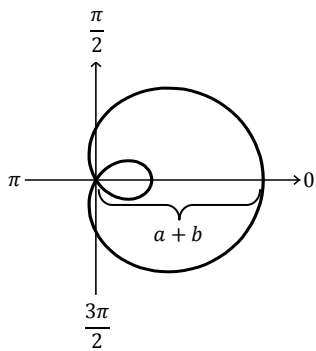


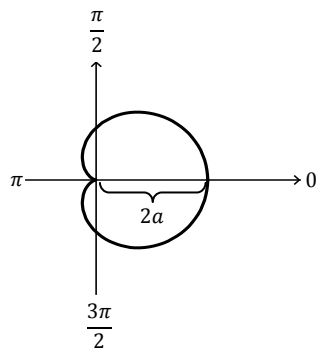
## Special Polar Graphs

**Limaçons:** (positive cosine orientation)      period =  $2\pi$        $r = a \pm b \cos(\theta)$        $r = a \pm b \sin(\theta)$       ( $a > 0, b > 0$ )



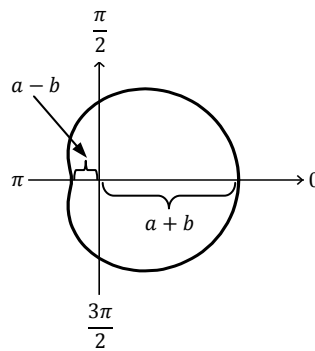
$$\frac{a}{b} < 1$$

Limaçon with inner loop



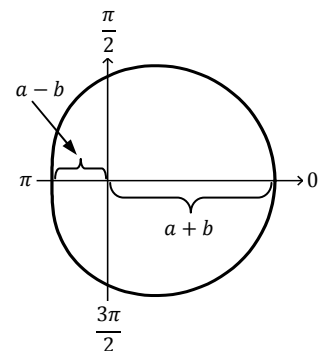
$$\frac{a}{b} = 1$$

Cardioid (heart-shaped)



$$1 < \frac{a}{b} < 2$$

Dimpled limaçon



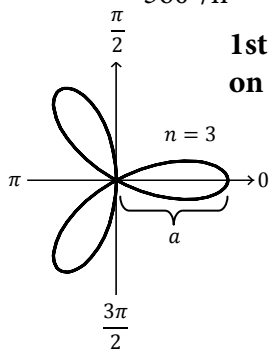
$$\frac{a}{b} \geq 2$$

Convex limaçon

**Rose Curves:**       $n$  petals if  $n$  is odd (period =  $\pi$ );  $2n$  petals if  $n$  is even ( $n \geq 2$  and period =  $2\pi$ )

$360^\circ/n$  --- Distance between leaves--- $360^\circ/2n$

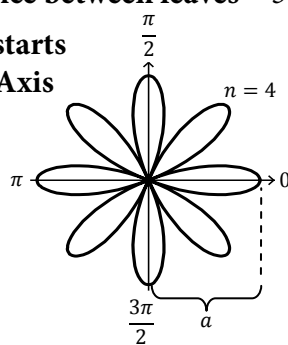
$360^\circ/n$  --- Distance between leaves--- $360^\circ/2n$



$$r = a \cos(n\theta)$$

Rose curve

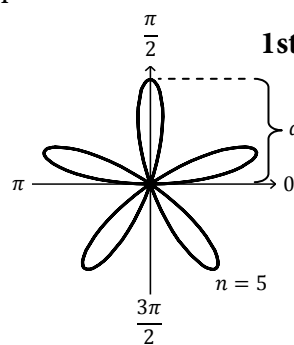
1st leaf starts  
on Polar Axis



$$r = a \cos(n\theta)$$

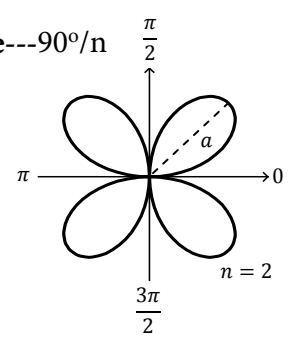
Rose curve

1st leaf--- $90^\circ/n$



$$r = a \sin(n\theta)$$

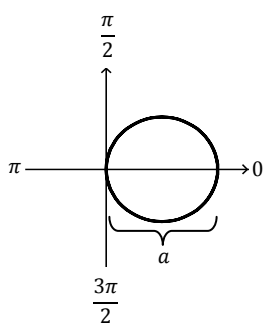
Rose curve



$$r = a \sin(n\theta)$$

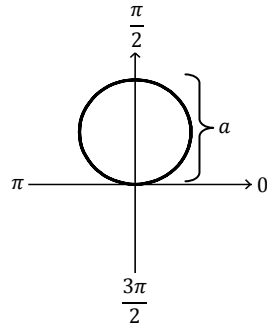
Rose curve

**Circles and Lemniscates:**      period =  $\pi$



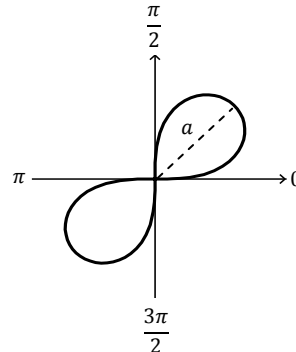
$$r = a \cos(\theta)$$

Circle



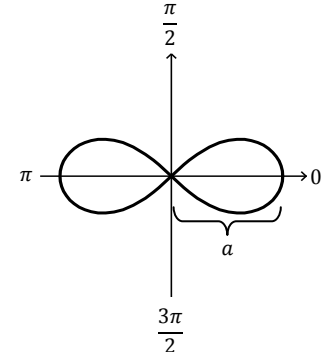
$$r = a \sin(\theta)$$

Circle



$$r^2 = a^2 \sin(2\theta)$$

Lemniscate



$$r^2 = a^2 \cos(2\theta)$$

Lemniscate