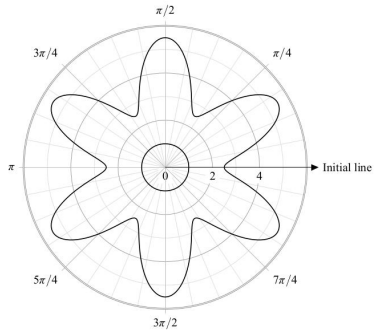
Question	Scheme		Marks
4(a)		Completes to a closed loop with "petals" containing circle of radius 1 (whether the circle is drawn or not)	**M1**
		Fully correct – 6 petals in roughly the right places, but allow if curvature is not quite smooth.	**A1**
		Circle centre *O* radius 1.	**B1**
			(3)
(b)	$\left(\frac{1}{2}\right)\int r^2\,\mathrm{d}\theta = \left(\frac{1}{2}\right)\int\left(\underline{16-12\cos 6\theta+\frac{9}{4}\cos^2 6\theta}\right)\mathrm{d}\theta$		**M1**
	$=\frac{1}{2}\int_0^{2\pi}\left(16-12\cos 6\theta+\underline{\frac{9}{8}(1+\cos 12\theta)}\right)\mathrm{d}\theta$		**M1**
	$=\frac{1}{2}\left[16\theta-2\sin 6\theta+\frac{9}{8}\left(\theta+\frac{1}{12}\sin 12\theta\right)\right]_0^{2\pi}$		**M1** **A1**
	$A_{outer}=\frac{1}{2}\int_0^{2\pi} r^2\,\mathrm{d}\theta=\frac{1}{2}\int_0^{2\pi}\left(16-12\cos 6\theta+\frac{9}{4}\cos^2 6\theta\right)\mathrm{d}\theta$ $=\frac{1}{2}\left(32\pi-0+\frac{9}{8}(2\pi+0)-(0)\right)$		**dM1**
	So Area required is $\frac{1}{2}\left(32\pi+\frac{9\pi}{4}\right)-\pi(1^2)=\ldots$		**B1**
	$=\frac{129}{8}\pi$		**A1**
			(7)
			(10 marks)

Notes:

(a)

M1: Allow for any closed loop that oscillates, though may not have the correct number of "petals" but require at least 4 . Need not have correct places of maximum radius.

A1: Fully correct sketch, 6 "petals" in the right places, with maximum radius between the 5 and 6 radius lines, minimum between the 2 and 3 radius lines.

B1: For a circle of radius 1 and centre *O* drawn.

(b)

M1: Attempts to square *r* as part of an integral for the outer curve, achieving a 3 term quadratic in $\cos 6\theta$

M1: Applies the double angle formula to the $\cos^2$ term from their expansion (not dependent on the first M, but must have a $\cos^2$ term). Accept $\cos^2 6\theta \to \frac{1}{2}(\pm 1 \pm \cos 12\theta)$

M1: Attempts to integrate, achieving the form $\alpha\theta+\beta\sin 6\theta+\gamma\sin 12\theta$ where $\alpha,\beta,\gamma\neq 0$

A1: Correct integration – limits and the $\frac{1}{2}$ not needed. Look for $16\theta - 2\sin 6\theta + \frac{9}{8}\left(\theta + \frac{1}{12}\sin 12\theta\right)$ oe.

dM1: Depends on at least two of the previous M's being scored. For a correct overall strategy for the area contained in the outer loop, with an attempt at the r^2 (should be 3 term expansion). Correct appropriate limits and the $\frac{1}{2}$ should be present or implied by working, but note variations on the scheme are possible, e.g. $2\times\frac{1}{2}\int_0^{\pi} r^2 \, \mathrm{d}\theta$, in which the $2\times\frac{1}{2}$ may be implied rather than seen.

B1: Subtracts correct area of π for inner circle

A1: cso. Check carefully the integration was correct as the sin terms disappear with the limits.