Question Number	Scheme	Marks
7 **(a)**	$r\sin\theta = 2a\sin\theta + 2a\sin\theta\cos\theta$ OR $r\sin\theta = 2a\sin\theta + a\sin 2\theta$	B1
	$\frac{\mathrm{d}(r\sin\theta)}{\mathrm{d}\theta} = 2a\cos\theta + 2a\cos^2\theta - 2a\sin^2\theta$ OR $\frac{\mathrm{d}(r\sin\theta)}{\mathrm{d}\theta} = 2a\cos\theta + 2a\cos 2\theta$	M1 A1
	$2\cos^2\theta + \cos\theta - 1 = 0$ terms in any order $(2\cos\theta - 1)(\cos\theta + 1) = 0$	
	$\cos\theta = \frac{1}{2}$ $\theta = \frac{\pi}{3}$ $(\theta = \pi$ need not be seen$)$	dM1A1
	$r = 2a \times \frac{3}{2} = 3a$	A1 (6)
(b)	Area $= \frac{1}{2}\int r^2 \mathrm{d}\theta = \frac{1}{2}\int_{\frac{\pi}{6}}^{\frac{\pi}{3}} 4a^2(1+\cos\theta)^2 \,\mathrm{d}\theta$	
	$= 2a^2\int_{\frac{\pi}{6}}^{\frac{\pi}{3}}(1 + 2\cos\theta + \cos^2\theta)\mathrm{d}\theta$	M1
	$= 2a^2\int_{\frac{\pi}{6}}^{\frac{\pi}{3}}\left(1 + 2\cos\theta + \frac{1}{2}(\cos 2\theta + 1)\right)\mathrm{d}\theta$	M1
	$= 2a^2\left[\theta + 2\sin\theta + \frac{1}{2}\left(\frac{1}{2}\sin 2\theta + \theta\right)\right]_{\frac{\pi}{6}}^{\frac{\pi}{3}}$	dM1A1
	$= 2a^2\left[\frac{\pi}{3} + \sqrt{3} + \frac{1}{4}\times\frac{\sqrt{3}}{2} + \frac{\pi}{6} - \left(\frac{\pi}{6} + 1 + \frac{1}{4}\times\frac{\sqrt{3}}{2} + \frac{\pi}{12}\right)\right]$	M1 NB: A1 on e-PEN
	$= 2a^2\left(\frac{\pi}{4} + \sqrt{3} - 1\right)$	
	Area of $\Delta OAB = \frac{1}{2}\times 3a \times (2+\sqrt{3})a \times \sin\frac{\pi}{6}$ $\left(= \frac{3}{4}a^2(2+\sqrt{3})\right)$	
	Shaded area $= 2a^2\left(\frac{\pi}{4} + \sqrt{3} - 1\right) - \frac{3}{4}a^2(2+\sqrt{3}) = \frac{a^2}{4}(2\pi - 14 + 5\sqrt{3})$	M1A1cao (7)
		[13]

Question Number	Scheme	Marks
(a)		
B1	Multiply r by $\sin\theta$ Award if not seen explicitly but a correct result following use of double angle formula is seen	
M1	Differentiate $r\sin\theta$ or $r\cos\theta$ (using product rule or using double angle formula first)	
A1	Correct derivative for $r\sin\theta$	
dM1	Use $\sin^2\theta+\cos^2\theta=1$ to form a 3TQ in $\cos\theta$ and attempt its solution by a valid method	
A1	Correct value for θ	
A1	Correct r	
(b)		
M1	Use area $=\frac{1}{2}\int r^2\mathrm{d}\theta$ with $r=2a+2a\cos\theta$, no limits needed,	
M1	Use a double angle formula to obtain a function ready for integrating (Alt method uses integration by parts – may be seen)	
dM1	Attempt the integration $\cos 2\theta\rightarrow\frac{1}{k}\sin 2\theta$ $k=\pm 2$ or ± 1	
A1	Correct integration,	
M1	Substitute the limits (need not be simplified). Limits $\frac{\pi}{6}$ and their θ from (a) provided this is $>\frac{\pi}{6}$ NB: A1 on e-PEN	
M1	Obtain the area of ΔOAB and subtract from their previous area	
A1	Correct answer	