Question	Scheme	Marks	AOs
6(a)	Examples: $\begin{pmatrix}\cos 120 & -\sin 120\\ \sin 120 & \cos 120\end{pmatrix}\begin{pmatrix}6\\2\end{pmatrix}=\ldots$ **or** $(6+2\text{i})\left(-\frac{1}{2}+\frac{\sqrt{3}}{2}\text{i}\right)$ **or** $\sqrt{40}\left(\cos\arctan\left(\frac{2}{6}\right)+\text{i}\sin\arctan\left(\frac{2}{6}\right)\right)\left(\cos\left(\frac{2\pi}{3}\right)+\text{i}\sin\left(\frac{2\pi}{3}\right)\right)$ **or** $\sqrt{40}\left(\cos\left(\arctan\left(\frac{2}{6}\right)+\frac{2\pi}{3}\right)+\text{i}\sin\left(\arctan\left(\frac{2}{6}\right)+\frac{2\pi}{3}\right)\right)$ **or** $\sqrt{40}\text{e}^{\text{i}\arctan\left(\frac{2}{6}\right)}\text{e}^{\text{i}\left(\frac{2\pi}{3}\right)}$	M1	3.1a
	$\left(-3-\sqrt{3}\right)$ **or** $\left(3\sqrt{3}-1\right)\text{i}$	A1	1.1b
	$\left(-3-\sqrt{3}\right)+\left(3\sqrt{3}-1\right)\text{i}$	A1	1.1b
	Examples: $\begin{pmatrix}\cos 240 & -\sin 240\\ \sin 240 & \cos 240\end{pmatrix}\begin{pmatrix}6\\2\end{pmatrix}=\ldots$ **or** $(6+2\text{i})\left(-\frac{1}{2}-\frac{\sqrt{3}}{2}\text{i}\right)$ **or** $\sqrt{40}\left(\cos\arctan\left(\frac{2}{6}\right)+\text{i}\sin\arctan\left(\frac{2}{6}\right)\right)\left(\cos\left(\frac{4\pi}{3}\right)+\text{i}\sin\left(\frac{4\pi}{3}\right)\right)$ **or** $\sqrt{40}\left(\cos\left(\arctan\left(\frac{2}{6}\right)+\frac{4\pi}{3}\right)+\text{i}\sin\left(\arctan\left(\frac{2}{6}\right)+\frac{4\pi}{3}\right)\right)$ **or** $\sqrt{40}\text{e}^{\text{i}\arctan\left(\frac{2}{6}\right)}\text{e}^{\text{i}\left(\frac{4\pi}{3}\right)}$	M1	3.1a
	$\left(-3+\sqrt{3}\right)$ **or** $\left(-3\sqrt{3}-1\right)\text{i}$	A1	1.1b
	$\left(-3+\sqrt{3}\right)+\left(-3\sqrt{3}-1\right)\text{i}$	A1	1.1b
		(6)	
(b) Way 1	Area $ABC = 3\times\frac{1}{2}\sqrt{6^2+2^2}\sqrt{6^2+2^2}\sin 120°$ or Area $AOB=\frac{1}{2}\sqrt{6^2+2^2}\sqrt{6^2+2^2}\sin 120°$	M1	2.1
	Area $DEF=\frac{1}{4}ABC$ or $\frac{3}{4}AOB$	dM1	3.1a
	$=\frac{3}{8}\times 40\times\frac{\sqrt{3}}{2}=\frac{15\sqrt{3}}{2}$	A1	1.1b
		(3)	

(b) Way 2	$D\left(\frac{3-\sqrt{3}}{2},\frac{3\sqrt{3}+1}{2}\right)$ $OD=\sqrt{\left(\frac{3-\sqrt{3}}{2}\right)^2+\left(\frac{3\sqrt{3}+1}{2}\right)^2}=\sqrt{10}$ Area $DOF=\frac{1}{2}\sqrt{10}\sqrt{10}\sin 120°$	M1	2.1
	Area $DEF = 3DOF$	**d**M1	3.1a
	$=3\times\frac{1}{2}\times\sqrt{10}\sqrt{10}\times\frac{\sqrt{3}}{2}=\frac{15\sqrt{3}}{2}$	A1	1.1b
(b) Way 3	$AB=\sqrt{\left(9+\sqrt{3}\right)^2+\left(3-3\sqrt{3}\right)^2}=\sqrt{120}$ Area $ABC=\frac{1}{2}\sqrt{120}\sqrt{120}\sin 60°\left(=30\sqrt{3}\right)$	M1	2.1
	Area $DEF=\frac{1}{4}ABC$	**d**M1	3.1a
	$=\frac{1}{4}\times 30\sqrt{3}=\frac{15\sqrt{3}}{2}$	A1	1.1b
(b) Way 4	$D\left(\frac{3-\sqrt{3}}{2},\frac{3\sqrt{3}+1}{2}\right)$, $E(-3,-1)$, $F\left(\frac{3+\sqrt{3}}{2},\frac{-3\sqrt{3}+1}{2}\right)$ $DE=\sqrt{\left(\frac{3-\sqrt{3}}{2}+3\right)^2+\left(\frac{3\sqrt{3}+1}{2}+1\right)^2}\left(=\sqrt{30}\right)$ Area $DEF=\frac{1}{2}\sqrt{30}\sqrt{30}\sin 60°$	M1 **d**M1	2.1 3.1a
	$=\frac{15\sqrt{3}}{2}$	A1	1.1b
(b) Way 5	Area $ABC=\frac{1}{2}\begin{vmatrix}6 & -3-\sqrt{3} & \sqrt{3}-3 & 6\\ 2 & 3\sqrt{3}-1 & -3\sqrt{3}-1 & 2\end{vmatrix}=30\sqrt{3}$	M1	2.1
	Area $DEF=\frac{1}{4}ABC$	**d**M1	3.1a
	$=\frac{1}{4}\times 30\sqrt{3}=\frac{15\sqrt{3}}{2}$	A1	1.1b

(9 marks)

Notes

(a)
M1: Identifies a suitable method to rotate the given point by 120° (or equivalent) about the origin. May see equivalent work with modulus/argument or exponential form e.g. an attempt to multiply by $\cos\frac{2\pi}{3}+\mathrm{i}\sin\frac{2\pi}{3}$ or $\mathrm{e}^{\frac{2\pi}{3}\mathrm{i}}$
A1: Correct real part or correct imaginary part
A1: Completely correct complex number
M1: Identifies a suitable method to rotate the given point by 240° (or equivalent e.g. rotate their B by 120°) about the origin

May see equivalent work with modulus/argument or exponential form e.g. an attempt to multiply $6+2\text{i}$ by $\cos\frac{4\pi}{3}+\text{i}\sin\frac{4\pi}{3}$ or $e^{\frac{4\pi}{3}\text{i}}$ or their B by $\cos\frac{2\pi}{3}+\text{i}\sin\frac{2\pi}{3}$ or $e^{\frac{2\pi}{3}\text{i}}$

A1: Correct real part or correct imaginary part

A1: Completely correct complex number

(b)

In general, the marks in (b) should be awarded as follows:

M1: Attempts to find the area of a relevant triangle

dM1: completes the problem by multiplying by an appropriate factor to find the area of *DEF*

Dependent on the first method mark

A1: Correct exact area

In some cases it may not be possible to distinguish the 2 method marks. In such cases they can be awarded together for a direct method that finds the area of *DEF*

Examples:

Way 1

M1: A correct strategy for the area of a relevant triangle such as *ABC* or *AOB*

dM1: Completes the problem by linking the area of *DEF* correctly with *ABC* or with *AOB*

A1: Correct value

Way 2

M1: A correct strategy for the area of a relevant triangle such as *DOF*

dM1: Completes the problem by linking the area of *DEF* correctly with *DOF*

A1: Correct value

Way 3

M1: A correct strategy for the area of a relevant triangle such as *ABC*

dM1: Completes the problem by linking the area of *DEF* correctly with *ABC*

A1: Correct value

Way 4

M1**d**M1: A correct strategy for the area of *DEF*. Finds 2 midpoints and attempts one side of *DEF* and uses a correct triangle area formula. By implication this scores both M marks.

A1: Correct value

Way 5

M1: A correct strategy for the area of *ABC* using the “shoelace” method.

dM1: Completes the problem by linking the area of *DEF* correctly with *ABC*

A1: Correct value

Note the marks in (b) can be scored using inexact answers from (a) and the A1 scored if an exact area is obtained.