Question	Scheme	Marks	AOs
1 (a)	$3x^3-17x^2-6x=0 \Rightarrow x(3x^2-17x-6)=0$	M1	1.1a
	$\Rightarrow x(3x+1)(x-6)=0$	dM1	1.1b
	$\Rightarrow x=0,-\frac{1}{3},6$	A1	1.1b
		(3)	
(b)	Attempts to solve $(y-2)^2=n$ where n is any solution …0 to (a)	M1	2.2a
	Two of $2, 2\pm\sqrt{6}$	A1ft	1.1b
	All three of $2, 2\pm\sqrt{6}$	A1	2.1
		(3)	
			(6 marks)

Notes

(a)

M1: Factorises out or cancels by x to form a quadratic equation.

dM1: Scored for an attempt to find x. May be awarded for factorisation of the quadratic or use of the quadratic formula.

A1: $x=0,-\frac{1}{3},6$ and no extras

(b)

M1: Attempts to solve $(y-2)^2=n$ where n is any solution …0 to (a). At least one stage of working must be seen to award this mark. Eg $(y-2)^2=0 \Rightarrow y=2$

A1ft: Two of $2, 2\pm\sqrt{6}$ but follow through on $(y-2)^2=n \Rightarrow y=2\pm\sqrt{n}$ where n is a positive solution to part (a). (Provided M1 has been scored)

A1: All three of $2, 2\pm\sqrt{6}$ and no extra solutions. (Provided M1A1 has been scored)

Question	Scheme	Marks	AOs
2 (a)	Deduces the line has gradient "-3" and point $(7,4)$ Eg $y-4=-3(x-7)$	M1	2.2a
	$y=-3x+25$	A1	1.1b
		(2)	
(b)	Solves $y=-3x+25$ and $y=\frac{1}{3}x$ simultaneously	M1	3.1a
	$P=\left(\frac{15}{2},\frac{5}{2}\right)$ oe	A1	1.1b
	Length $PN=\sqrt{\left(\frac{15}{2}-7\right)^2+\left(4-\frac{5}{2}\right)^2}=\left(\sqrt{\frac{5}{2}}\right)$	M1	1.1b
	Equation of C is $(x-7)^2+(y-4)^2=\frac{5}{2}$ o.e.	A1	1.1b
		(4)	
(c)	Attempts to find where $y=\frac{1}{3}x+k$ meets C using vectors Eg: $\begin{pmatrix}7.5\\2.5\end{pmatrix}+2\times\begin{pmatrix}-0.5\\1.5\end{pmatrix}$	M1	3.1a
	Substitutes their $\left(\frac{13}{2},\frac{11}{2}\right)$ in $y=\frac{1}{3}x+k$ to find k	M1	2.1
	$k=\frac{10}{3}$	A1	1.1b
		(3)	
			(9 marks)
(c)	Attempts to find where $y=\frac{1}{3}x+k$ meets C via simultaneous equations proceeding to a 3TQ in x (or y) FYI $\frac{10}{9}x^2+\left(\frac{2}{3}k-\frac{50}{3}\right)x+k^2-8k+\frac{125}{2}=0$	M1	3.1a
	Uses $b^2-4ac=0$ oe and proceeds to $k=...$	M1	2.1
	$k=\frac{10}{3}$	A1	1.1b
		(3)	

Notes:

(a)

M1: Uses the idea of perpendicular gradients to deduce that gradient of PN is -3 with point $(7,4)$ to find the equation of line PN

So sight of $y-4=-3(x-7)$ would score this mark

If the form $y=mx+c$ is used expect the candidates to proceed as far as $c=...$ to score this mark.

A1: Achieves $y=-3x+25$

(b)

M1: Awarded for an attempt at the key step of finding the coordinates of point *P*. ie for an attempt at solving their $y=-3x+25$ and $y=\frac{1}{3}x$ simultaneously. Allow any methods (including use of a calculator) but it must be a valid attempt to find both coordinates.

A1: $P=\left(\frac{15}{2},\frac{5}{2}\right)$

M1: Uses Pythagoras' Theorem to find the radius or radius ^{2} using their $P=\left(\frac{15}{2},\frac{5}{2}\right)$ and $(7,4)$.
There must be an attempt to find the difference between the coordinates in the use of Pythagoras

A1: Full and careful work leading to a correct equation. Eg $(x-7)^2+(y-4)^2=\frac{5}{2}$ or its expanded form. Do not accept $(x-7)^2+(y-4)^2=\left(\sqrt{\frac{5}{2}}\right)^2$

(c)

M1: Attempts to find where $y=\frac{1}{3}x+k$ meets *C* using a vector approach

M1: For a full method leading to k . Scored for substituting their $\left(\frac{13}{2},\frac{11}{2}\right)$ in $y=\frac{1}{3}x+k$

A1: $k=\frac{10}{3}$ only

Alternative I

M1: For solving $y=\frac{1}{3}x+k$ with their $(x-7)^2+(y-4)^2=\frac{5}{2}$ and creating a quadratic eqn of the form $ax^2+bx+c=0$ **where both *b* and *c* are dependent upon *k***. The terms in x^2 and x must be collected together or implied to have been collected by their correct use in "b^2-4ac"
FYI the correct quadratic is $\frac{10}{9}x^2+\left(\frac{2}{3}k-\frac{50}{3}\right)x+k^2-8k+\frac{125}{2}=0$ oe

M1: For using the discriminant condition $b^2-4ac=0$ to find k. It is not dependent upon the previous M and may be awarded from only one term in *k*.
Award if you see use of correct formula but it would be implied by ± correct roots

A1: $k=\frac{10}{3}$ only

Alternative II

M1: For solving $y=-3x+25$ with their $(x-7)^2+(y-4)^2=\frac{5}{2}$, creating a 3TQ and solving.

M1: For substituting their $\left(\frac{13}{2},\frac{11}{2}\right)$ into $y=\frac{1}{3}x+k$ and finding k

A1: $k=\frac{10}{3}$ only

Question	Scheme	Marks	AOs
3(a)	$f(-3) = 2(-3)^3 + 5(-3)^2 + 2(-3) + 15$ $= -54 + 45 - 6 + 15$	M1	1.1b
	$f(-3) = 0 \Rightarrow (x + 3)$ is a factor	A1	2.4
		(2)	
(b)	At least 2 of: $a = 2,\ b = -1,\ c = 5$	M1	1.1b
	All of: $a = 2,\ b = -1,\ c = 5$	A1	1.1b
		(2)	
(c)	$b^2 - 4ac = (-1)^2 - 4(2)(5)$	M1	2.1
	$b^2 - 4ac = -39$ which is < 0 so the quadratic has no real roots so f(x) = 0 has only 1 real root	A1	2.4
		(2)	
(d)	$(x =)\ 2$	B1	2.2a
		(1)	
		(7 marks)	

Notes

(a)

M1: Attempts f(–3). Attempted division by $(x+3)$ or $f(3)$ is M0
Look for evidence of embedded values or two correct terms of
$f(-3) = -54 + 45 - 6 + 15 = ...$

A1: Achieves and states f(–3) = 0, and makes a suitable conclusion. Sight of f(x)=0 when $x = -3$ is also acceptable.
It must follow M1. Accept, for example, $f(-3) = 0 \Rightarrow (x+3)$ is a factor

This may be seen in a preamble before finding $f(-3) = 0$ but in these cases there must be a minimal statement ie QED, "proved", tick etc.

(b)

M1: Correct method implied by values for at least 2 correct constants. Allow embedded in their f(x) or within their working if they use algebraic division/other methods which may be seen in part (a) and used in part (b).

A1: All values correct. Allow embedded in their f(x) or seen as the quotient from algebraic division. Isw incorrectly stated values of a b and c following a correct quadratic expression seen.

$$
\begin{array}{r}
2x^2 - x + 5 \\
x+3\overline{\smash{)}2x^3 + 5x^2 + 2x + 15} \\
2x^3 + 6x^2 \qquad\qquad \\
-x^2 + 2x \qquad \\
-x^2 - 3x \qquad \\
5x + 15 \\
5x + 15 \\
0
\end{array}
$$

scores M1A1

(c)

M1: Either:

- considers the discriminant using their *a*, *b* and *c* (does not need to be evaluated) $(b^2 - 4ac =)\ (-1)^2 - 4(2)(5)$ (the $(-1)^2$ may appear as 1^2 and condone missing brackets for this mark for -1^2). Discriminant $= -39$ is sufficient for M1
- attempts to complete the square so score for $2\left(x \pm \frac{1}{4}\right)^2 + \ldots$
- attempts to find the roots of the quadratic using the formula. The values embedded in the formula score this mark. $\frac{1 \pm \sqrt{(-1)^2 - 4 \times 2 \times 5}}{2 \times 2}$ (the $(-1)^2$ may appear as 1^2 and condone missing brackets for this mark for -1^2)
- Sketches a graph of the quadratic. It must be a U shaped quadratic which does not cross the *x*-axis.

A1: Provides a correct explanation from correct working. They must

- Have a correct calculation
- Explanation that the quadratic has no (real) roots
- Minimal conclusion stating that $\mathrm{f}(x) = 0$ has only one root

eg $b^2 - 4ac = -39 < 0$ so only one root is M1A0 (needs to explain the quadratic has no real roots)

eg $2\left(x - \frac{1}{4}\right)^2 + \frac{39}{8} > 0$ **so no real roots** (for the quadratic) **so** (f(*x*) has) **only one (**real**) root** is M1A1

The value of the discriminant, completed square form $2\left(x - \frac{1}{4}\right)^2 + \frac{39}{8}$ or roots of the quadratic $\left(= \frac{1 \pm \sqrt{39}i}{4}\right)$ must be correct.

If they sketch the quadratic graph it must be a U shaped quadratic which crosses the *y*-axis at 5 and has a minimum in the 1st quadrant. They must explain that the graph does not cross the *x*-axis so no real roots for the quadratic so only one root for $\mathrm{f}(x) = 0$.

(d)

B1: 2 condone (2, 0)

Question	Scheme	Marks	AOs
4	Let $u=\sqrt{x}$ $\quad 6x+7\sqrt{x}-20=0 \Rightarrow 6u^2+7u-20=0$ $\Rightarrow (3u-4)(2u+5)\{=0\}$	M1A1	1.1b 1.1b
	Attempts $\sqrt{x}="\frac{4}{3}","-\frac{5}{2}" \Rightarrow x=...$	M1	1.1b
	$x=\frac{16}{9}$ only	A1 cso	2.3
		(4)	
		(4 marks)	
Alt 1	$6x+7\sqrt{x}-20=0 \Rightarrow 7\sqrt{x}=20-6x \Rightarrow 49x=(20-6x)^2$ $\Rightarrow 49x=400-240x+36x^2$	M1	1.1b
	$36x^2-289x+400\{=0\}$	A1	1.1b
	$(9x-16)(4x-25)=0$	M1	1.1b
	$x=\frac{16}{9}$ only	A1 cso	2.3
		(4)	
Alt 2	$6x+7\sqrt{x}-20=0 \Rightarrow (3\sqrt{x}-4)(2\sqrt{x}+5)=0$	M1 A1	1.1b 1.1b
	Attempts $\sqrt{x}="\frac{4}{3}","-\frac{5}{2}" \Rightarrow x=...$	M1	1.1b
	$x=\frac{16}{9}$ only	A1 cso	2.3
		(4)	

Notes:

M1: Attempts a valid method that enables the problem to be solved. See General Principles for Pure Mathematics Marking at the front of the mark scheme for guidance. Score for either letting $u=\sqrt{x}$ and attempting to factorise to $(au\pm c)(bu\pm d)$ with $ab=6, cd=20$

or making $7\sqrt{x}$ the subject and attempting to square both sides.

or attempting to factorise to $(a\sqrt{x}\pm c)(b\sqrt{x}\pm d)$ with $ab=6, cd=20$

or by quadratic formula or completing the square following usual rules.

A1: $(3u-4)(2u+5)\{=0\}$ **or** $36x^2-289x+400\{=0\}$ **or** $(3\sqrt{x}-4)(2\sqrt{x}+5)\{=0\}$

If they use the formula, it must be correct e.g., $u\,\{\text{or}\sqrt{x}\}=\frac{-7\pm\sqrt{7^2-4(6)(-20)}}{12}$ followed by $u\,\{\text{or}\sqrt{x}\}=\frac{4}{3}$ or equivalent e.g., $\frac{16}{12}$. Ignore if they have $u\,\{\text{or}\sqrt{x}\}=-\frac{5}{2}$ or not.

If they complete the square, they must have $\left(u+\frac{7}{12}\right)^2=\frac{529}{144}$ followed by $u\ \{\text{or}\ \sqrt{x}\}=\frac{4}{3}$ or equivalent e.g., $\frac{16}{12}$. Ignore if they have $u\ \{\text{or}\ \sqrt{x}\}=-\frac{5}{2}$ or not.

M1: Correct method from $p\sqrt{x}\pm q=0$ leading to $x=\ldots$ by squaring

In Alt 1, it is for solving their quadratic using the General Principles for Pure Mathematics Marking. There must be a method shown, i.e., the solutions should not come straight from a calculator. If attempting to factorise, it must be to $(ax\pm c)(bx\pm d)$ with $ab=36, cd=400$

In Alt 2, it is for squaring their value(s) for u to get $x=\ldots$

A1: **cso** $x=\frac{16}{9}$ only. $x=\frac{25}{4}$ must be discarded. Note 0011 is not possible.

Allow "incorrect" $x=-\frac{16}{9}$ or $x=-\frac{25}{4}$ to be seen as long as they are discarded.

Ignore any reason they give for rejecting solutions.

Note that a method to solve their quadratic must be seen – solutions must not come directly from a calculator. Simply stating the quadratic formula (without substitution) is insufficient.

Question	Scheme	Marks	AOs
5 (a)	Attempts both $y=8-10\times1+6\times1^2-1^3$ and $y=1^2-12\times1+14$	M1	1.1b
	Achieves $y=3$ for both equations and gives a minimal conclusion / statement, e.g., $(1, 3)$ lies on both curves so they intersect at $x=1$	A1	1.1b
		(2)	
(b)	(Curves intersect when) $x^2-12x+14=8-10x+6x^2-x^3$ $\Rightarrow x^3-5x^2-2x+6=0$	M1	1.1b
	For the key step in dividing by $(x-1)$ $x^3-5x^2-2x+6=(x-1)(x^2+px\pm6)$	dM1	3.1a
	$x^3-5x^2-2x+6=(x-1)(x^2-4x-6)$	A1	1.1b
	Solves $x^2-4x-6=0$ $(x-2)^2=10\Rightarrow x=...$	ddM1	1.1b
	$x=2-\sqrt{10}$ only	A1	1.1b
		(5)	
			(7 marks)

Notes:

(a) **Must be seen in (a)**

M1: As scheme.
For M1 A0, allow a statement that $(1,3)$ lies on both curves without sight of the calculation.
Amongst various alternatives are:

- Setting $x^2-12x+14=8-10x+6x^2-x^3$ and attempting to rearrange to $x^3-5x^2-2x+6=0$ before substituting in $x=1$
- Setting $x^2-12x+14=8-10x+6x^2-x^3$ and attempting to divide x^3-5x^2-2x+6 by $(x-1)$ either by long division or inspection

A1: For the complete mathematical argument.
Requires both correct calculations with a minimal conclusion, which may be as a preamble.
e.g., in the alternatives

- as $1^3-5\times1^2-2\times1+6=0$, hence curves meet when $x=1$
- $x^3-5x^2-2x+6=(x-1)(x^2-4x-6)$ so the curves intersect when $x=1$

(b) **Allow the use of *x* or *k* throughout this part.**

M1: Sets $x^2-12x+14=8-10x+6x^2-x^3$ and proceeds to a cubic equation set = 0
Must be seen or used in (b)

dM1: For the key step in realising that $(x-1)$ is a factor of the cubic.
It is for dividing by $(x-1)$ to get the quadratic factor.

For division look for their first two terms, i.e., $x^2 \pm 4x$

(This will need checking if they have made an error in rearranging the cubic.)

$$\begin{array}{r} x^2 \pm 4x\ldots\ldots\ldots\ldots\ldots \\ x-1\overline{)\,x^3-5x^2-2x+6} \\ \underline{x^3-1x^2\quad\quad\quad} \\ -4x^2\quad\quad\quad \end{array}$$

By inspection look for the first and last term $x^3-5x^2-2x+6=(x-1)\left(x^2+px\pm 6\right)$

A1: $x^3-5x^2-2x+6=(x-1)\left(x^2-4x-6\right)$ or just x^2-4x-6 or k^2-4k-6 as their quadratic factor following algebraic division.

ddM1: Attempts to solve their $x^2-4x-6=0$, which must be a 3TQ, by completing the square or the quadratic formula, leading to an exact solution. Their quadratic factor must **not** factorise. Their quadratic "factor" may come from algebraic division that has a remainder but we will still allow them to score this mark.

If using the quadratic formula, they need to have, e.g., $\dfrac{4-\sqrt{4^2-4(-6)}}{2}$

or $\dfrac{4-\sqrt{40}}{2}$ as a minimum (i.e., they must not jump straight to $2-\sqrt{10}$ from a calculator).

A1: $k=2-\sqrt{10}$ or exact equivalent but allow the use of x e.g., $x=\dfrac{4-\sqrt{40}}{2}$

If using the quadratic formula, the discriminant must be processed.
Must come from a correct quadratic factor.
They must have discarded $2+\sqrt{10}$ if seen.

Question	Scheme	Marks	AOs
6(a)	$\mathrm{f}(x) = (x-2)^2 \pm \ldots$	M1	1.2
	$\mathrm{f}(x) = (x-2)^2 + 1$	A1	1.1b
		(2)	
(b)(i)	$P = (0, 5)$	B1	1.1b
(b)(ii)	$Q = (2, 1)$	B1ft	1.1b
		(2)	
		(4 marks)	
Notes			

(a)

M1: Achieves $(x-2)^2 \pm \ldots$ or states $a = -2$

A1: Correct expression $(x-2)^2 + 1$ ISW after sight of this

Condone $a = -2$ and $b = 1$. Condone $(x-2)^2 + 1 = 0$

(b)

(i) B1: Correct coordinates for *P*. Allow to be expressed $x = 0,\ y = 5$

(ii) B1ft: Correct coordinates for *Q*. Allow to be expressed $x = 2,\ y = 1$ (Score for the correct answer or follow through their part (a) so allow $(-a, b)$ where a and b are numeric)

Score in any order if they state $P = (0, 5)$ and $Q = (2, 1)$

....

Allow part (b) to be awarded from a sketch. So award

First B1 from a sketch crossing the *y*-axis at 5

Second B1 from a sketch with minimum at $(2, 1)$

....

Question	Scheme	Marks	AOs
7(a)	$H = ax^2 + bx + c$ and $x=0,\ H=3 \Rightarrow H = ax^2 + bx + 3$	M1	3.3
	$H = ax^2 + bx + 3$ and $x = 120, H = 27 \Rightarrow 27 = 14400a + 120b + 3$ **or** $\frac{\mathrm{d}H}{\mathrm{d}x} = 2ax + b = 0$ when $x = 90 \Rightarrow 180a + b = 0$	M1 A1	3.1b 1.1b
	$H = ax^2 + bx + 3$ and $x = 120, H = 27 \Rightarrow 27 = 14400a + 120b + 3$ **and** $\frac{\mathrm{d}H}{\mathrm{d}x} = 2ax + b = 0$ when $x = 90 \Rightarrow 180a + b = 0$ $\Rightarrow a = ..., b = ...$	dM1	3.1b
	$H = -\frac{1}{300}x^2 + \frac{3}{5}x + 3$ o.e.	A1	1.1b
		(5)	
(b)(i)	$x = 90 \Rightarrow H\left(= -\frac{1}{300}(90)^2 + \frac{3}{5}(90) + 3\right) = 30\,\text{m}$	B1	3.4
(b)(ii)	$H = 0 \Rightarrow -\frac{1}{300}x^2 + \frac{3}{5}x + 3 = 0 \Rightarrow x = ...$	M1	3.4
	$x = (-4.868...,)\ 184.868...$ $\Rightarrow x = 185\,(\text{m})$	A1	3.2a
		(3)	
(c)	Examples must focus on why the model may not be appropriate or give values/situations where the model would break down: E.g. • The ground is unlikely to be horizontal • The ball is not a particle so has dimensions/size • The ball is unlikely to travel in a vertical plane (as it will spin) • *H* is not likely to be a quadratic function in *x*	B1	3.5b
		(1)	
		(9 marks)	

Notes

(a)

M1: Translates the problem into a suitable model and uses $H = 3$ when $x = 0$ to establish $c = 3$
Condone with $a = \pm 1$ so $H = x^2 + bx + 3$ will score M1 but little else

M1: For a correct attempt at **using one of the two other pieces** of information within a quadratic model
Either uses $H = 27$ when $x = 120$ (with $c = 3$) to produce a linear equation connecting a and b for the model **Or** differentiates and uses $\frac{\mathrm{d}H}{\mathrm{d}x} = 0$ when $x = 90$. Alternatives exist here, using the symmetrical nature of the curve, so they could use $x = -\frac{b}{2a}$ at vertex or use point (60, 27) or (180,3).

A1: At least one correct equation connecting a and b. Remember "a" could have been set as negative so an equation such as $27 = -14400a + 120b + 3$ would be correct in these circumstances.

dM1: Fully correct strategy that uses $H = ax^2 + bx + 3$ with the two other pieces of information in order to establish the values of **both** a **and** b for the model

A1: Correct equation, not just the correct values of a, b and c. Award if seen in part (b)

(b)(i)

B1: Correct height including the units. CAO

(b)(ii)

M1: Uses $H = 0$ and attempts to solve for x. Usual rules for quadratics.

A1: Discards the negative solution (may not be seen) and identifies awrt 185 m. Condone lack of units

(c)
B1: Candidate should either refer to an issue with one of the four aspects of how the situation has been modelled or give a situation where the model breaks down

- the ball has been modelled as a particle
- there may be trees (or other hazards) in the way that would affect the motion

Condone answers (where the link to the model is not completely made) such as

- the ball will spin
- ground is not flat

Do not accept answers which refer to the situation after it hits the ground (this isn't what was modelled)

- the ball will bounce after hitting the ground
- it gives a negative height for some values for x

Do not accept answers that do not refer to the model in question, or else give single word vague answers

- the height of tee may have been measured incorrectly
- "friction", "spin", "force" etc
- it does not take into account the weight of the ball
- it depends on how good the golfer is
- the shape of the ball will affect the motion
- you cannot hit a ball the same distance each time you hit it

The method using an alternative form of the equation can be scored in a very similar way.
The first M is for the completed square form of the quadratic showing a maximum at $x=90$

So award M1 for $H=\pm a(x-90)^2+c$ or $H=\pm a(90-x)^2+c$. Condone for this mark an equation with

$a=1 \Rightarrow H=(x-90)^2+c$ or $c=3 \Rightarrow H=a(x-90)^2+3$ but will score little else

Alt (a)	$H=a(x+b)^2+c$ and $x=90$ at $H_{max} \Rightarrow H=a(x-90)^2+c$	M1	3.3
	$H=3$ when $x=0 \Rightarrow 3=8100a+c$ **or** $H=27$ when $x=120 \Rightarrow 27=900a+c$	M1 A1	3.1b 1.1b
	$H=3$ when $x=0 \Rightarrow 3=8100a+c$ **and** $H=27$ when $x=120 \Rightarrow 27=900a+c$ $\Rightarrow a=...,c=...$	dM1	3.1b
	$H=-\frac{1}{300}(x-90)^2+30$ o.e	A1	1.1b
		(5)	
(b)	$x=90 \Rightarrow H=0^2+30=30\text{ m}$	B1	3.4
		(1)	
	$H=0 \Rightarrow 0=-\frac{1}{300}(x-90)^2+30 \Rightarrow x=...$	M1	3.4
	$\Rightarrow x=185\text{(m)}$	A1	3.2a
		(2)	

Note that $H=-\frac{1}{300}(x-90)^2+30$ is equivalent to $H=-\frac{1}{300}(90-x)^2+30$

Other versions using symmetry are also correct so please look carefully at all responses

E.g. Using a starting equation of $H=a(x-60)(x-120)+b$ leads to $H=-\frac{1}{300}(x-60)(x-120)+27$

Question	Scheme	Marks	AOs
8(a)	$a = 60$	B1	3.1b
	$2 = "60" - b(-20)^2 \Rightarrow b = ...$	M1	3.4
	$H = 60 - 0.145(t-20)^2$	A1	3.3
		(3)	
(b)	Height = 2 m	B1	3.4
		(1)	
(c)	$\alpha = 180$ or $\beta = 31$	M1	3.4
	$H = 29\cos(9t+180)° + 31$	A1	3.3
		(2)	
(d)	e.g. "The model allows for more than one circuit"	B1	3.5a
		(1)	
		(7 marks)	

Notes

(a)

B1: $a = 60$ (may be seen in their final equation of the model or implied by 60 substituted for *a* in the model)

M1: Attempts to find *b* by substituting in $t = 0$, $H = 2$ and their *a* and proceeding to a value for *b*. May be seen as two simultaneous equations formed:
$2 = a - b(-20)^2$ and $60 = a - b(20-20)^2$ proceeding to a value for *b*

A1: $H = 60 - 0.145(t-20)^2$ or equivalent such as $H = -\frac{29}{200}t^2 + 5.8t + 2$ or $H = 60 - \frac{29}{200}(t-20)^2$ isw once a correct equation for the model is seen. Must be in terms of *H* and *t*. If they just state $a = 60,\ b = 0.145$ then A0
A correct answer with no working seen scores full marks.

(b)

B1: 2 cao (condone lack of units) This can be scored even if their model in (a) is incorrect (they may have used symmetry to determine this value)

(c)

M1: $(\alpha =)\ 180$ or $(\beta =)\ 31$ Condone $(\alpha =)\ \pi$

A1: $H = 29\cos(9t+180)° + 31$ or equivalent e.g. $H = -29\cos(9t) + 31$ isw once a correct equation for the model is seen. Must be in terms of *H* and *t*. If they just state $\alpha = 180,\ \beta = 31$ then A0.
A correct equation with no working seen scores both marks. Does not require the degree symbol.

(d)

B1: Score for a reason which makes reference to any of

- the alternative model allows repetition (allow phrases e.g. "multiple cycles", "repeated circuits", "cyclical", "periodic", "loops around", "the original model can only go up and down once")
- the alternative model after 2 minutes the carriage will be back at the start (e.g."at 2 mins, $H = 2$")
- the original/quadratic model after 40 seconds (or any time after this) will be negative (e.g. "the height will be negative which cannot happen")
- the original model after 2 minutes would not be back at the start

Do not allow vague responses on their own e.g. "the original model is a parabola"
If calculations are used then they must be correct using a correct model (allow rounded or truncated)
Look for a valid reason and ignore reference to anything else as long as it does not contradict

t	0	5	10	15	20	25	30	35	40	45	50	55	60	80	100	120
h	2	27	46	56	60	56	46	27	2	-31	-71	-118	-172	-462	-868	-1390