(b) **Way 3**	$\int_0^4 \left(x^2-8x+16\right)\mathrm{e}^{2x}\,\mathrm{d}x = \int_0^4 x^2\mathrm{e}^{2x}\,\mathrm{d}x - \int_0^4 8x\mathrm{e}^{2x}\,\mathrm{d}x + \int_0^4 16\mathrm{e}^{2x}\,\mathrm{d}x$	
	$= \left("\frac{\pi}{16}"\right)\left(x^2\frac{\mathrm{e}^{2x}}{2} - \int 2x\times\frac{\mathrm{e}^{2x}}{2}\mathrm{d}x + \ldots\right)$	**M1A1**
	$\int_0^4 x^2\mathrm{e}^{2x}\,\mathrm{d}x - \int_0^4 8x\mathrm{e}^{2x}\,\mathrm{d}x + \int_0^4 16\mathrm{e}^{2x}\,\mathrm{d}x$ $= \left("\frac{\pi}{16}"\right)\left(x^2\frac{\mathrm{e}^{2x}}{2} - \left\{x\times\frac{\mathrm{e}^{2x}}{2} - \int\frac{\mathrm{e}^{2x}}{2}\mathrm{d}x\right\} - 8\left\{x\times\frac{\mathrm{e}^{2x}}{2} - \int\frac{\mathrm{e}^{2x}}{2}\mathrm{d}x\right\} + 8\mathrm{e}^{2x}\right)$ **Depends on the first method mark.**	**dM1**
	$\left(\frac{\pi}{16}\right)\left[\frac{x^2\mathrm{e}^{2x}}{2} - \frac{9x\mathrm{e}^{2x}}{2} + \frac{41\mathrm{e}^{2x}}{4}\right]_0^4 = \frac{\pi}{16}\left(8e^8 - 18e^8 + \frac{41}{4}e^8 - \frac{41}{4}\right)$ **Depends on both previous method marks.**	**ddM1**
	$= \frac{\pi}{64}\left(\mathrm{e}^8 - 41\right)$ (cm^3)	**A1**

(8 marks)

Notes:

(a)

M1: Sets up the volume using the volume formula, but allow limits and π and the "dx" to be missing. No need to square f(x) for this mark as long as the intent to do so is clear. There should be an integral

M1: Attempts to square f(x) (need not be part of an integral). The power of e should be correct and the bracket expanded, but allow if the $\frac{1}{4}$ is not squared.

A1: Correct expression for the integral, π and limits must be included, and no errors seen in working so the "dx" must be present throughout.

(b)

M1: Attempts integration by parts the correct way at least once on the given integral to obtain

$$\alpha\left(x^2-8x+16\right)\mathrm{e}^{2x} \pm \beta\int\left(ax-b\right)\mathrm{e}^{2x}\,\mathrm{d}x$$

A1: Correct first application of parts: $(x^2-8x+16)\frac{\mathrm{e}^{2x}}{2} - \int\left(2x-8\right)\times\frac{\mathrm{e}^{2x}}{2}\mathrm{d}x$ or equivalent.

dM1: Attempts integration by parts again in the same direction on $\int\left(2x-8\right)\times\frac{\mathrm{e}^{2x}}{2}\mathrm{d}x$ and proceeds to complete the integration. Look for $K\left(\ldots+\alpha\left(ax-b\right)\mathrm{e}^{2x} \pm \beta\int\mathrm{e}^{2x}\mathrm{d}x\right)$.

ddM1: Applies the limits to their integral and subtracts, (but this need not have the K or π for this mark.) May be done in stages, so look for reaching a value using correct limits on each part of their integral.

A1: Correct answer achieved from correct work and the π must have been introduced before the final step, it should have been part of their answer to (a). Condone lack of units.

Way 2

M1: Attempts integration by parts the correct way at least once on the given integral to obtain

$$\alpha(4-x)^2\mathrm{e}^{2x} \pm \beta\int(4-x)\mathrm{e}^{2x}\,\mathrm{d}x.$$

A1: Correct first application of parts: $(4-x)^2\dfrac{\mathrm{e}^{2x}}{2}+\displaystyle\int(4-x)\mathrm{e}^{2x}\,\mathrm{d}x$ or equivalent.

dM1: Attempts integration by parts again in the same direction on $\displaystyle\int(4-x)\mathrm{e}^{2x}\,\mathrm{d}x$ **and proceeds to complete the integration**. Look for $K\left(\ldots+\alpha(4-x)\mathrm{e}^{2x} \pm \beta\displaystyle\int \mathrm{e}^{2x}\mathrm{d}x\right)$ for the parts.

ddM1: Applies the limits to their integral and subtracts, (but this need not have the K or π for this mark.) May be done in stages, so look for reaching a value using correct limits on each part of their integral.

A1: Correct answer achieved from correct work and the π must have been introduced before the final step, it should have been part of their answer to (a). Condone lack of units.

Way 3

M1: Splits the integral and attempts integration by parts the correct way at least once on $\displaystyle\int x^2\mathrm{e}^{2x}\,\mathrm{d}x$.

Look for $\alpha x^2\mathrm{e}^{2x} \pm \beta\displaystyle\int x\mathrm{e}^{2x}\,\mathrm{d}x$.

A1: Correct first application of parts: $x^2\dfrac{\mathrm{e}^{2x}}{2}-\displaystyle\int 2x\frac{\mathrm{e}^{2x}}{2}\mathrm{d}x$ or equivalent.

dM1: Applies parts a second time on both occurrences of $\displaystyle\int x\,\mathrm{e}^{2x}\,\mathrm{d}x$ and completes the integration.

ddM1: Applies the limits to their integral and subtracts, (but this need not have the K or π for this mark.) May be done in stages, so look for reaching a value using correct limits on each part of their integral.

A1: Correct answer achieved from correct work and the π must have been introduced before the final step, it should have been part of their answer to (a). Condone lack of units.

Question	Scheme	Marks
8(a)	Attempts $\pm\left(\begin{pmatrix}6\\0\\7\end{pmatrix}-\begin{pmatrix}6\\6\\2\end{pmatrix}\right)=\pm\begin{pmatrix}0\\-6\\5\end{pmatrix}$	**M1**
	$\mathbf{r}=\begin{pmatrix}6\\6\\2\end{pmatrix}+\lambda\begin{pmatrix}0\\-6\\5\end{pmatrix}$ or $\mathbf{r}=\begin{pmatrix}6\\0\\7\end{pmatrix}+\lambda\begin{pmatrix}0\\6\\-5\end{pmatrix}$ oe	**A1**
		(2)
(b)	Meet if $\begin{pmatrix}6\\6\\2\end{pmatrix}+\lambda\begin{pmatrix}0\\-6\\5\end{pmatrix}=\begin{pmatrix}3\\1\\4\end{pmatrix}+\mu\begin{pmatrix}1\\5\\9\end{pmatrix}$ so $\begin{cases}6=3+\mu\\6-6\lambda=1+5\mu\\2+5\lambda=4+9\mu\end{cases}$	**M1**
	From first equation $\mu=3$ Alt: solves equations 2 and 3 to give either $\mu=\frac{13}{79}$ or $\lambda=\frac{55}{79}$	**A1**
	Then need $\lambda=\frac{5-5\times3}{6}=-\frac{5}{3}$ from 2nd equation, $\lambda=\frac{2+9\times3}{5}=\frac{29}{5}$ from 3rd equation Alt: checks their μ in the first equation	**M1**
	Values of λ do not agree and hence lines do not meet.	**A1**
		(4)
(c)	$\overrightarrow{OC}=\begin{pmatrix}3\\1\\4\end{pmatrix}-\left(\begin{pmatrix}1\\5\\9\end{pmatrix}\left(=\begin{pmatrix}2\\-4\\-5\end{pmatrix}\right)\right)$	**M1**
	$\overrightarrow{AC}=\overrightarrow{OC}-\overrightarrow{OA}=\begin{pmatrix}2\\-4\\-5\end{pmatrix}-\begin{pmatrix}6\\6\\2\end{pmatrix}=\begin{pmatrix}-4\\-10\\-7\end{pmatrix}$ Accept $\pm$. **Depends on first mark.**	**dM1**
	$\frac{\pm\overrightarrow{AC}\bullet(\mathbf{i}+5\mathbf{j}+9\mathbf{k})}{\left\lvert\overrightarrow{AC}\right\rvert\lvert\mathbf{i}+5\mathbf{j}+9\mathbf{k}\rvert}=\pm\frac{-4\times1+-10\times5+-7\times9}{\sqrt{16+100+49}\sqrt{1+25+81}}$ **Depends on both previous marks.**	**ddM1A1**
	$\Rightarrow\theta=\arccos\left\lvert\frac{-117}{\sqrt{165}\sqrt{107}}\right\rvert=28.3°$ or e.g. $\Rightarrow\theta=90°-\arcsin\left\lvert\frac{-117}{\sqrt{165}\sqrt{107}}\right\rvert=28.3°$	**A1**
		(5)
		(11 marks)