Question Number	Scheme	Marks
4(a)	Attempts direction vector by subtracting $(5\mathbf{i}+6\mathbf{j}+3\mathbf{k})$ and $(4\mathbf{i}+8\mathbf{j}+\mathbf{k})$ either way around.	M1
	E.g. $\mathbf{r}=4\mathbf{i}+8\mathbf{j}+\mathbf{k}+\lambda(\mathbf{i}-2\mathbf{j}+2\mathbf{k})$, $\mathbf{r}=5\mathbf{i}+6\mathbf{j}+3\mathbf{k}+\mu(\mathbf{i}-2\mathbf{j}+2\mathbf{k})$	A1
		(2)
(b)	E.g $\overrightarrow{PC}=\begin{pmatrix}4+\lambda\\8-2\lambda\\1+2\lambda\end{pmatrix}-\begin{pmatrix}2\\-2\\1\end{pmatrix}=\begin{pmatrix}2+\lambda\\10-2\lambda\\2\lambda\end{pmatrix}$	M1
	Uses $\overrightarrow{PC}.(\mathbf{i}-2\mathbf{j}+2\mathbf{k})=0$ E.g. $\Rightarrow 1(2+\lambda)-2(10-2\lambda)+2\times 2\lambda=0\Rightarrow\lambda=...$	dM1
	E.g I $\lambda=2\Rightarrow\mathbf{c}=(4+2)\mathbf{i}+(8-4)\mathbf{j}+(1+4)\mathbf{k}$ E.g II $\mu=1\Rightarrow\mathbf{c}=(5+1)\mathbf{i}+(6-2)\mathbf{j}+(3+2)\mathbf{k}$	ddM1
	$(6,\ 4,\ 5)$	A1
		(4)
(c)	$\overrightarrow{OP'}=\mathbf{p}+2\overrightarrow{PC}=2\mathbf{i}-2\mathbf{j}+\mathbf{k}+2(4\mathbf{i}+6\mathbf{j}+4\mathbf{k})$	M1
	$(10,\ 10,\ 9)$	A1
		(2)
(d)	$\left\lvert\overrightarrow{PP'}\right\rvert=2\left\lvert\overrightarrow{PC}\right\rvert=2\sqrt{4^2+6^2+4^2}=...$	M1
	$4\sqrt{17}$	A1
		(2)
		Total 10

General rule in this question: If no method is shown look for two "correct" components for their vector

(a) **There are many correct versions so please check the candidates answer carefully**

M1: Attempts the direction of *l* by subtracting $(5\mathbf{i}+6\mathbf{j}+3\mathbf{k})$ and $(4\mathbf{i}+8\mathbf{j}+\mathbf{k})$ either way around.

If no method is shown look for two correct components of $(\pm 1\mathbf{i}\pm 2\mathbf{j}\pm 2\mathbf{k})$ or a multiple of this

A1: Any correct equation including the lhs of '$\mathbf{r}=$'

Allow in the form $\mathbf{r}=\begin{pmatrix}4\\8\\1\end{pmatrix}+\lambda\begin{pmatrix}1\\-2\\2\end{pmatrix}$ but $l=\begin{pmatrix}4\\8\\1\end{pmatrix}+\lambda\begin{pmatrix}1\\-2\\2\end{pmatrix}$ and is $\mathbf{r}=\begin{pmatrix}4\\8\\1\end{pmatrix}+\lambda\begin{pmatrix}\mathrm{i}\\-2\mathrm{j}\\2\mathrm{k}\end{pmatrix}$ A0

(b)

M1: Attempts the general vector from *P* to *l* forming $\overrightarrow{PC}$ where *C* is a general point on *l*.

Look for an attempt to subtract their "$\begin{pmatrix}4+\lambda\\8-2\lambda\\1+2\lambda\end{pmatrix}$" and $\begin{pmatrix}2\\-2\\1\end{pmatrix}$ either way around

dM1: Attempts $\overrightarrow{PC}.\text{their}(\mathbf{i}-2\mathbf{j}+2\mathbf{k})=0$ and solves for λ.

It is dependent upon the previous M and the scalar product of this vector must be attempted with their gradient for the line *l* to produce and solve a linear equation for λ.

ddM1: Uses their λ to find *C*. Scored for substituting their correctly found λ into their equation for *l*

A1: Correct coordinates or vector.

Only penalise an error such as $\begin{pmatrix}6\mathrm{i}\\4\mathrm{j}\\5\,\mathrm{k}\end{pmatrix}$ once, the first time that it is made. Hence award if a mark has already been withheld for such a mistake.

(c)

M1: Correct strategy for $\overrightarrow{OP'}$ Can be implied by two correct coordinates using their *P* and *C*

For example look for $\overrightarrow{OP'} = \overrightarrow{OP} + 2 \times \overrightarrow{PC}$ using the coordinates of *C* found in part (b).

A1: Correct coordinates or vector

(d)

M1: Correct method for $\left|\overrightarrow{PP'}\right|$ using their values for *P* and *P*' or *P* and *C* or *P*' and *C* . E.g $\left|\overrightarrow{PP'}\right| = 2 \times \left|\overrightarrow{PC}\right|$

There are many ways to do this but it must be a complete method, not a distance squared.

A1: CAO

Alternative part (b) using shortest distance

M1: Attempts the general vector from *P* to *l*.

Look for an attempt to subtract their "$\begin{pmatrix} 4+\lambda \\ 8-2\lambda \\ 1+2\lambda \end{pmatrix}$" and $\begin{pmatrix} 2 \\ -2 \\ 1 \end{pmatrix}$ either way around

dM1: Finds an expression for *d* or d^2 , differentiates and sets = 0 to find λ.

As it is a quadratic expression an equivalent method would be via completing the square .

FYI : $D^2 = (2+\lambda)^2 + (10-2\lambda)^2 + (2\lambda)^2 = 9\lambda^2 - 36\lambda + 104 \Rightarrow \dfrac{\mathrm{d}D^2}{\mathrm{d}\lambda} = 18\lambda - 36 = 0 \Rightarrow \lambda = 2$

ddM1: Uses their λ to find *C*.

A1: Correct coordinates or vector

Alternative part (b) using Pythagoras' Theorem

M1: Attempts the general vector from *P* to *l*.

Look for an attempt to subtract their "$\begin{pmatrix} 4+\lambda \\ 8-2\lambda \\ 1+2\lambda \end{pmatrix}$" and $\begin{pmatrix} 2 \\ -2 \\ 1 \end{pmatrix}$ either way around

dM1: Uses $PC^2 + CB^2 = PB^2$ or $PC^2 + CA^2 = PA^2$ to set up and solve an equation in λ.

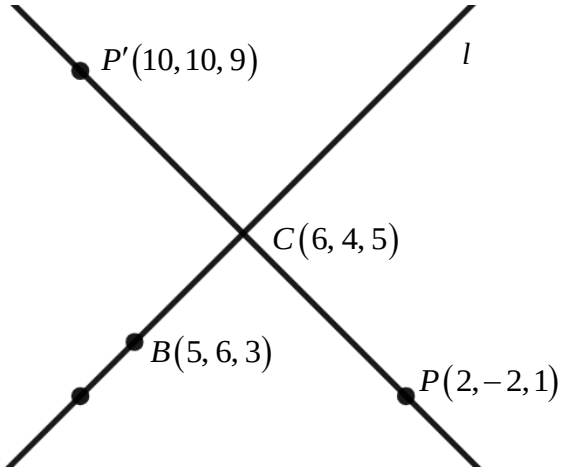
E.g Using $PC^2 + CB^2 = PB^2$ the equations are

$(2+\lambda)^2 + (10-2\lambda)^2 + (2\lambda)^2 + (\lambda-1)^2 + (2-2\lambda)^2 + (2\lambda-2)^2 = 77$

$\Rightarrow 18\lambda^2 - 54\lambda + 36 = 0 \Rightarrow \lambda = 2(1)$

ddM1: Uses their λ to find *C*.

A1: Correct coordinates or vector



Question Number	Scheme	Marks
5(i)	$\int x^2 e^x \, dx = x^2 e^x - \int 2x e^x \, dx \left(+c\right)$	M1A1
	$\int x e^x \, dx = x e^x - \int e^x \, dx \left(+c\right)$	M1
	$\int x^2 e^x \, dx = x^2 e^x - 2x e^x + 2e^x \left(+c\right)$ Also allow $\int x^2 e^x \, dx = x^2 e^x - \left(2x e^x - 2e^x\right)\left(+c\right)$	A1
		(4)
(ii)	$u = \left(1-3x\right)^{\frac{1}{2}} \Rightarrow u^2 = 1-3x \Rightarrow 2u\frac{du}{dx} = -3$ or $u = \left(1-3x\right)^{\frac{1}{2}} \Rightarrow \frac{du}{dx} = -\frac{3}{2}\left(1-3x\right)^{-\frac{1}{2}}$	B1
	$\int \frac{27x}{\sqrt{1-3x}} dx = 27\int \frac{\frac{1-u^2}{3}}{u}\left(-\frac{2u}{3}\right) du$ or $\int \frac{27x}{\sqrt{1-3x}} dx = 27\int \frac{\frac{1-u^2}{3}}{\sqrt{1-3x}}\left(-\frac{2}{3}\sqrt{1-3x}\right) du$	M1
	$6\int \left(u^2-1\right) du$ or $-6\int \left(1-u^2\right) du$	A1
	$6\left(\frac{u^3}{3}-u\right)\left(+k\right)$	A1ft
	$6\left(\frac{\left(1-3x\right)^{\frac{3}{2}}}{3}-\left(1-3x\right)^{\frac{1}{2}}\right)\left(+k\right) = 2\left(1-3x\right)^{\frac{1}{2}}\left(1-3x-3\right)\left(+k\right)$	M1
	$= -2\left(1-3x\right)^{\frac{1}{2}}\left(2+3x\right)\left(+k\right)$ or $= -2\left(1-3x\right)^{\frac{1}{2}}\left(3x+2\right)\left(+k\right)$	A1
		(6)
		Total 10

(i) Condone missing dx's here

M1: For applying parts to obtain $x^2 e^x - k\int x e^x \, dx \left(+c\right)$ where $k > 0$

A1: Correct expression. No requirement for + c

M1: Applies parts again to $\int x e^x \, dx$ and obtains $\int x e^x \, dx = x e^x - \alpha \int e^x \, dx \left(+c\right)$ where $\alpha > 0$

Note that if the whole expression is written out then this mark is implied by

$\int x^2 e^x \, dx = x^2 e^x - \alpha x e^x \pm \int \beta e^x \, dx$ or $\int x^2 e^x \, dx = x^2 e^x - \alpha x e^x \pm \beta e^x$ where $\alpha > 0$