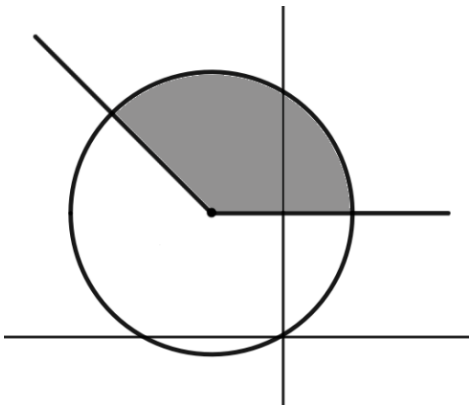
Question Number	Scheme	Marks
2(a)	$\left(\cos\frac{5\pi}{12}+\mathrm{i}\sin\frac{5\pi}{12}\right)^4=\cos\frac{20\pi}{12}+\mathrm{i}\sin\frac{20\pi}{12}$ or/and $\left(\cos\frac{\pi}{3}-\mathrm{i}\sin\frac{\pi}{3}\right)^3=\cos(-\pi)+\mathrm{i}\sin(-\pi)$	M1 / A1
	$(z_1=)\dfrac{\cos\frac{5\pi}{3}+\mathrm{i}\sin\frac{5\pi}{3}}{\cos(-\pi)+\mathrm{i}\sin(-\pi)}=\cos\left(\frac{5\pi}{3}-(-\pi)\right)+\mathrm{i}\sin\left(\frac{5\pi}{3}-(-\pi)\right)$ Alt : $(z_1=)\dfrac{\cos\frac{5\pi}{3}+\mathrm{i}\sin\frac{5\pi}{3}}{-1}=-\cos\frac{5\pi}{3}-\mathrm{i}\sin\frac{5\pi}{3}$	M1
	$=\cos\frac{8\pi}{3}+\mathrm{i}\sin\frac{8\pi}{3}\quad=\cos\frac{2\pi}{3}+\mathrm{i}\sin\frac{2\pi}{3}$ * Alt: if denominator −1 used via e.g. $\cos\left(\frac{5\pi}{3}-\pi\right)+\mathrm{i}\sin\left(-\frac{5\pi}{3}\right)$	A1*
		(4)
(b)	$\lvert z-z_1\rvert\leqslant 1\qquad 0\leqslant \arg(z-z_1)\leqslant\frac{3\pi}{4}$	
	 A circle in any position (may just see the minor arc)	M1
	A pair of **half**–lines in correct directions from their centre, one with negative gradient and one parallel to (but not) the *x*–axis. *If full lines are used the M marks can be implied by their shading*	M1
	Area shaded inside their circle between the two half lines from from the parallel one anticlockwise to the negative gradient line.	M1
	Fully correct shaded sector. See notes.	A1
		(4)
(c)	$\arctan\left(\frac{'\frac{\sqrt{3}}{2}'}{'\frac{1}{2}'}\right)=\ldots\qquad\frac{\pi}{3}\quad\left(\text{or }60^\circ\right)$	M1 A1
		(2)
		Total 10

Notes

(a)

M1: One correct use of de Moivre in polar (or exponential) form. Allow use of $\mathrm{e}^{\mathrm{i}\theta}$ for $\cos\theta+\mathrm{i}\sin\theta$ throughout until the final A.

A1: Both correct (unsimplified) in polar form. Accept for both marks use of $\left(\cos\frac{\pi}{3}-\mathrm{i}\sin\frac{\pi}{3}\right)^3\to\cos\pi-\mathrm{i}\sin\pi$ but denominator directly to $\cos\pi+\mathrm{i}\sin\pi$ with no evidence of dealing with the negative between terms is A0.

M1: A correct method shown for the division of the two complex numbers. No need to simplify for this mark, a difference of argument in the trig terms is fine. Look for the subtraction of the arguments. Sight of the $\frac{8\pi}{3}$ can imply the mark if no incorrect work is seen. Note it is M0 if the arguments are added (so

$\cos\left(\frac{5\pi}{3}-\pi\right)+\mathrm{i}\sin\left(\frac{5\pi}{3}-\pi\right)$ is M0 unless the denominator has clearly been written as $\cos\pi+\mathrm{i}\sin\pi$ first.)

May write the denominator as −1 first, which is correct, score for $-\cos\frac{5\pi}{3}-\mathrm{i}\sin\frac{5\pi}{3}$.

Accept methods that convert both numbers into exact Cartesian form, apply a correct process to realise the denominator and convert back to polar form.

Do not allow going straight to $\cos\frac{2\pi}{3}+\mathrm{i}\sin\frac{2\pi}{3}$ for this mark as it is a given answer. Justification is required and an incorrect method is M0.

A1cso: Obtains $\cos\frac{2\pi}{3}+\mathrm{i}\sin\frac{2\pi}{3}$ with suitable intermediate step shown and no errors in the work. Must have scored the preceding 3 marks. This will usually be via $\cos\frac{8\pi}{3}+\mathrm{i}\sin\frac{8\pi}{3}$ unless equivalent suitable working has been shown to justify the correct modulus (e.g. proceeding via −1 in the denominator).

(b)

Do not be concerned about lines being dashed or dotted in this part. Accept either.

M1: A circle in any position. You may see just the minor arc of a circle, which is acceptable as long as it is clearly an arc of a circle (e.g. implied by their shading) and not just a angle demarcation.

M1: Draws or indicates a pair of half–lines from their centre (which need not be in quadrant 2) with one with negative gradient proceeding up and left and one parallel to the *x*–axis proceeding right but not the *x*-axis itself. If full lines are used this can be implied by the shading of the correct region between lines.

M1: Shades the area between their pair of rays (the second ray may have positive gradient for this mark) and inside their circle, anticlockwise from the horizontal line. The half line need not stem from the centre of the circle for this mark, and accept the *x*-axis as the horizontal line for this mark.

A1: Fully correct shaded sector. Must

- be in quadrants 1 and 2
- have approximately correct gradients for the half-lines (−1 and 0)
- have circle with centre in quadrant 2 and (if whole circle shown) passing roughly through the origin. If only an arc is shown apply bod as long as the position is reasonable.

Ignore any centre coordinates and axes intersections of any major sector. If extra regions are shaded they must make clear which their region *R* is in order to access the mark.

(c)

M1: Identifies the correct point for their sector, which must be from a circle with centre in quadrant 1 or 2 (above the real axis) and ray parallel to the real axis, and attempts the relevant angle. Look for selecting the point (*c*, *d*) at the "3 o'clock" position having identified a suitable sector and proceeding to find a relevant positive angle (e.g., allow if $\pi-\theta$ is found) (accept $\arctan\pm\frac{c}{d}$ or $\arctan\pm\frac{d}{c}$ as an attempt at the angle).

Their point must be in quadrants 1 or 2. If no shading was shown in (b) allow for attempts at the relevant point of horizontal ray and circle intersection. Could use other trig.

A1 : Either correct value. Mark final answer.