Question Number	Scheme	Marks
6(a)	$\frac{\mathrm{d}\theta}{\mathrm{d}t} = -k(\theta - 15)^2 \Rightarrow \int \frac{\mathrm{d}\theta}{(\theta-15)^2} = \int -k\,\mathrm{d}t$	B1
	$\int \frac{\mathrm{d}\theta}{(\theta-15)^2} = -(\theta-15)^{-1}$	M1
	$-\frac{1}{\theta-15} = -kt + c$	A1
	$t = 0, \theta = 85 \Rightarrow -\frac{1}{70} = c$	M1
	$t = 10, \theta = 40 \Rightarrow \frac{1}{25} = 10k + \frac{1}{70} \Rightarrow k = ...\left(\frac{9}{3500}\right)$	M1
	$\frac{1}{\theta-15} = \frac{9t}{3500} + \frac{1}{70} \Rightarrow \theta = ...$	M1
	$\theta = \frac{135t + 4250}{9t + 50}$	A1
		(7)
(b)	$20 = \frac{135t + 4250}{9t + 50} \Rightarrow t = ...$	M1
	$t =$ awrt 72	A1
		(2)
		Total 9

(a) **Note that candidates cannot work backwards from the answer using differentiation**

B1: Correct separation of variables.
The integral signs do not have to be present, but the $\mathrm{d}\theta$ and $\mathrm{d}t$ do, and be in the correct positions

M1: Integrates $\int \frac{1}{(\theta-15)^2}\,\mathrm{d}\theta$ to $\frac{\alpha}{\theta-15}$

A1: Correct equation including a *k* and another **different** constant.

M1: Uses $t = 0, \theta = 85$ to find "*c*". May be awarded after incorrect integration. May be also awarded if the constant *k* had been assigned a value using given values of θ and t.
Their initial equation may have been (incorrectly) adapted but it must be solvable with $t = 0, \theta = 85$ used leading to c =...

M1: Uses t = 10 and θ = 40 with their value of "c" to find k.
May be awarded after incorrect integration but there must have been two constants. Their initial equation may have been adapted but it must be solvable with t = 10, θ = 40 AND their c =...

M1: Rearranges using correct algebra to obtain θ in terms of *t*.
For this to be awarded the integral must be in the correct form and both constants found using a correct method . Condone slips in working but the overall process should be sound.
Look for $\frac{1}{\theta-15} = \alpha t + \beta \Rightarrow \theta = \frac{ct + d}{et + f}$

A1: Correct expression. Allow integer multiples of the given answer E.g. $\theta = \frac{297500 + 9450t}{3500 + 630t}$

(b)

M1: Uses their answer to part (a) or equivalent (or possibly an earlier equation) to find t when $\theta = 20$.

For this to be awarded, substitute $\theta = 20$ into a "correct" form such as $\frac{1}{\theta - 15} = \alpha t + \beta \Rightarrow t = ...$

Or substitute $\theta = 20$ into a "correct" form such as $\theta = \frac{ct + d}{et + f} \Rightarrow t = ...$ where $c, d, e, f \neq 0$

They cannot just make values up for the c, d, e and f for example. It must follow their work in (a)

A1: Correct value which must have come from a correct equation. Exact value is $\frac{650}{9}$ but allow awrt 72

Of course candidates can move the "k" or "$-k$" term over to the LHS or use limits .

6(a)	$\frac{d\theta}{dt} = -k(\theta - 15)^2 \Rightarrow \int \frac{d\theta}{-k(\theta - 15)^2} = \int dt$	B1
	$\int \frac{d\theta}{(\theta - 15)^2} = \alpha(\theta - 15)^{-1}$	M1
	$\frac{1}{k(\theta - 15)} = t + \beta$	A1
	$t = 0, \theta = 85 \Rightarrow \frac{1}{70k} = \beta$	M1
	$t = 10, \theta = 40 \Rightarrow \frac{1}{25k} = \beta + 10 \Rightarrow k = ...\left(\frac{9}{3500}\right) \quad \beta = ...\left(\frac{50}{9}\right)$	M1
	$\frac{3500}{9(\theta - 15)} = t + \frac{50}{9} \Rightarrow \theta = ...$	M1
	$\theta = \frac{135t + 4250}{9t + 50}$	A1

6(a)	$\frac{d\theta}{dt} = -k(\theta - 15)^2 \Rightarrow \int \frac{d\theta}{(\theta - 15)^2} = \int -k\, dt$	B1
	$\int \frac{d\theta}{(\theta - 15)^2} = -(\theta - 15)^{-1}$	M1
	Correct equation using limits $\left[-\frac{1}{\theta - 15}\right]_{85}^{40} = [-kt]_0^{10}$ Or $\left[\frac{1}{\theta - 15}\right]_{85}^{40} = [kt]_0^{10}$	A1
	Correct attempt to find k $-\frac{1}{25} + \frac{1}{70} = -10k \Rightarrow k = ...\left(\frac{9}{3500}\right)$	M1
	Correct attempt to find equation linking θ and t E.g. $\left[-\frac{1}{\theta - 15}\right]_{85}^{\theta} = [-kt]_0^t$	M1
	$-\frac{1}{\theta - 15} + \frac{1}{70} = -\frac{9t}{3500} \Rightarrow \theta = ...$	M1
	$\theta = \frac{135t + 4250}{9t + 50}$	A1

Question Number	Scheme	Marks
7	Assume that $\sqrt{7}$ is rational so that $\sqrt{7}=\frac{a}{b}\Rightarrow 7=\frac{a^2}{b^2}$ (where a and b have no factors in common)	M1
	$7=\frac{a^2}{b^2}\Rightarrow 7b^2=a^2$ So a^2 is a multiple of 7 which means a is a multiple of 7	A1
	$a=7k\Rightarrow 7b^2=49k^2\Rightarrow b^2=7k^2$	M1
	So b^2 is a multiple of 7 which means b is a multiple of 7. As a and b are both multiples of 7, this contradicts the fact that a and b have no factors in common. Hence $\sqrt{7}$ must be irrational.	A1
		(4)
		Total 4

Any variables may be used

M1: Starts the proof by contradicting the given statement and squares both sides.

Condone the omission of the statement about common factors here.

As a minimum allow "assume $\sqrt{7}=\frac{a}{b}\Rightarrow 7=\frac{a^2}{b^2}$" or similar "let $\sqrt{7}=\frac{p}{q}\Rightarrow p^2=7q^2$"

A1: Reaches for example $7b^2=a^2$ and deduces that a^2 is a multiple of 7 which means a is a multiple of 7
Condone these being the "wrong way around" as long as they state both a and a^2 are multiples of 7
Look for

- $7b^2=a^2$
- states a is a multiple of 7 (which may be implied by setting $a=7k$ for example)
- states a^2 is a multiple of 7

M1: Sets $a=7k$ and proceeds to $b^2=7k^2$

A1: Fully Correct proof. This must include

- an initial statement that included that a and b had no common factors. Allow equivalent statements such as $\frac{a}{b}$ is a fraction in simplest form or co-prime, relatively prime, mutually prime
- the statements and conclusions the correct way around.
  E.g. a^2 is a multiple of 7 which means a is a multiple of 7 (not the other way around)
  and b^2 is a multiple of 7 which means b is a multiple of 7 (not the other way around)
- a minimal conclusion

Be tolerant of slight issues with terminology/language used as this may not be the students first language.