Question Number	Scheme	Marks
9	$\begin{pmatrix} 2-\lambda \\ 8+2\lambda \\ 10+3\lambda \end{pmatrix} = \begin{pmatrix} -4+5\mu \\ -1+4\mu \\ 2+8\mu \end{pmatrix}$ Attempts to solve any two of the three equations Either (1) and (2) $\left.\begin{matrix} 2-\lambda=-4+5\mu \\ 8+2\lambda=-1+4\mu \end{matrix}\right\} \Rightarrow \lambda=-\frac{3}{2}, \mu=\frac{3}{2}$ (1) and (3) $\left.\begin{matrix} 2-\lambda=-4+5\mu \\ 10+3\lambda=2+8\mu \end{matrix}\right\} \Rightarrow \lambda=\frac{8}{23}, \mu=\frac{26}{23}$ (2) and (3) $\left.\begin{matrix} 8+2\lambda=-1+4\mu \\ 10+3\lambda=2+8\mu \end{matrix}\right\} \Rightarrow \lambda=-10, \mu=-\frac{11}{4}$	M1, A1
	Substitutes their values of λ and μ into both sides of the "third" equation E.g. $\lambda=-\frac{3}{2}$ into $10+3\lambda=\frac{11}{2}$ and $\mu=\frac{3}{2}$ into $2+8\mu=14$	dM1
	Concludes that lines don't intersect with correct calculations and minimal reason	A1
	Additionally states that $\begin{pmatrix} -1 \\ 2 \\ 3 \end{pmatrix}$ is not parallel to $\begin{pmatrix} 5 \\ 4 \\ 8 \end{pmatrix}$ with a minimal reason So lines are skew CSO *	A1*
		(5) **(5 marks)**

Notes:
Main method seen
M1: Attempts to solve two of the three equations.
Accept as an attempt, writing down two of the three equations (condoning slips) followed by values for
both λ and μ
A1: Solves two of the three equations to find correct values for both λ and μ, Allow equivalent fractions
dM1: Either: Substitutes their values of λ and μ into both sides of the third equation....or into the equations of both lines to find both coordinates
A1: Having achieved correct values for λ and μ, the values for the third equation are found to enable a comparison to be made. E.g. solving equations (1) and (2) and using equation (3) stating $10+3\times-\frac{3}{2} \neq 2+8\times\frac{3}{2}$ is sufficient. If the values are found they must be correct.
Important: Additionally, to score this mark, a minimal statement must be made that states that the lines do not intersect /cross. Condone statements such as $l_1 \neq l_2$
Stating that the lines are skew at this point is not sufficient to score this mark
In the alternative stating that "as the values are not the same, the lines cannot intersect" is sufficient.

A1*: CSO . Hence all previous marks must have been scored.
In addition to not intersecting there must be a statement, with a minimal reason, that the lines are not parallel and hence skew. Accept statements like, not intersecting, not parallel (with reason), hence proven.

Reasons could be $\begin{pmatrix}5\\4\\8\end{pmatrix} \neq k\begin{pmatrix}-1\\2\\3\end{pmatrix}$ o.e such as $5 = -5\times -1$ but $4 = 2\times 2$ so they are not parallel.

Accept an argument based around the scalar product of the direction vectors. If parallel $\cos\theta = 1$

A reason for the lines not being parallel cannot be $\begin{pmatrix}5\\4\\8\end{pmatrix} \neq \begin{pmatrix}-1\\2\\3\end{pmatrix}$

Note: Other methods are possible and it is important that you look at their complete attempt at proving that they don't intersect.

Alternative 1

For example it is possible to solve equations (1) and (2) to find just λ

then solve equations (1) and (3) to find just λ

and then conclude that "as the two values are not the same, the lines don't intersect"

M1 dM1 marks are scored together. Both aspects have to be attempted

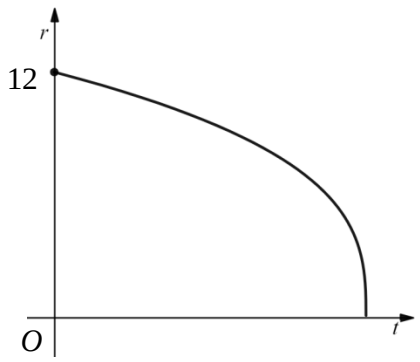
Attempts to solve two of the three equations to find λ (or μ)

Attempts to solve a different pair of equations to find λ (or μ)

A1: Correct values for λ (or μ).

A1: conclude that "as the two values are not the same, the lines don't intersect"

If you see something that you feel deserves credit AND that you cannot mark, then please send to review

Question Number	Scheme	Marks
10 (a)	States or uses $\frac{\mathrm{d}r}{\mathrm{d}t} \propto \pm\frac{1}{r^2}$ or $\frac{\mathrm{d}r}{\mathrm{d}t} = \pm\frac{k}{r^2}$	B1
	$\frac{\mathrm{d}r}{\mathrm{d}t} = \pm\frac{k}{r^2} \Rightarrow \int r^2 \mathrm{d}r = \int \pm k \mathrm{d}t$	
	$\frac{1}{3}r^3 = \pm kt + c$	M1 A1
	Substitutes $t = 0, r = 12 \Rightarrow c = \left(576\right)$	
	AND $t = 15, r = 6$ and their $c = \left(576\right) \Rightarrow k = \left(\pm 33.6\right)$	M1
	$\frac{1}{3}r^3 = -33.6t + 576$ or $r^3 = -100.8t + 1728$ o.e.	A1
		(5)
(b)	Sets $r = 0 \Rightarrow -100.8t + 1728 = 0$	M1
	$\frac{120}{7}$ minutes or awrt 17.1 minutes	A1
		(2)
(c)		B1
		(1)
		(8 marks)

(a)

B1: States or uses $\frac{\mathrm{d}r}{\mathrm{d}t} \propto \pm\frac{1}{r^2}$, $\frac{\mathrm{d}r}{\mathrm{d}t} = \pm\frac{k}{r^2}$ or $\frac{\mathrm{d}r}{\mathrm{d}t} = \pm\frac{1}{kr^2}$ Accept $k \leftrightarrow \lambda$ or other constant. Condone $\frac{\mathrm{d}r}{\mathrm{d}t} = \pm\frac{1}{r^2}$

M1: Integrates to achieve an expression of the correct form $...r^3 = ...t\left(+c\right)$ o.e

There is no requirement for + c

A1: Correct integration with two different unknown constants. E.g. look for $\frac{1}{3}r^3 = \pm kt + c$ o.e

So if for example $\frac{\mathrm{d}r}{\mathrm{d}t} = -\frac{1}{r^2} \Rightarrow \frac{1}{3}r^3 = -t + c$ the score would be B1, M1, A0 then dM0, A0

M1: Uses both boundary conditions to form an equation involving r and t. For this to be awarded there must be two different unknown constants that are initially correctly placed.

It is dependent upon having achieved $...r^n = \pm"k"t + "c"$ which may have been achieved from an

incorrect assumption. E.g. $\frac{\mathrm{d}r}{\mathrm{d}t} = \pm kr^2$