Question Number	Scheme	Marks
6 (a)	Position vector of a general point on $l_1 = \begin{pmatrix} -3+2\lambda \\ 0+1\lambda \\ 5-3\lambda \end{pmatrix}$	
	$\begin{pmatrix} -3+2\lambda \\ 0+1\lambda \\ 5-3\lambda \end{pmatrix} \bullet \begin{pmatrix} 2 \\ 1 \\ -3 \end{pmatrix} = 0 \Rightarrow -6+4\lambda+\lambda-15+9\lambda=0 \Rightarrow \lambda = \frac{3}{2}$	M1, A1
	Substitute $\lambda = \frac{3}{2}$ into $\begin{pmatrix} -3+2\lambda \\ 0+1\lambda \\ 5-3\lambda \end{pmatrix} \Rightarrow P = \left(0, \frac{3}{2}, \frac{1}{2}\right)$	dM1, A1
		(4)
(b)	Lines intersect when $\begin{pmatrix} -3 \\ 0 \\ 5 \end{pmatrix} + \lambda \begin{pmatrix} 2 \\ 1 \\ -3 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} + \mu \begin{pmatrix} 4 \\ a \\ -2 \end{pmatrix}$	
	Solves $-3+2\lambda = 4\mu$ and $5-3\lambda = -2\mu \Rightarrow \lambda = \frac{7}{4}, \mu = \frac{1}{8}$	M1, A1
	Uses $\mu a = \lambda \Rightarrow \frac{1}{8}a = \frac{7}{4} \Rightarrow a = 14$	dM1, A1
		(4)
(c)	For Example: Attempts $\mu \begin{pmatrix} 4 \\ a \\ -2 \end{pmatrix}$ o.e. with their a and $\mu \Rightarrow Q = \left(\frac{1}{2}, \frac{7}{4}, -\frac{1}{4}\right)$	M1, A1
		(2)
		(10 marks)
6 (a) ALT way	$OP^2 = (-3+2\lambda)^2 + (\lambda)^2 + (5-3\lambda)^2 = 14\lambda^2 - 42\lambda + 34$	
	Find the value of λ at the minimum, e.g. $\frac{\mathrm{d}\left(OP^2\right)}{\mathrm{d}\lambda} = 28\lambda - 42 = 0 \Rightarrow \lambda = \frac{3}{2}$	M1, A1
	Substitute $\lambda = \frac{3}{2}$ into $\begin{pmatrix} -3+2\lambda \\ 0+1\lambda \\ 5-3\lambda \end{pmatrix} \Rightarrow P = \left(0, \frac{3}{2}, \frac{1}{2}\right)$	dM1, A1
		(4)

(a)

M1: Sets up an equation and solves to find λ.

For example, attempts $\begin{pmatrix}-3+2\lambda\\0+1\lambda\\5-3\lambda\end{pmatrix}\bullet\begin{pmatrix}2\\1\\-3\end{pmatrix}=0\Rightarrow-6+4\lambda+\lambda-15+9\lambda=0\Rightarrow\lambda=...$

Alternatively attempts to find the distance OP^2 and finds the value of λ at the minimum. For example, via differentiation $\frac{\mathrm{d}\left(OP^2\right)}{\mathrm{d}\lambda}=28\lambda-42=0\Rightarrow\lambda=...$ or completing the square $OP^2=14\lambda^2-42\lambda+34=14\left(\lambda-1.5\right)^2-14\times1.5^2+34$ but other methods may exist.

Condone slips, e.g. signs, but the overall method must be sound

A1: Achieves $\lambda=\frac{3}{2}$ following M1. **Achieving this by setting the *x* coordinate = 0 scores 0 marks**

dM1: Uses their value of λ (found using a correct method) to find the coordinates or position vector of *P*.

If the calculation is not written out it is implied by two correct coordinates for their λ

A1: Correct coordinates or position vector of *P*.

Withold this mark if the only answer given is written with incorrect notation, e.g $\left(0\mathbf{i},\frac{3}{2}\mathbf{j},\frac{1}{2}\mathbf{k}\right)$

(b)

M1: Set up and solve equations using the *x* and *z* components. Condone slips, e.g signs and coefficients as long as the intention is clear. Scored for $-3+2\lambda=4\mu$ and $5-3\lambda=-2\mu\Rightarrow\lambda=...,\mu=...$. The method of solving the simultaneous equations is not important, just look for two equations leading to values for both λ and μ

A1: $\lambda=\frac{7}{4},\mu=\frac{1}{8}$ o.e

dM1: Dependent upon previous M. Scored for a **correct** method of using the *y* components to find the value for *a*.

Look for $'\lambda'='\mu'\times a\Rightarrow a=\frac{'\lambda'}{'\mu'}$

A1: $a=14$. Condone an equivalent value such as $\frac{56}{4}$

(c)

M1: Uses the equation of either line to find the coordinates or position vector of *Q*.

It is dependent upon the first M mark in part (b)

Look for an attempt at $\mu\begin{pmatrix}4\\a\\-2\end{pmatrix}$ with their *a* and μ OR $\begin{pmatrix}-3+2\lambda\\0+1\lambda\\5-3\lambda\end{pmatrix}$ with their λ

If the calculation is not explicitly seen it can be implied by two correct coordinates for their values

A1: $Q=\left(\frac{1}{2},\frac{7}{4},-\frac{1}{4}\right)$ or correct position vector.

Withold this mark if the only answer given is written with incorrect notation, e.g $\left(\frac{1}{2}\mathbf{i},\frac{7}{4}\mathbf{j},-\frac{1}{4}\mathbf{k}\right)$ but only penalise this the first time it occurs….so not in both (a) and (c).

Question Number	Scheme	Marks
7(a)	$x^2 \tan\frac{\pi}{4} + \frac{32}{\pi^2}\times\left(\frac{\pi}{4}\right)^2 = 11 \Rightarrow x^2 = (9)$	M1
	$x = \pm 3$	A1
		(2)
(b)	Attempt at chain rule $\quad y^2 \to ...y\frac{dy}{dx}$	M1
	Attempt at product rule $\quad x^2\tan y \to x^2\sec^2 y\frac{dy}{dx} + ...x\tan y$	M1
	Correct differentiation $\quad 2x\tan y + x^2\sec^2 y\frac{dy}{dx} + \frac{64y}{\pi^2}\frac{dy}{dx} = 0$	A1
	Substitutes $x = 3, y = \frac{\pi}{4} \Rightarrow 18\frac{dy}{dx} + 6 + \frac{16}{\pi}\frac{dy}{dx} = 0 \Rightarrow \frac{dy}{dx} = -\frac{3\pi}{8+9\pi}$	dM1, A1
		(5)
(c)	Calculates the gradient of the tangent at Q is $"\frac{3\pi}{8+9\pi}"$ o.e.	M1
	$\left(\text{grad of tan to } C \text{ at } P\right)\times\left(\text{grad of norm to } C \text{ at } Q\right) = -\frac{3\pi}{8+9\pi}\times -\frac{8+9\pi}{3\pi} = 1$	A1
		(2)
		(9 marks)

(a)

M1: Substitutes $y = \frac{\pi}{4}$ in equation of curve and proceeds to $x^2 = ...$ using $\tan\frac{\pi}{4} = 1$

This may be implied by $x^2 + ... = ... \Rightarrow x = ...$

A1: $x = \pm 3$ following the award of M1

(b)

M1: Attempts at chain rule $\quad y^2 \to ...y\frac{dy}{dx}$

M1: Attempt at product rule $\quad x^2\tan y \to x^2\sec^2 y\frac{dy}{dx} + ...x\tan y$

A1: Correct differentiation $x^2\sec^2 y\frac{dy}{dx} + 2x\tan y + \frac{64y}{\pi^2}\frac{dy}{dx} = 0$

You may see different forms such as $\pi^2x^2\sec^2 y\frac{dy}{dx} + 2\pi^2 x\tan y + 64y\frac{dy}{dx} = 0$ or

$x^2\sec^2 y dy + 2x\tan y dx + \frac{64y}{\pi^2}dy = 0$

Do not allow $\frac{dy}{dx} = x^2\sec^2 y\frac{dy}{dx} + 2x\tan y + \frac{64y}{\pi^2}\frac{dy}{dx}$ unless subsequent work is correct