Math Objectives

- Students will understand the role of the values of *a* and *n* in the equation $r = asin(n\theta)$.
- Students will be able to predict the number of petals and their length by examining the polar equation.
- Students will understand the relationship between the equation of a rose curve and the equation of a sinusoidal function.

Vocabulary

- amplitude
- rose curve
- frequency
- sinusoidal function

About the Lesson

- Students will investigate the effect of changing the values of *a* and *n* in the equation $r = asin(n\theta)$.
- Students will generalize the roles of *a* and *n* in the equation $r = asin(n\theta)$.
- Students will compare the graphs of the sinusoidal function, $f(x) = asin(nx)$, and the rose curve, $r = asin(n\theta)$ and make generalizations about the relationship between the graphs.
- Students will write equations of rose curves when given information about the petals of the curve.

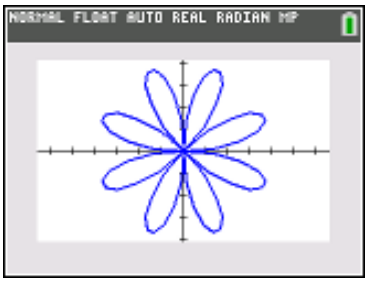
Teacher Preparation and Notes.

- This activity is done with the use of the TI-84 family as an aid to the problems.

Activity Materials

- Compatible TI Technologies: TI-84 Plus*, TI-84 Plus Silver Edition*, TI-84 Plus C Silver Edition, TI-84 Plus CE

** with the latest operating system (2.55MP) featuring MathPrint™ functionality.*



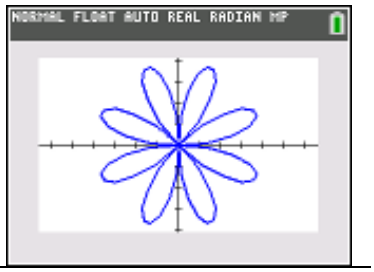
Tech Tips:

- This activity includes screen captures taken from the TI-84 Plus CE. It is also appropriate for use with the rest of the TI-84 Plus family. Slight variations to these directions may be required if using other calculator models.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity
Rose_Curve_84_Student.pdf
Rose_Curve_84_Student.doc

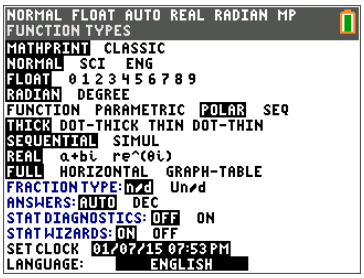
In this activity, you will investigate the effect of changing the values of *a* and *n* in the equation $r = asin(n\theta)$. You will also explore the relationship between the polar rose curve $r = asin(n\theta)$ and the sinusoidal function $f(x) = asin(nx)$.



Discussion Points and Possible Answers

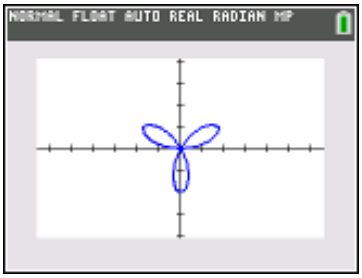
Tech Tip: The default setting for θstep for polar graphs is π/24 (0.1308996939). The value may need to be adjusted to π/48.

To set your calculator to Polar mode, press [mode] and select **POLAR** as shown to the right. At this time, also set your graphing calculator to Radian mode by selecting **RADIAN** on this screen as well.
To graph a polar equation on your graphing calculator, press [y=] and enter your equation. . The [X,T,θ,n] key produces θ in your equation when you are in Polar mode.



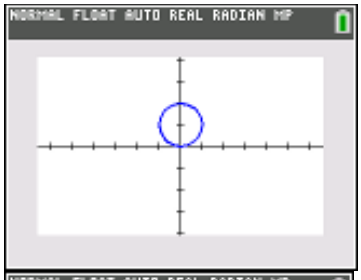
1. Graph $r1 = 2sin(3\theta)$. Press [zoom] and select 4: ZDecimal. A polar curve with an equation in the form of $r = asin(n\theta)$ is called a polar rose. Why do you think this is so?

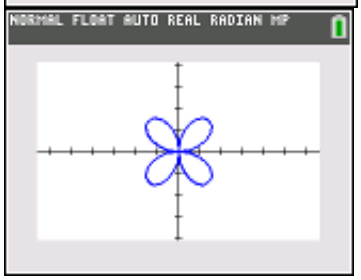
   Answer: The graph of the polar equation $r = asin(n\theta)$ forms a curve that looks like a flower.



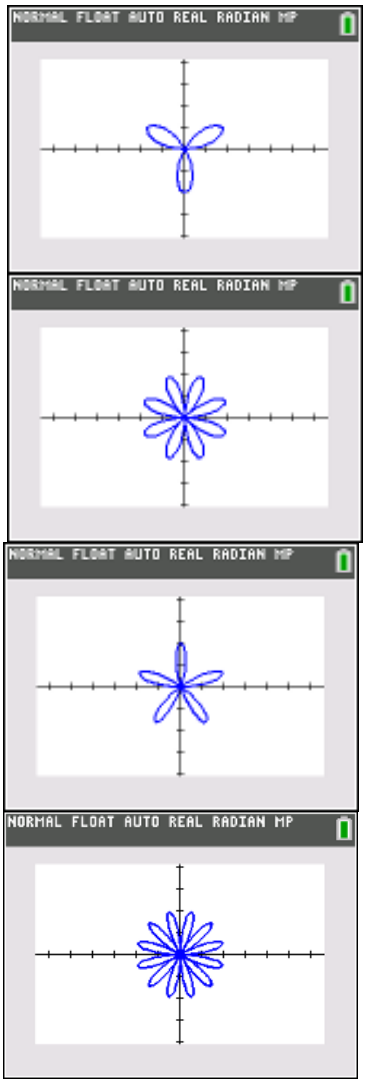
2. Graph the following by editing $r1$ to observe each graph, then complete the table below.

   $i)\ r1 = 2sin(\theta)$ $ii)\ r1 = 2sin(2\theta)$
   $iii)\ r1 = 2sin(3\theta)$ $iv)\ r1 = 2sin(4\theta)$
   $v)\ r1 = 2sin(5\theta)$ $vi)\ r1 = 2sin(6\theta)$





Graph	n	Number of petals
$i)\ r1 = 2sin(\theta)$	1	1
$i)\ r1 = 2sin(\theta)$	2	4
$iii)\ r1 = 2sin(3\theta)$	3	3
$iv)\ r1 = 2sin(4\theta)$	4	8
$v)\ r1 = 2sin(5\theta)$	5	5
$vi)\ r1 = 2sin(6\theta)$	6	12



3. What effect does the value of n have on the graph of the curve?

   Answer: The value of n determines the number of petals on the rose curve.

4. How many petals does the curve have when n = 3? When n = 4? Predict the number of petals when n = 9 and when n = 10.

   Answer: When $n = 3$, there are 3 petals. When $n = 4$, there are 8 petals. When $n = 9$, there are 9 petals. When $n = 10$, there are 20 petals.

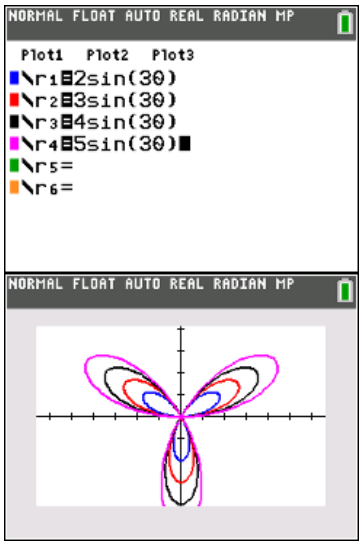
5. Write a rule to determine the number of petals of a rose curve.

   Answer: When n is an even integer, there are $2n$ petals. When n is an odd integer, there are n petals

6. Graph the following.

   $i)\ r1 = 2sin(3\theta)$ $\quad ii)\ r2 = 3sin(3\theta)$

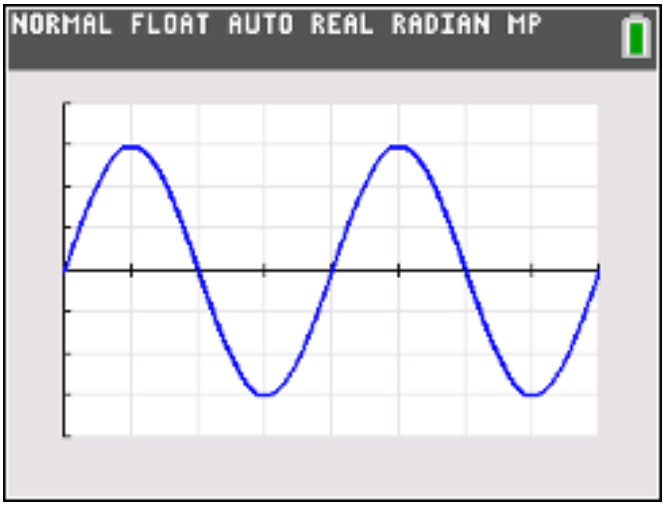
   $iii)\ r3 = 4sin(3\theta)$ $\quad iv)\ r4 = 5sin(3\theta)$

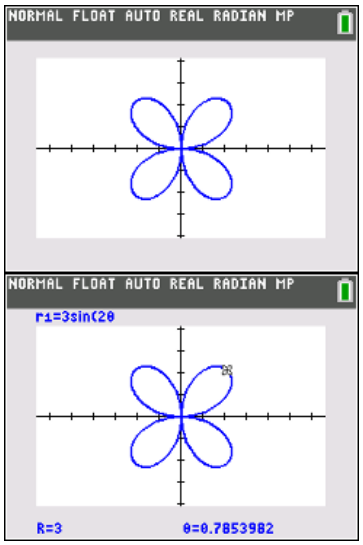


   Explain the effect that the value of a in the equation $r = asin(n\theta)$ has on the graph.

   Answer:
   The value of a determines the length of each of the petals, from the pole to the tip. As we increase the value of a, the length of the petals increases.

7. The graph of the sinusoidal function $f(x) = 3sin(2x)$ is shown below. The *x*-scale for the gridlines is $\pi/4$.





Graph the polar rose given by $r1 = 3sin(2\theta)$. Press [2nd][zoom] to access format. In the first row, use the right arrow to highlight **PolarGC** and press [enter]. Press [trace] and then the right arrow to move your cursor. Observe the change in the *r* and θ values.

a) When the *r* value is 3, your cursor will be at the tip of the first petal. Notice that the θ value is $\pi/4 \approx 0.7853982$. On the interval from $x = 0$ to $x = \pi/2$, which point on the graph of the sinusoidal function would correspond to $\left(\frac{\pi}{4}, 3\right)$? How is the value of a in a sinusoidal function related to the graph of the polar rose?

Answer: The maximum of the sinusoidal function graph is located at the point $\left(\frac{\pi}{4}, 3\right)$ and this point corresponds to the tip of the polar rose. The amplitude of the sinusoidal function corresponds to the length of a rose petal; that is, the length of the petal from the pole to the tip.

b) What part of the sinusoidal function graph corresponds to the first petal of the rose graph?

Answer: The first petal of the rose graph corresponds to the arch of the sinusoidal graph from $x = 0$ to $x = \pi/2$.

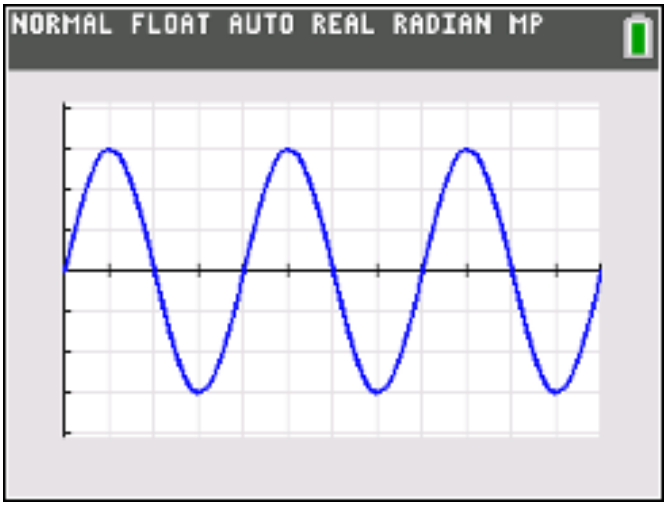
c) From $x = \pi/2$ to $x = \pi$, the graph of the sinusoidal function has an arch that is below the *x*-axis. Continue to trace around the polar rose. In what quadrant is the second petal of the polar rose located? Why?

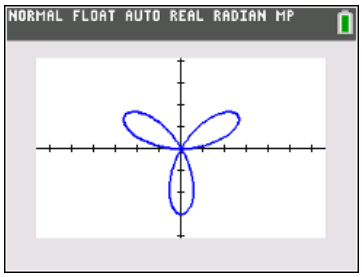
Answer: The petal is in quadrant 4 because the *r* values are negative.

d) The graph of the sinusoidal function has two intervals where the graph is above the *x*-axis and two intervals where the graph is below the x-axis. How does this correspond to the graph of the polar rose?

Answer: The graph has two intervals where the sinusoidal function graph is above the *x*-axis and this corresponds to two petals. One is in quadrant 1 and the second one is in quadrant 3. The graph has two intervals where the sinusoidal function graph is below the *x*-axis and this also corresponds to two petals. One is in quadrant 4 and the second one is in quadrant 2.

8. The graph of the sinusoidal function $f(x) = 3sin(3x)$ is shown below. The *x*-scale for the gridlines is $\pi/6$.



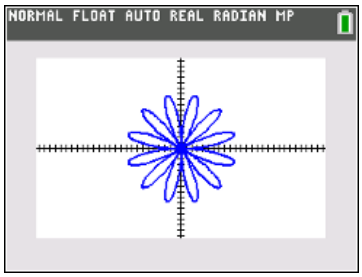


Graph the polar rose given by $r1 = 3sin(3\theta)$. Press [trace] and then the right arrow to move your cursor. Observe the change in the *r* and θ values. Explain why the polar curve $r = 3sin(3\theta)$ has only

three petals, while the function $f(x) = 3sin(3x)$ has six arches in the interval $0 \leq \theta \leq 2\pi$.

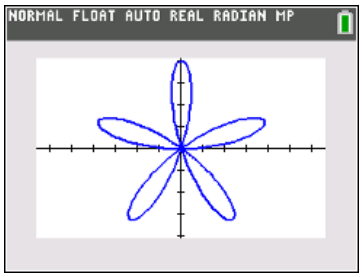
Answer: The three petals of the rose curve are sketched for values of θ in the interval $0 \leq \theta \leq \pi$. For the interval $\pi \leq \theta \leq 2\pi$ the three petals are traced a second time.

9. What is the equation of a rose curve in the form of $r = asin(n\theta)$ that has 12 petals, each of length 10? Check your answer by graphing your polar equation.



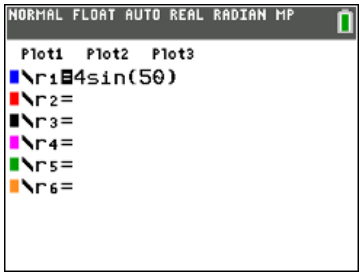
Answer: Since the length of each curve is 10, $a = 10$. To have 12 petals, we would need n value of 6. The correct equation is $r = 10sin(6\theta)$.

10. What is the equation of a rose curve in the form of $r = asin(n\theta)$ that has 5 petals, each of length 4? Check your answer by graphing your polar equation.

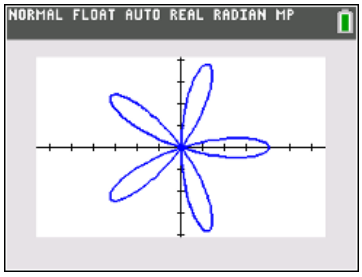


Answer: Since the length of each curve is 4, $a = 4$. To have 5 petals, we would need n value of 5. The correct equation is $r = 4sin(5\theta)$.

11. Explain the similarities and differences you would expect if we replaced the sine graphs with cosine graphs. How does this affect the polar rose graph?



Answer: The cosine functions are horizontal translations of the sine functions. The polar rose would appear rotated.



Teacher Tip: This might make a good extension question. You can develop this question into a part of your lesson, or omit it entirely.

Extensions

1. Ask students to determine what happens to the rose curve when n Is a non-positive integer.

Wrap Up

Upon completion of the lesson, the teacher should ensure that students are able to understand:

- The role of the values of *a* and *n* in the equation $r = asin(n\theta)$.
- How to predict the number of petals and their length by examining the polar equation.
- How the equation of a rose curve is related to the equation of a sinusoidal function.