadratic equation in e^{p}	AO1.1a	M1	
	Obtains a correct quadratic equation	AO1.1b	A1	
	Obtains 2 correct solutions for e^{p} from 'their' quadratic FT only applies if previous mark has been awarded	AO1.1b	A1F	
	Obtains final answers in an exact form FT applies if previous mark has been awarded	AO2.2a	A1F	

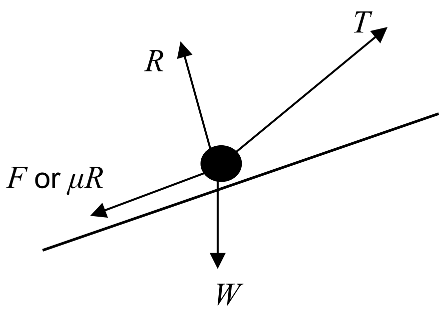
Q	Marking Instructions	AO	Marks	Typical Solution
9 (b)	Finds a ratio between two consecutive terms (no requirement to use a and r)	AO3.1a	M1	Assume it is possible that $3e^{-q}$, 5 and $3e^{q}$ are three consecutive terms of a geometric sequence $a = 3e^{-q}$, $ar = 5$, $ar^2 = 3e^q$
	Compares two ratios (could be ratios of successive terms, no requirement to use a and r)	AO3.1a	M1	$\frac{ar}{a} = \frac{5}{3e^{-q}} \Rightarrow r = \frac{5e^q}{3}$ $\frac{ar^2}{ar} = \frac{3e^q}{5} \Rightarrow r = \frac{3e^q}{5}$
	Identifies a contradiction	AO2.1	R1	$\frac{5}{3e^{-q}} = \frac{3e^q}{5} \Rightarrow 25 = 9$
	Draws a conclusion about k	AO2.4	R1	This is a contradiction therefore $3e^{-q}$, 5 and $3e^{q}$ cannot form three consecutive terms of a geometric sequence.
	Total		**10**	

Q	Marking Instructions	AO	Marks	Typical Solution
10	Circles correct answer	AO1.1b	B1	80 m s^{-2}
	Total		**1**	
11	Uses correct forces to form a moment equation **(PI)**	AO1.1a	M1	Take moments about *C*: $Mg \times 0.8 = 0.7 \times 24g$
	Obtains correct value	AO1.1b	A1	$M = 21$
	Total		**2**	
12(a)	States correct expression for a	AO1.1b	B1	$a = \dfrac{V-U}{T}$
(b)	Rearranges to make T the subject of the formula	AO2.1	R1	$T = \dfrac{V-U}{a}$
	Uses given expression for S and attempts to eliminate T	AO2.1	R1	$S = \dfrac{1}{2}(U+V) \times \dfrac{V-U}{a}$ $2as = (U+V)(V-U)$
	Completes argument to reach required result **AG** Only award if they have a completely correct solution, which is clear, easy to follow and contains no slips	AO2.1	R1	$V^2 = U^2 + 2aS$ **(AG)**
	Total		**4**	

Q	Marking Instructions	AO	Marks	Typical Solution
13(a)(i)	Sums the forces given correctly	AO1.1b	B1	$\mathbf{F} = \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3$ $= 33\mathbf{i} - 11\mathbf{j}$
	Uses Pythagoras to find the magnitude of the vector and obtains correct magnitude (given to 3 sig figs)	AO1.1b	B1	$\lvert\mathbf{F}\rvert = \sqrt{33^2 + (-11)^2}$ $= 34.8$ N (3 sf)
(a)(ii)	Uses trig expression with appropriate values	AO1.1a	M1	$\tan\theta = \frac{11}{33}$
	Obtains correct angle (given to nearest 0.1°)	AO1.1b	A1	$\theta = \tan^{-1}(\frac{1}{3})$ $= 18.4°$ (3 sf) **OR** $\sin\theta = \frac{11}{\sqrt{1210}}$ $\theta = \sin^{-1}\left(\frac{11}{\sqrt{1210}}\right)$ $= 18.4°$ (3 sf) **OR** $\cos\theta = \frac{33}{\sqrt{1210}}$ $\theta = \cos^{-1}\left(\frac{33}{\sqrt{1210}}\right)$ $= 18.4°$ (3 sf)
(b)	States negative of 'their' part **(a)(i)**	AO2.2a	B1F	$\mathbf{F}_4 = -33\mathbf{i} + 11\mathbf{j}$
	Total		**5**	

Q	Marking Instructions	AO	Marks	Typical Solution
14(a)	Calculates two (or four) appropriate distances	AO3.1b	M1	$s_1 = \frac{1}{2}(6+10)\times 8 = 64$ m
	Obtains correct distances	AO1.1b	A1	$s_2 = \frac{1}{2}\times 10\times 2 = 10$ m
	Obtains correct sum of 'their' distances	AO1.1b	A1F	$s_1 + s_2 = 64 + 10 = 74$ m **OR** $S_1 = 6 \times 8 = 48$ m $S_2 = \frac{1}{2}\times 4\times 8 = 16$ m $S_3 = \frac{1}{2}\times 4\times 2 = 4$ m $S_4 = \frac{1}{2}\times 6\times 2 = 6$ m $S_1 + S_2 + S_3 + S_4 = 74$ m
(b)	Finds difference of 'their' distances from part **(a)**	AO2.2a	B1F	64 – 10 = 54 m
(c)	Calculates magnitude of acceleration	AO3.1b	M1	$a_{\max} = \frac{8}{4} = 2$
	Obtains correct resultant force	AO1.1b	A1	$F_{\max} = 800\times 2 = 1600$ N
(d)	Explains that abrupt changes and straight lines in the graph are unlikely in reality	AO3.5b	E1	Change of velocity is unlikely to result in abrupt changes I would expect to see curves on the graph
	Total		**6**	

Q	Marking Instructions	AO	Marks	Typical Solution
15(a)	Integrates both components with at least one correct	AO1.1a	M1	$\mathbf{r} = \int 40\mathrm{e}^{-0.2t}\mathrm{d}t\mathbf{i} + \int 50(\mathrm{e}^{-0.2t} - 1)\mathrm{d}t\mathbf{j}$ $= (-200\mathrm{e}^{-0.2t} + c)\mathbf{i} + (-250\mathrm{e}^{-0.2t} - 50t + d)\mathbf{j}$
	Obtains correct terms. (condone missing constants)	AO1.1b	A1	$t = 0, \mathbf{r} = 0\mathbf{i} + 0\mathbf{j} \Rightarrow c = 200,\ d = 250$ OR
	Evaluates both constants (or uses definite integration) using 'their' expression for **r**	AO3.4	M1	$\mathbf{r} = \int_0^t 40\mathrm{e}^{-0.2t}\mathrm{d}t\mathbf{i} + \int_0^t 50(\mathrm{e}^{-0.2t} - 1)\mathrm{d}t\mathbf{j}$ $= \left[-200\mathrm{e}^{-0.2t}\mathbf{i} + (-250\mathrm{e}^{-0.2t} - 50t)\mathbf{j}\right]_0^t$
	Obtains correct expression	AO1.1b	A1	$\mathbf{r} = 200(1 - \mathrm{e}^{-0.2t})\mathbf{i} + (250 - 250\mathrm{e}^{-0.2t} - 50t)\mathbf{j}$
(b)	Forms equation to find t based on horizontal component	AO3.4	M1	$200(1 - \mathrm{e}^{-0.2t}) = 100$ $t = 5\ln 2 = 3.4657$ $y = 250 - 250\mathrm{e}^{-0.2\times 5\ln 2} - 50 \times 5\ln 2$ $= -48.3$
	Obtains correct time	AO1.1b	A1	
	Substitutes 'their' time into vertical component	AO1.1a	M1	
	Obtains correct displacement for 'their' time (to 1 sf only, must have metres) FT only if both M1 marks have been awarded	AO3.2a	A1F	The parachutist has a vertical displacement of 50 m below the origin
(c)	Identifies vertical component of the velocity as first step	AO2.4	M1	$\frac{\mathrm{d}}{\mathrm{d}t}(50(\mathrm{e}^{-0.2t} - 1) = -10\mathrm{e}^{-0.2t}$
	Differentiates vertical component of velocity correctly	AO1.1b	A1	As there is no initial vertical component of velocity (and hence no air resistance) the initial acceleration is only due to gravity Hence g is taken as 10 m s^{-2}
	Considers implication of initial motion and reaches correct conclusion	AO2.2a	R1	
	Total		**11**	

Q	Marking Instructions	AO	Marks	Typical Solution
16(a)	Resolves horizontally and vertically to obtain expressions for F and R (allow consistent mixing of sin and cos)	AO3.4	M1	Resolving vertically $R = 8\times 9.8 - 50\sin 40°$ Resolving horizontally $F = 50\cos 40°$
	Obtains correct expressions for R and F	AO1.1b	A1	
	States friction model $F = \mu R$ with 'their' values for F and R	AO1.2	B1	$F = \mu R$ $50\cos 40° = \mu(8\times 9.8 - 50\sin 40°)$ $\mu = \dfrac{50\cos 40°}{8\times 9.8 - 50\sin 40°}$
	Completes a rigorous argument that results with correct μ **AG** Only award if they have a completely correct solution, which is clear, easy to follow and contains no slips	AO2.1	R1	$\mu = 0.8279660445 = 0.83$ (2 sf) **AG**
(b)(i)	Draws correct diagram with exactly four forces showing arrow heads and labels Can use Mg or $8g$ or 78.4 for W	AO3.3	B1	

Q	Marking Instructions	AO	Marks	Typical Solution
16(b)(ii)	Resolves perpendicular to the plane resulting in a three term equation containing; R, $8g\cos 5°$ and $T\sin 40°$ (or $T\cos 50°$) OR Resolves horizontally and vertically to obtain equations of motion in horizontal and vertical directions	AO3.1b	M1	$R = 8 \times 9.8\cos 5° - T\sin 40°$ $= 78.1 - T\sin 40°$ $T\cos 40° - 8 \times 9.8\sin 5° - F = 8 \times 3$
	Obtains correct expression for R OR Obtains correct horizontal and vertical equations	AO1.1b	A1	$T\cos 40° - 8 \times 9.8\sin 5° - 0.827\ldots\times(8 \times 9.8\cos 5° - T\sin 40°) = 24$
	Forms a four term equation of motion parallel to the plane with correct terms (allow sign errors) OR Eliminates R to solve for T	AO3.1b	M1	$T = \dfrac{24 + 8\times 9.8\sin 5^{\circ} + 0.827\ldots\times 8\times 9.8\cos 5^{\circ}}{\cos 40^{\circ} + 0.827\ldots\times\sin 40^{\circ}}$ $T = 73.55939193 = 74$ (2 sf)
	Obtains correct equation of motion OR Obtains correct expression(s) without R	AO1.1b	A1	
	Uses the friction model in the four term equation of motion where R is in the form $a - bT$ and a and b are positive constants OR Uses the friction model in the horizontal and vertical equations Dependent on previous M1	AO3.1b	dM1	
	Solves for T	AO1.1b	A1	
	Obtains correct value of T with 2sf accuracy. FT incorrect value found for T provided both M1 marks and dM1 mark have been awarded	AO3.2a	A1F	
	Total		**12**	

Q	Marking Instructions	AO	Marks	Typical Solution
17(a)	Obtains correct horizontal component of the initial velocity	AO1.1b	B1	$2.5U = 40$ $U = 16$
	Forms equation to find vertical component of initial velocity	AO3.3	M1	$-10 = 2.5V - 0.5\times 9.81\times 2.5^2$
	Obtains correct vertical component of initial velocity	AO1.1b	A1	$V = 8.2625$
	Forms equation for vertical component of velocity at height 3 using 'their' derived values for U and V	AO3.4	M1	$v_y^2 = 8.2625^2 + 2\times(-9.81)\times 3$
	Obtains correct component of velocity	AO1.1b	A1	$v_y = 3.067...$
	Correct final speed with units, correct for 'their' U and v_y FT applies only if both M1 marks have been awarded	AO3.2a	A1F	$v = \sqrt{16^2 + 3.067^2} = 16.3\text{ m s}^{-1}$
(b)	States 'their' value of horizontal component of the initial velocity from part **(a)**	AO3.4	A1F	16 m s^{-1}
(c)	Explains that horizontal velocity has been assumed to be constant in their model and that this is not likely to be true, with valid reasoning	AO3.5b	E1	It was assumed that there were no resistance forces acting on the ball which is unlikely to be true in reality. The horizontal speed of the ball is likely to vary… air resistance would slow the ball down, wind might speed the ball up
	Total		**8**	
	TOTAL		**100**	