Question Number	Scheme	Marks
6(a)	$\left(2,3,-7\right)$	B1
		(1)
(b)	Attempts $\begin{pmatrix}1\\2\\2\end{pmatrix}\bullet\begin{pmatrix}4\\-1\\8\end{pmatrix}=1\times4+2\times-1+2\times8=\left(18\right)$	M1
	Attempts $\mathbf{a}.\mathbf{b}=\left\|\mathbf{a}\right\|\left\|\mathbf{b}\right\|\cos\theta$: $18=\sqrt{1^2+2^2+2^2}\times\sqrt{4^2+\left(-1\right)^2+8^2}\cos\theta$	**d**M1
	$\cos\theta=\frac{2}{3}$	A1
		(3)
(b) Alt	e.g. $\pm\left(\begin{pmatrix}4\\-1\\8\end{pmatrix}-\begin{pmatrix}1\\2\\2\end{pmatrix}\right)=\pm\begin{pmatrix}3\\-3\\6\end{pmatrix}$	M1
	$3^2+3^2+6^2=1^2+2^2+2^2+4^2+\left(-1\right)^2+8^2-2\sqrt{1^2+2^2+2^2}\times\sqrt{4^2+\left(-1\right)^2+8^2}\cos\theta$	dM1
	$\cos\theta=\frac{2}{3}$	A1
(c)	Uses $\lambda=6$ to find length PQ E.g. $\overrightarrow{PQ}=6\mathbf{i}+12\mathbf{j}+12\mathbf{k}\Rightarrow PQ=\sqrt{6^2+12^2+12^2}=\left(18\right)$ Or $PQ=6\times\sqrt{1^2+2^2+2^2}=\left(18\right)$	M1
	Area $QPR=\frac{1}{2}ab\sin C=\frac{1}{2}\times18^2\times\sqrt{1-\left(\frac{2}{3}\right)^2}=54\sqrt{5}$	M1 A1
		(3)
(d)	Attempts a correct method of finding at least one value for μ e.g. $\left(4\mu\right)^2+\mu^2+\left(8\mu\right)^2=6^2+12^2+12^2$ $\Rightarrow\mu=\frac{\text{"18"}}{\sqrt{4^2+\left(-1\right)^2+8^2}}=\left(\pm\right)2$	M1
	Attempts one correct position $\mathbf{r}=\begin{pmatrix}2\\3\\-7\end{pmatrix}\pm2\begin{pmatrix}4\\-1\\8\end{pmatrix}$	**d**M1
	Possible coordinates $\left(10,1,9\right)$ and $\left(-6,5,-23\right)$	A1
		(3)
		(10 marks)

(a)

B1: Correct coordinates or position vector e.g. as shown or $x = 2$, $y = 3$, $z = -7$ or $2\mathbf{i} + 3\mathbf{j} - 7\mathbf{k}$ or $\begin{pmatrix} 2 \\ 3 \\ -7 \end{pmatrix}$

Condone $\left(2\mathbf{i}, 3\mathbf{j}, -7\mathbf{k}\right)$

(b)

M1: Attempts $\begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix} \bullet \begin{pmatrix} 4 \\ -1 \\ 8 \end{pmatrix}$ condoning slips. Note that any non-zero multiples of these vectors can be used.

If the method is not explicit then this mark may be implied by 2 correct components.

dM1: Full attempt at $\mathbf{a}.\mathbf{b} = |\mathbf{a}||\mathbf{b}|\cos\theta$ where **a** and **b** are the direction vectors or multiples of them.

Depends on the first method mark.

Note that $\cos\theta = \dfrac{4-2+16}{\sqrt{1^2+2^2+2^2}\sqrt{4^2+1^2+8^2}}$ would imply both method marks.

A1: $\cos\theta = \dfrac{2}{3}$

(b) Alternative using the cosine rule:

M1: Attempts $\pm\left(\alpha\begin{pmatrix} 4 \\ -1 \\ 8 \end{pmatrix} - \beta\begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix}\right)$

dM1: Full attempt at the cosine rule using the appropriate lengths.

Depends on the first method mark.

A1: $\cos\theta = \dfrac{2}{3}$

(c)

M1: Uses $\lambda = 6$ to find the length of PQ. E.g. uses Pythagoras to calculate $|6\mathbf{i}+12\mathbf{j}+12\mathbf{k}|$ or $6|\mathbf{i}+2\mathbf{j}+2\mathbf{k}|$

If the method is not explicit then the attempt at $\overrightarrow{PQ}$ may be implied by 2 correct components.

M1: Full attempt at $\dfrac{1}{2}ab\sin C$ where $a = b = |\overrightarrow{PQ}|$ and C is their θ which may be attempted in decimals.

Their θ or $\sin\theta$ must follow an attempt to use their $\cos\theta$.

A1: $54\sqrt{5}$ or exact equivalent e.g. $\dfrac{162\sqrt{5}}{3}$

(d)

M1: Attempts a **correct** method of finding at least one value for μ.

Pythagoras must be used correctly and both sides of their equation must be consistent e.g.

$\left(4\mu\right)^2-\mu^2+\left(8\mu\right)^2=18^2$ and $\left(4\mu\right)^2+\mu^2+\left(8\mu\right)^2=18$ both score M0

Must be correct work here so must be using the length of *PQ* not *OQ*.

dM1: Attempts one correct position $\mathbf{r}=\begin{pmatrix}2\\3\\-7\end{pmatrix}\pm 2\begin{pmatrix}4\\-1\\8\end{pmatrix}$ **Depends on the first method mark.**

A1: Gives both possible coordinates $\left(10,\ 1,\ 9\right)$ and $\left(-6,\ 5,\ -23\right)$

Allow as coordinates or vectors or as $x = \ldots$, $y = \ldots$, $z = \ldots$

Question Number	Scheme	Marks
7(a)	Substitutes $x = 3$ and $t = 0$ into $x = \dfrac{k(9t+5)}{4t+3}$	M1
	$\Rightarrow 3 = \dfrac{5k}{3} \Rightarrow k = 1.8$ *	A1*
		(2)
(b)	4050	B1
		(1)
(c)	$\dfrac{3}{x(9-2x)} \equiv \dfrac{A}{x} + \dfrac{B}{9-2x}$	M1
	Either $A = \dfrac{1}{3}$ or $B = \dfrac{2}{3}$	A1
	$\dfrac{3}{9x-2x^2} \equiv \dfrac{1}{3x} + \dfrac{2}{3(9-2x)}$	A1
		(3)
(d)	$3\dfrac{\mathrm{d}x}{\mathrm{d}t} = x(9-2x) \Rightarrow \displaystyle\int \frac{3}{x(9-2x)}\,\mathrm{d}x = \int \mathrm{d}t$ **Or** $3\dfrac{\mathrm{d}x}{\mathrm{d}t} = x(9-2x) \Rightarrow \displaystyle\int \frac{1}{x(9-2x)}\,\mathrm{d}x = \int \frac{1}{3}\,\mathrm{d}t$ $\Rightarrow \dfrac{1}{3}\ln x - \dfrac{1}{3}\ln(9-2x) = t(+c)$ **or** $\dfrac{1}{9}\ln x - \dfrac{1}{9}\ln(9-2x) = \dfrac{1}{3}t(+c)$	M1 A1ft
	Substitutes $t = 0, x = 3 \Rightarrow c = 0$	M1
	$\dfrac{1}{3}\ln x - \dfrac{1}{3}\ln(9-2x) = t \Rightarrow \left(\dfrac{x}{9-2x}\right) = \mathrm{e}^{3t}$	**dd**M1
	$\left(\dfrac{9-2x}{x}\right) = \mathrm{e}^{-3t} \Rightarrow \dfrac{9}{x} - 2 = \mathrm{e}^{-3t} \Rightarrow x = \dfrac{9}{2+\mathrm{e}^{-3t}}$*	A1*
		(5)
(e)	4500	B1
		(1)
		(12 marks)

(a)

M1: Substitutes $x = 3$ and $t = 0$ into the given equation

A1*: Shows that $k = 1.8$ (oe e.g. $\dfrac{9}{5}$) with no errors and with at least one correct line of the form $ak = b$

e.g. $3 = \dfrac{k(9\times 0+5)}{4\times 0+3} \Rightarrow k = 1.8$, $3 = \dfrac{k(0+5)}{0+3} \Rightarrow k = 1.8$, $3 = \dfrac{5k}{3} \Rightarrow k = 1.8$ **all score M1A1**

Alternative by verification:

M1: Substitutes $k = 1.8$ and $t = 0$ into the given equation

A1*: Shows that $x = 3$ with at least one correct intermediate line and a concluding statement that this is 3000