Question Number	Scheme	Marks
7(a)	$3\cot^2 2\theta - 7 = \dfrac{13}{2\sin\theta\cos\theta}$ **or** $2\sin\theta\left(3(\text{cosec}^2 2\theta - 1) - 7\right) = 13\sec\theta$ **oe**	M1
	$3(\text{cosec}^2 2\theta - 1) - 7 = \dfrac{13}{2\sin\theta\cos\theta}$	dM1
	$\Rightarrow 3\text{cosec}^2 2\theta - 10 = 13\text{cosec}\,2\theta \Rightarrow 3\text{cosec}^2 2\theta - 13\text{cosec}\,2\theta - 10 = 0$*	ddM1A1*
		(4)
(b)	$3\text{cosec}^2 2\theta - 13\text{cosec}\,2\theta - 10 = 0$	
	$(3\text{cosec}\,2\theta + 2)(\text{cosec}\,2\theta - 5) = 0 \Rightarrow (\text{cosec}\,2\theta) = 5 \Rightarrow (\sin 2\theta) = \dfrac{1}{5}$	M1A1
	$\theta = \dfrac{\sin^{-1}\left("\frac{1}{5}"\right)}{2} = \ldots$	dM1
	$(\theta =)$ awrt 0.101, 1.47	A1
		(4)
		(8 marks)
Alt(a)	$2\sin\theta\left(\dfrac{3(1-\sin^2 2\theta)}{\sin^2 2\theta} - 7\right) = 13\sec\theta$	M1
	$\dfrac{3(1-\sin^2 2\theta)}{\sin^2 2\theta} - 7 = \dfrac{13}{2\sin\theta\cos\theta}$	dM1
	$\dfrac{3}{\sin^2 2\theta} - 10 = \dfrac{13}{\sin 2\theta}$	ddM1
	$3\text{cosec}^2 2\theta - 13\text{cosec}\,2\theta - 10 = 0$ *	A1*

(a)

M1 Attempts **EITHER**

- to divide both sides by $(2)\sin\theta$ and use $\sec\theta = \dfrac{1}{\cos\theta}$ (or $\text{cosec}\,\theta = \dfrac{1}{\sin\theta}$) to achieve a term of the form $\dfrac{A}{B\sin\theta\cos\theta}$ oe (implied by $\dfrac{\ldots}{\ldots\sin 2\theta}$ or $\ldots\text{cosec}\,\theta\sec\theta$).
  Note $\sin 2\theta(3\cot^2 2\theta - 7) = 13$ does not score this mark. They have not divided by (2)$\sin\theta$

- to use $\pm 1 \pm \cot^2 2\theta = \pm\text{cosec}^2 2\theta$ to replace the $\cot^2 2\theta$ term in the equation or in the alternative method it is for using $\cot^2 2\theta = \dfrac{\cos^2 2\theta}{\sin^2 2\theta}$ and using $\pm 1 \pm \sin^2 2\theta = \pm\cos^2 2\theta$ to replace the $\cos^2 2\theta$

  Condone arithmetical slips and invisible brackets.

dM1 Attempts **BOTH**

- to divide both sides by $(2)\sin\theta$ and use $\sec\theta = \frac{1}{\cos\theta}$ (or $\text{cosec}\,\theta = \frac{1}{\sin\theta}$) to achieve a term of the form $\frac{A}{B\sin\theta\cos\theta}$ oe (implied by $\frac{...}{...\sin 2\theta}$ or $...\,\text{cosec}\,\theta\sec\theta$). May be implied
- to use $\pm 1 \pm \cot^2 2\theta = \pm\text{cosec}^2 2\theta$ to replace the $\cot^2 2\theta$ term in the equation or in the alternative method it is for using $\cot^2 2\theta = \frac{\cos^2 2\theta}{\sin^2 2\theta}$ and using $\pm 1 \pm \sin^2 2\theta = \pm\cos^2 2\theta$ to replace the $\cos^2 2\theta$

Condone arithmetical slips and invisible brackets. It is dependent on the first mark.

ddM1 A full attempt to achieve a 3TQ in cosec 2θ only. It is dependent on both of the previous method marks. They must

- use the identity $\sin 2\theta = 2\sin\theta\cos\theta$ (or $\text{cosec}\,2\theta = \frac{1}{2}\text{cosec}\,\theta\sec\theta$) and proceed to a cosec 2θ term
- multiply out the brackets and collect terms on one side to form a 3TQ in cosec 2θ only.

Do not be concerned with the mechanics of their arrangement and they may proceed to the printed answer at this stage. Condone arithmetical slips and invisible brackets.

A1* Achieves $3\text{cosec}^2 2\theta - 13\text{cosec}\,2\theta - 10 = 0$ with no arithmetical errors in the main body of their solution. You must see either $\sin\theta\cos\theta$ or $\sin 2\theta$ within their working.
Allow recovery of invisible brackets in their solution.
Withhold the final mark for poor notation such as $\text{cosec}^2 2\theta$ being written as $\text{cosec}\,2\theta^2$ or if the 2 is missing from 2θ
They may work in a different variable, but the final answer must be in terms of 2θ

(b) *Be aware that answers with no intermediate working seen is not acceptable*

M1 Attempts to solve the quadratic and finds the reciprocal of one of their roots (usual rules apply for solving a quadratic). Do not be concerned by their labelling.
Look for eg $.... = 5 \to \frac{1}{5}$ or eg $.... = -\frac{3}{2} \to -\frac{2}{3}$

A1 $(\sin 2\theta =)\ \frac{1}{5}$ (Ignore any reference to $-\frac{3}{2}$) $\frac{1}{5}$ on its own is sufficient. Condone eg $\sin^2 2\theta = \frac{1}{5}$ or $\sin X = \frac{1}{5}$ or $\sin\theta = \frac{1}{5}$

dM1 Correct method to find a value for θ by finding arcsin(their $\frac{1}{5}$) and dividing by 2.
May be implied by awrt 0.10 or awrt 1.5 (or in degrees awrt 5.8 or awrt 84).
It is dependent on seeing either the quadratic solved or their root from the quadratic (either $\geqslant 1$ or $\leqslant -1$) or the reciprocal of the root being stated first.
It cannot be scored for solving eg $\sin^2 2\theta = ...$

A1 $(\theta =)$ awrt 0.101, awrt 1.47 and no other angles within the given interval.
Some intermediate working must be shown. Examples of minimum working shown in (b):

$\sin 2\theta = \frac{1}{5} \Rightarrow (\theta =)\ 0.101, 1.47$

$\text{cosec}\ 2\theta = 5 \Rightarrow (\theta =)\ 0.101, 1.47$

Question Number	Scheme	Marks
8(a)	$\frac{dv}{dt} = -e^{t-10} + 9e^{-0.75t} = 0 \Rightarrow 9 = e^{1.75t-10}$ or $9e^{-0.75t} = e^{t-10}$	M1A1
	$9 = e^{1.75t-10} \Rightarrow t = \frac{10+\ln 9}{1.75}$ or $\ln 9 - 0.75t = t - 10 \Rightarrow t = \frac{10+\ln 9}{1.75}$	M1
	$t = \text{awrt } 6.97$	A1
	awrt $11.9\ (\text{ms}^{-1})$	A1
		(5)
(b)	$\int 12 - 12e^{-0.75t} - e^{(t-10)}\,dt = 12t - e^{(t-10)} + 16e^{-0.75t}\ (+C)$	M1A1
	$\left[12t - e^{(t-10)} + 16e^{-0.75t}\right]_0^T = 100 \Rightarrow 12T = \ldots$	M1
	$T = \frac{1}{12}\left(116 - 16e^{-0.75T} + e^{T-10} - e^{-10}\right)$ *	A1*
		(4)
(c) **(i)**	$T_2 = \frac{1}{12}\left(116 - 16e^{-0.75\times 10} + e^{10-10} - e^{-10}\right)$	M1
	$T_2 = \text{awrt } 9.7493$	A1
(ii)	9.7293 (seconds)	A1
		(3)
		(12 marks)

(a) *** Be aware this can be solved directly on a calculator. Calculus must be seen***

M1 Differentiates to $\pm Ae^{t-10} \pm Be^{-0.75t}$ and **sets equal to 0** Must be seen in (a) Do not accept differentiating to eg $\ldots te^{t-10}$. Condone an expression of $12 \pm Ae^{t-10} \pm Be^{-0.75t}$ only

A1 $9 = e^{1.75t-10}$ or equivalent eg $9e^{-0.75t} - e^{t-10} = 0$

M1 Proceeds from their equation of the form $Ae^{Ct\pm D} - Be^{Et\pm F} = 0$ or equivalent leading to a value or an expression (which may be unsimplified) for *t*. If log work is seen it must be correct.

Eg $\frac{40+4\ln 9}{7}$ or $\frac{10+\ln 9}{1.75}$ will score this mark

$9e^{-0.75t} - e^{t-10} = 0 \Rightarrow$ awrt 6.97 can also score this mark

This cannot be scored from an unsolvable equation.