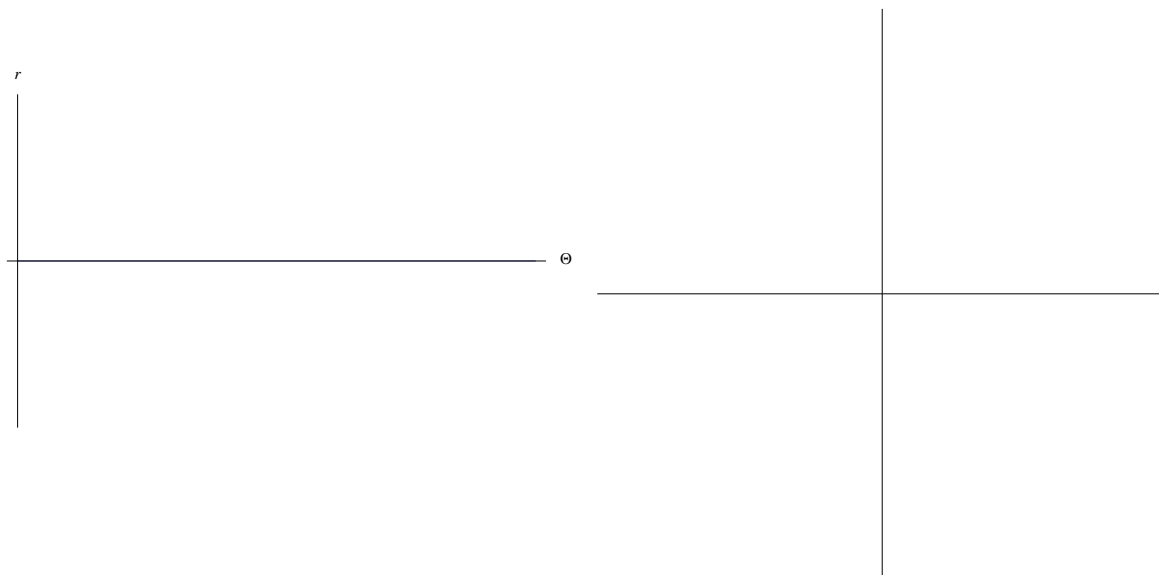


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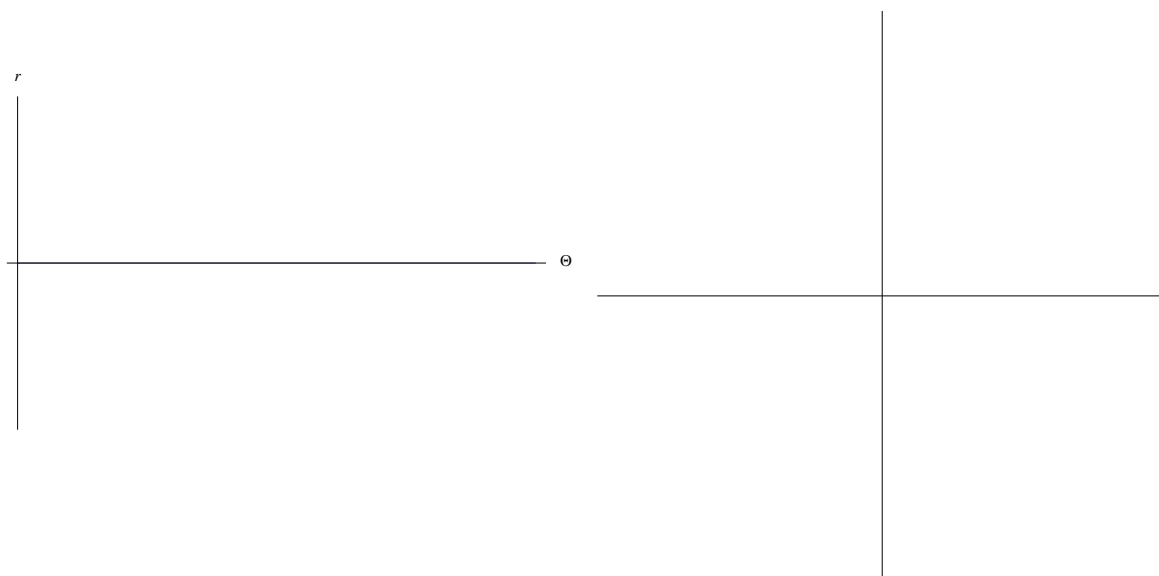
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Math 231 A. Worksheet 19.

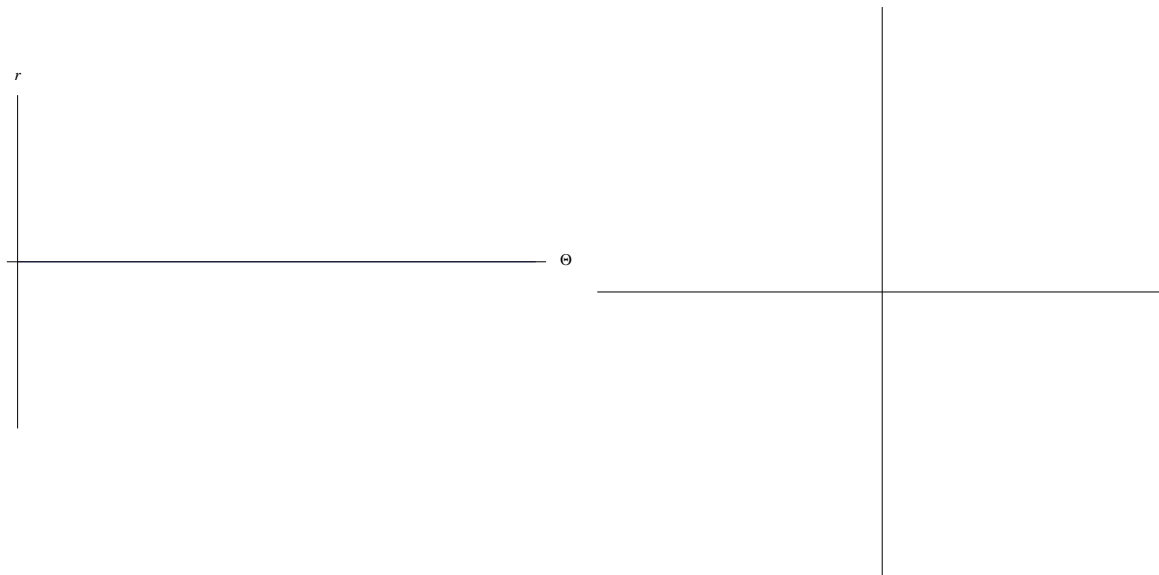
1. A four-leaved rose is defined in polar coordinates by the equation $r = \sin(2\theta)$. Make a **careful** sketch of r against θ on the rectangular axes. Use this to make a **careful** sketch of the polar curve. Be sure that important angles are labelled clearly.



2. A cardioid is defined in polar coordinates by the equation $r = 1 + \sin \theta$. Make a **careful** sketch of r against θ on the rectangular axes. Use this to make a **careful** sketch of the polar curve. Be sure that important angles are labelled clearly.



3. A limaçon is defined in polar coordinates by the equation $r = 2 \sin \theta - 1$. Make a **careful** sketch of r against θ on the rectangular axes. Use this to make a **careful** sketch of the polar curve. Be sure that important angles are labelled clearly.



4. Recall the basic formulas $x = r \cos \theta$, $y = r \sin \theta$ and the chain rule: $\frac{dy}{dx} = \frac{dy/d\theta}{dx/d\theta}$.

Use these to find a general formula for the slope of the tangent line of the limaçon in the previous problem in terms of θ . Find the slope of the tangent line at the points where $\theta = 0$ and at $\theta = \pi/2$, and sketch those tangent lines **carefully** on your graph.

5. Repeat Problem 4 for the cardioid which you sketched on the previous page at the points where $\theta = 0$ and $\theta = \pi$.