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Graph the lemniscate $r^2 = 81 \cos 2\theta$. What symmetries does the curve have?

To sketch the curve $r^2 = 81 \cos 2\theta$ it is useful to identify the range of θ values that will give the whole graph. The equation requires $\cos 2\theta \geq 0$. The maximum value must be $\cos 2\theta = 1$.

What is the full range of θ values that will supply all of the values between 0 and 1?

$-\dfrac{\pi}{4} \leq \theta \leq \dfrac{\pi}{4}$.

This range is appropriate, since plotting from 0 to $\dfrac{\pi}{4}$ will give only half the graph, with points in the first and third quadrant plotted. To obtain the reflection of this, plot from $-\dfrac{\pi}{4}$ to 0 also.

Since $r^2 = 81 \cos 2\theta$, there are two values for r, one positive and one negative, for each value of theta. Use the range $-\dfrac{\pi}{4} \leq \theta \leq \dfrac{\pi}{4}$ to identify some of the values for $r = \pm 9\sqrt{\cos 2\theta}$. Use the θ in the equation for r to find the corresponding values for r. All values are rounded to the nearest hundredth.

θ	$r = \pm 9\sqrt{\cos 2\theta}$
$\theta = 0$	$r = \pm 9$
$\theta = \dfrac{\pi}{16}$	$r = \pm 8.65$
$\theta = \dfrac{\pi}{8}$	$r = \pm 7.57$
$\theta = \dfrac{3}{16}\pi$	$r = \pm 5.57$
$\theta = \dfrac{\pi}{4}$	$r = \pm 0$

Using the values for r and θ it is possible to construct a sketch of $r^2 = 81 \cos 2\theta$.
It can be seen that the curve is symmetric about the x-axis, about the y-axis and about the origin.