Question	Scheme	Marks	AOs
6(a)	$\begin{pmatrix}3\\0\\1\end{pmatrix}\bullet\begin{pmatrix}1\\2\\-3\end{pmatrix}=3\{+0\}-3$	M1	1.1b
	= **0** therefore the lines are **perpendicular.**	A1	2.4
		(2)	
(b)	$\mathbf{r}\bullet\begin{pmatrix}1\\2\\-3\end{pmatrix}=\begin{pmatrix}-2\\2\\0\end{pmatrix}\bullet\begin{pmatrix}1\\2\\-3\end{pmatrix}=\ldots\{2\}$	M1	1.1b
	$x+2y-3z=2$ o.e.	A1	2.5
		(2)	
(c)	$3+2(1)-3(1)=2$ (therefore lies on the plane)	B1	1.1b
		(1)	
(d)	$\begin{pmatrix}p\\q\\r\end{pmatrix}=\begin{pmatrix}2\\3\\2\end{pmatrix}+\mu\begin{pmatrix}1\\2\\-3\end{pmatrix}$ **or** $\begin{pmatrix}p\\q\\r\end{pmatrix}+\mu\begin{pmatrix}1\\2\\-3\end{pmatrix}=\begin{pmatrix}2\\3\\2\end{pmatrix}$ leading to $p=2-\mu$, $q=3-2\mu$, $r=2+3\mu$	M1	3.1a
	$(p-3)^2+(q-1)^2+(r-1)^2=(2\sqrt{5})^2$ $((2+\mu)-3)^2+((3+2\mu)-1)^2+((2-3\mu)-1)^2=(2\sqrt{5})^2$ $(-1+\mu)^2+(2+2\mu)^2+(1-3\mu)^2=20$ **or** $(p-3)^2+(q-1)^2+(r-1)^2=(2\sqrt{5})^2$ $((2-\mu)-3)^2+((3-2\mu)-1)^2+((2+3\mu)-1)^2=(2\sqrt{5})^2$ $(-1-\mu)^2+(2-2\mu)^2+(1+3\mu)^2=20$	M1	3.1a
	$14\mu^2-14=0$ o.e	A1	1.1b
	Solves their quadratic $\{\mu=-1 \text{ or } \mu=1\}$	M1	1.1b
	Uses $\mu=-1$ Using $\mu=1$	ddM1	1.1b

	$p=2+(-1)=...$ or $p=2-(1)=...$ $q=3+2(-1)=...$ or $q=3-2(1)=...$ $r=2-3(-1)=...$ or $r=2+3(1)=...$		
	$(1,1,5)$ only	A1	3.2a
		(6)	
	Alternative $\lvert AX\rvert=\sqrt{(3-2)^2+(1-3)^2+(1-2)^2}=\sqrt{6}$	M1	3.1a
	Correctly uses Pythagoras to find the length of *XB* $\lvert XB\rvert=\sqrt{(2\sqrt{5})^2-6}=\sqrt{14}$	M1	3.1a
	Find the magnitude of the direction vector and compares to the length of *XB* to find a value for μ	M1	1.1b
	$\mu=-1$ or $\mu=1$	A1	1.1b
	Uses $\mu=-1$ / Using $\mu=1$ $p=2+(-1)=...$ or $p=2-(1)=...$ $q=3+2(-1)=...$ or $q=3-2(1)=...$ $r=2-3(-1)=...$ or $r=2+3(1)=...$	ddM1	1.1b
	$(1,1,5)$ only	A1	3.2a
		(6)	

(11 marks)

Notes:

(a)
M1: Applies the dot product to the direction vectors. Minimum requirement is 3 – 3
A1: Shows that the dot product **= 0** and concludes that the lines are **perpendicular**.

(b)
M1: Applies $\mathbf{r}\bullet\begin{pmatrix}1\\2\\-3\end{pmatrix}=\begin{pmatrix}-2\\2\\0\end{pmatrix}\bullet\begin{pmatrix}1\\2\\-3\end{pmatrix}=...$ or $\begin{pmatrix}x\\y\\z\end{pmatrix}\bullet\begin{pmatrix}1\\2\\-3\end{pmatrix}=\begin{pmatrix}-2\\2\\0\end{pmatrix}\bullet\begin{pmatrix}1\\2\\-3\end{pmatrix}=...$

A1: Correct Cartesian equation $x+2y-3z=2$ o.e.

Note: $\mathbf{i}+2\mathbf{j}-3\mathbf{k}=2$ is M1A0

(c)
B1: See scheme, no conclusion required

(d)
M1: Uses the point of intersection to find the coordinates of *B* as functions of a parameter
M1: Uses the distance between the point *A* and the point *B* to form an equation for their parameter only.
A1: Correct simplified quadratic equation

M1: Solves their quadratic equation to find a value for μ

ddM1: Dependent on the first two method marks. Uses any one of their values for their parameter to find the coordinates of *B*, it need not be the correct one.

A1: Correct coordinates for *B*, condone as a vector, if seen (3, 5, -1) must be disregarded

Alternative

M1: Finds the length *AX*

M1: Uses Pythagoras to find the length of *XB*

NOTE the change in order of the M1 and A1

M1: Find the length of the direction vector and compares to find a value for μ

A1: A correct values for μ

ddM1: Dependent on the first two method marks. Uses any one of their values for their parameter to find the coordinates of *B*, it need not be the correct one.

A1: Correct coordinates for *B*, condone as a vector, if seen (3, 5, -1) must be disregarded