Question Number	Scheme	Marks
6 (a) Mark (i) and (ii) together	$\begin{vmatrix} 3-5 & 0 & 1 \\ 1 & 2-5 & 2 \\ 4 & 0 & 3-5 \end{vmatrix} = -2(-3)(-2)-4(-3)=0 \Rightarrow 5$ is an eigenvalue This mark is for demonstrating that 5 is an eigenvalue as above and **requires a conclusion**. This may also be done by **substituting** $\lambda = 5$ into their CE to obtain 0 **with a conclusion** or by performing long division and obtaining a remainder of 0 **with conclusion**. However if the candidate forms and solves the CE and correctly obtains $\lambda = 5$ this is sufficient without a conclusion. The conclusion can be minimal e.g. "proven", "QED", tick etc.	B1 **M1 on ePEN**
	$\begin{vmatrix} 3-\lambda & 0 & 1 \\ 1 & 2-\lambda & 2 \\ 4 & 0 & 3-\lambda \end{vmatrix} = (3-\lambda)(2-\lambda)(3-\lambda)-4(2-\lambda)$ M1: Attempts determinant of **A - λI** Whichever method is chosen e.g. row/column/Sarrus, the expression should be similar to the above e.g. • Row 2: $(2-\lambda)\{(3-\lambda)(3-\lambda)-4\}$ • Row 3: $4(0-(2-\lambda))+(3-\lambda)(3-\lambda)(2-\lambda)$ • Column 1 = as Row 1 • Column 2 = as Row 2 • Column 3 = as Row 3 A1: Correct equation including " = 0" which may be implied by an attempt to solve. NB Correct expanded cubic is $\lambda^3 - 8\lambda^2 + 17\lambda - 10 = 0$	M1A1
	$(2-\lambda)(\lambda-5)(\lambda-1)=0 \Rightarrow \lambda = ...$ Attempts to solve cubic – **may just be seen from calculator**	M1
	$\lambda = 2,\ 1,\ (5)$ — Other eigenvalues 2 and 1	A1
		(5)
(b)	$\begin{pmatrix} 3 & 0 & 1 \\ 1 & 2 & 2 \\ 4 & 0 & 3 \end{pmatrix}\begin{pmatrix} x \\ y \\ z \end{pmatrix} = 5\begin{pmatrix} x \\ y \\ z \end{pmatrix}$ or $\begin{pmatrix} 3-5 & 0 & 1 \\ 1 & 2-5 & 2 \\ 4 & 0 & 3-5 \end{pmatrix}\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$ Demonstrates the understanding that 5 is an eigenvalue Either of these statements is sufficient	M1
	$3x+z=5x$ $x+2y+2z=5y$ $4x+3z=5z$ — Multiplies out to obtain at least 2 **correct** equations	M1
	$\therefore$ Eigenvector is $\begin{pmatrix} 3 \\ 5 \\ 6 \end{pmatrix}$ — Allow any multiple of this vector e.g. $\begin{pmatrix} 1 \\ \frac{5}{3} \\ 2 \end{pmatrix}$ will be common. Allow $x = \ldots$, $y = \ldots$, and $z = \ldots$ where x, y and z were seen in a vector earlier and isw.	A1
		(3)

(c)	$\begin{pmatrix}3&0&1\\1&2&2\\4&0&3\end{pmatrix}\begin{pmatrix}2\\1\\-3\end{pmatrix}=...$ **or** $\begin{pmatrix}3&0&1\\1&2&2\\4&0&3\end{pmatrix}\begin{pmatrix}1\\2\\-1\end{pmatrix}=...$ Attempts to multiply one of the given vectors by **M** to find at least one image	M1 **B1 on ePEN**
	$\begin{pmatrix}3&0&1\\1&2&2\\4&0&3\end{pmatrix}\begin{pmatrix}2\\1\\-3\end{pmatrix}=...$ **and** $\begin{pmatrix}3&0&1\\1&2&2\\4&0&3\end{pmatrix}\begin{pmatrix}1\\2\\-1\end{pmatrix}=...$ Attempts to multiply both of the given vectors by **M** to find both images	M1
	Note that an attempt at $\begin{pmatrix}3&0&1\\1&2&2\\4&0&3\end{pmatrix}\begin{pmatrix}2+\mu\\1+2\mu\\-3-\mu\end{pmatrix}=...$ scores both M's provided this results in the parametric image	
	$\begin{pmatrix}3\\-2\\-1\end{pmatrix}$ **or** $\begin{pmatrix}2\\3\\1\end{pmatrix}$ — One correct	A1 **M1 on ePEN**
	$\begin{pmatrix}3\\-2\\-1\end{pmatrix}$ **and** $\begin{pmatrix}2\\3\\1\end{pmatrix}$ — Both correct	A1
	$\begin{pmatrix}3+2\mu\\-2+3\mu\\-1+\mu\end{pmatrix}$ scores both A marks	
	$(\mathbf{r}-\mathbf{c})\times\mathbf{d}=\mathbf{0}$ where $\mathbf{c}=3\mathbf{i}-2\mathbf{j}-\mathbf{k}$ and $\mathbf{d}=2\mathbf{i}+3\mathbf{j}+\mathbf{k}$ Or $(\mathbf{r}-(3\mathbf{i}-2\mathbf{j}-\mathbf{k}))\times(2\mathbf{i}+3\mathbf{j}+\mathbf{k})=\mathbf{0}$ Correct equation in the correct form. Follow through their vectors but they must be correctly placed and **depends on both method marks.**	A1ft
		(5)
		[Total 13]

Note that candidates may transform 2 points on l_1 and then use the transformed points to find the direction of l_2. In this case the second M and the second A1 will only be scored when the direction of l_2 is found and then the final mark becomes available.