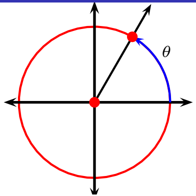
Precalculus
Definition of the trigonometric functions and basic computations

Todor Milev

2019

Outline

Definition of the trigonometric functions



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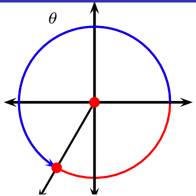

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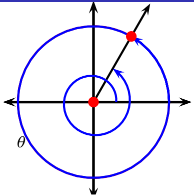

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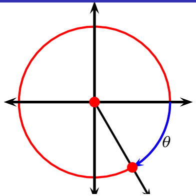

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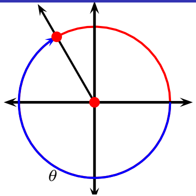

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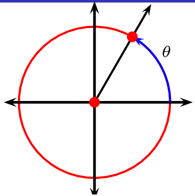

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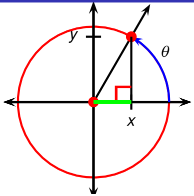

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Definition (sin and cos)

The sine and cosine functions of the angle θ, denoted by $\sin\theta$ and $\cos\theta$, are defined by

$$\cos\theta = x \qquad\qquad \sin\theta = y.$$

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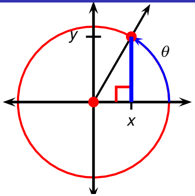

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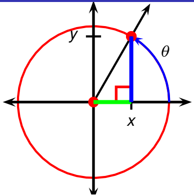

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The functions tangent, cotangent, secant and cosecant of the angle θ, denoted by $\tan\theta$, $\cot\theta$, $\sec\theta$, $\csc\theta$, are defined by

$$\tan\theta = \frac{\sin\theta}{\cos\theta} \qquad \cot\theta = \frac{\cos\theta}{\sin\theta} \qquad \sec\theta = \frac{1}{\cos\theta} \qquad \csc\theta = \frac{1}{\sin\theta}.$$

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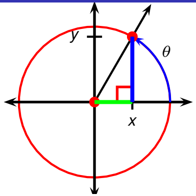

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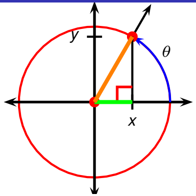

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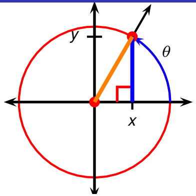

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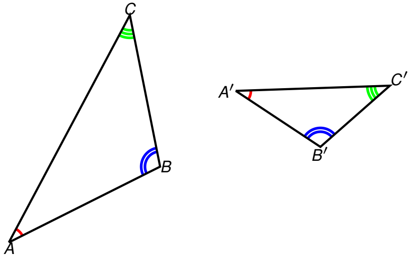

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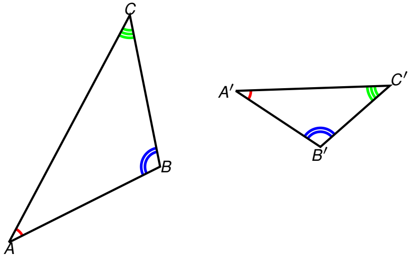

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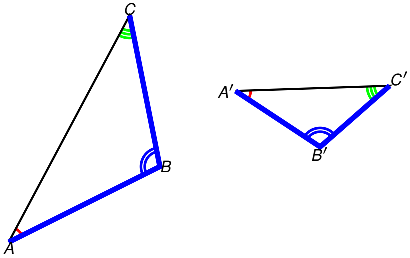

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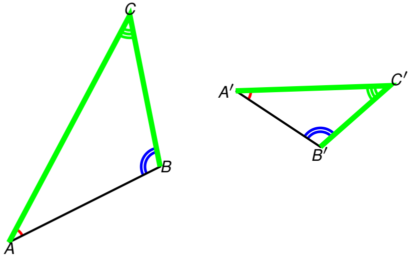

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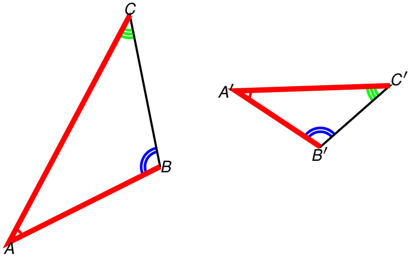
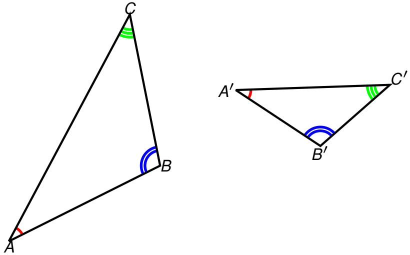


The following statement is proved in the subject of Euclidean (planar) geometry.

Theorem (Similar triangles have equal side ratios)

Let $\triangle ABC$ and $\triangle A'B'C'$ be two similar triangles. Then the ratios of the lengths of the sides of the two triangles are equal, that is

$$\frac{|AB|}{|BC|} = \frac{|A'B'|}{|B'C'|} \qquad \frac{|BC|}{|CA|} = \frac{|B'C'|}{|C'A'|} \qquad \frac{|CA|}{|AB|} = \frac{|C'A'|}{|A'B'|}$$



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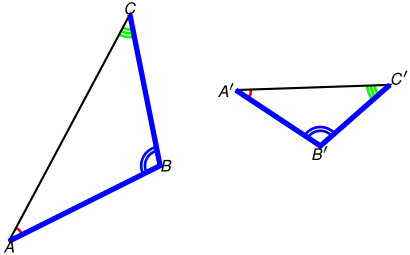

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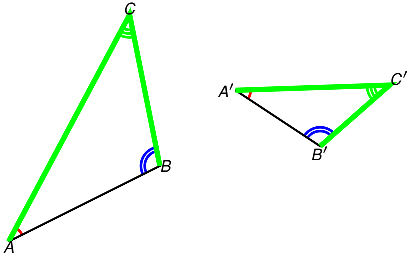

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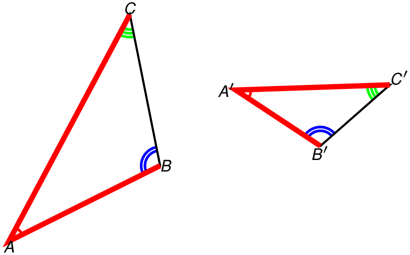
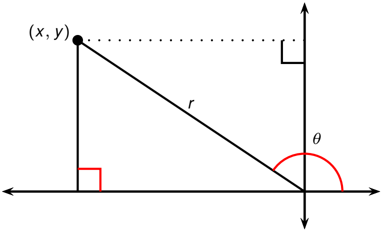
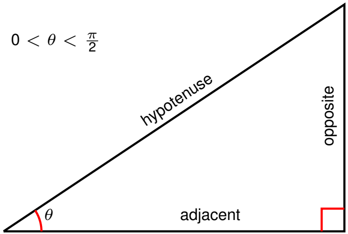


Trigonometric Functions and Right Angle Triangles





$\cos\theta$	$\sec\theta$	$\cos\theta$	$\sec\theta$
$\sin\theta$	$\csc\theta$	$\sin\theta$	$\csc\theta$
$\tan\theta$	$\cot\theta$	$\tan\theta$	$\cot\theta$
All angles		Acute angles	

- The trigonometric functions can be defined without requesting that the pt. (x, y) on the terminal arm of the angle lie on the unit circle.

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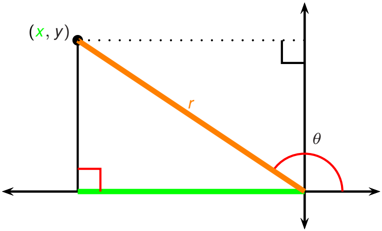

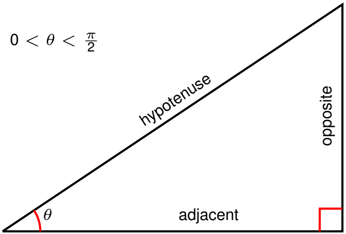

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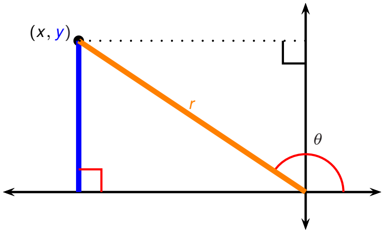

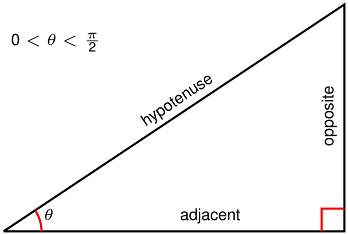

$\cos\theta = \frac{x}{r}$	$\sec\theta$	$\cos\theta$	$\sec\theta$
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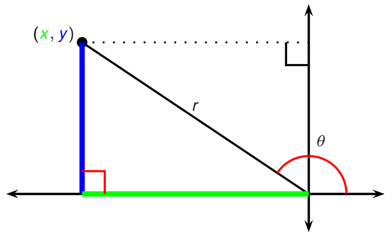

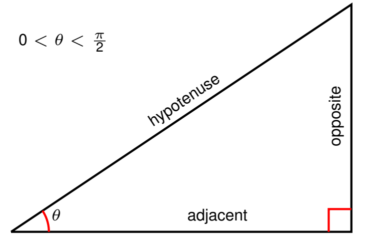

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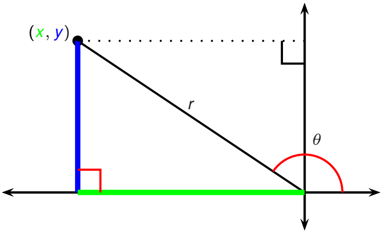

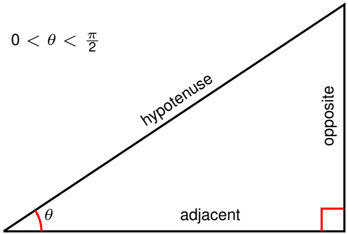

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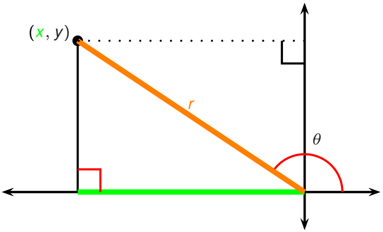

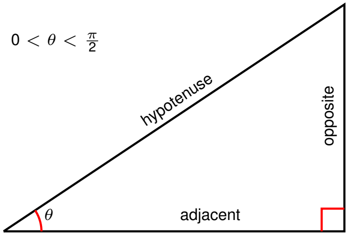

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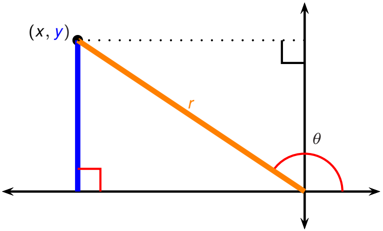

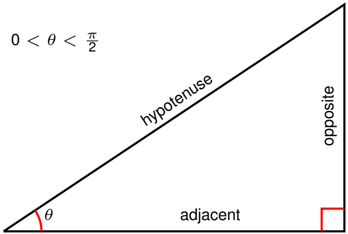

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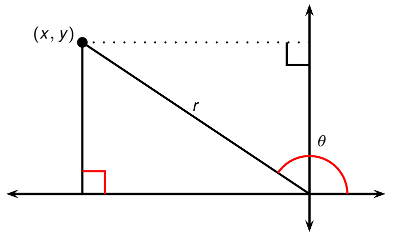		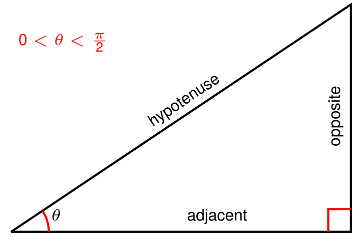	
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- The trigonometric functions can be defined without requesting that the pt. (x, y) on the terminal arm of the angle lie on the unit circle.
- To do so we rescale by the distance r from the origin.
- The trig functions of acute θ (between 0 and $\frac{\pi}{2}$) can be interpreted as ratios of sides of right angle triangle with angle θ.

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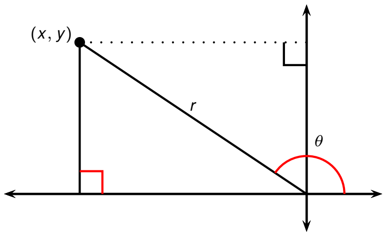

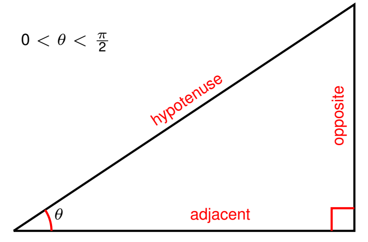

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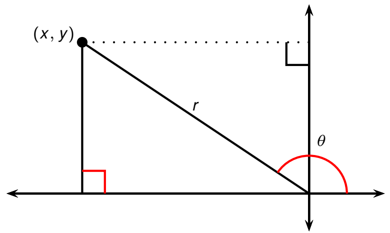
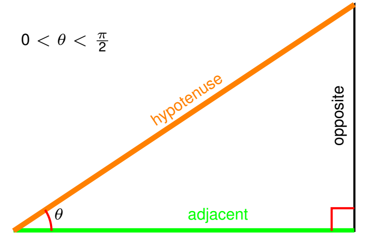
Trigonometric Functions and Right Angle Triangles





$\cos\theta = \frac{x}{r}$	$\sec\theta = \frac{r}{x}$	$\cos\theta = \frac{\text{adj}}{\text{hyp}}$	$\sec\theta$
$\sin\theta = \frac{y}{r}$	$\csc\theta = \frac{r}{y}$	$\sin\theta$	$\csc\theta$
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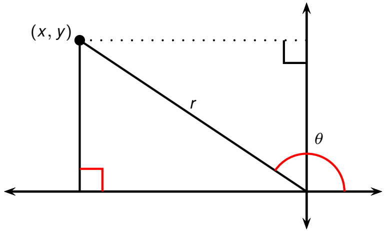		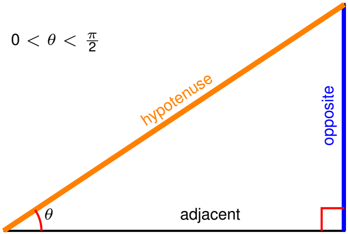	
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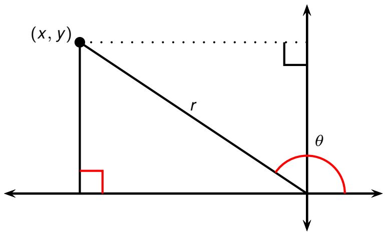

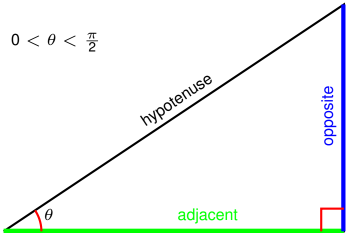

$\cos\theta = \frac{x}{r}$	$\sec\theta = \frac{r}{x}$	$\cos\theta = \frac{\text{adj}}{\text{hyp}}$	$\sec\theta$
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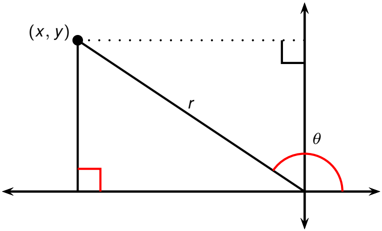

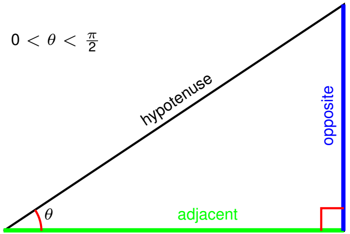

All angles		Acute angles	
$\cos\theta = \frac{x}{r}$	$\sec\theta = \frac{r}{x}$	$\cos\theta = \frac{\text{adj}}{\text{hyp}}$	$\sec\theta$
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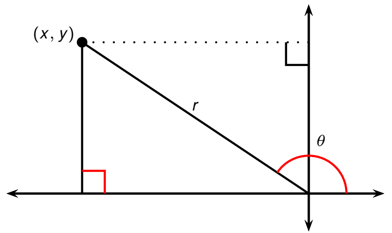

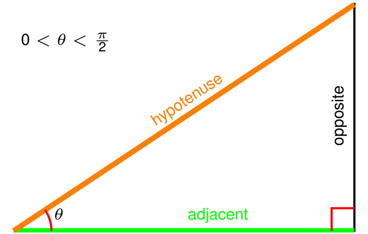

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$\sin\theta = \frac{y}{r}$	$\csc\theta = \frac{r}{y}$	$\sin\theta = \frac{\text{opp}}{\text{hyp}}$	$\csc\theta$
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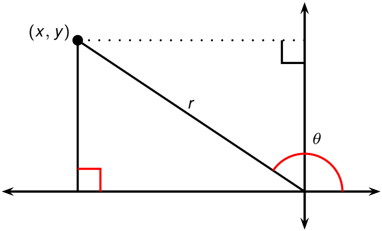

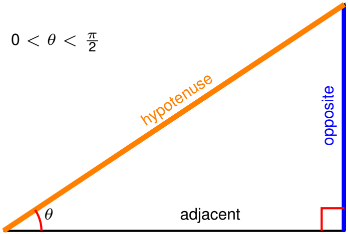

$\cos\theta = \frac{x}{r}$	$\sec\theta = \frac{r}{x}$	$\cos\theta = \frac{\text{adj}}{\text{hyp}}$	$\sec\theta = \frac{\text{hyp}}{\text{adj}}$
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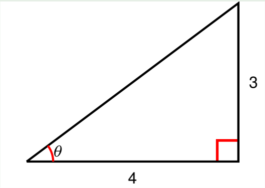
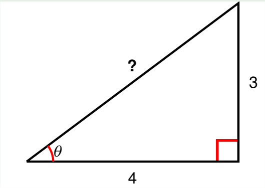


Let the angle θ be as indicated in the figure. Find the values of the six trigonometric functions of θ.

$\sin\theta =$ $\cos\theta =$ $\tan\theta =$

$\csc\theta =$ $\sec\theta =$ $\cot\theta =$

Example



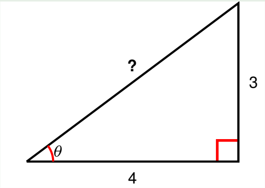
Let the angle θ be as indicated in the figure. Find the values of the six trigonometric functions of θ.

To find the trigonometric functions, we need to know the length of the hypotenuse.

$$\sin\theta = \qquad \cos\theta = \qquad \tan\theta =$$

$$\csc\theta = \qquad \sec\theta = \qquad \cot\theta =$$

Example



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To find the trigonometric functions, we need to know the length of the hypotenuse.

$$\text{hypotenuse} = \textbf{?}$$

$$\sin\theta = \qquad \cos\theta = \qquad \tan\theta =$$

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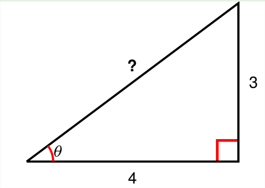
Example



Let the angle θ be as indicated in the figure. Find the values of the six trigonometric functions of θ.

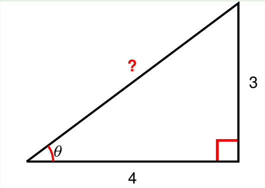
To find the trigonometric functions, we need to know the length of the hypotenuse.

$$\text{hypotenuse} = \sqrt{4^2 + 3^2}$$

$$\sin\theta = \qquad \cos\theta = \qquad \tan\theta =$$

$$\csc\theta = \qquad \sec\theta = \qquad \cot\theta =$$

Example



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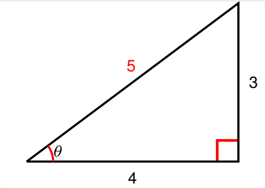
To find the trigonometric functions, we need to know the length of the hypotenuse.

$$\text{hypotenuse} = \sqrt{4^2 + 3^2} = \sqrt{25}$$

$$\sin\theta = \qquad \cos\theta = \qquad \tan\theta =$$

$$\csc\theta = \qquad \sec\theta = \qquad \cot\theta =$$

Example



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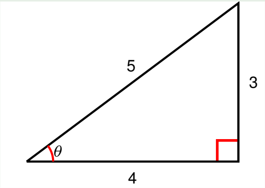
Example



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Using the right angle triangle ratio interpretations of the trig functions, we can compute:

$$\sin\theta = \textbf{?} \qquad \cos\theta = \qquad \tan\theta =$$

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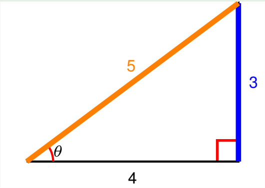
Example



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Using the right angle triangle ratio interpretations of the trig functions, we can compute:

$$\sin\theta = \frac{3}{5} \quad \cos\theta = \quad \tan\theta =$$

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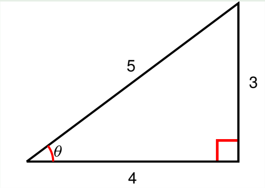
Example



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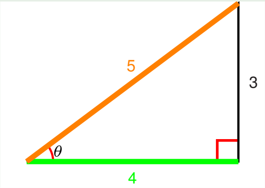

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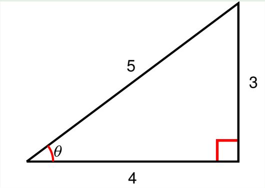

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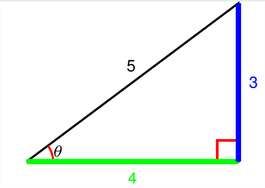

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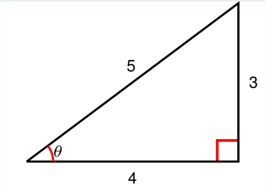

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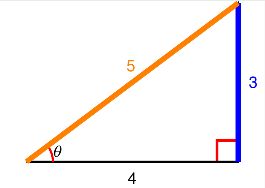

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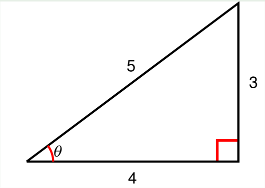

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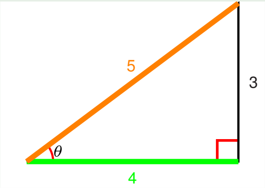

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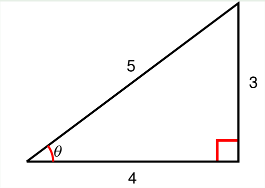

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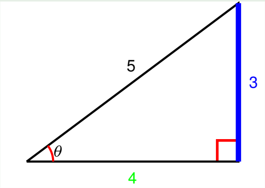
Example



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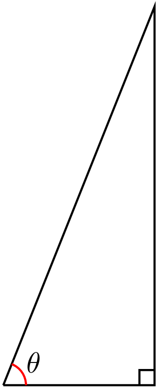
Using the right angle triangle ratio interpretations of the trig functions, we can compute:

$$\sin\theta = \frac{3}{5} \quad \cos\theta = \frac{4}{5} \quad \tan\theta = \frac{3}{4}$$
$$\csc\theta = \frac{5}{3} \quad \sec\theta = \frac{5}{4} \quad \cot\theta = \frac{4}{3}$$

Example

If $\cos\theta = \frac{2}{5}$ and $0 < \theta < \frac{\pi}{2}$, find the other five trigonometric functions of θ.



$\sin\theta =$ $\tan\theta =$

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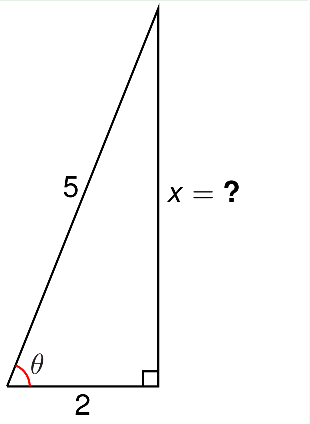


- Label the hypotenuse with length 5 and the adjacent side with length 2.

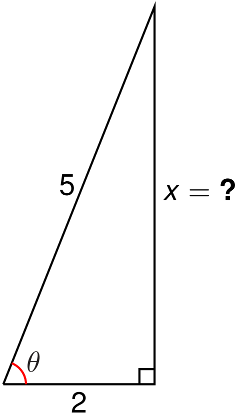
$\sin\theta =$ $\quad$ $\tan\theta =$

$\csc\theta =$ $\quad$ $\sec\theta =$

$\cot\theta =$

Example

If $\cos\theta = \frac{2}{5}$ and $0 < \theta < \frac{\pi}{2}$, find the other five trigonometric functions of θ.



- Label the hypotenuse with length 5 and the adjacent side with length 2.
- Pythagorean theorem: $x^2 + 2^2 = 5^2$.

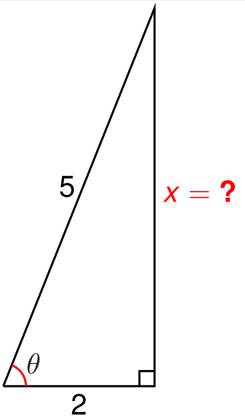
$\sin\theta =$ $\tan\theta =$

$\csc\theta =$ $\sec\theta =$

$\cot\theta =$

Example

If $\cos\theta = \frac{2}{5}$ and $0 < \theta < \frac{\pi}{2}$, find the other five trigonometric functions of θ.



- Label the hypotenuse with length 5 and the adjacent side with length 2.
- Pythagorean theorem: $x^2 + 2^2 = 5^2$.
- Therefore $x^2 =$ **?** , so $x =$ **?** .

$\sin\theta =$ $\qquad$ $\tan\theta =$

$\csc\theta =$ $\qquad$ $\sec\theta =$

$\cot\theta =$

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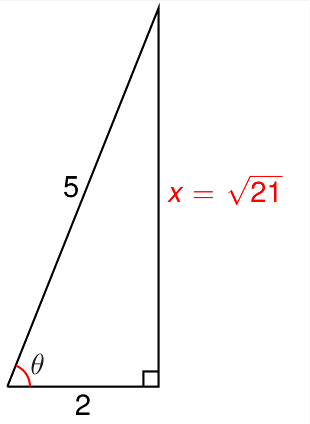

- Label the hypotenuse with length 5 and the adjacent side with length 2.
- Pythagorean theorem: $x^2 + 2^2 = 5^2$.
- Therefore $x^2 = 21$, so $x = \sqrt{21}$.

$$\sin\theta = \qquad \tan\theta =$$

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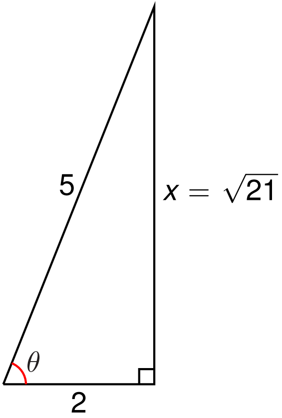

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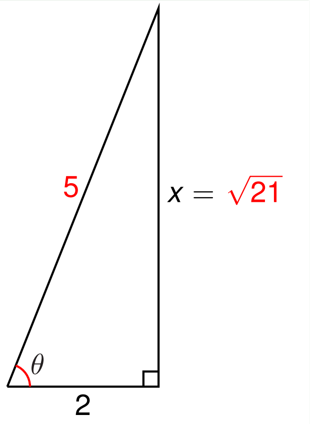

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$\sin\theta = \frac{\sqrt{21}}{5}$ $\tan\theta =$

$\csc\theta =$ $\sec\theta =$

$\cot\theta =$

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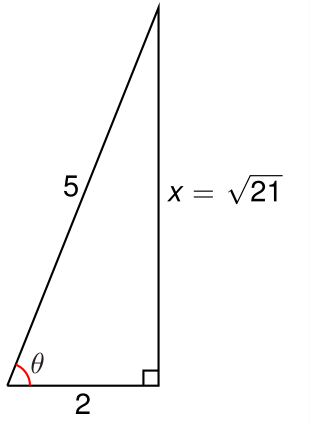

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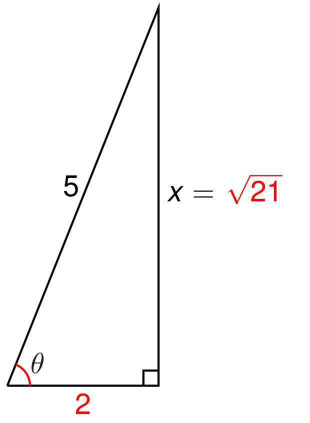

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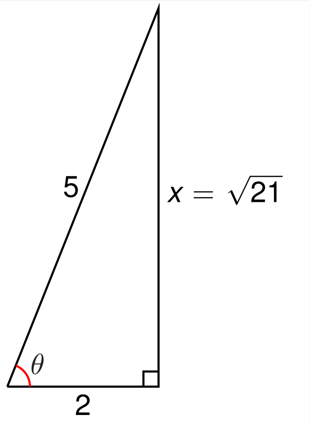

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$$\cot\theta =$$

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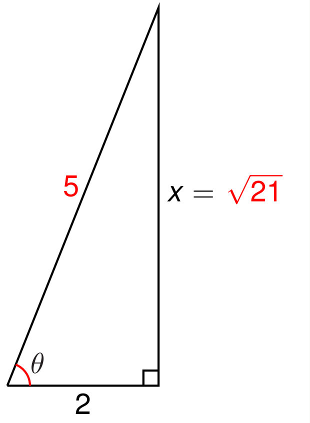

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$$\csc\theta = \frac{5}{\sqrt{21}} \quad \sec\theta =$$

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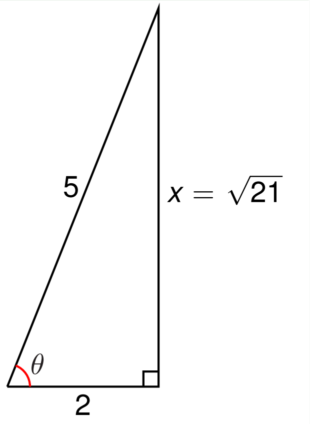
If $\cos\theta = \frac{2}{5}$ and $0 < \theta < \frac{\pi}{2}$, find the other five trigonometric functions of θ.



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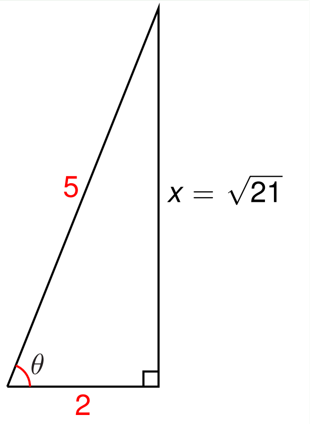

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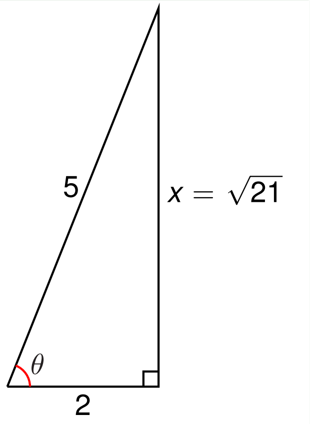

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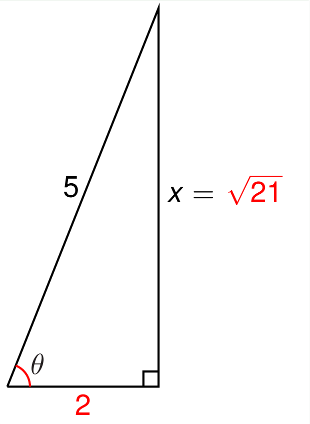

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$$\sin\theta = \frac{\sqrt{21}}{5} \qquad \tan\theta = \frac{\sqrt{21}}{2}$$

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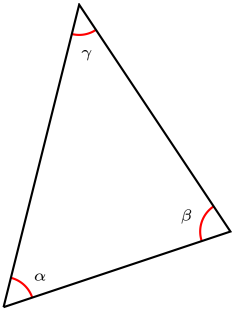
$$\cot\theta = \frac{2}{\sqrt{21}}$$



Proposition

The angles of every triangle sum up to $\pi = 180°$.

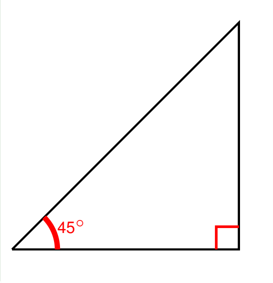
In other words, if α, β, γ are the angles indicated in the figure, then we have:

$$\alpha + \beta + \gamma = 180°.$$

Example

Find the values of $\sin 45^\circ, \cos 45^\circ, \tan 45^\circ$.

Example

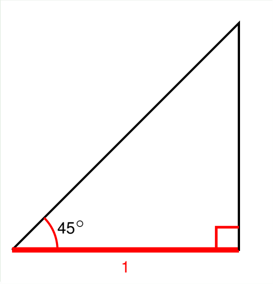


Find the values of $\sin 45^\circ, \cos 45^\circ, \tan 45^\circ$.

- Draw the 45° angle in right angle triangle,

.

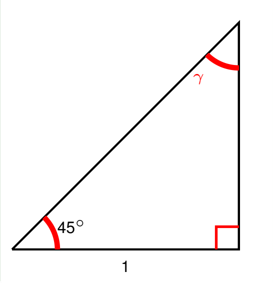
Example



Find the values of $\sin 45^\circ, \cos 45^\circ, \tan 45^\circ$.

- Draw the 45° angle in right angle triangle, adjacent side of length 1.

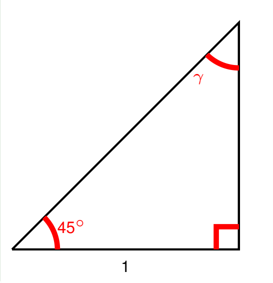
Example



Find the values of $\sin 45^\circ, \cos 45^\circ, \tan 45^\circ$.

- Draw the 45° angle in right angle triangle, adjacent side of length 1.
- Let γ be the angle indicated on the plot.

Example

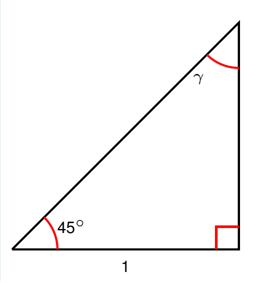


Find the values of $\sin 45^\circ, \cos 45^\circ, \tan 45^\circ$.

- Draw the 45° angle in right angle triangle, adjacent side of length 1.
- Let γ be the angle indicated on the plot.
- Angles in triangle sum to 180°:

$$45^\circ + 90^\circ + \gamma = 180^\circ$$

Example



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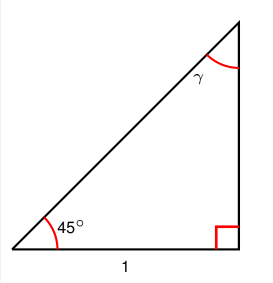

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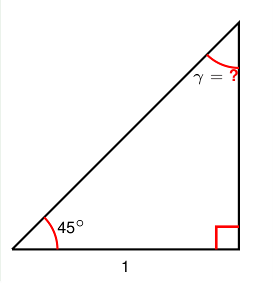
$$\begin{aligned} 45^\circ + 90^\circ + \gamma &= 180^\circ \\ \gamma &= 180^\circ - 90^\circ - 45^\circ \end{aligned}$$

Example



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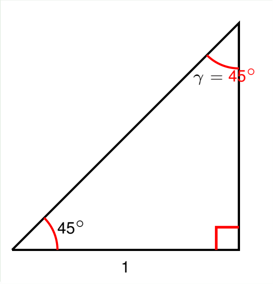

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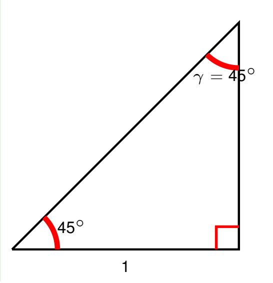

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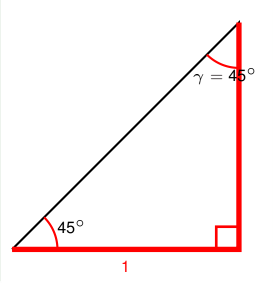
- Triangle has two equal angles

Example



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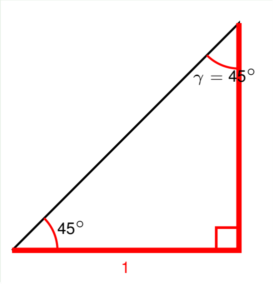
- Triangle has two equal angles $\Rightarrow$ is isosceles

Example



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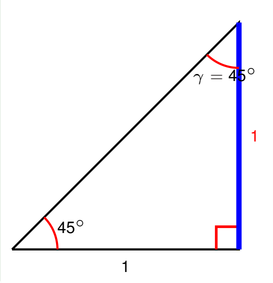
- Triangle has two equal angles $\Rightarrow$ is isosceles (has two equal sides).

Example



Find the values of $\sin 45°, \cos 45°, \tan 45°$.

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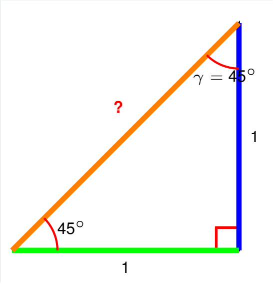
- Let γ be the angle indicated on the plot.
- Angles in triangle sum to 180°:

$$\begin{aligned} 45° + 90° + \gamma &= 180° \\ \gamma &= 180° - 90° - 45° = 45°. \end{aligned}$$

- Triangle has two equal angles $\Rightarrow$ is isosceles (has two equal sides).
- $\Rightarrow$ Opposite leg: length 1 .

Example



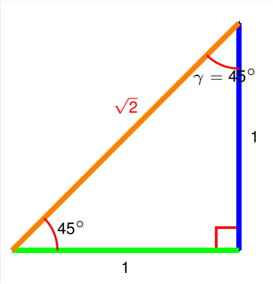
Find the values of $\sin 45^\circ, \cos 45^\circ, \tan 45^\circ$.

- Draw the 45° angle in right angle triangle, adjacent side of length 1.
- Let γ be the angle indicated on the plot.
- Angles in triangle sum to 180°:

$$\begin{aligned} 45^\circ + 90^\circ + \gamma &= 180^\circ \\ \gamma &= 180^\circ - 90^\circ - 45^\circ = 45^\circ. \end{aligned}$$

- Triangle has two equal angles $\Rightarrow$ is isosceles (has two equal sides).
- $\Rightarrow$ Opposite leg: length 1 $\Rightarrow$ length(hyp) $=$ **?** .

Example



Find the values of $\sin 45°, \cos 45°, \tan 45°$.

- Draw the $45°$ angle in right angle triangle, adjacent side of length 1.
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- Angles in triangle sum to $180°$:

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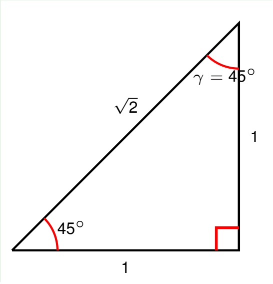
- Triangle has two equal angles $\Rightarrow$ is isosceles (has two equal sides).
- $\Rightarrow$ Opposite leg: length 1 $\Rightarrow$ length(hyp) $= \sqrt{1^2 + 1^2} = \sqrt{2}$.

Example



Find the values of $\sin 45^\circ, \cos 45^\circ, \tan 45^\circ$.

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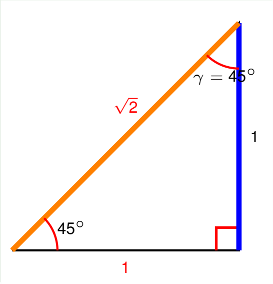
- $\sin 45^\circ = \textbf{?}$ $\cos 45^\circ = \textbf{?}$

$\tan 45^\circ = \textbf{?}$

Example



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- $\sin 45^\circ = \frac{\text{opp}}{\text{hyp}} = \frac{\sqrt{2}}{2}$ $\quad\quad$ $\cos 45^\circ = \textbf{?}$

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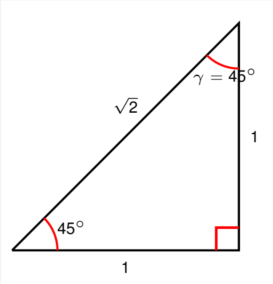
Example



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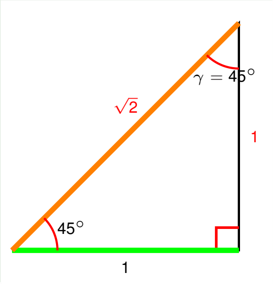
Example



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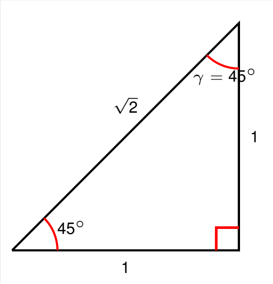
Example



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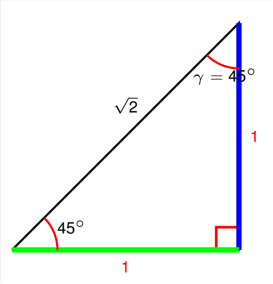
$\tan 45^\circ = \textbf{?}$

Example



Find the values of $\sin 45^\circ, \cos 45^\circ, \tan 45^\circ$.

- Draw the 45° angle in right angle triangle, adjacent side of length 1.
- Let γ be the angle indicated on the plot.
- Angles in triangle sum to 180°:

$$\begin{aligned} 45^\circ + 90^\circ + \gamma &= 180^\circ \\ \gamma &= 180^\circ - 90^\circ - 45^\circ = 45^\circ. \end{aligned}$$

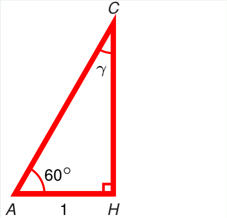
- Triangle has two equal angles $\Rightarrow$ is isosceles (has two equal sides).
- $\Rightarrow$ Opposite leg: length 1 $\Rightarrow$ length(hyp) $= \sqrt{1^2 + 1^2} = \sqrt{2}$.
- $\sin 45^\circ = \frac{\text{opp}}{\text{hyp}} = \frac{\sqrt{2}}{2} \qquad \cos 45^\circ = \frac{\text{adj}}{\text{hyp}} = \frac{\sqrt{2}}{2}$

  $\tan 45^\circ = \frac{\text{opp}}{\text{adj}} = \frac{1}{1} = 1.$

Example

Find the values of $\sin 60^\circ, \cos 60^\circ, \tan 60^\circ$, $\sin 30^\circ, \cos 30^\circ, \tan 30^\circ$.

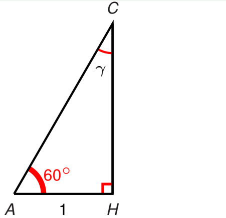
Example



Find the values of $\sin 60^\circ, \cos 60^\circ, \tan 60^\circ$, $\sin 30^\circ, \cos 30^\circ, \tan 30^\circ$.

Construct a right angled $\triangle AHC$ as indicated:

Example



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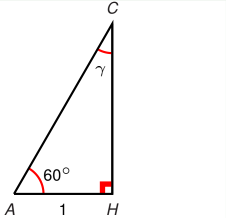

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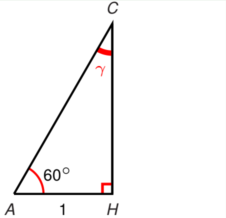

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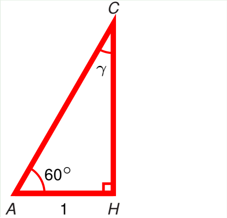

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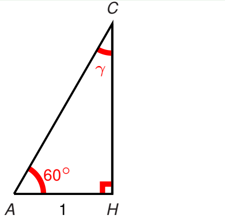

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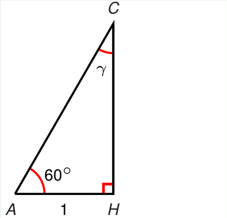

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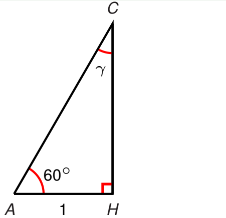

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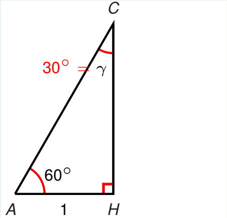

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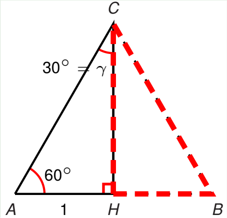

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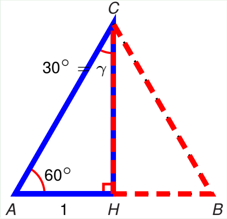

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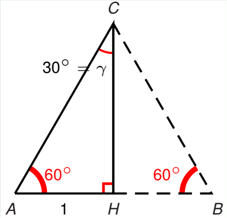

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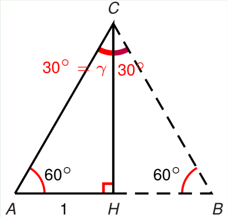

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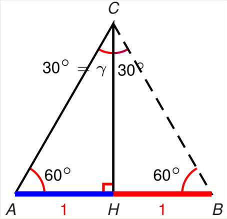

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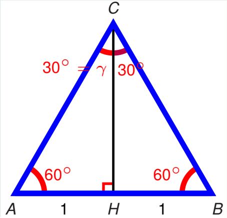

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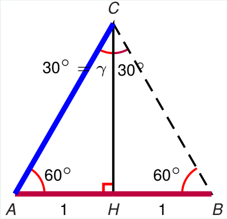
Construct $\triangle HBC$ as indicated so that $\triangle HBC \cong \triangle HAC$. $\triangle ABC$ has three equal angles ($= 60^\circ$)

Example



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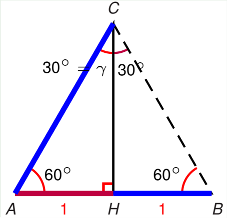
$$|AC| = |AB|$$

Example



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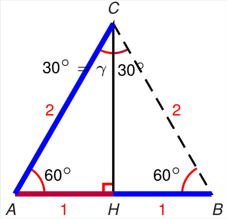
$$|AC| = |AB| = 1 + 1$$

Example



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Construct $\triangle HBC$ as indicated so that $\triangle HBC \cong \triangle HAC$. $\triangle ABC$ has three equal angles $(= 60^\circ) \Rightarrow$ its sides are of equal length. Therefore

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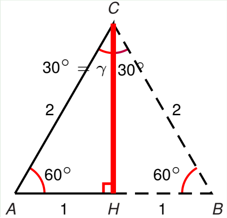
Example



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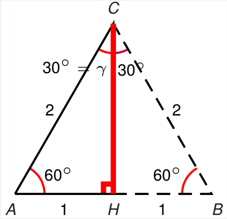

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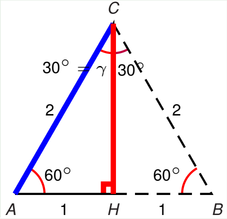

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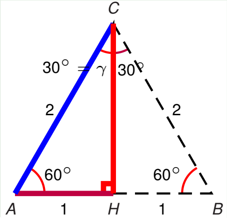

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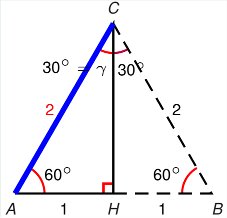

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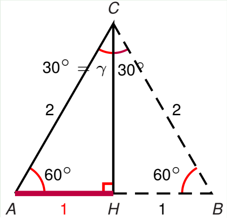

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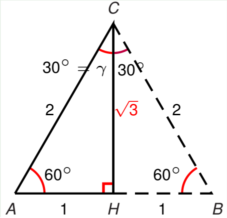

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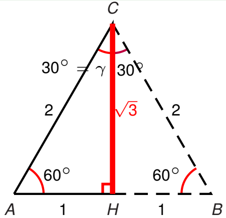

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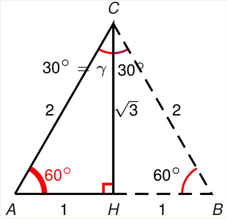

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$\sin 60^\circ = \textbf{?}$ $\quad \cos 60^\circ = \textbf{?}$ $\quad \tan 60^\circ = \textbf{?}$

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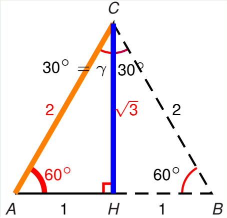

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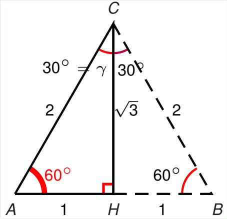

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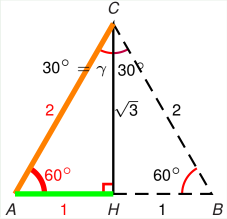

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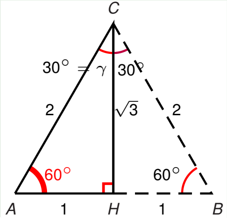

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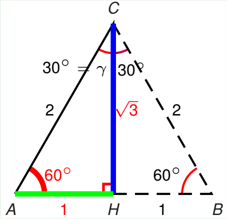

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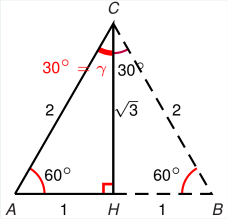

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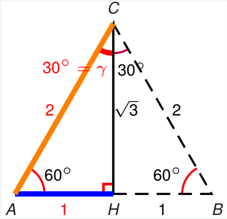

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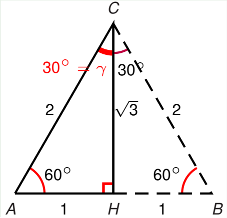

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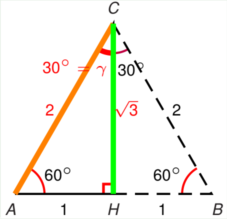

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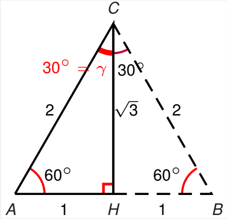

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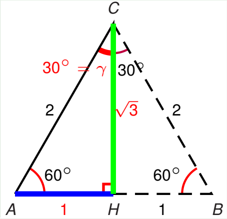

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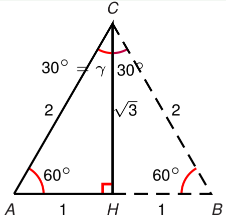

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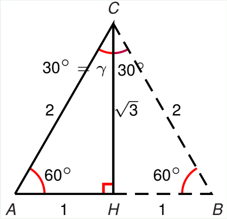

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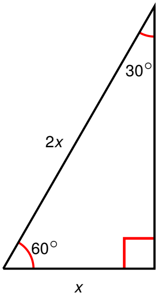
Observation

- *If the hypotenuse of a right angle triangle is twice larger than one of the sides, then the angle opposite to that side is* 30°*.*
- *Conversely, in a right angle triangle with angle* 30°*, the hypotenuse is twice longer than the shorter of the two legs.*



To compute trigonometric functions from obtuse ($> 90^\circ$) or negative angles, we can use the following visual aid.

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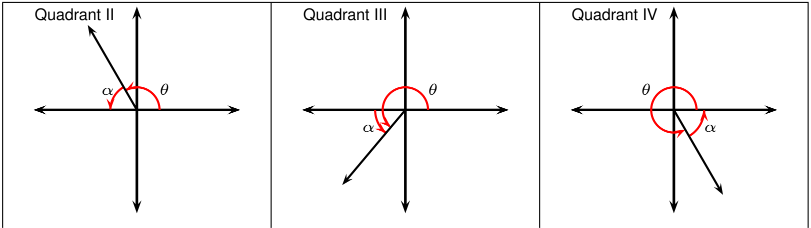
Let θ be an angle in standard position. Its reference angle is the acute positive angle formed by the terminal arm and the *x* axis.

The computation of the reference angle α depends on the quadrant.



Quadrant II	Quadrant III	Quadrant IV
α = **?**	$\alpha =$	$\alpha =$
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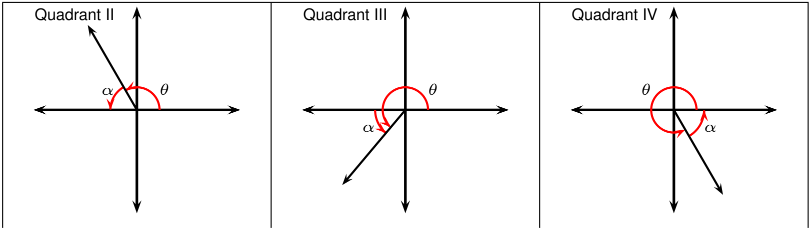

Quadrant II	Quadrant III	Quadrant IV
$\alpha = \pi - \theta$	$\alpha =$	$\alpha =$
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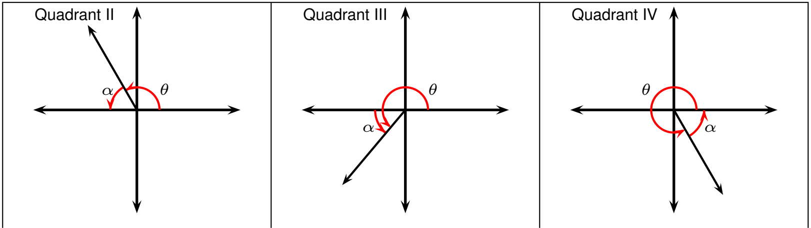

Quadrant II	Quadrant III	Quadrant IV
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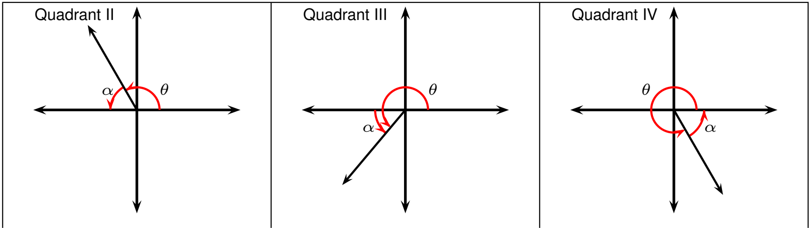

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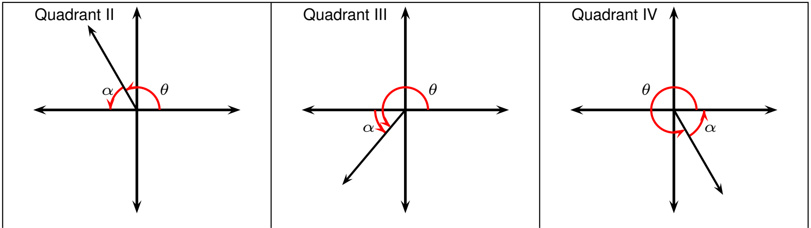

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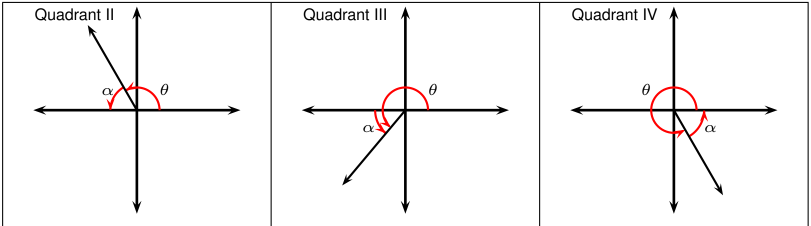

Quadrant II	Quadrant III	Quadrant IV
$\alpha = \pi - \theta$	$\alpha = \theta - \pi$	$\alpha = 2\pi - \theta$
$\alpha = 180^\circ - \theta$	$\alpha = \theta - 180^\circ$	$\alpha = 360^\circ - \theta$

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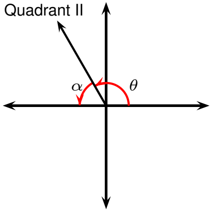

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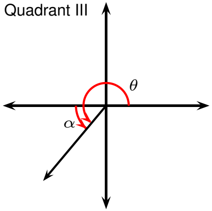
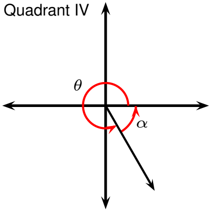


$$\alpha = \theta - \pi$$
$$\alpha = \theta - 180^\circ$$



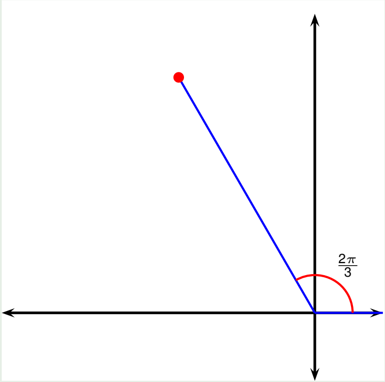
$$\alpha = 2\pi - \theta$$
$$\alpha = 360^\circ - \theta$$

Observation

One can find the value of a trigonometric function of θ as follows.

- *Find the reference angle α associated to θ.*
- *Find the trig function of α.*
- *Use the quadrant in which θ lies to affix an appropriate sign to the function value.*

Example



Find the exact values of the trigonometric functions of $\theta = \frac{2\pi}{3} = 120^\circ$.

$$\sin\left(\frac{2\pi}{3}\right) = \qquad \cos\left(\frac{2\pi}{3}\right) = \qquad \tan\left(\frac{2\pi}{3}\right) =$$

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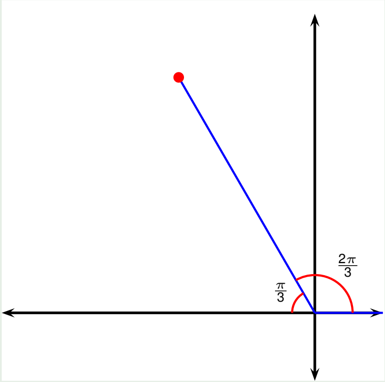

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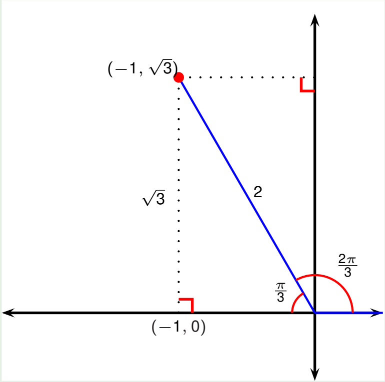
$$\csc\left(\frac{2\pi}{3}\right) = \qquad \sec\left(\frac{2\pi}{3}\right) = \qquad \cot\left(\frac{2\pi}{3}\right) =$$

Example

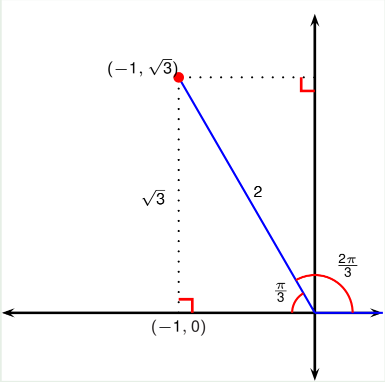


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120^\circ$.

$$\sin\left(\frac{2\pi}{3}\right) = \qquad \cos\left(\frac{2\pi}{3}\right) = \qquad \tan\left(\frac{2\pi}{3}\right) =$$

$$\csc\left(\frac{2\pi}{3}\right) = \qquad \sec\left(\frac{2\pi}{3}\right) = \qquad \cot\left(\frac{2\pi}{3}\right) =$$

Example

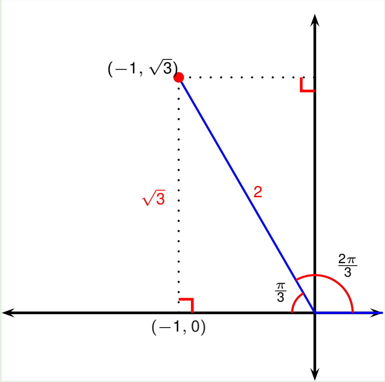


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120^\circ$.

$\sin\left(\dfrac{2\pi}{3}\right) = ?$ $\quad \cos\left(\dfrac{2\pi}{3}\right) =$ $\quad \tan\left(\dfrac{2\pi}{3}\right) =$

$\csc\left(\dfrac{2\pi}{3}\right) =$ $\quad \sec\left(\dfrac{2\pi}{3}\right) =$ $\quad \cot\left(\dfrac{2\pi}{3}\right) =$

Example

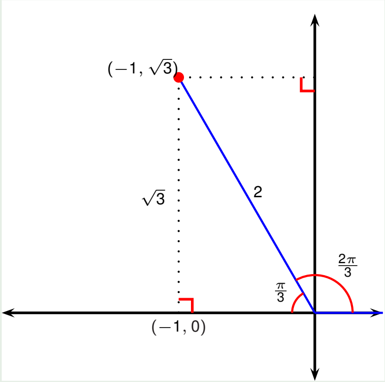


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120^\circ$.

$$\sin\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{2} \qquad \cos\left(\frac{2\pi}{3}\right) = \qquad \tan\left(\frac{2\pi}{3}\right) =$$

$$\csc\left(\frac{2\pi}{3}\right) = \qquad \sec\left(\frac{2\pi}{3}\right) = \qquad \cot\left(\frac{2\pi}{3}\right) =$$

Example

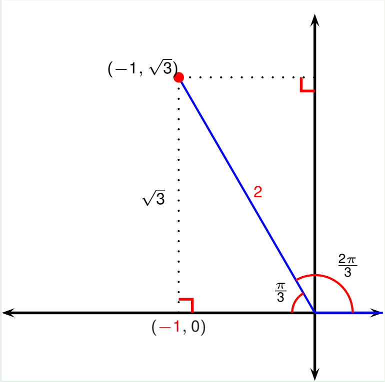


Find the exact values of the trigonometric functions of $\theta = \frac{2\pi}{3} = 120^\circ$.

$$\sin\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{2} \quad \cos\left(\frac{2\pi}{3}\right) = \mathbf{?} \quad \tan\left(\frac{2\pi}{3}\right) =$$

$$\csc\left(\frac{2\pi}{3}\right) = \quad \sec\left(\frac{2\pi}{3}\right) = \quad \cot\left(\frac{2\pi}{3}\right) =$$

Example

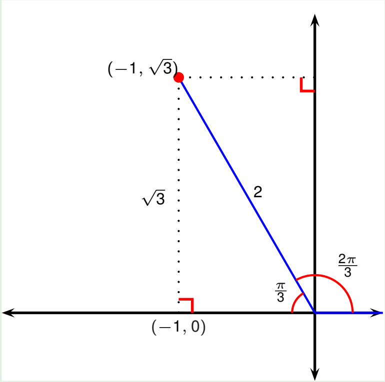


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120°$.

$\sin\left(\dfrac{2\pi}{3}\right) = \dfrac{\sqrt{3}}{2}$ $\quad\cos\left(\dfrac{2\pi}{3}\right) = -\dfrac{1}{2}$ $\quad\tan\left(\dfrac{2\pi}{3}\right) =$

$\csc\left(\dfrac{2\pi}{3}\right) =$ $\quad\sec\left(\dfrac{2\pi}{3}\right) =$ $\quad\cot\left(\dfrac{2\pi}{3}\right) =$

Example

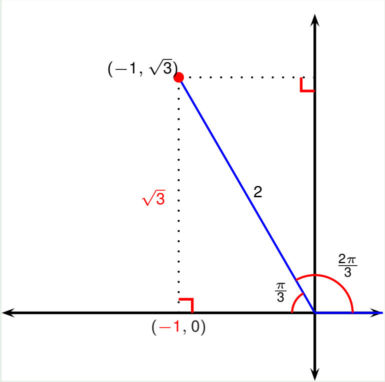


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120^\circ$.

$$\sin\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{2} \quad \cos\left(\frac{2\pi}{3}\right) = -\frac{1}{2} \quad \tan\left(\frac{2\pi}{3}\right) = \textbf{?}$$

$$\csc\left(\frac{2\pi}{3}\right) = \quad \sec\left(\frac{2\pi}{3}\right) = \quad \cot\left(\frac{2\pi}{3}\right) =$$

Example

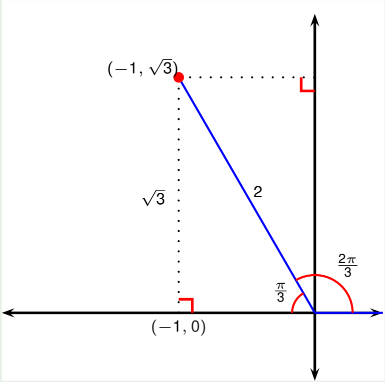


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120^\circ$.

$$\sin\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{2} \qquad \cos\left(\frac{2\pi}{3}\right) = -\frac{1}{2} \qquad \tan\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{-1} = -\sqrt{3}$$

$$\csc\left(\frac{2\pi}{3}\right) = \qquad \sec\left(\frac{2\pi}{3}\right) = \qquad \cot\left(\frac{2\pi}{3}\right) =$$

Example

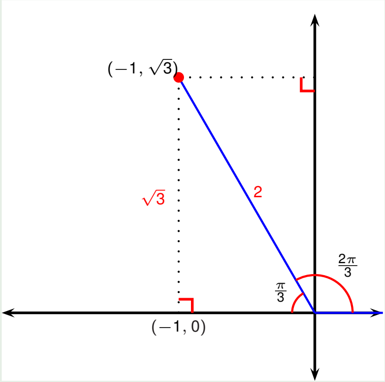


Find the exact values of the trigonometric functions of $\theta = \frac{2\pi}{3} = 120^\circ$.

$$\sin\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{2} \quad \cos\left(\frac{2\pi}{3}\right) = -\frac{1}{2} \quad \tan\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{-1} = -\sqrt{3}$$

$$\csc\left(\frac{2\pi}{3}\right) = \mathbf{?} \quad \sec\left(\frac{2\pi}{3}\right) = \quad \cot\left(\frac{2\pi}{3}\right) =$$

Example

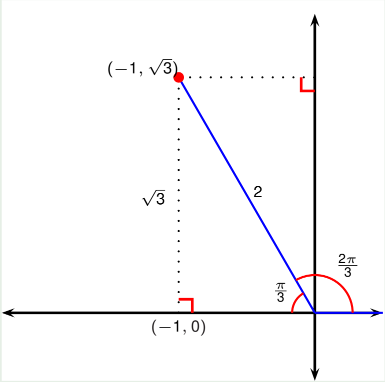


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120^\circ$.

$$\sin\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{2} \quad \cos\left(\frac{2\pi}{3}\right) = -\frac{1}{2} \quad \tan\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{-1} = -\sqrt{3}$$

$$\csc\left(\frac{2\pi}{3}\right) = \frac{2}{\sqrt{3}} \quad \sec\left(\frac{2\pi}{3}\right) = \quad \cot\left(\frac{2\pi}{3}\right) =$$

Example

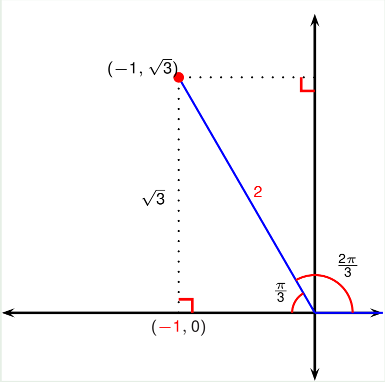


Find the exact values of the trigonometric functions of $\theta = \frac{2\pi}{3} = 120^\circ$.

$$\sin\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{2} \quad \cos\left(\frac{2\pi}{3}\right) = -\frac{1}{2} \quad \tan\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{-1} = -\sqrt{3}$$

$$\csc\left(\frac{2\pi}{3}\right) = \frac{2}{\sqrt{3}} \quad \sec\left(\frac{2\pi}{3}\right) = ? \quad \cot\left(\frac{2\pi}{3}\right) =$$

Example

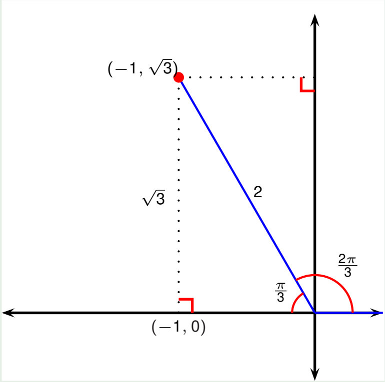


Find the exact values of the trigonometric functions of $\theta = \frac{2\pi}{3} = 120^\circ$.

$$\sin\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{2} \quad \cos\left(\frac{2\pi}{3}\right) = -\frac{1}{2} \quad \tan\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{-1} = -\sqrt{3}$$

$$\csc\left(\frac{2\pi}{3}\right) = \frac{2}{\sqrt{3}} \quad \sec\left(\frac{2\pi}{3}\right) = -\frac{2}{1} = -2 \quad \cot\left(\frac{2\pi}{3}\right) =$$

Example

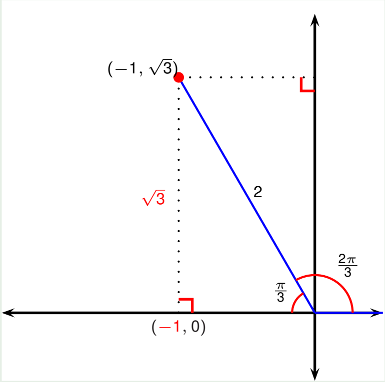


Find the exact values of the trigonometric functions of $\theta = \frac{2\pi}{3} = 120^\circ$.

$$\sin\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{2} \quad \cos\left(\frac{2\pi}{3}\right) = -\frac{1}{2} \quad \tan\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{-1} = -\sqrt{3}$$

$$\csc\left(\frac{2\pi}{3}\right) = \frac{2}{\sqrt{3}} \quad \sec\left(\frac{2\pi}{3}\right) = -\frac{2}{1} = -2 \quad \cot\left(\frac{2\pi}{3}\right) = \mathbf{?}$$

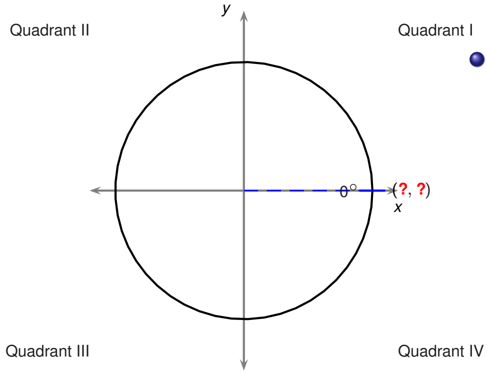
Example



Find the exact values of the trigonometric functions of $\theta = \frac{2\pi}{3} = 120^\circ$.

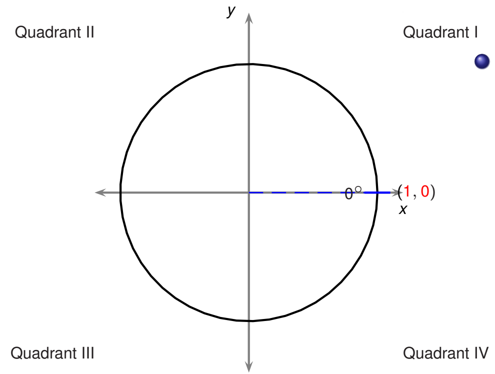
$$\sin\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{2} \quad \cos\left(\frac{2\pi}{3}\right) = -\frac{1}{2} \quad \tan\left(\frac{2\pi}{3}\right) = \frac{\sqrt{3}}{-1} = -\sqrt{3}$$

$$\csc\left(\frac{2\pi}{3}\right) = \frac{2}{\sqrt{3}} \quad \sec\left(\frac{2\pi}{3}\right) = -\frac{2}{1} = -2 \quad \cot\left(\frac{2\pi}{3}\right) = -\frac{1}{\sqrt{3}}$$



- One only needs to memorize sines and cosines in Quadrant I and on the axes.

Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	?										
cos	?										



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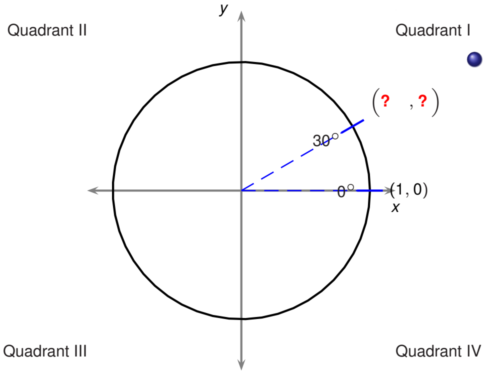
Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0										
cos	1										



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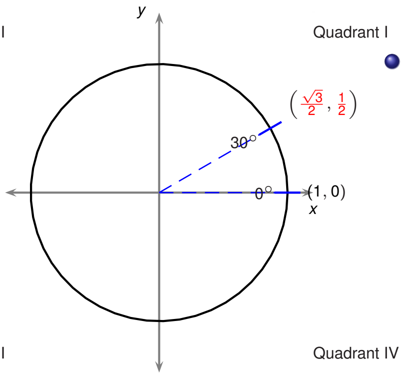
Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	?									
cos	1	?									



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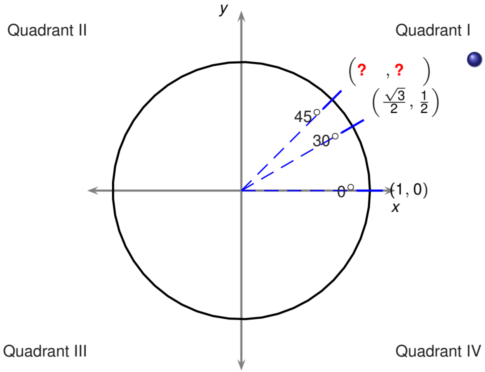
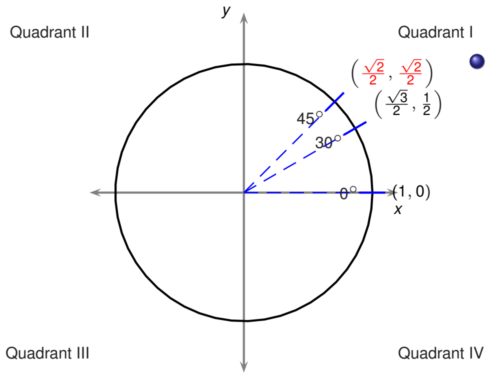
Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$									
cos	1	$\frac{\sqrt{3}}{2}$									



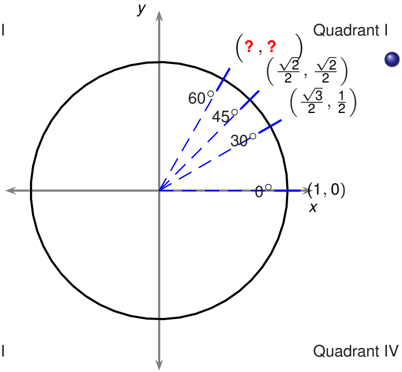
- One only needs to memorize sines and cosines in Quadrant I and on the axes.

Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	?								
cos	1	$\frac{\sqrt{3}}{2}$	?								



- One only needs to memorize sines and cosines in Quadrant I and on the axes.

Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$								
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$								



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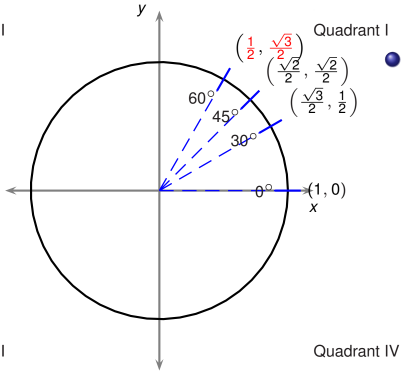
Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	?							
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	?							



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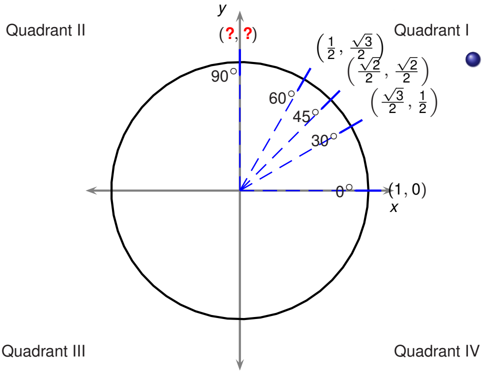
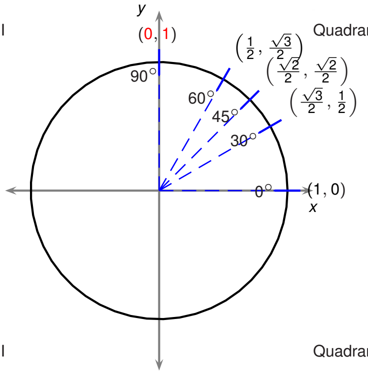
Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$							
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$							



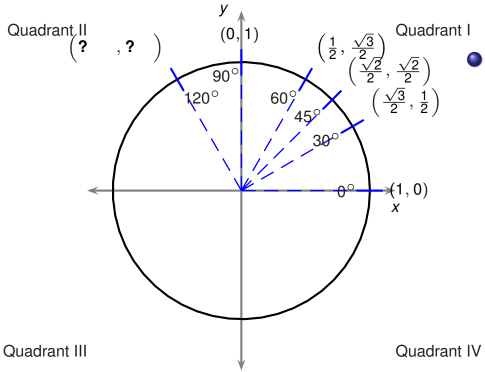
- One only needs to memorize sines and cosines in Quadrant I and on the axes.

Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	?						
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	?						



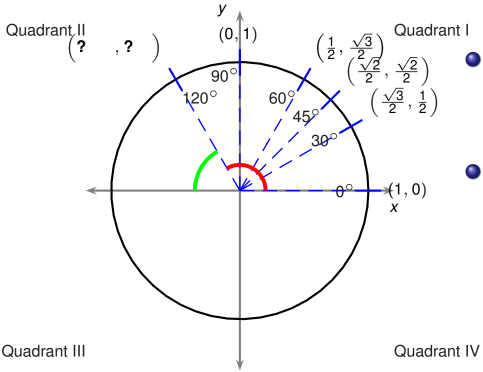
- One only needs to memorize sines and cosines in Quadrant I and on the axes.

Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1						
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0						



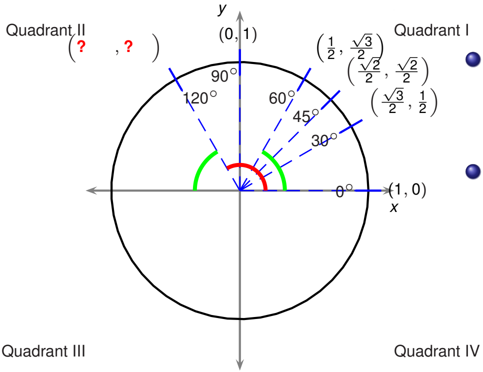
- One only needs to memorize sines and cosines in Quadrant I and on the axes.

Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	**?**					
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	**?**					



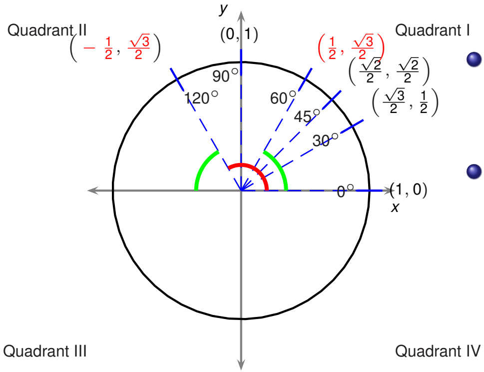
- One only needs to memorize sines and cosines in Quadrant I and on the axes.
- The remaining sines and cosines are extracted by
  - taking the sine/cosine of the reference angle

Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	**?**					
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	**?**					



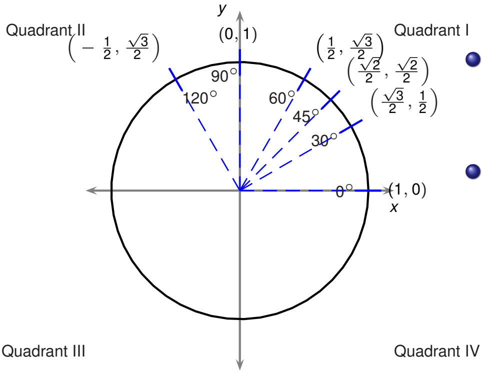
- One only needs to memorize sines and cosines in Quadrant I and on the axes.
- The remaining sines and cosines are extracted by
  - taking the sine/cosine of the reference angle

Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	?					
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	?					



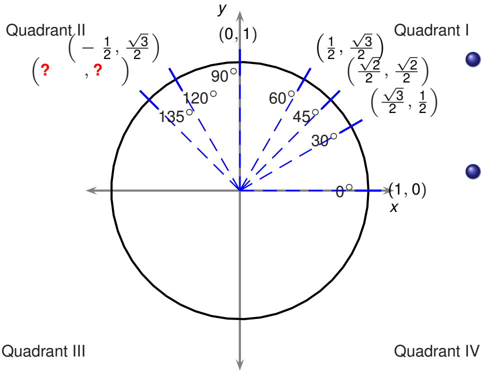
- One only needs to memorize sines and cosines in Quadrant I and on the axes.
- The remaining sines and cosines are extracted by
  - taking the sine/cosine of the reference angle

Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$					
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$					



- One only needs to memorize sines and cosines in Quadrant I and on the axes.
- The remaining sines and cosines are extracted by
  - taking the sine/cosine of the reference angle
  - and adjusting the sign according to the quadrant.

Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$					
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$					



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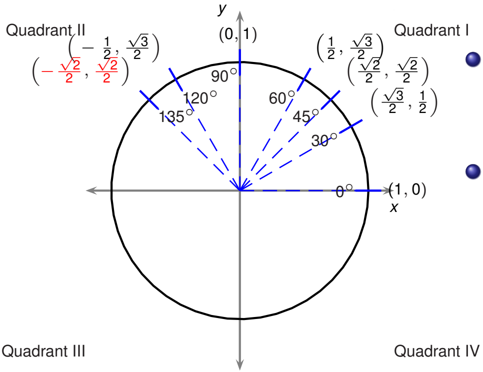
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	?				
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	?				



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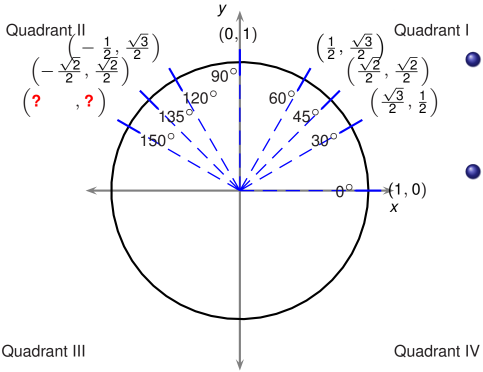
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$				
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$				



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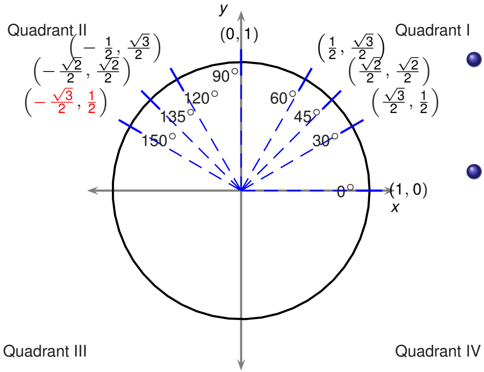
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	?			
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	?			



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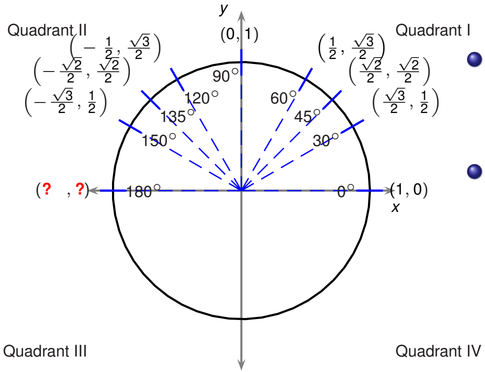
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$			
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$			



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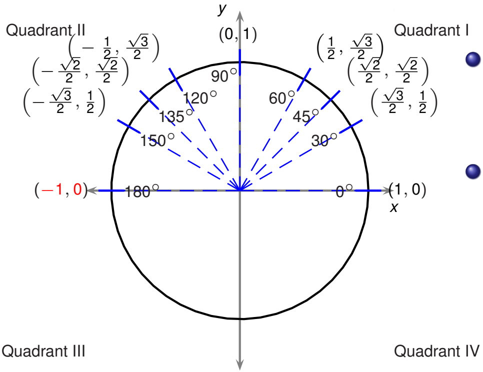
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	?		
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	?		



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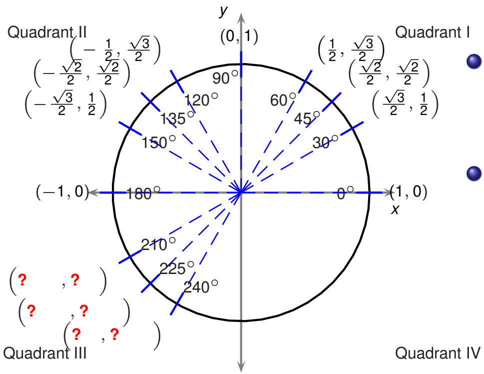
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0		
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1		



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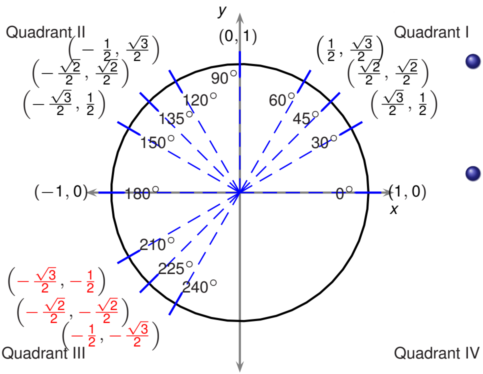
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0		
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1		



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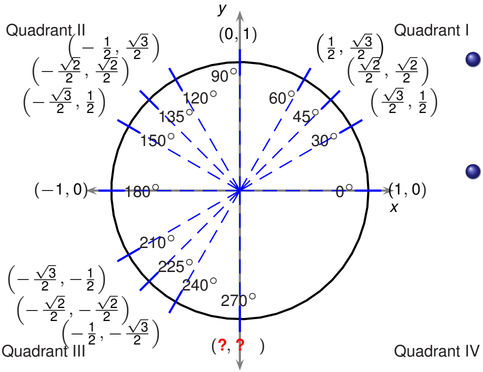
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0		
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1		



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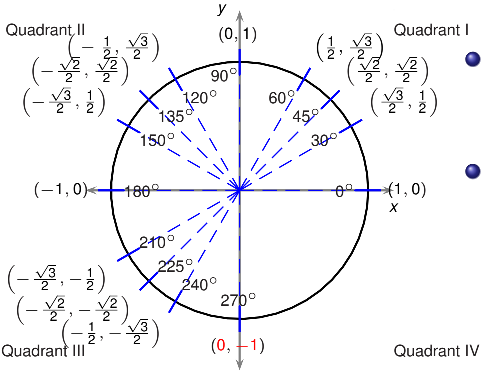
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	?	
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	?	



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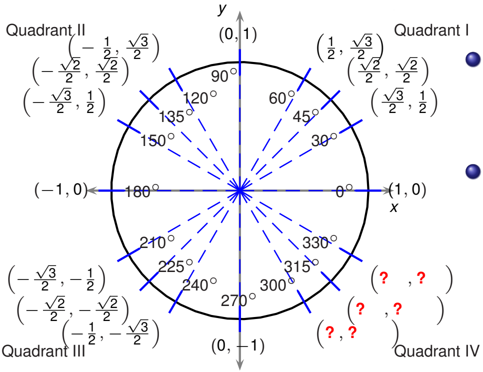
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	0	



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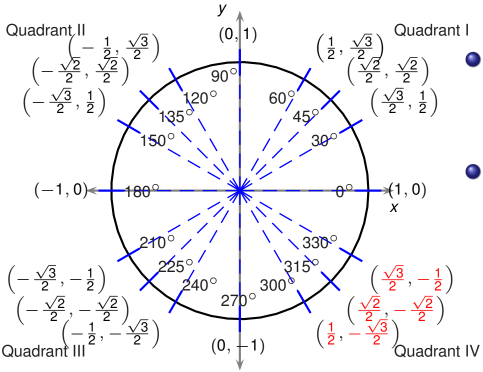
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	0	



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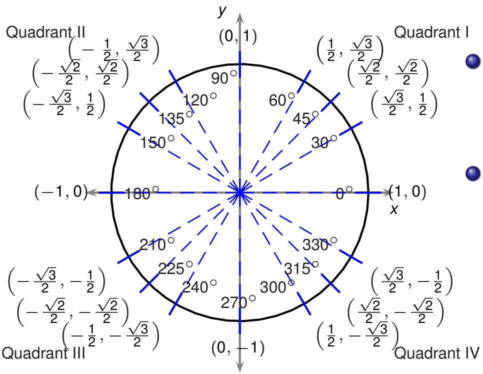
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	0	



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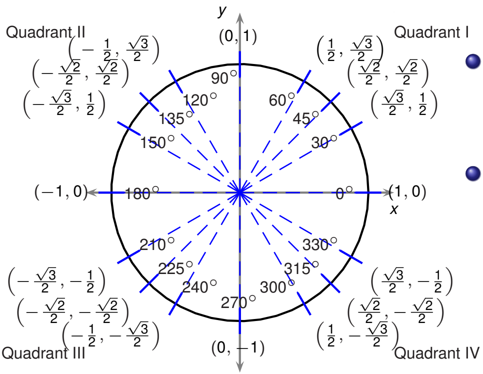
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	**?**
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	0	**?**



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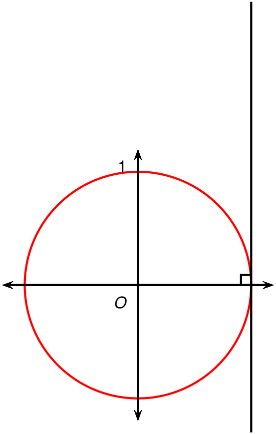
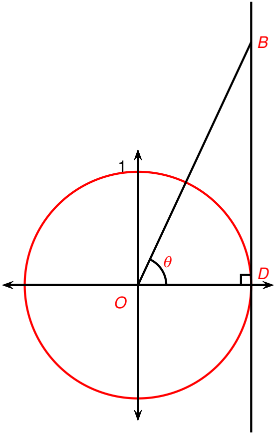
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	0
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	0	1

Geometric interpretation of all trigonometric functions



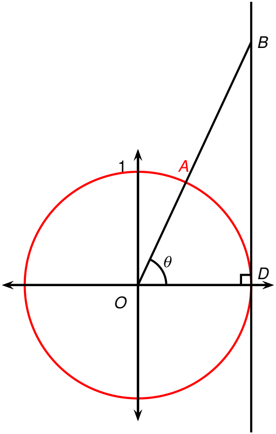
Fix unit circle, center O, coordinates $(0, 0)$.

Geometric interpretation of all trigonometric functions



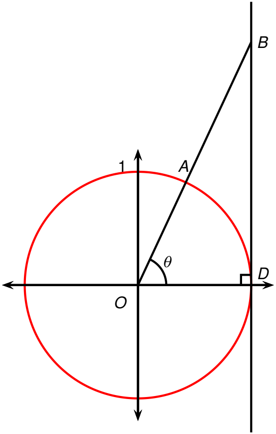
Fix unit circle, center O, coordinates $(0,0)$.
Let $\angle DOB = \theta$.

Geometric interpretation of all trigonometric functions



Fix unit circle, center O, coordinates $(0, 0)$. Let $\angle DOB = \theta$. Let OB intersect the circle at point A.

Geometric interpretation of all trigonometric functions



Fix unit circle, center O, coordinates $(0, 0)$. Let $\angle DOB = \theta$. Let OB intersect the circle at point A. Coordinates of A are $(\cos\theta, \sin\theta)$.

$\sin\theta$

$\cos\theta$

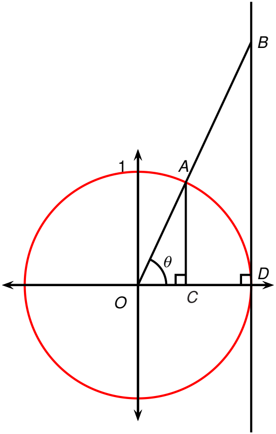
$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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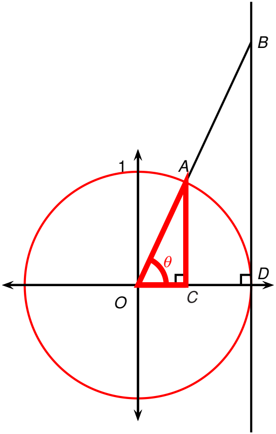

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$$\sin\theta = \frac{\text{opp}}{\text{hyp}}$$

$\cos\theta$

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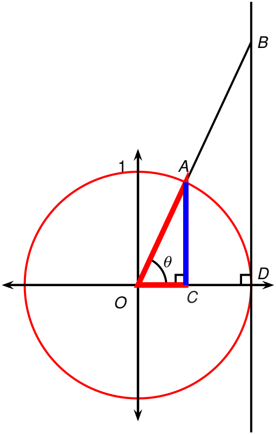
Geometric interpretation of all trigonometric functions



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$$\sin\theta = \frac{\text{opp}}{\text{hyp}} = \frac{|AC|}{|OA|}$$

$\cos\theta$

$\tan\theta$

$\cot\theta$

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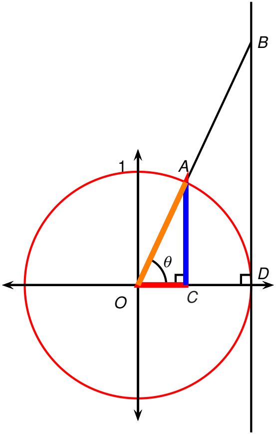
Geometric interpretation of all trigonometric functions



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$\tan\theta$

$\cot\theta$

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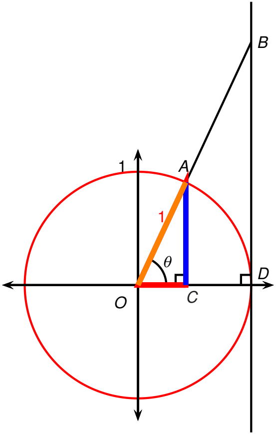
$\csc\theta$

Geometric interpretation of all trigonometric functions



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$$\sin\theta = \frac{\text{opp}}{\text{hyp}} = \frac{|AC|}{|OA|} = \frac{|AC|}{1}$$

$\cos\theta$

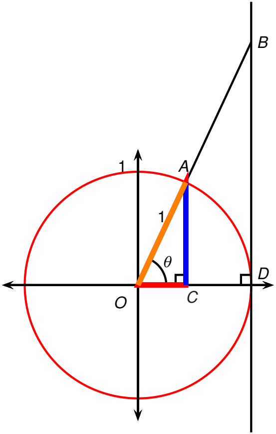
$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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$$\sin\theta = \frac{\text{opp}}{\text{hyp}} = \frac{|AC|}{|OA|} = \frac{|AC|}{1} = |AC|$$

$\cos\theta$

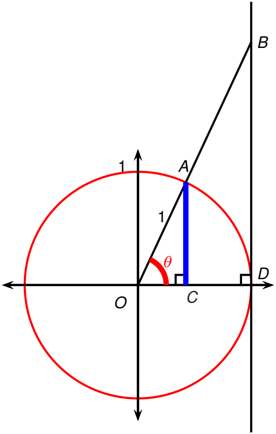
$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



Fix unit circle, center O, coordinates $(0,0)$. Let $\angle DOB = \theta$. Let OB intersect the circle at point A. Coordinates of A are $(\cos\theta, \sin\theta)$.

$$\sin\theta = \frac{\text{opp}}{\text{hyp}} = \frac{|AC|}{|OA|} = \frac{|AC|}{1} = |AC|$$

$\cos\theta$

$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

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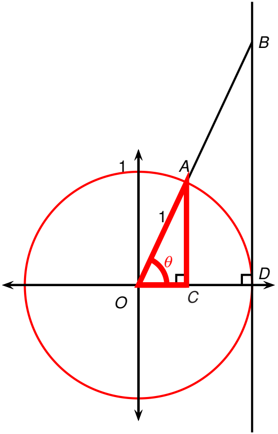

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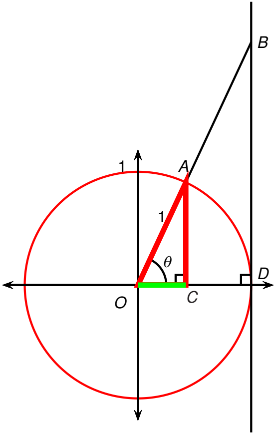

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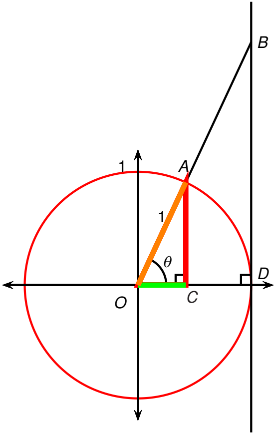

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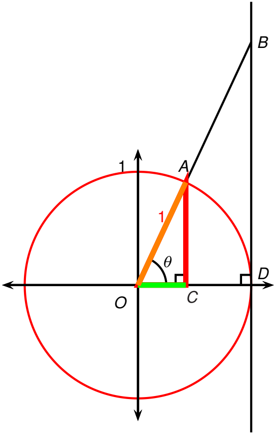

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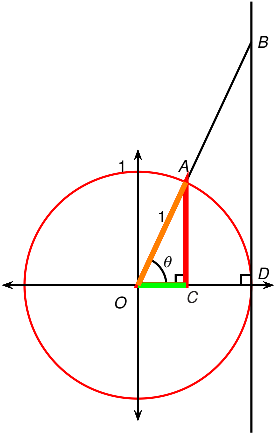

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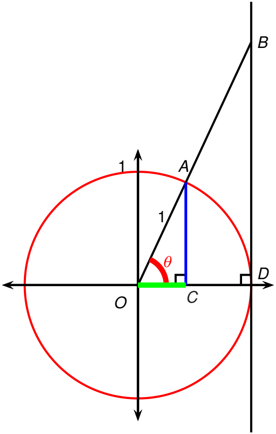

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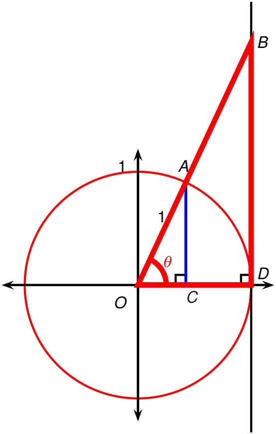

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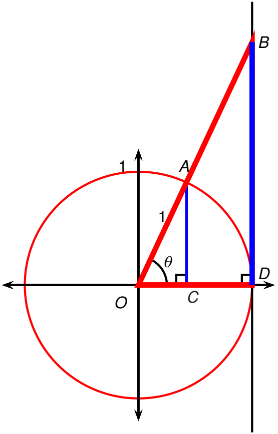

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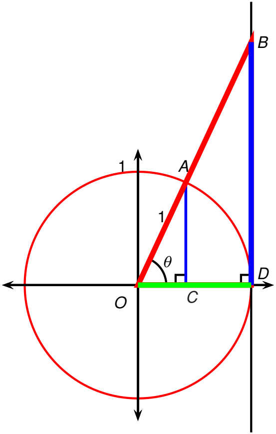

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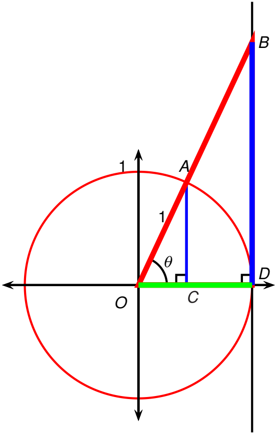

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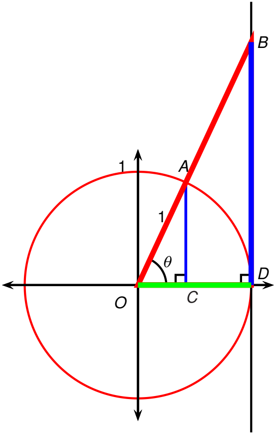

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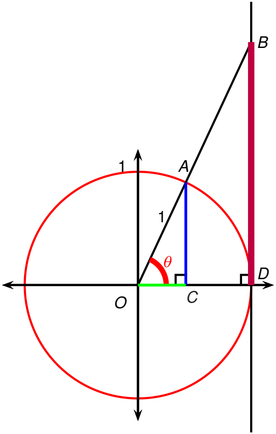

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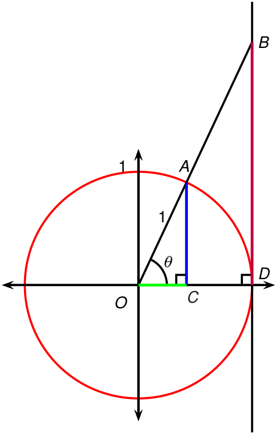

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\sec\theta & \\
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\end{aligned}
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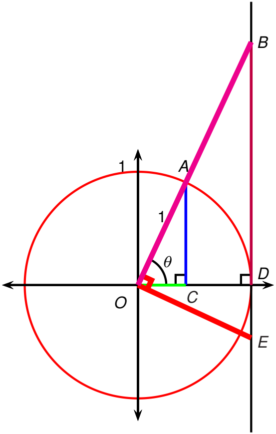

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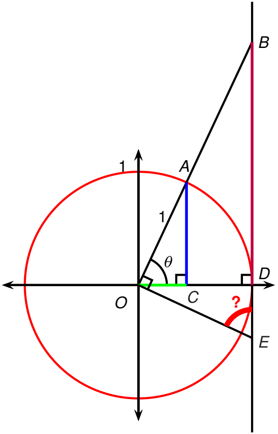

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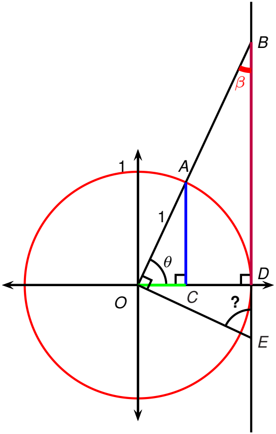
\cot\theta &= \frac{\text{adj}}{\text{opp}} \\
\sec\theta & \\
\csc\theta &
\end{aligned}
$$

$\angle OED = \textbf{?}$

Geometric interpretation of all trigonometric functions



$\beta = \mathbf{?}$

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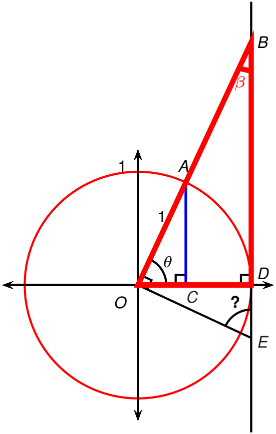

$\beta = 180° - 90° - \theta$

$\angle OED =$ **?**

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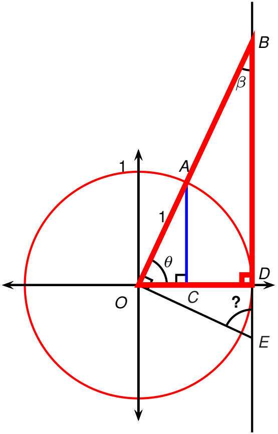

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\sec\theta & \\
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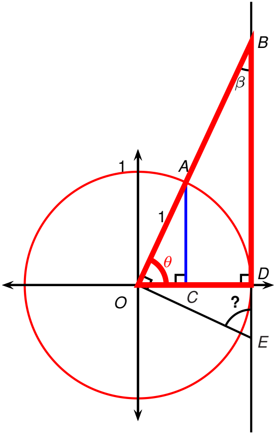

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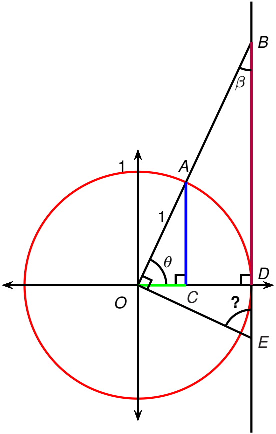

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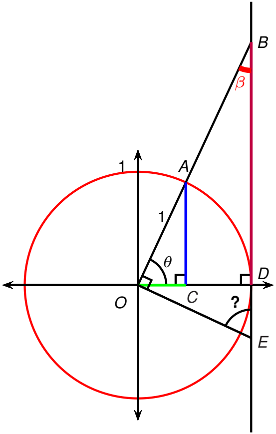

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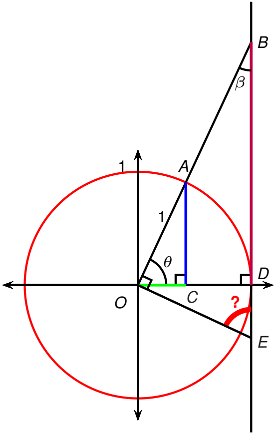

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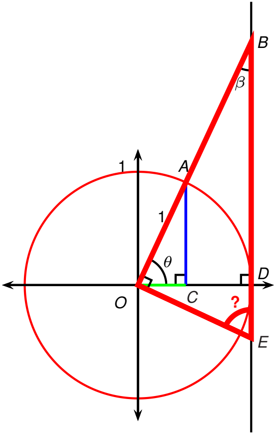

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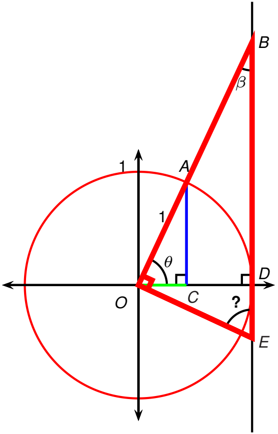

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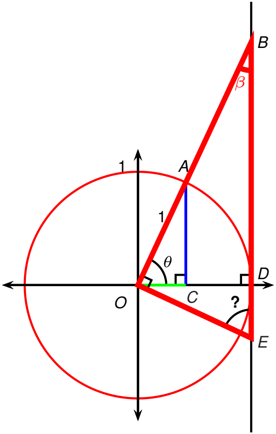

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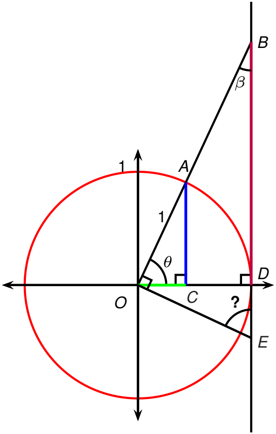
Geometric interpretation of all trigonometric functions



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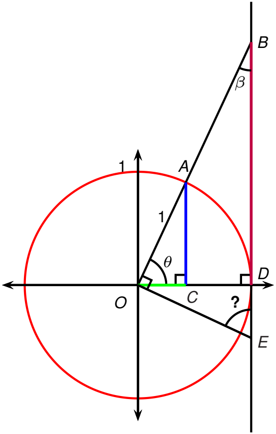

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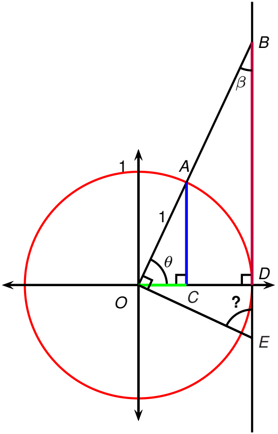

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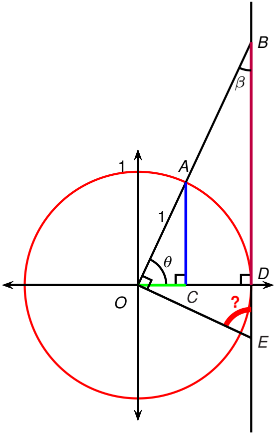
Geometric interpretation of all trigonometric functions



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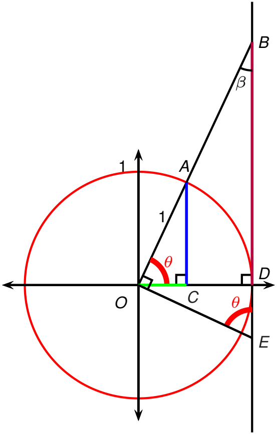
Geometric interpretation of all trigonometric functions



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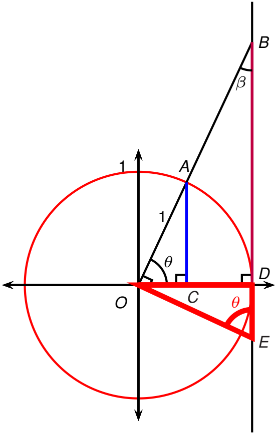
Geometric interpretation of all trigonometric functions



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$\sec\theta$

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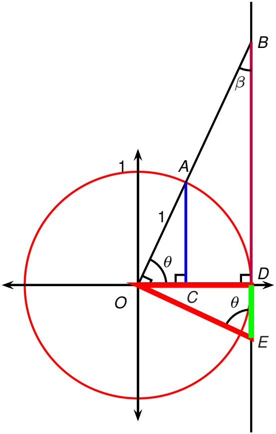
Geometric interpretation of all trigonometric functions



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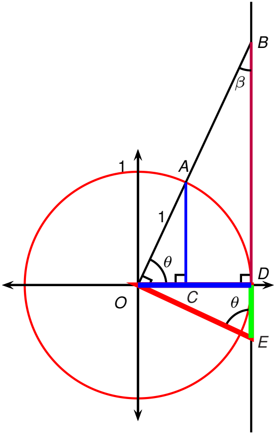
Geometric interpretation of all trigonometric functions



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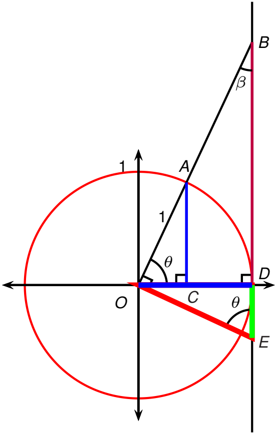
Geometric interpretation of all trigonometric functions



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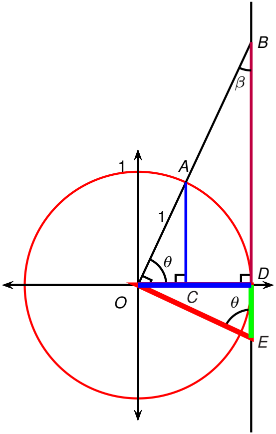
Geometric interpretation of all trigonometric functions



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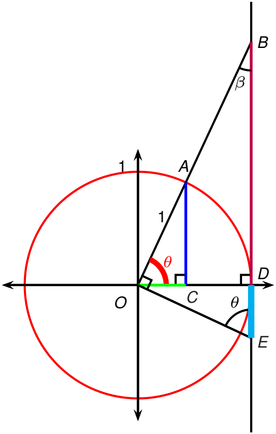
Geometric interpretation of all trigonometric functions



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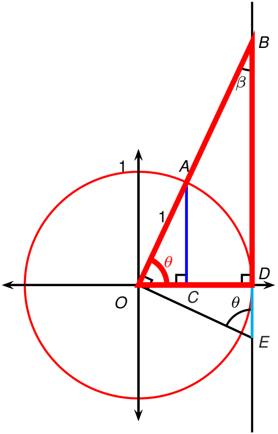
Geometric interpretation of all trigonometric functions



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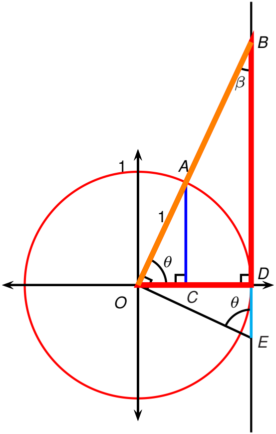
Geometric interpretation of all trigonometric functions



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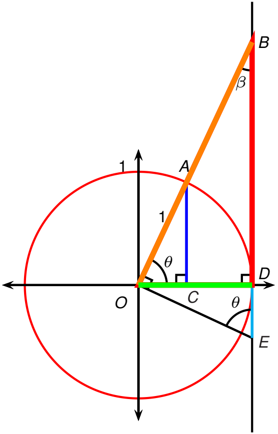
Geometric interpretation of all trigonometric functions



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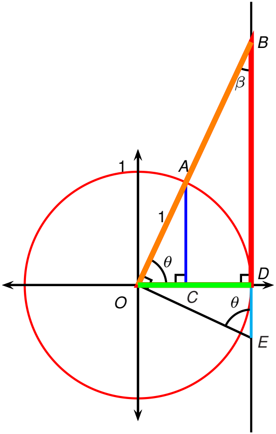
Geometric interpretation of all trigonometric functions



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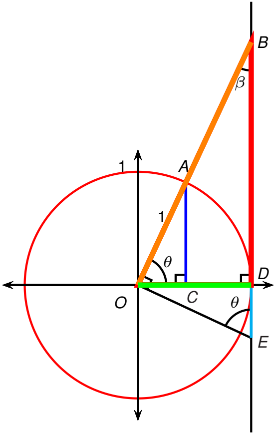
Geometric interpretation of all trigonometric functions



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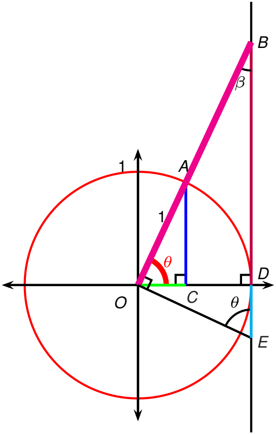
Geometric interpretation of all trigonometric functions



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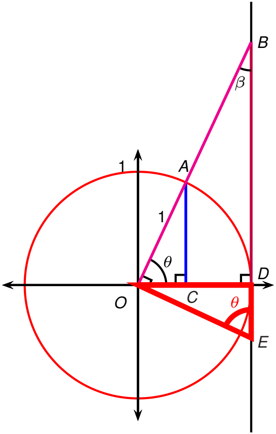
Geometric interpretation of all trigonometric functions



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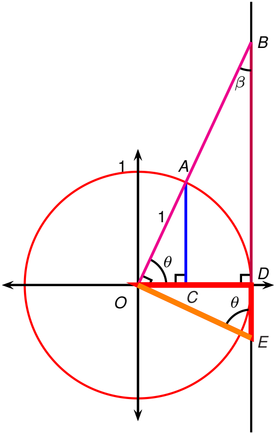
Geometric interpretation of all trigonometric functions



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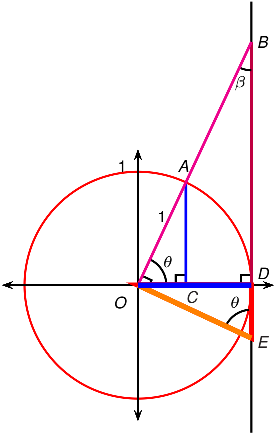
$$

Geometric interpretation of all trigonometric functions



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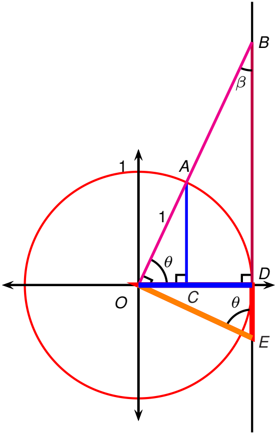

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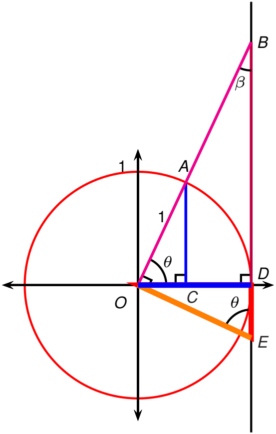

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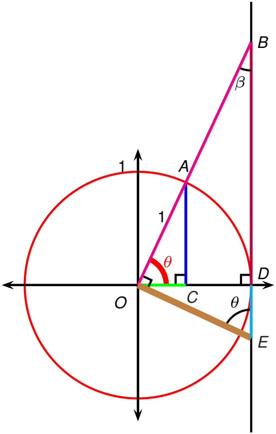

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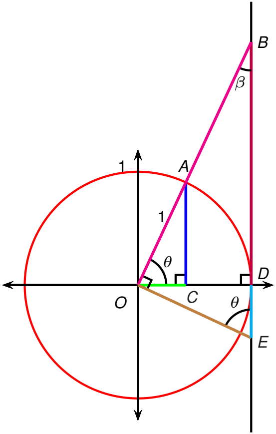

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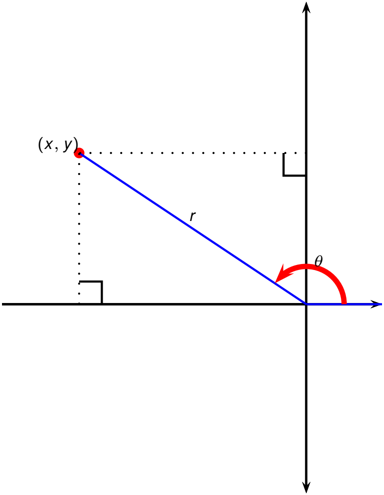

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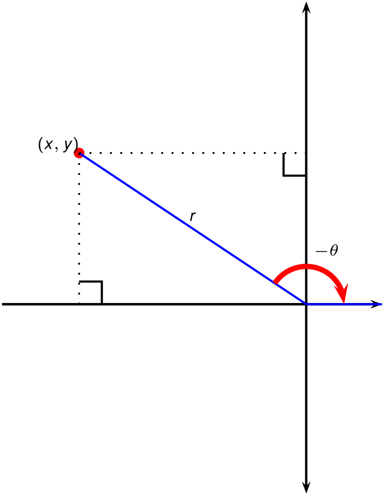

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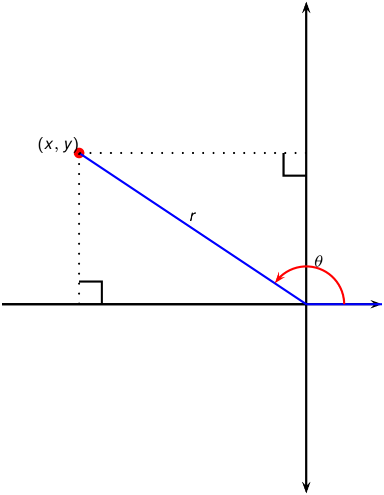

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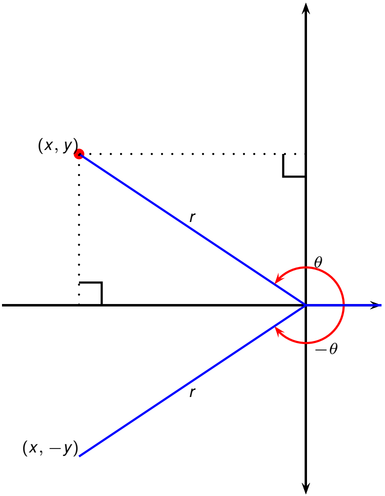

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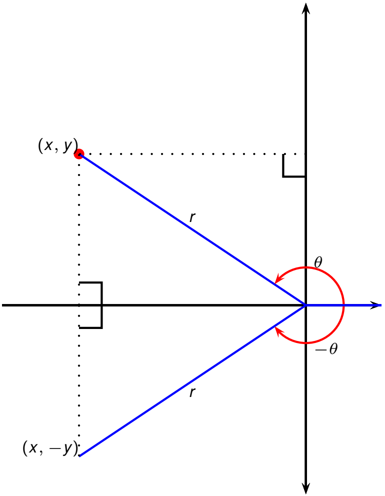

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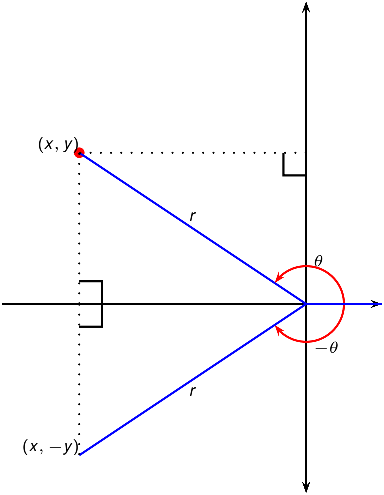

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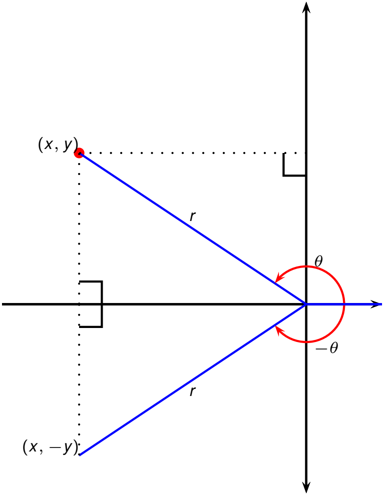

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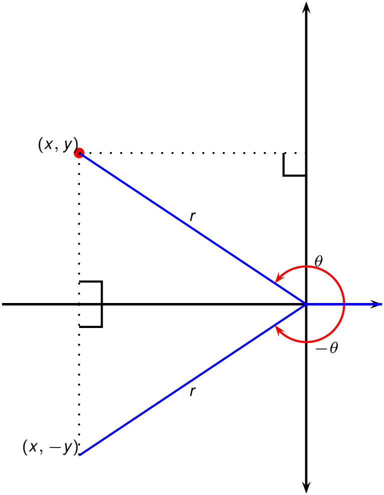

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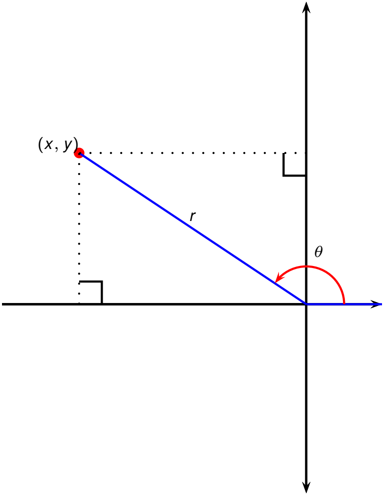

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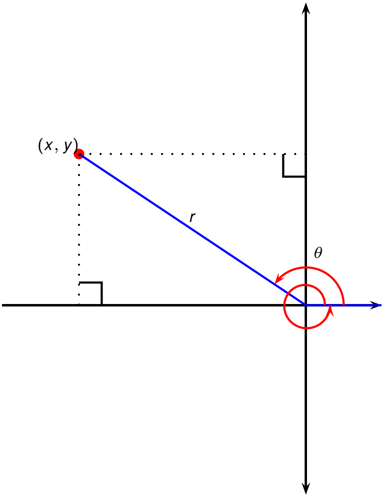

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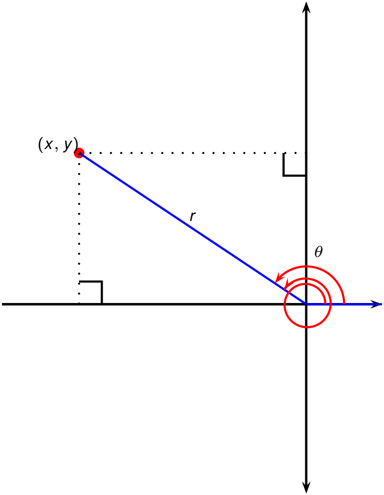

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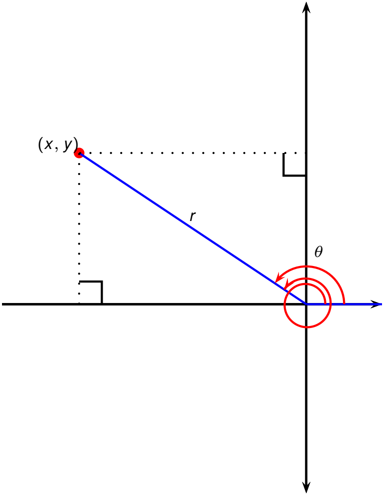

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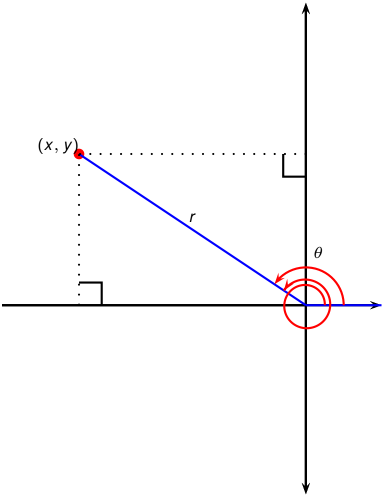

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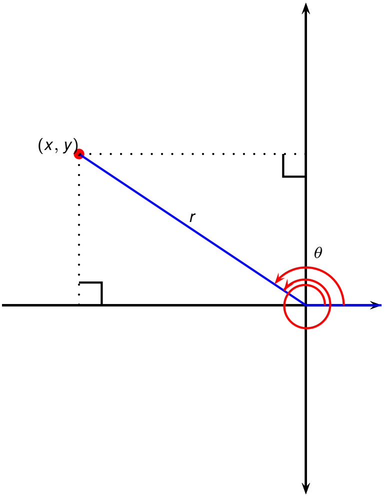

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- We say $\sin$ and $\cos$ are 2π-periodic.

Trigonometric Identities

Definition (Trigonometric Identity)

A trigonometric identity is an equality between the trigonometric functions in one or more variables that holds for all values of the involved variables in the domains of all of the expressions.

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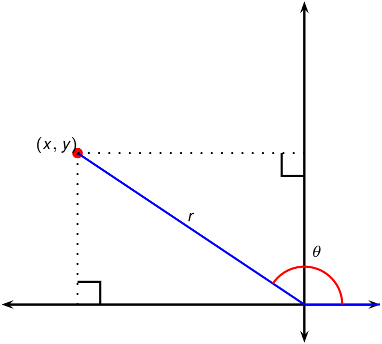
- By convention, when dealing with trigonometric identities we do not account for the domains of the involved expressions.
- For example, $\frac{\sin\theta}{\sin\theta} = 1$ is considered a valid trigonometric identity, although, when considered as a function, the left hand side is not defined for $\theta \neq 0$.



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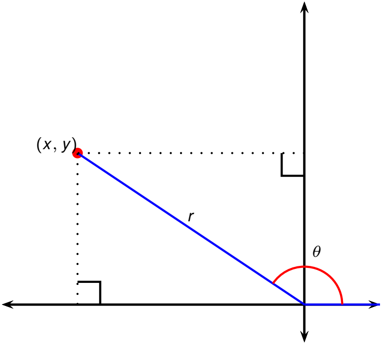

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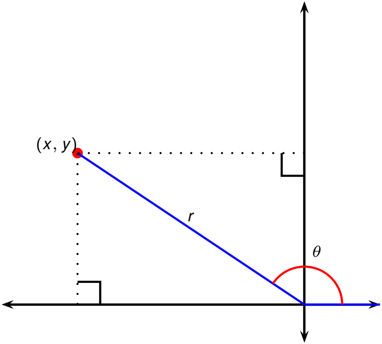

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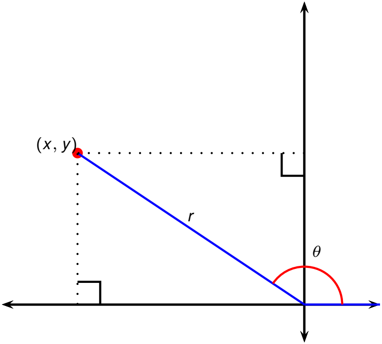
$$\sin^2\theta + \cos^2\theta$$



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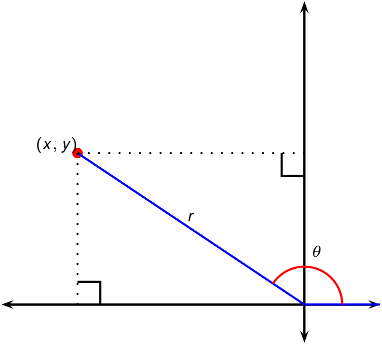

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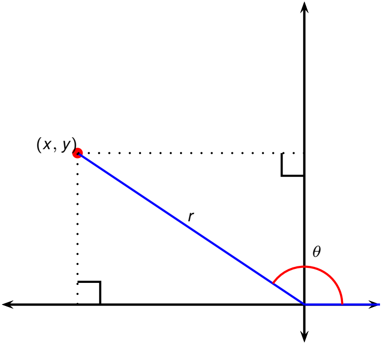

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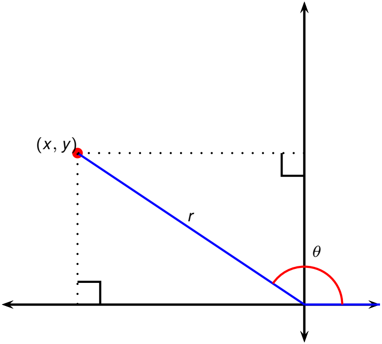

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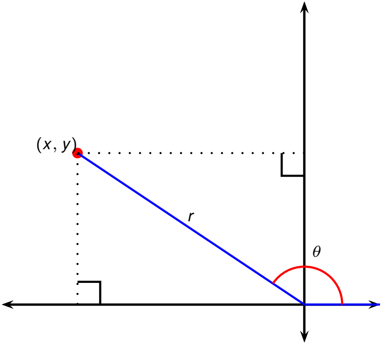
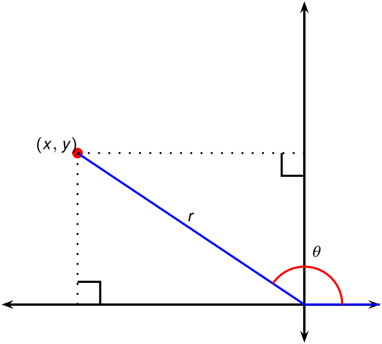
$$\begin{aligned} & \sin^2\theta + \cos^2\theta \\ = \quad & \frac{y^2}{r^2} + \frac{x^2}{r^2} \\ = \quad & \frac{y^2 + x^2}{r^2} \\ = \quad & \frac{r^2}{r^2} \\ = \quad & 1 \end{aligned}$$



$$\begin{aligned} \sin\theta &= \frac{y}{r} & \csc\theta &= \frac{r}{y} \\ \cos\theta &= \frac{x}{r} & \sec\theta &= \frac{r}{x} \\ \tan\theta &= \frac{y}{x} & \cot\theta &= \frac{x}{y} \end{aligned}$$

$$\begin{aligned} & \sin^2\theta + \cos^2\theta \\ = \quad & \frac{y^2}{r^2} + \frac{x^2}{r^2} \\ = \quad & \frac{y^2 + x^2}{r^2} \\ = \quad & \frac{r^2}{r^2} \\ = \quad & 1 \end{aligned}$$

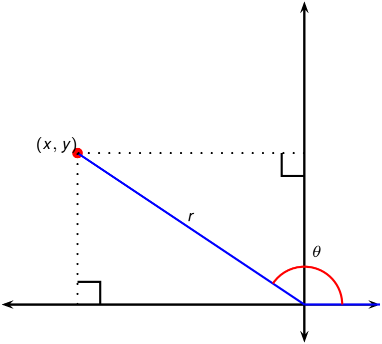
Therefore $\sin^2\theta + \cos^2\theta = 1$.



$$\sin\theta = \frac{y}{r} \quad \csc\theta = \frac{r}{y}$$
$$\cos\theta = \frac{x}{r} \quad \sec\theta = \frac{r}{x}$$
$$\tan\theta = \frac{y}{x} \quad \cot\theta = \frac{x}{y}$$

Example ($\tan^2\theta + 1 = \sec^2\theta$)

Prove the identity
$\tan^2\theta + 1 = \sec^2\theta$.



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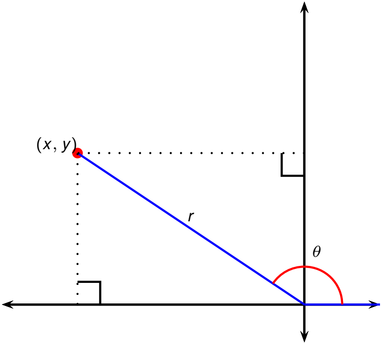
Example ($\tan^2\theta + 1 = \sec^2\theta$)

Prove the identity
$\tan^2\theta + 1 = \sec^2\theta$.

$$\sin^2\theta + \cos^2\theta = 1$$



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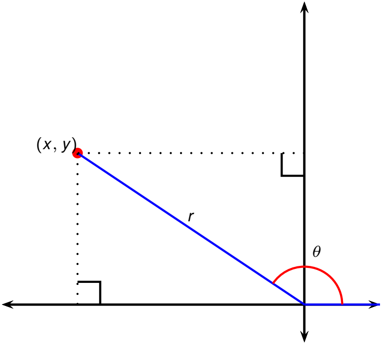
Example ($\tan^2\theta + 1 = \sec^2\theta$)

Prove the identity
$\tan^2\theta + 1 = \sec^2\theta$.

$$\begin{aligned} \sin^2\theta + \cos^2\theta &= 1 \\ \frac{\sin^2\theta}{\cos^2\theta} + \frac{\cos^2\theta}{\cos^2\theta} &= \frac{1}{\cos^2\theta} \end{aligned}$$



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$$\tan\theta = \frac{y}{x} \quad \cot\theta = \frac{x}{y}$$

Example ($\tan^2\theta + 1 = \sec^2\theta$)

Prove the identity
$\tan^2\theta + 1 = \sec^2\theta$.

$$\begin{aligned} \sin^2\theta + \cos^2\theta &= 1 \\ \frac{\sin^2\theta}{\cos^2\theta} + \frac{\cos^2\theta}{\cos^2\theta} &= \frac{1}{\cos^2\theta} \\ \tan^2\theta + 1 &= \sec^2\theta \end{aligned}$$