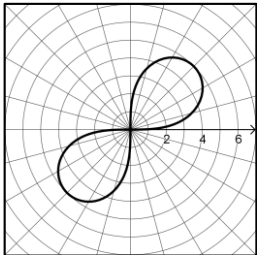
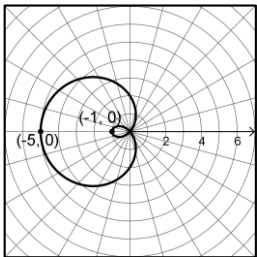
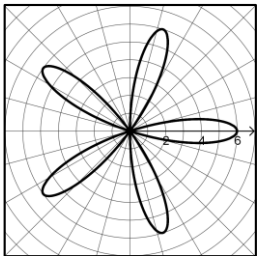


| Type of Graph | Equations   | Properties   | Example  |
|---------------|---|--|--|
| Spiral        | $r = a\theta$                                       | Begins at the origin spiraling outward in a counter-clockwise direction, crossing the polar axis at $(2\pi ak, 0)$ for $k=0,1,2,3,\dots$   | $r = \frac{1}{3}\theta$ with $0 \leq \theta \leq 6\pi$<br> |
| Circles       | $r = a$<br>$r = 2a\sin\theta$<br>$r = 2a\cos\theta$ | If $r = a$ , then a circle with radius $ a $ centered at $(0,0)$<br>If $\sin\theta$ , then a circle with radius $ a $ centered at $(0,a)$<br>If $\cos\theta$ , then a circle with radius $ a $ centered at $(a,0)$ | $r = 6\sin\theta$<br>                                      |
| Lines         | $\theta = \theta_0$                                 | A line passing through the origin with slope $m = \tan\theta_0$  | $\theta = \frac{\pi}{5}$<br>                               |

| Type of Graph   | Equations  | Properties   | Example   |
|---|--|--|---|
| Lemniscates   | $r^2 = a^2 \sin \theta$<br>$r^2 = a^2 \cos \theta$     | <p>If <math>\sin \theta</math>, then two loops along the <math>y = x</math> line each having a radius <math> a </math></p> <p>If <math>\cos \theta</math>, then two loops along the <math>y = 0</math> line each having a radius <math> a </math></p>  | $r^2 = 25 \sin(2\theta)$<br> |
| <b>Limaçons</b><br>Inner Loop ( $a < b$ )<br>Cardioid ( $a = b$ )<br>Dimple ( $a > b$ ) | $r = a \pm b \sin \theta$<br>$r = a \pm b \cos \theta$ | <p>If <math>+b \sin \theta</math> then extends upward, if <math>-b \sin \theta</math> then extends downward; has <math>y</math>-intercepts at <math>(0, b \pm a)</math>; has <math>x</math>-intercepts at <math>(\pm a, 0)</math>; inner loop and cardioid also cross through origin</p> <p>If <math>+b \cos \theta</math> then extends right, if <math>-b \cos \theta</math> then extends left; has <math>x</math>-intercepts at <math>(b \pm a, 0)</math>; has <math>y</math>-intercepts at <math>(0, \pm a)</math>; inner loop and cardioid also cross through origin</p> | $r = 2 - 3 \cos \theta$<br>  |
| Roses   | $r = a \sin(n\theta)$<br>$r = a \cos(n\theta)$         | <p>If <math>\sin(n\theta)</math>, then no petals on either axis if <math>n</math> is even or 1 petal on <math>y</math>-axis if <math>n</math> is odd (alternates <math>+y</math> or <math>-y</math> for incrementally odd values)</p> <p>If <math>\cos(n\theta)</math>, then first petal on positive <math>x</math>-axis</p> <p># of petals: if <math>n</math> is odd then <math>n</math> petals, if <math>n</math> is even then <math>2n</math> petals</p>  | $r = 6 \cos(5\theta)$<br>  |