Question	Scheme	Marks	AOs
2(a)	$\alpha = 210$	B1	1.1b
		(1)	
(b)	Require k×their '210' divisible by 360	M1	1.1b
	$k = 12$	A1	1.1b
		(2)	
(c)	$\{\mathbf{N} =\}\begin{pmatrix}1 & 0 & 0\\ 0 & -1 & 0\\ 0 & 0 & 1\end{pmatrix}$	B1	1.1b
		(1)	
(d)	$\mathbf{MA} = \begin{pmatrix}-\frac{\sqrt{3}}{2} & \frac{1}{2} & 0\\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} & 0\\ 0 & 0 & 1\end{pmatrix}\begin{pmatrix}-2\\ 4\\ 3\end{pmatrix} = \begin{pmatrix}\sqrt{3}+2\\ 1-2\sqrt{3}\\ 3\end{pmatrix}$ $\mathbf{NMA} = \begin{pmatrix}1 & 0 & 0\\ 0 & -1 & 0\\ 0 & 0 & 1\end{pmatrix}\begin{pmatrix}\sqrt{3}+2\\ 1-2\sqrt{3}\\ 3\end{pmatrix} = \begin{pmatrix}\sqrt{3}+2\\ 2\sqrt{3}-1\\ 3\end{pmatrix}$ * Or $\mathbf{NM} = \begin{pmatrix}1 & 0 & 0\\ 0 & -1 & 0\\ 0 & 0 & 1\end{pmatrix}\begin{pmatrix}-\frac{\sqrt{3}}{2} & \frac{1}{2} & 0\\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} & 0\\ 0 & 0 & 1\end{pmatrix} = \begin{pmatrix}-\frac{\sqrt{3}}{2} & \frac{1}{2} & 0\\ \frac{1}{2} & \frac{\sqrt{3}}{2} & 0\\ 0 & 0 & 1\end{pmatrix}$ $\mathbf{NMA} = \begin{pmatrix}-\frac{\sqrt{3}}{2} & \frac{1}{2} & 0\\ \frac{1}{2} & \frac{\sqrt{3}}{2} & 0\\ 0 & 0 & 1\end{pmatrix}\begin{pmatrix}-2\\ 4\\ 3\end{pmatrix} = \begin{pmatrix}\sqrt{3}+2\\ 2\sqrt{3}-1\\ 3\end{pmatrix}$ *	M1	1.1a
	i.e. $B\left(2+\sqrt{3},\ 2\sqrt{3}-1,\ 3\right)$ *	A1*	1.1b
		(2)	

(e)	$AB^2 = OA^2 + OB^2 - 2OA.OB\cos AOB$ $\Rightarrow \left(4+\sqrt{3}\right)^2 + \left(5-2\sqrt{3}\right)^2 = 29+29-2\sqrt{29}.\sqrt{29}\cos AOB$ or $OA.OB = \begin{pmatrix}-2\\4\\3\end{pmatrix} \bullet \begin{pmatrix}2+\sqrt{3}\\2\sqrt{3}-1\\3\end{pmatrix} = 1+6\sqrt{3} = \sqrt{29}\sqrt{29}\cos AOB$	M1	3.1a
	$AOB = 66.9°$ *	A1*	1.1b
		(2)	
(f)	Area AOB = $\frac{1}{2}\sqrt{29}\sqrt{29}\sin 66.9°$ You may see this outside spec from candidates studying 8FM0 21 $\frac{1}{2}\begin{vmatrix}\mathbf{i} & \mathbf{j} & \mathbf{k}\\ -2 & 4 & 3\\ 2+\sqrt{3} & 2\sqrt{3}-1 & 3\end{vmatrix}$ $=\frac{1}{2}\left\|\left[12-3\left(2\sqrt{3}-1\right)\right]\mathbf{i}-\left[-6-3\left(2+\sqrt{3}\right)\right]\mathbf{j}+\left[-2\left(2\sqrt{3}-1\right)-4\left(2+\sqrt{3}\right)\right]\mathbf{k}\right\|$ $=\frac{1}{2}\left\|\left(15-6\sqrt{3}\right)\mathbf{i}+\left(12+3\sqrt{3}\right)\mathbf{j}+\left(-6-8\sqrt{3}\right)\mathbf{k}\right\|$ $=\frac{1}{2}\sqrt{\left(15-6\sqrt{3}\right)^2+\left(12+3\sqrt{3}\right)^2+\left(-6-8\sqrt{3}\right)^2}$	M1	1.1b
	= 13.3 cao	A1	1.1b
		(2)	
			(10 marks)

Notes

(a)

B1: Correct value, check within the question. If more than one value is stated the correct value must clearly be selected.

(b)

M1: Uses their answer from part (a) to determine a value for *k* so that *k*×their 210 is divisible by 360. If their answer to part (a) is in radians $k \times$ their $\frac{7\pi}{6}$ is divisible by 2π.

A1: Correct value must be using an angle of 210. There may be no working but allow M1 A1 for *k* = 12 following an answer of 210 or $\frac{7\pi}{6}$ in part (a)

Note: an angle of 30, 150, 330 also gives *k* = 12 but is M1A0

(c)

B1: Correct matrix

(d)

M1: Complete method to find the coordinates of *B*. Look for at least two correct terms for each multiplication, follow through when multiplying by **N.**

Alternatively finds **NM** (not **MN**), look for 4 correct non zero terms if no method is shown and then multiplies to find the coordinates of *B*.

A1*: Correct coordinates (condone vector) Must have been working with exact values throughout. If working in decimals M1 A0

It is insufficient to just write $\mathbf{NM}\begin{pmatrix}-2\\4\\3\end{pmatrix}=\begin{pmatrix}\sqrt{3}+2\\2\sqrt{3}-1\\3\end{pmatrix}$ there must be some evidence of matrix multiplication seen.

(e)

M1: Identifies and applies an appropriate strategy to find the required angle e.g. cosine rule or scalar product. Note: $AB^2=56-12\sqrt{3}$ and $AB=3\sqrt{6}-\sqrt{2}=5.93...$

A1*: Correct value from correct equation

(f)

M1: Uses the given angle with $\frac{1}{2}ab\sin C$ with appropriate *a*, *b* and *C*

Outside spec: uses the cross product $\frac{1}{2}\left|\overrightarrow{OA}\times\overrightarrow{OB}\right|$

A1: Correct area to 3 significant figures