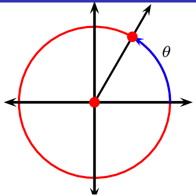
Precalculus
Definition of the trigonometric functions and basic computations

Todor Milev

2019

Outline

Definition of the trigonometric functions



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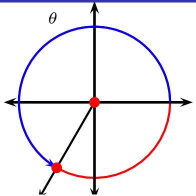

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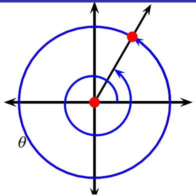

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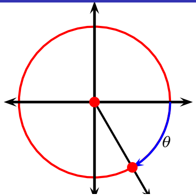

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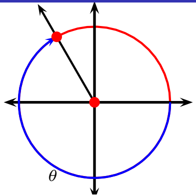

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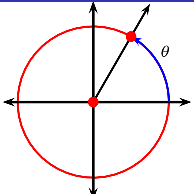

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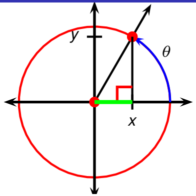

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Definition (sin and cos)

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

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

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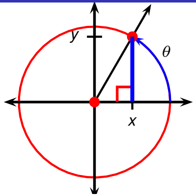

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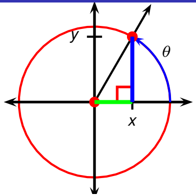

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The functions tangent, cotangent, secant and cosecant of the angle θ, denoted by $\tan\theta$, $\cot\theta$, $\sec\theta$, $\csc\theta$, are defined by

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

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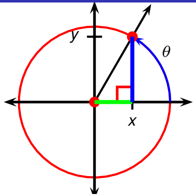

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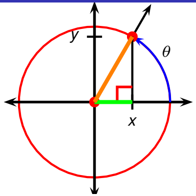

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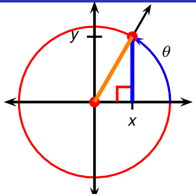

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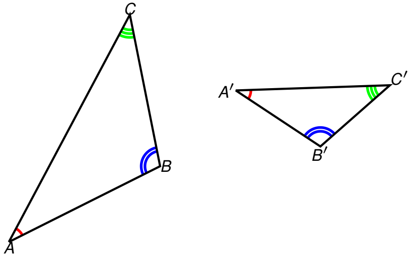
We say that a triangle $\triangle ABC$ is similar to a triangle $\triangle A'B'C'$ if the two triangles have equal angles.



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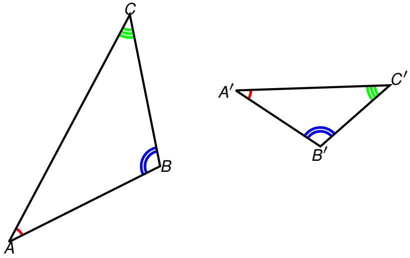

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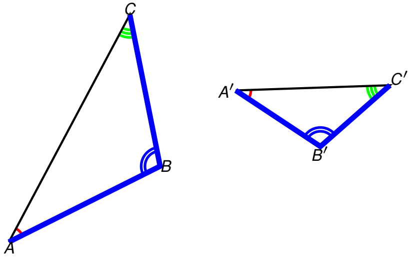

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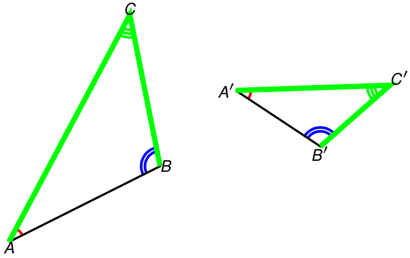

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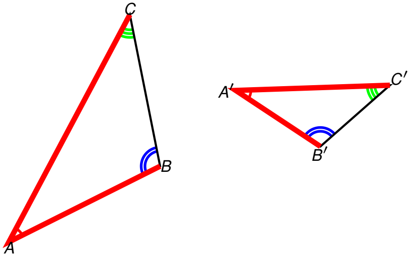
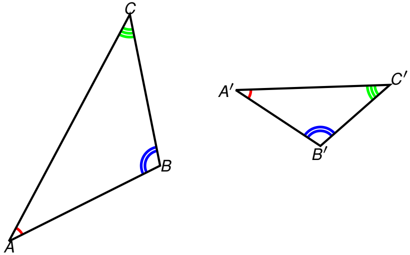


The following statement is proved in the subject of Euclidean (planar) geometry.

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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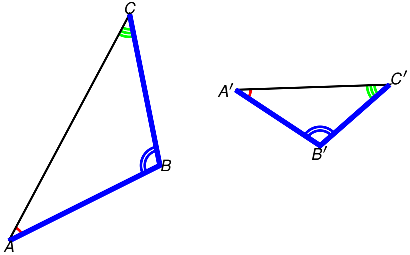

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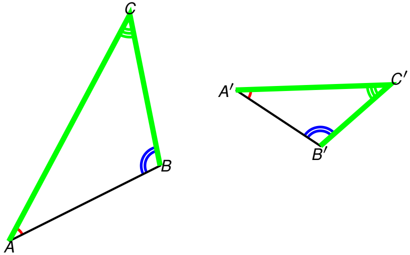

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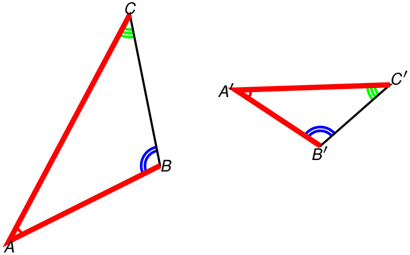
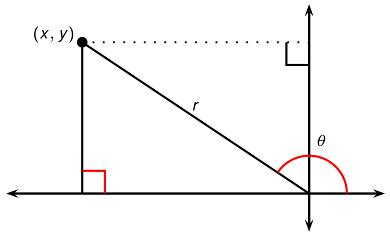
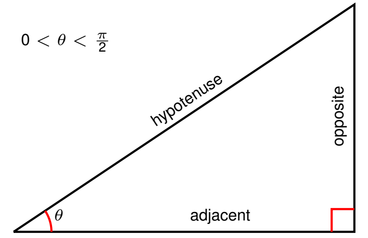


Trigonometric Functions and Right Angle Triangles





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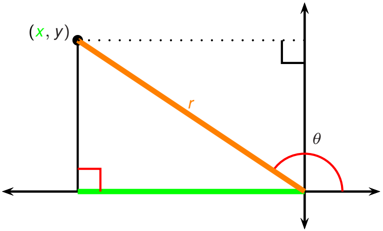	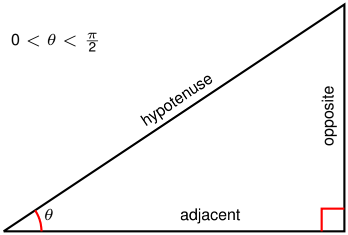
$\cos\theta = \frac{x}{r}$ $\sec\theta$ $\sin\theta$ $\csc\theta$ $\tan\theta$ $\cot\theta$	$\cos\theta$ $\sec\theta$ $\sin\theta$ $\csc\theta$ $\tan\theta$ $\cot\theta$
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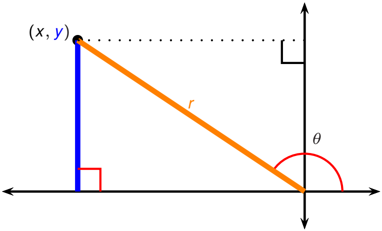

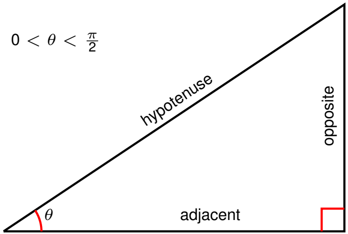

$\cos\theta = \frac{x}{r}$	$\sec\theta$	$\cos\theta$	$\sec\theta$
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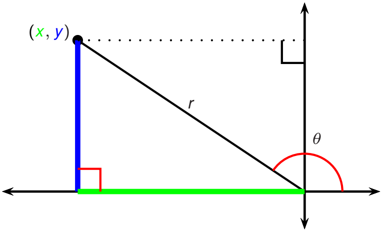

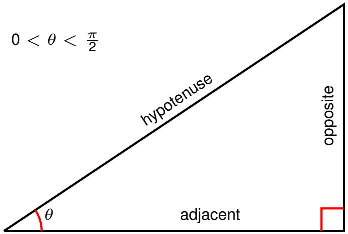

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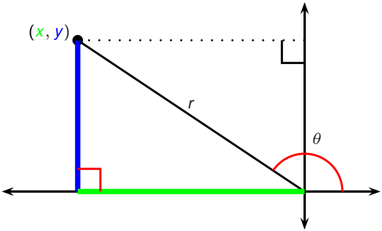

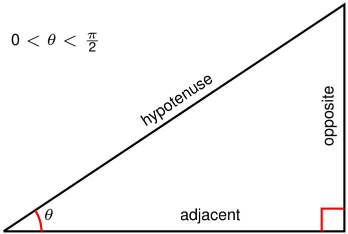

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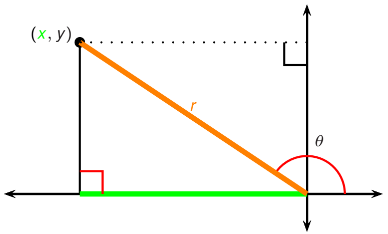

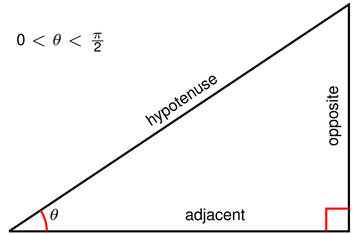

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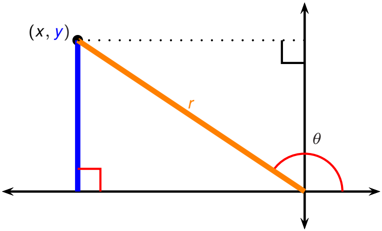

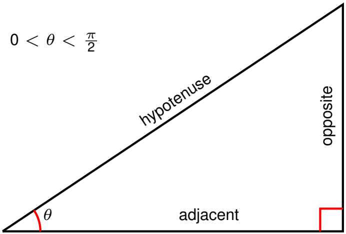

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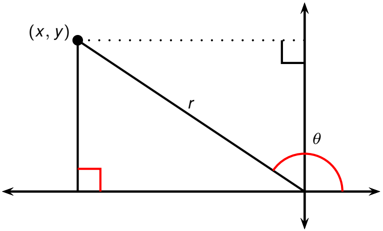

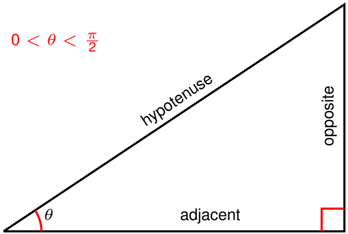

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- The trigonometric functions can be defined without requesting that the pt. (x, y) on the terminal arm of the angle lie on the unit circle.
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- The trig functions of acute θ (between 0 and $\frac{\pi}{2}$)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

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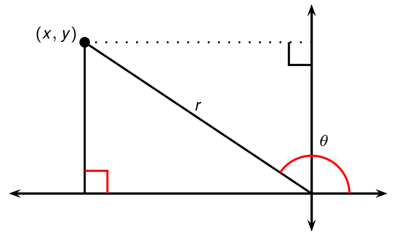	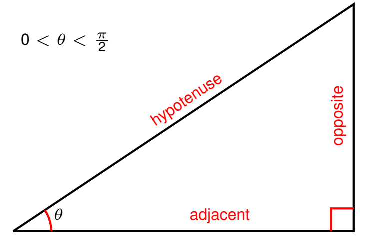
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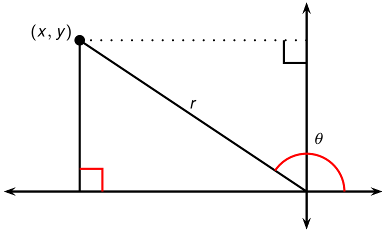
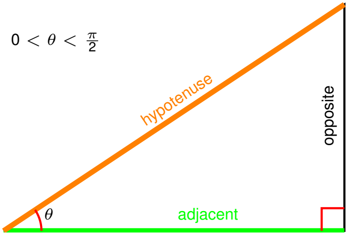
Trigonometric Functions and Right Angle Triangles





$\cos\theta = \frac{x}{r}$	$\sec\theta = \frac{r}{x}$	$\cos\theta = \frac{\text{adj}}{\text{hyp}}$	$\sec\theta$
$\sin\theta = \frac{y}{r}$	$\csc\theta = \frac{r}{y}$	$\sin\theta$	$\csc\theta$
$\tan\theta = \frac{y}{x}$	$\cot\theta = \frac{x}{y}$	$\tan\theta$	$\cot\theta$
All angles		Acute angles	

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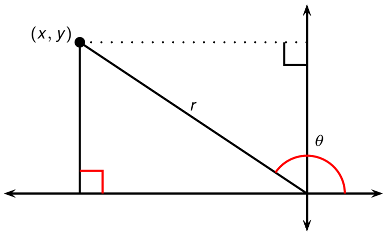

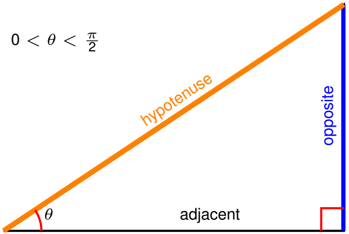

$\cos\theta = \frac{x}{r}$	$\sec\theta = \frac{r}{x}$	$\cos\theta = \frac{\text{adj}}{\text{hyp}}$	$\sec\theta$
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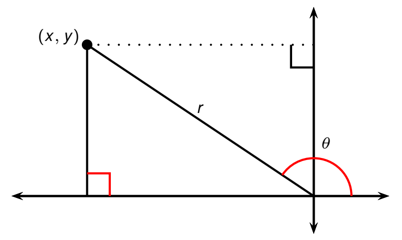

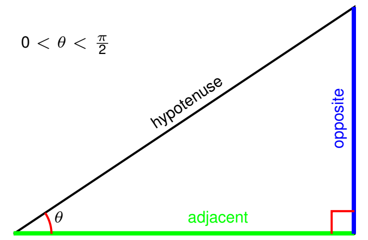

$\cos\theta = \frac{x}{r}$	$\sec\theta = \frac{r}{x}$	$\cos\theta = \frac{\text{adj}}{\text{hyp}}$	$\sec\theta$
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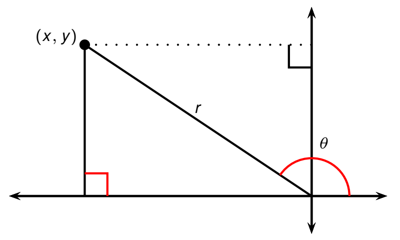

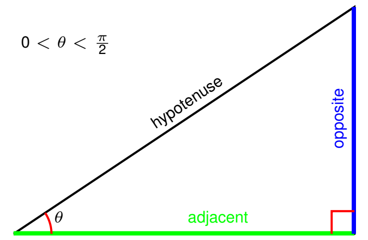

All angles		Acute angles	
$\cos\theta = \frac{x}{r}$	$\sec\theta = \frac{r}{x}$	$\cos\theta = \frac{\text{adj}}{\text{hyp}}$	$\sec\theta$
$\sin\theta = \frac{y}{r}$	$\csc\theta = \frac{r}{y}$	$\sin\theta = \frac{\text{opp}}{\text{hyp}}$	$\csc\theta$
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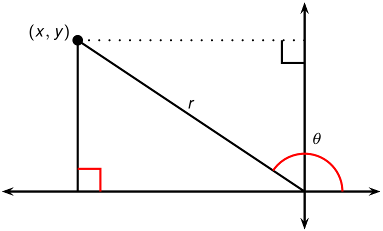

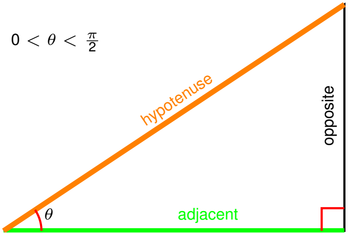

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$\cos\theta = \frac{x}{r}$	$\sec\theta = \frac{r}{x}$	$\cos\theta = \frac{\text{adj}}{\text{hyp}}$	$\sec\theta = \frac{\text{hyp}}{\text{adj}}$
$\sin\theta = \frac{y}{r}$	$\csc\theta = \frac{r}{y}$	$\sin\theta = \frac{\text{opp}}{\text{hyp}}$	$\csc\theta$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

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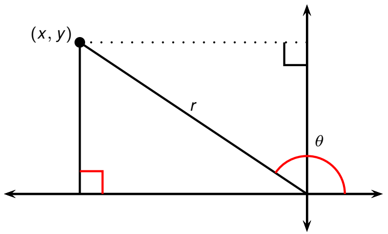

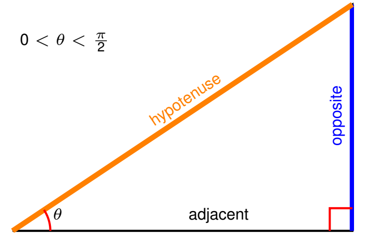

$\cos\theta = \frac{x}{r}$	$\sec\theta = \frac{r}{x}$	$\cos\theta = \frac{\text{adj}}{\text{hyp}}$	$\sec\theta = \frac{\text{hyp}}{\text{adj}}$
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$\tan\theta = \frac{y}{x}$	$\cot\theta = \frac{x}{y}$	$\tan\theta = \frac{\text{opp}}{\text{adj}}$	$\cot\theta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

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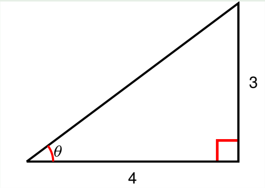
Example

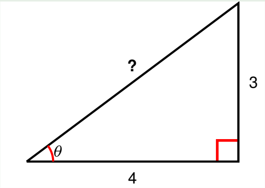


Let the angle θ be as indicated in the figure. Find the values of the six trigonometric functions of θ.

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

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

Example



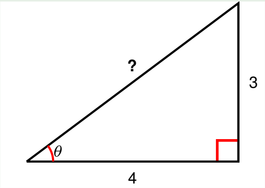
Let the angle θ be as indicated in the figure. Find the values of the six trigonometric functions of θ.

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

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

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

Example



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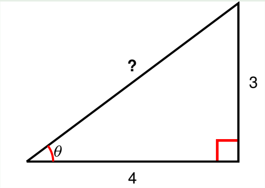
To find the trigonometric functions, we need to know the length of the hypotenuse.

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

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

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

Example



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

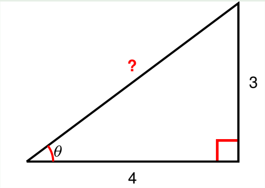
To find the trigonometric functions, we need to know the length of the hypotenuse.

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

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

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

Example



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

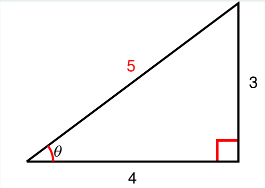
To find the trigonometric functions, we need to know the length of the hypotenuse.

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

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

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

Example



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$$\text{hypotenuse} = \sqrt{4^2 + 3^2} = \sqrt{25} = 5.$$

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

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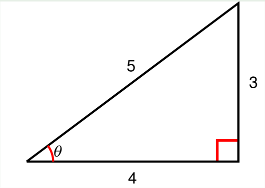
Example



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$$\text{hypotenuse} = \sqrt{4^2 + 3^2} = \sqrt{25} = 5.$$

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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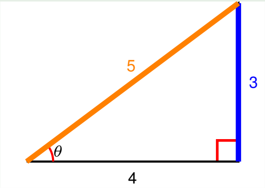
Example



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

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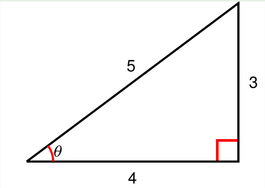
Example



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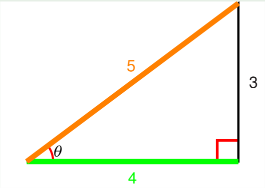

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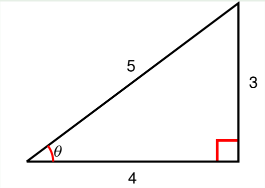

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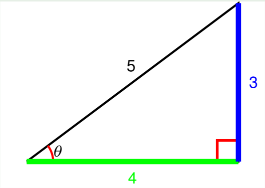

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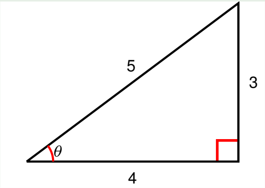

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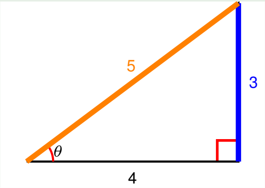

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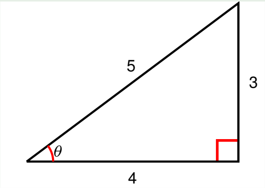
Example



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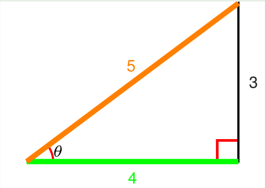
Example



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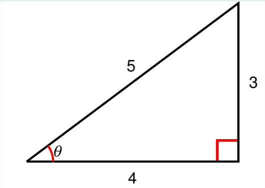
Example



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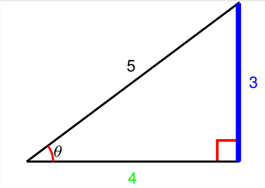
$$\csc\theta = \frac{5}{3} \quad \sec\theta = \frac{5}{4} \quad \cot\theta = \mathbf{?}$$

Example



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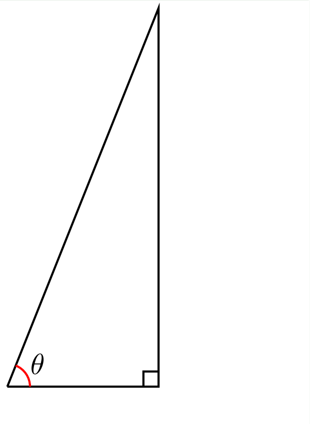
Using the right angle triangle ratio interpretations of the trig functions, we can compute:

$$\begin{array}{ccc} \sin\theta = \frac{3}{5} & \cos\theta = \frac{4}{5} & \tan\theta = \frac{3}{4} \\ \csc\theta = \frac{5}{3} & \sec\theta = \frac{5}{4} & \cot\theta = \frac{4}{3} \end{array}$$

Example

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



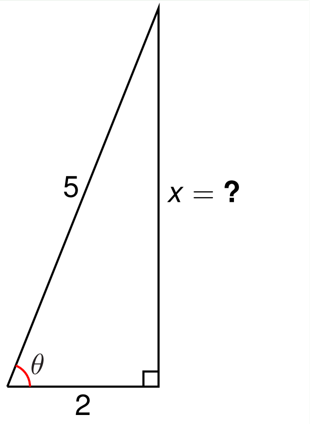
$\sin\theta =$ $\qquad$ $\tan\theta =$

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

$\cot\theta =$

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.

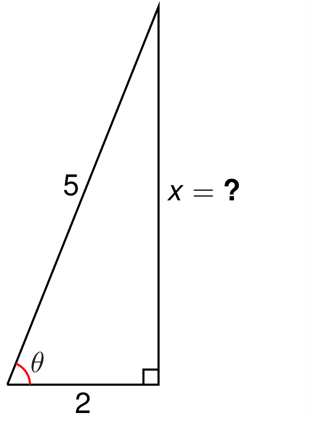
$\sin\theta =$ $\tan\theta =$

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

$\cot\theta =$

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: $x^2 + 2^2 = 5^2$.

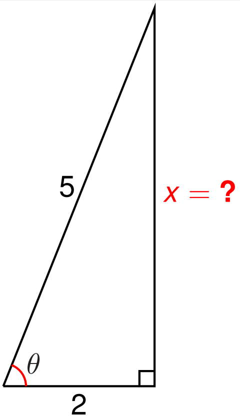
$\sin\theta =$ $\qquad$ $\tan\theta =$

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

$\cot\theta =$

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 $x =$ **?** .

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

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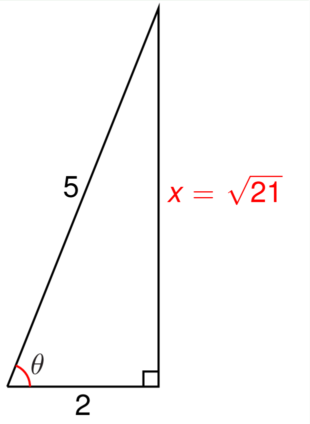

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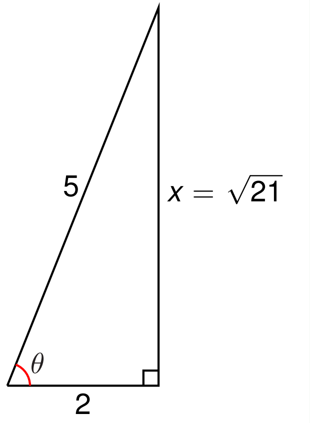

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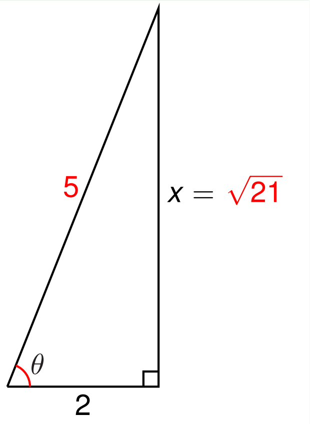

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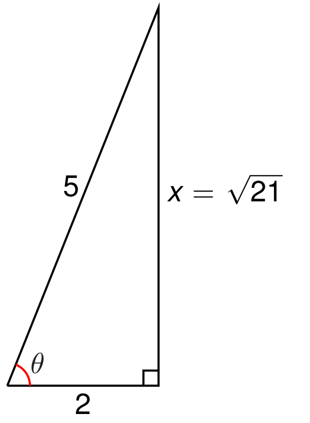

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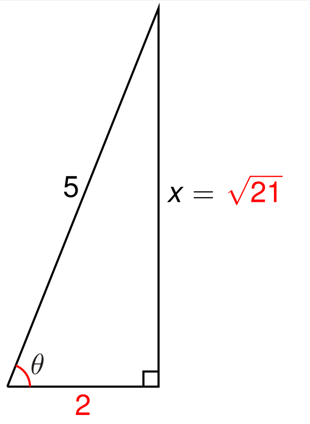

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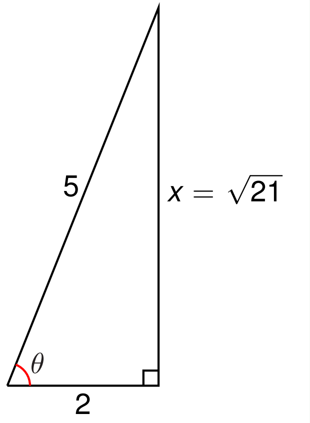

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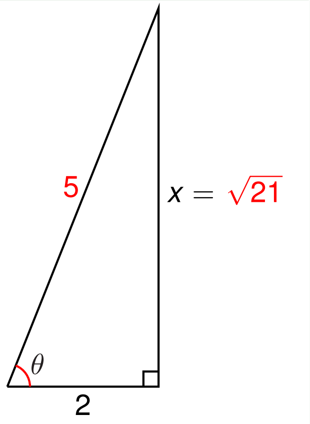

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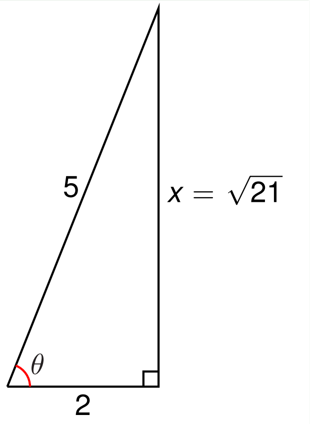

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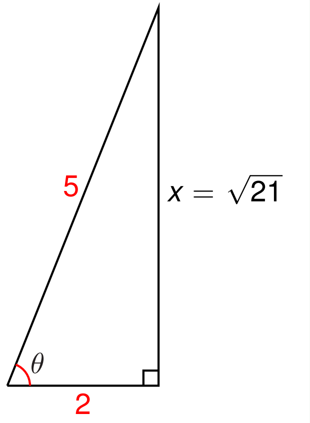

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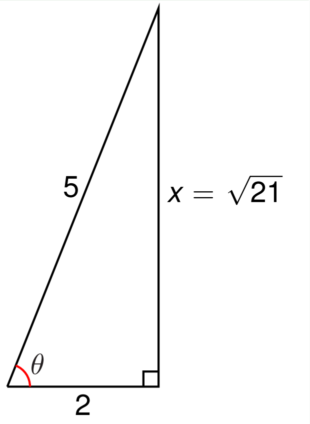

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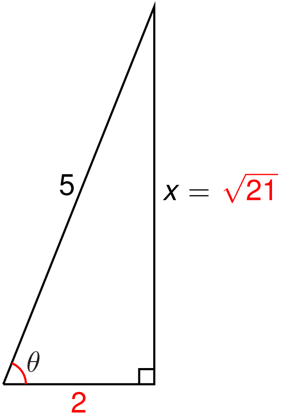

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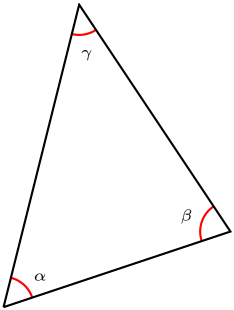


Proposition

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

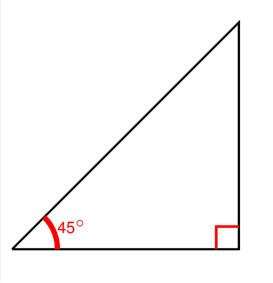
In other words, if α, β, γ are the angles indicated in the figure, then we have:

$$\alpha + \beta + \gamma = 180^\circ.$$

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,

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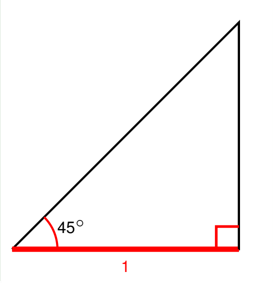
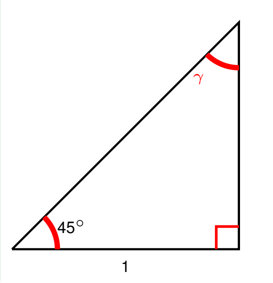
Example



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.

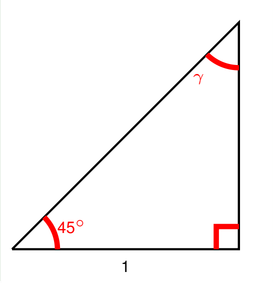
Example



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



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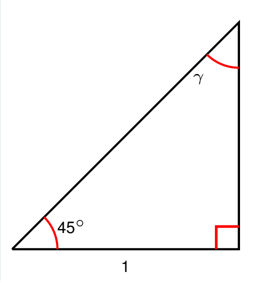
- Angles in triangle sum to 180°:

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

Example



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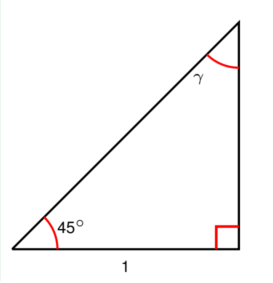

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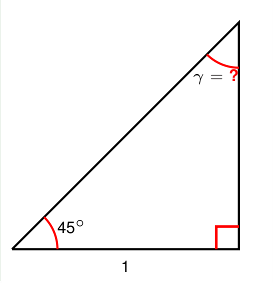

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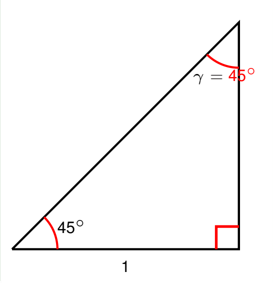

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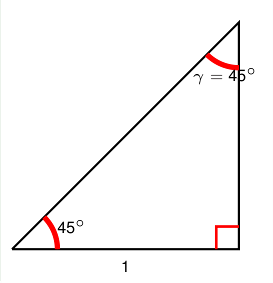

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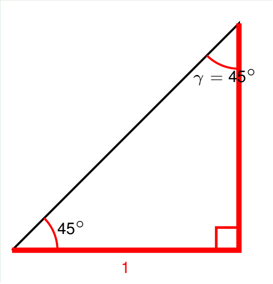
- Triangle has two equal angles

Example



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

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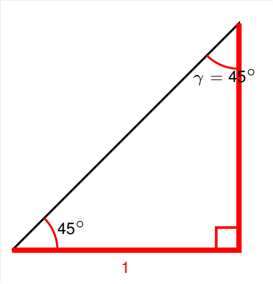

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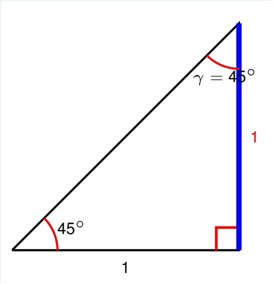

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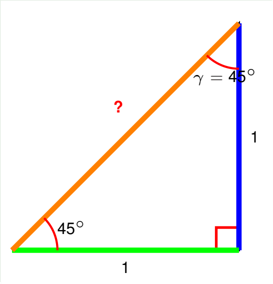

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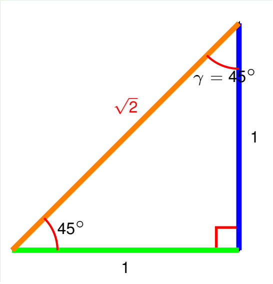

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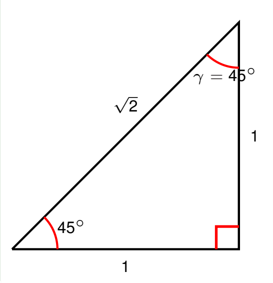

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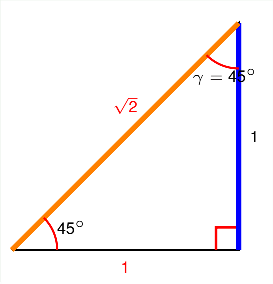

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- $\sin 45^\circ = \frac{\text{opp}}{\text{hyp}} = \frac{\sqrt{2}}{2}$ $\qquad \cos 45^\circ = \mathbf{?}$

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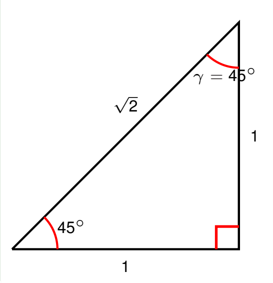

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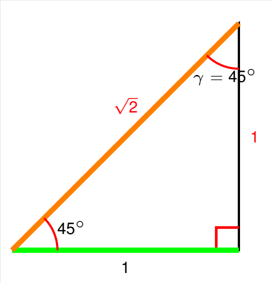

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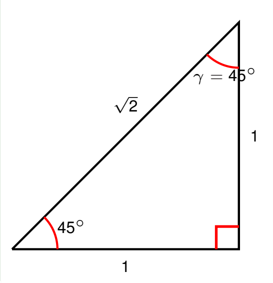
Example



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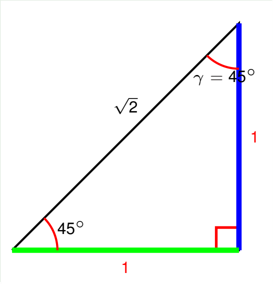
  $\tan 45^\circ = \textbf{?}$

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°:

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

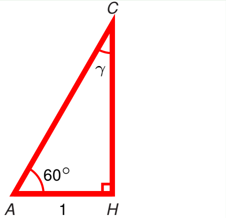
- Triangle has two equal angles $\Rightarrow$ is isosceles (has two equal sides).
- $\Rightarrow$ Opposite leg: length 1 $\Rightarrow$ length(hyp) $= \sqrt{1^2+1^2} = \sqrt{2}$.
- $\sin 45^\circ = \dfrac{\text{opp}}{\text{hyp}} = \dfrac{\sqrt{2}}{2} \qquad \cos 45^\circ = \dfrac{\text{adj}}{\text{hyp}}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

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

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:

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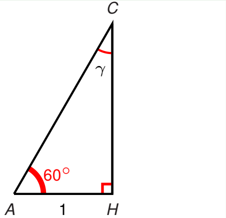

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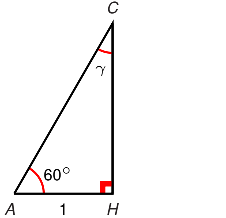

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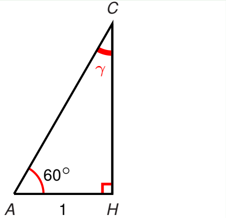

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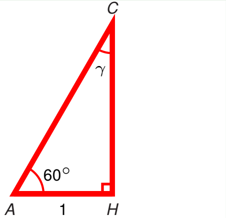

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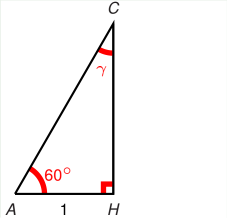

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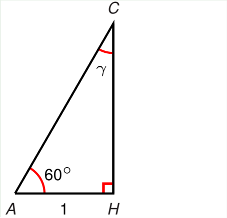

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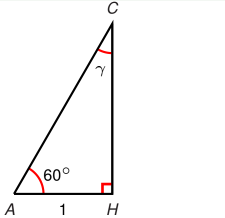

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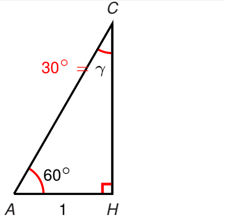

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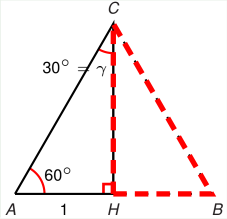

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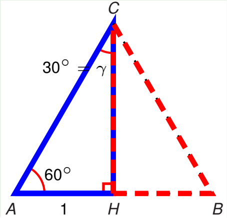

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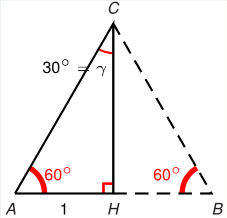

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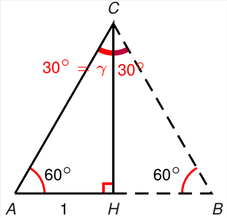

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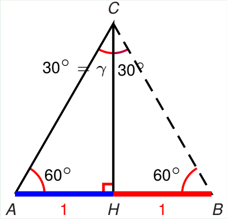

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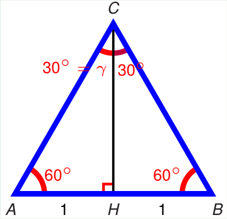

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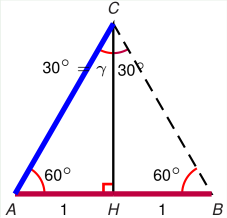
Construct $\triangle HBC$ as indicated so that $\triangle HBC \cong \triangle HAC$. $\triangle ABC$ has three equal angles ($= 60^\circ$)

Example



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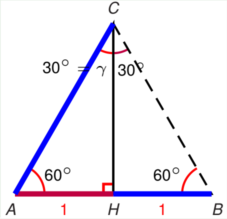

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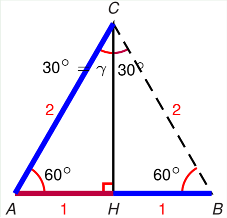
$$|AC| = |AB| = 1 + 1$$

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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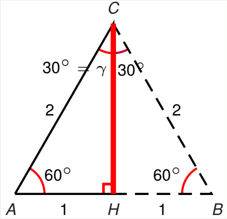

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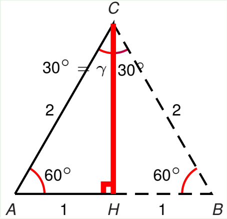

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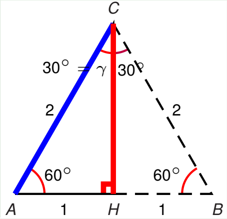

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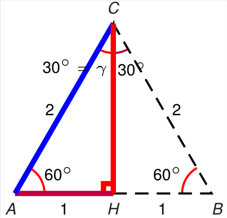

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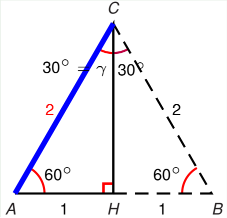

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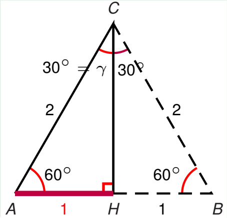

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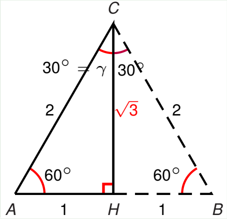

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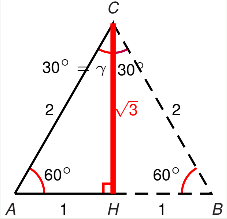

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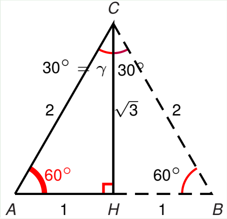

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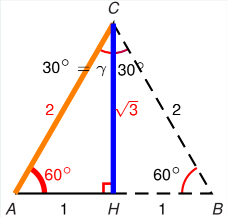

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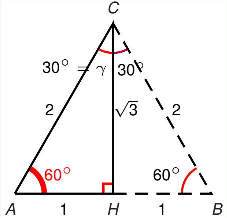

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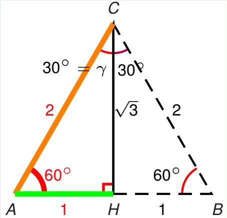

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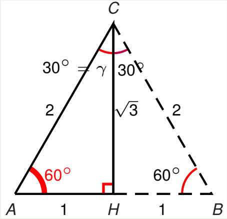

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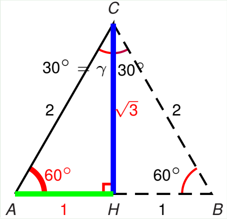

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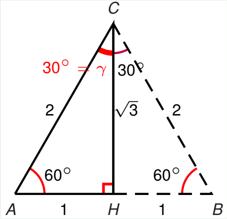

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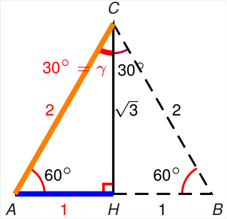

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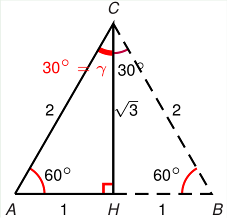

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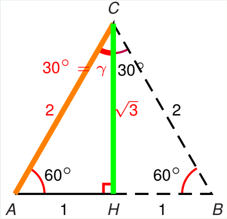

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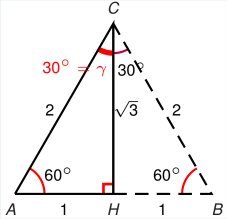

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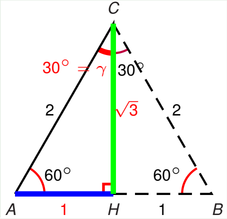

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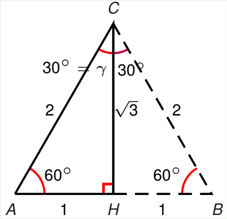

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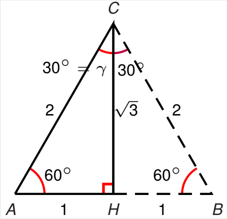

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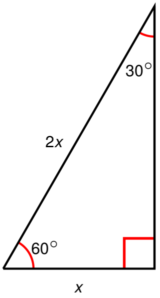
Observation

- *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.*

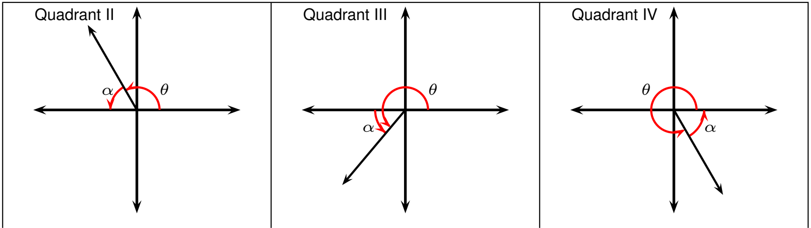


To compute trigonometric functions from obtuse ($> 90^\circ$) or negative angles, we can use the following visual aid.

Definition (Reference Angle)

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.



$\alpha = ?$	$\alpha =$	$\alpha =$
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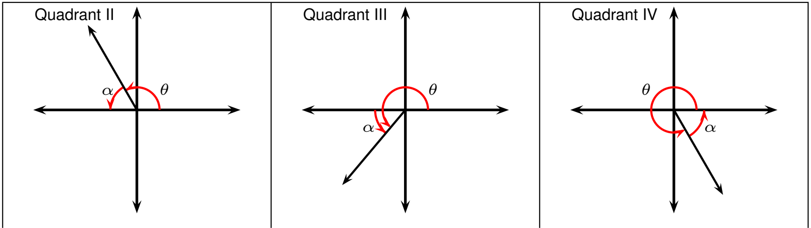

$\alpha = \pi - \theta$	$\alpha =$	$\alpha =$
$\alpha = 180^\circ - \theta$	$\alpha =$	$\alpha =$

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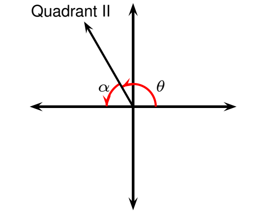

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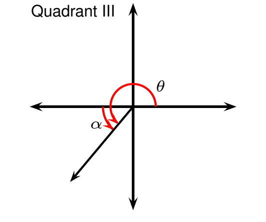

$$\alpha = \textbf{?}$$
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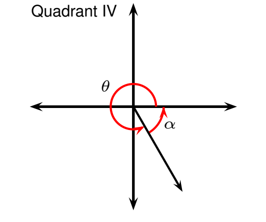

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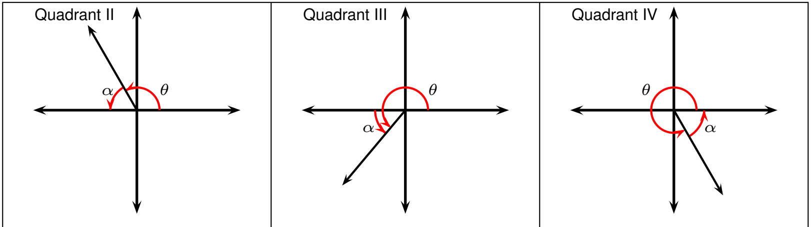

$\alpha = \pi - \theta$	$\alpha = \theta - \pi$	$\alpha =$
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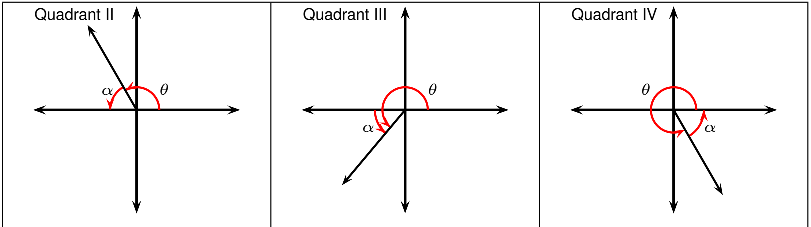

Quadrant II	Quadrant III	Quadrant IV
$\alpha = \pi - \theta$	$\alpha = \theta - \pi$	$\alpha =$ **?**
$\alpha = 180^\circ - \theta$	$\alpha = \theta - 180^\circ$	$\alpha =$ **?**

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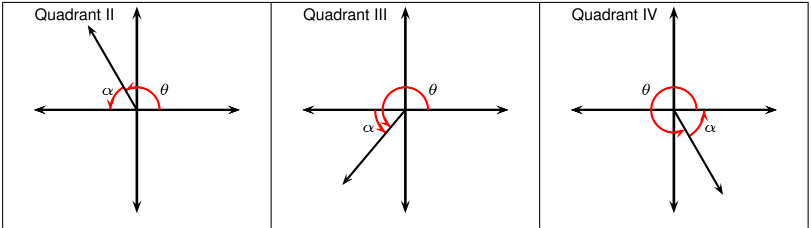

Quadrant II	Quadrant III	Quadrant IV
$\alpha = \pi - \theta$	$\alpha = \theta - \pi$	$\alpha = 2\pi - \theta$
$\alpha = 180^\circ - \theta$	$\alpha = \theta - 180^\circ$	$\alpha = 360^\circ - \theta$

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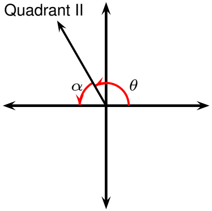

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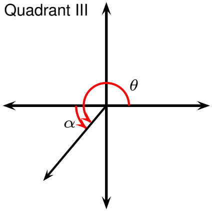
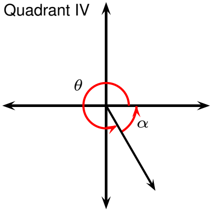


$$\alpha = \theta - \pi$$
$$\alpha = \theta - 180^\circ$$



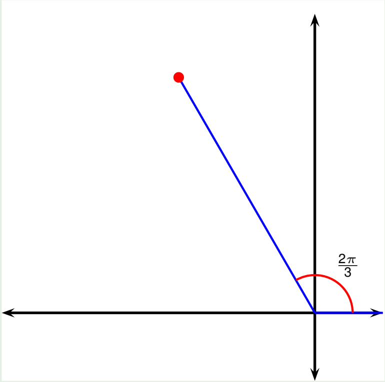
$$\alpha = 2\pi - \theta$$
$$\alpha = 360^\circ - \theta$$

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

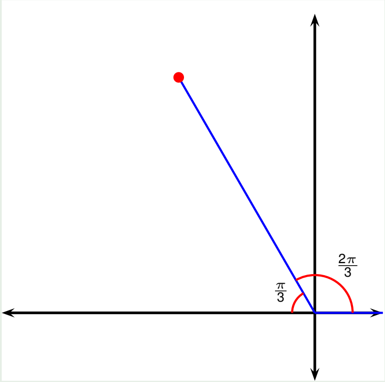


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120^\circ$.

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

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

Example

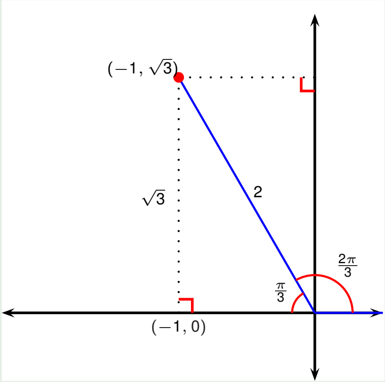


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120^\circ$.

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

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

Example

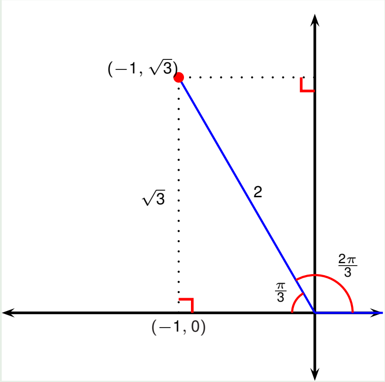


Find the exact values of the trigonometric functions of $\theta = \frac{2\pi}{3} = 120^\circ$.

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

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

Example

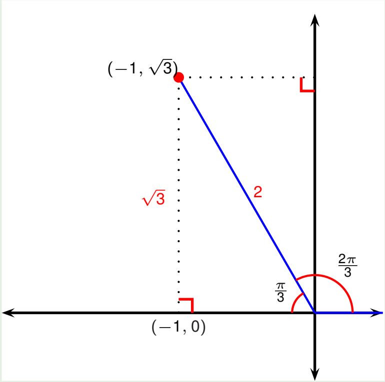


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120^\circ$.

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

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

Example

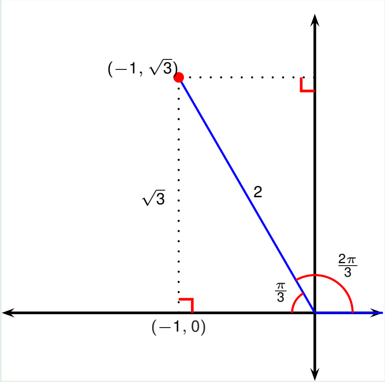


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120^\circ$.

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

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

Example

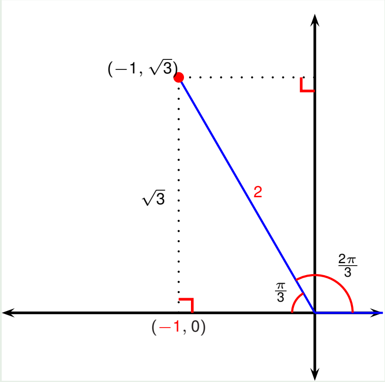


Find the exact values of the trigonometric functions of $\theta = \dfrac{2\pi}{3} = 120^\circ$.

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

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

Example



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

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

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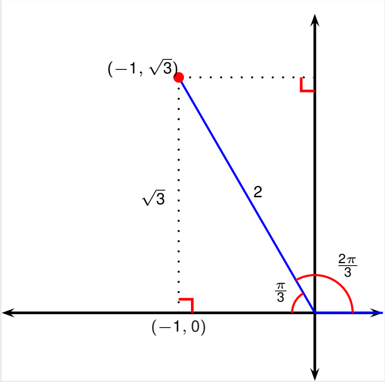
Example



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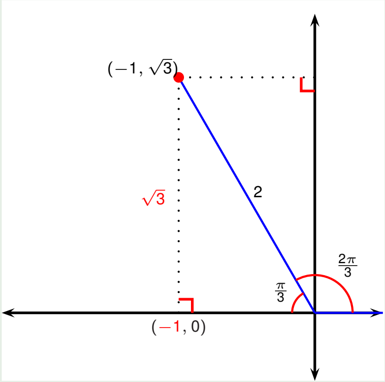
Example



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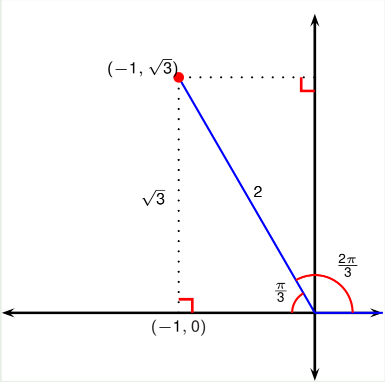
$$\csc\left(\frac{2\pi}{3}\right) = \qquad \sec\left(\frac{2\pi}{3}\right) = \qquad \cot\left(\frac{2\pi}{3}\right) =$$

Example



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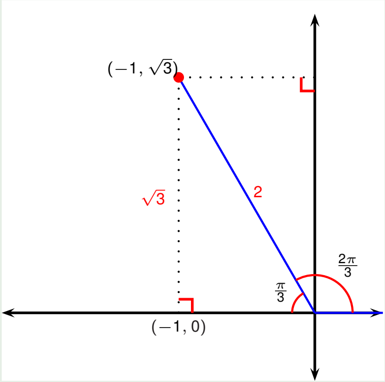
$$\csc\left(\frac{2\pi}{3}\right) = \textbf{?} \quad \sec\left(\frac{2\pi}{3}\right) = \quad \cot\left(\frac{2\pi}{3}\right) =$$

Example



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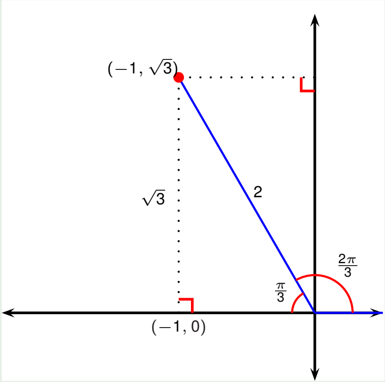
$$\csc\left(\frac{2\pi}{3}\right) = \frac{2}{\sqrt{3}} \quad \sec\left(\frac{2\pi}{3}\right) = \quad \cot\left(\frac{2\pi}{3}\right) =$$

Example



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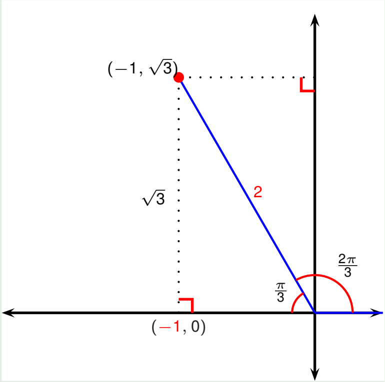
$$\csc\left(\frac{2\pi}{3}\right) = \frac{2}{\sqrt{3}} \quad \sec\left(\frac{2\pi}{3}\right) = \mathbf{?} \quad \cot\left(\frac{2\pi}{3}\right) =$$

Example



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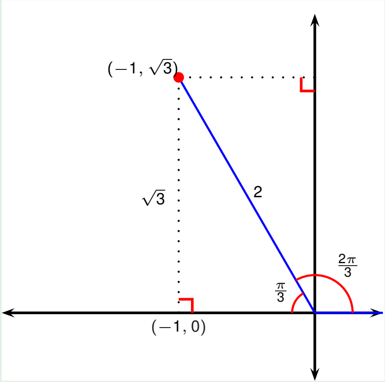
$$\csc\left(\frac{2\pi}{3}\right) = \frac{2}{\sqrt{3}} \quad \sec\left(\frac{2\pi}{3}\right) = -\frac{2}{1} = -2 \quad \cot\left(\frac{2\pi}{3}\right) =$$

Example



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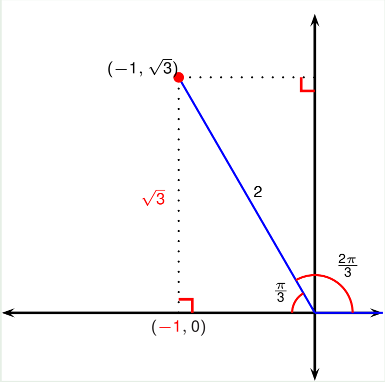
$$\csc\left(\frac{2\pi}{3}\right) = \frac{2}{\sqrt{3}} \quad \sec\left(\frac{2\pi}{3}\right) = -\frac{2}{1} = -2 \quad \cot\left(\frac{2\pi}{3}\right) = \textbf{?}$$

Example



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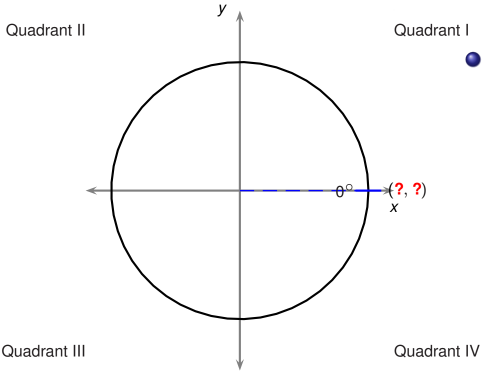
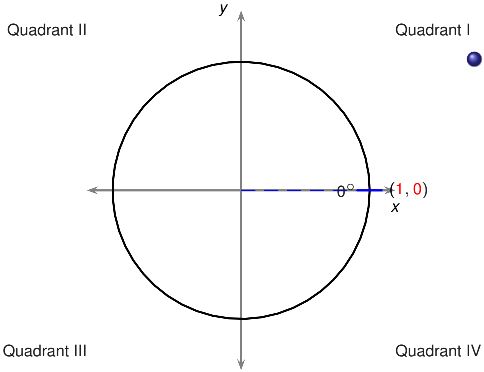
$$\csc\left(\frac{2\pi}{3}\right) = \frac{2}{\sqrt{3}} \quad \sec\left(\frac{2\pi}{3}\right) = -\frac{2}{1} = -2 \quad \cot\left(\frac{2\pi}{3}\right) = -\frac{1}{\sqrt{3}}$$



- 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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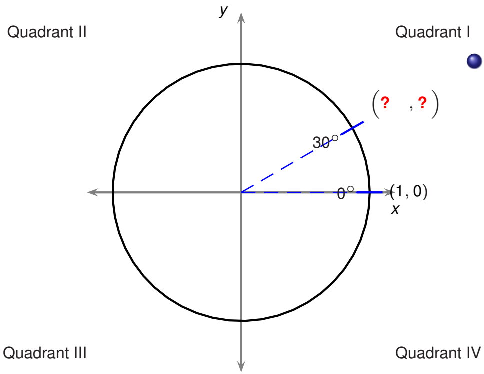
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0										
cos	1										



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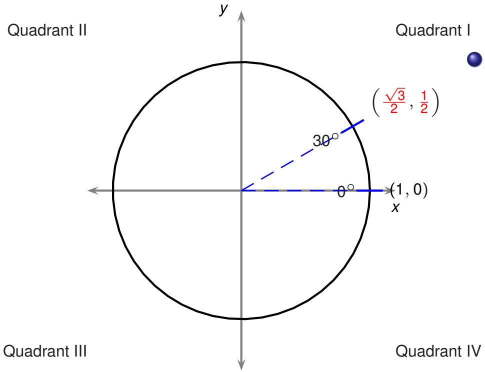
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	?									
cos	1	?									



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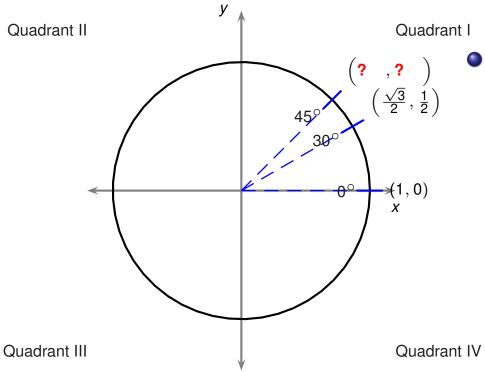
Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$									
cos	1	$\frac{\sqrt{3}}{2}$									



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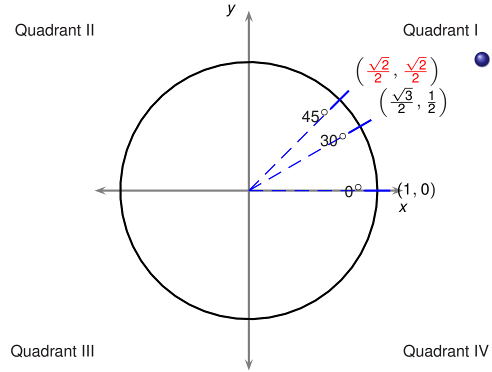
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	?								
cos	1	$\frac{\sqrt{3}}{2}$	?								



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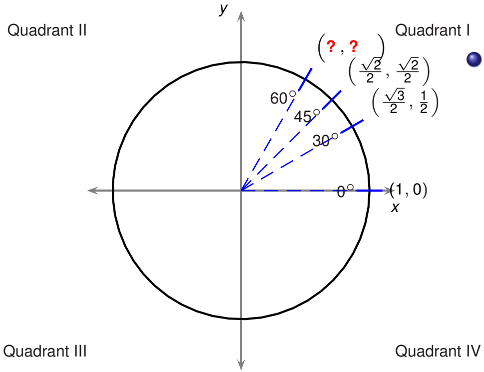
Deg.	0°	30°	45°	60°	90°	120°	135°	150°	180°	270°	360°
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$								
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$								



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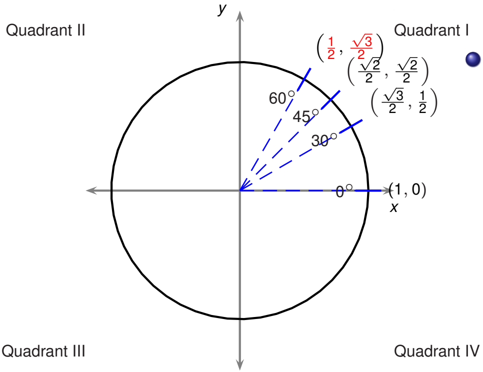
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	?							
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	?							



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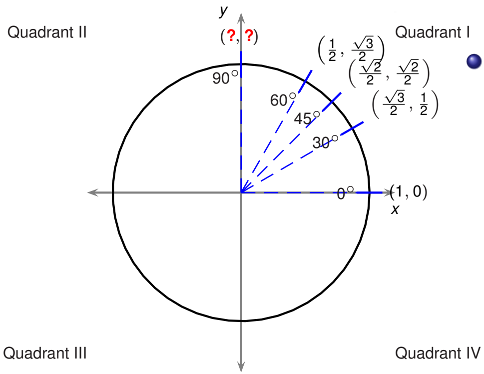
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$							
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$							



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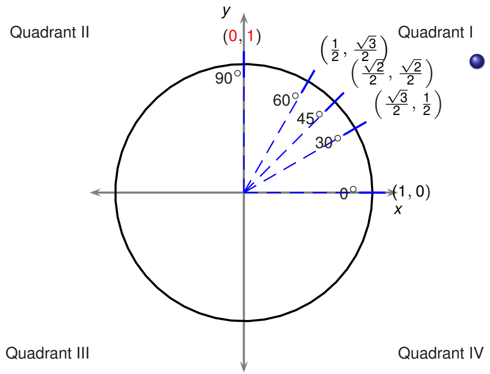
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	?						
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	?						



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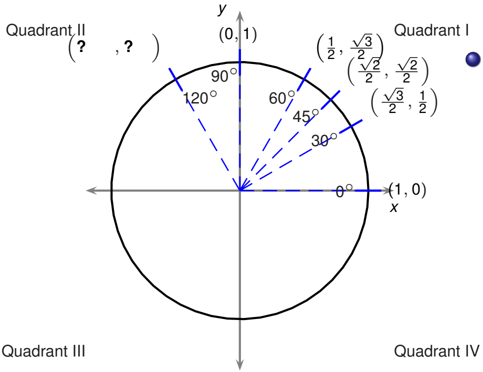
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1						
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0						



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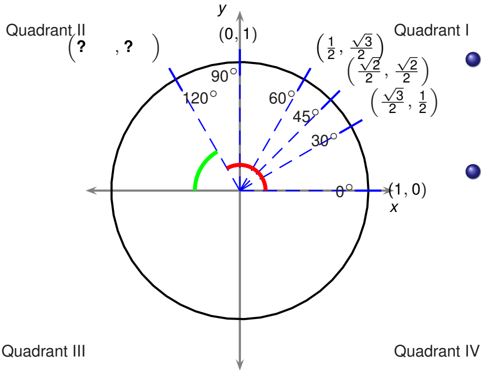
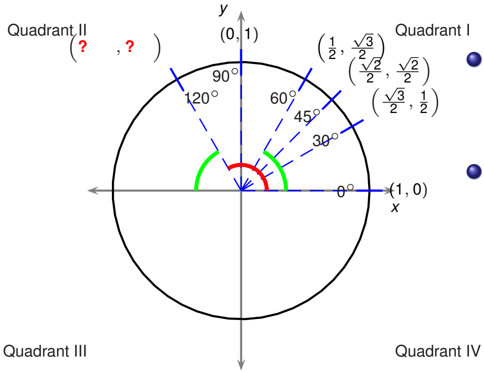
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	**?**					
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	**?**					



- 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	**?**					



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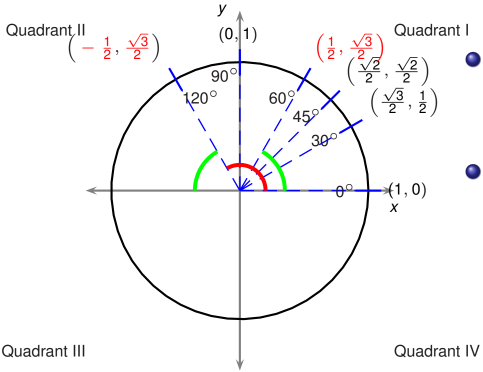
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	?					
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	?					



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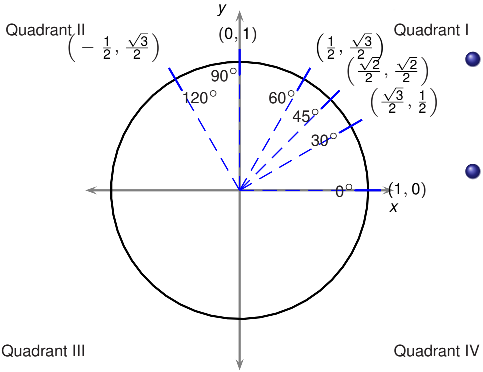
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$					
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$					



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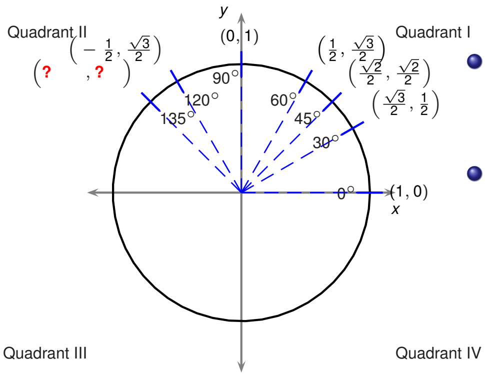
Rad.	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{3\pi}{2}$	2π
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$					
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$					



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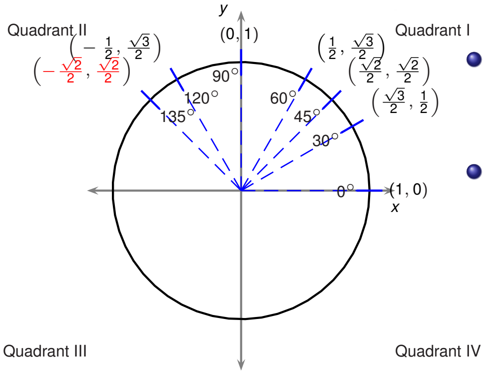
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	?				
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	?				



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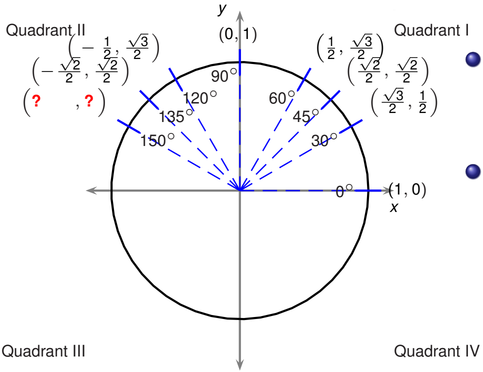
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$				
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$				



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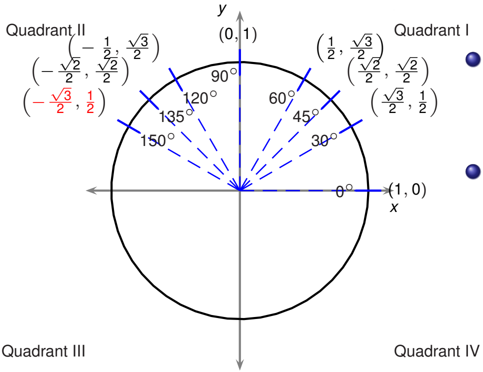
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	?			
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	?			



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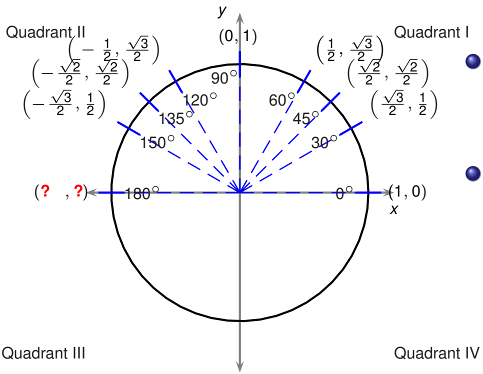
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$			
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$			



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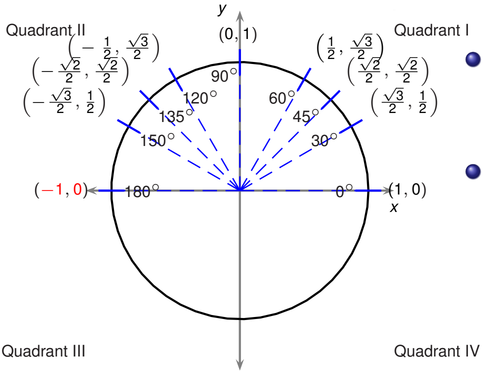
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	?		
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	?		



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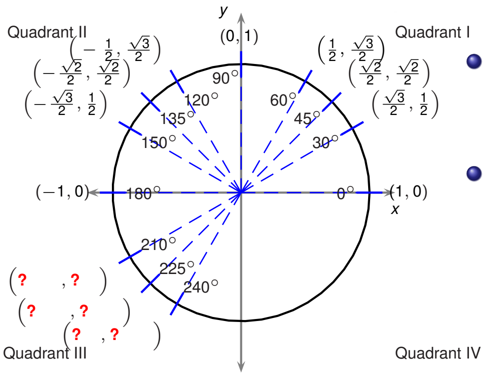
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0		
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1		



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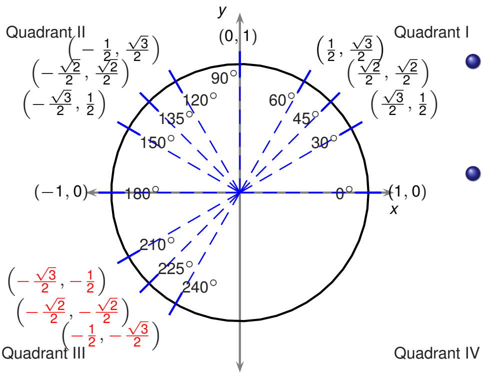
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0		
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1		



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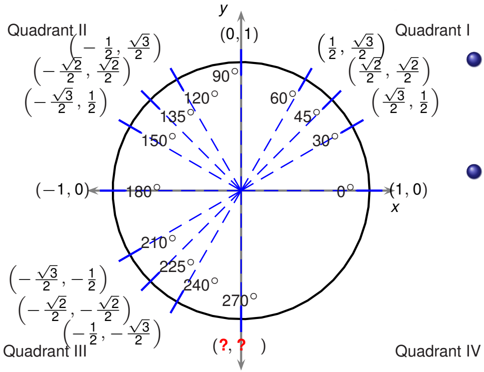
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0		
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1		



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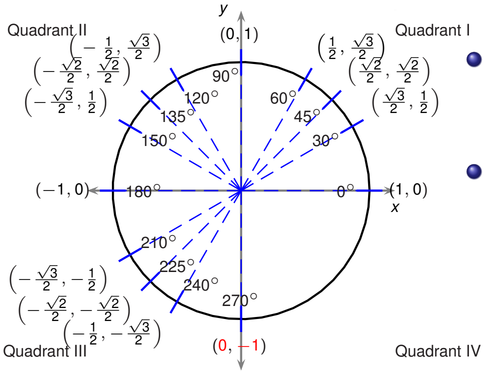
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	?	
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	?	



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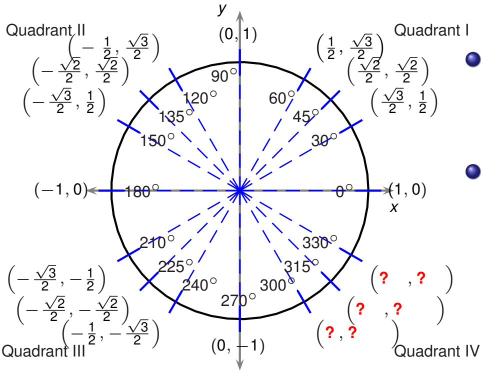
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	0	



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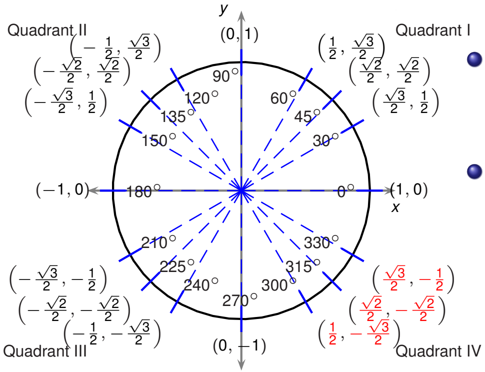
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	0	



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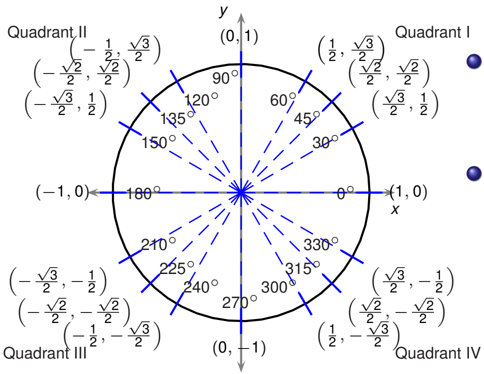
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	0	



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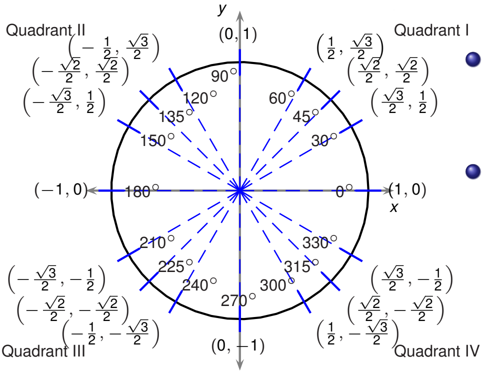
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	**?**
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	0	**?**



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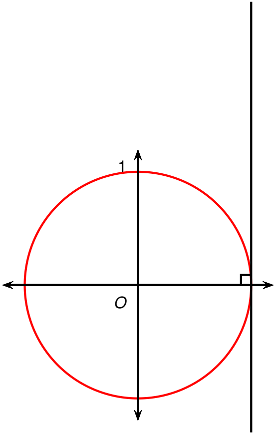
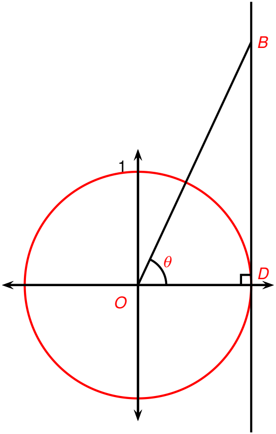
sin	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	-1	0
cos	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	0	1

Geometric interpretation of all trigonometric functions



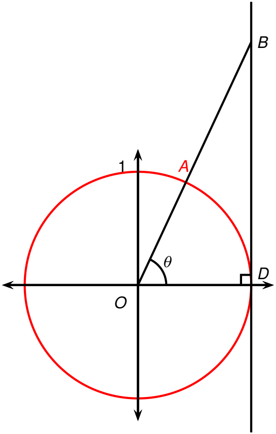
Fix unit circle, center O, coordinates $(0, 0)$.

Geometric interpretation of all trigonometric functions



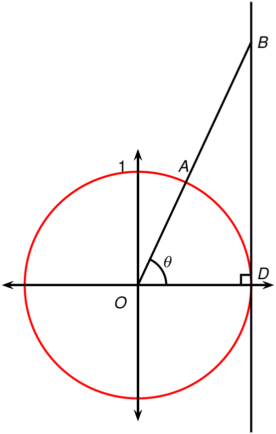
Fix unit circle, center O, coordinates $(0, 0)$.
Let $\angle DOB = \theta$.

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 $(\cos\theta, \sin\theta)$.

$\sin\theta$

$\cos\theta$

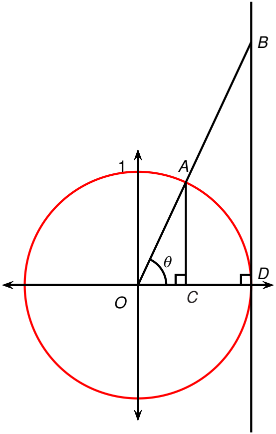
$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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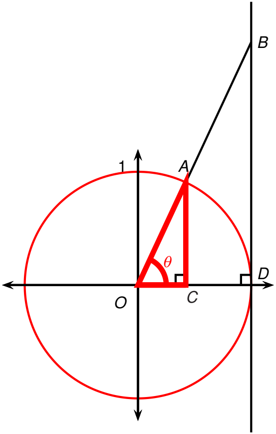

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$$\sin\theta = \frac{\text{opp}}{\text{hyp}}$$

$\cos\theta$

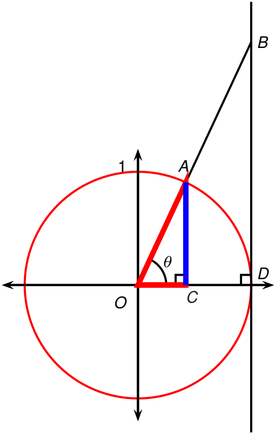
$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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

$\cos\theta$

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$\cot\theta$

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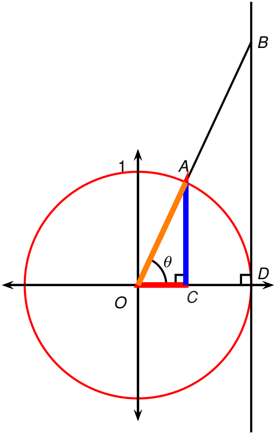
$\csc\theta$

Geometric interpretation of all trigonometric functions



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$\tan\theta$

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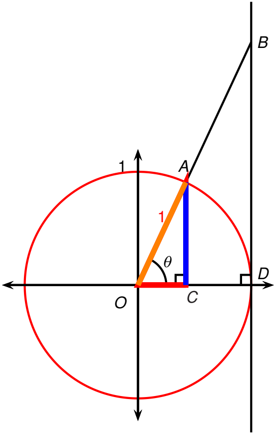
$\csc\theta$

Geometric interpretation of all trigonometric functions



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

$\cos\theta$

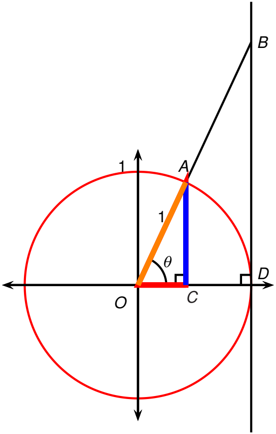
$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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

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

$\cos\theta$

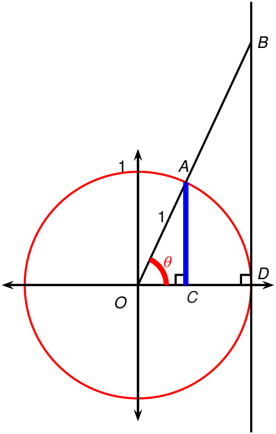
$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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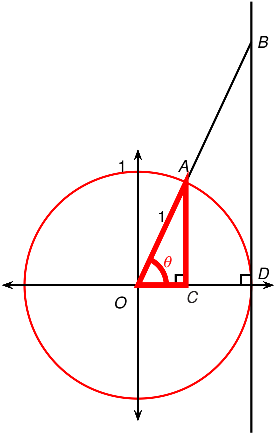
$\csc\theta$

Geometric interpretation of all trigonometric functions



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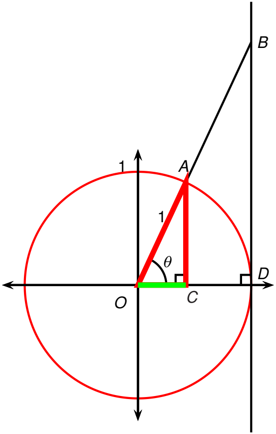
$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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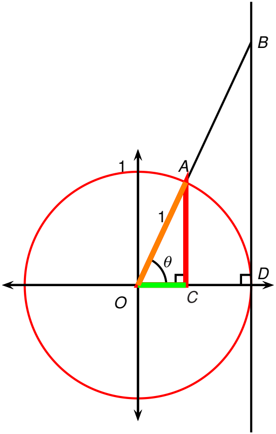
$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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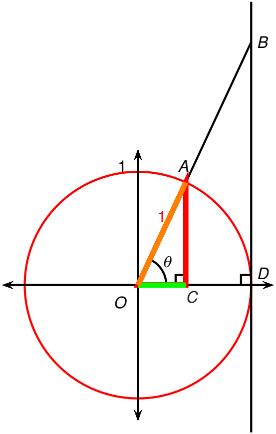
$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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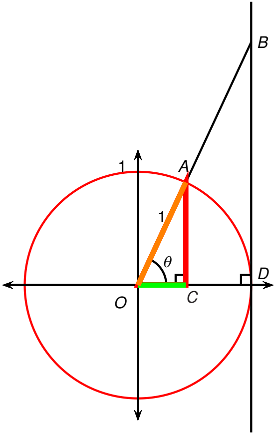
$\tan\theta$

$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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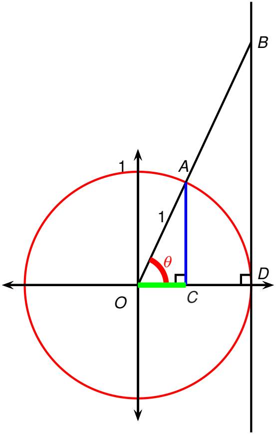
Geometric interpretation of all trigonometric functions



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$\tan\theta$

$\cot\theta$

$\sec\theta$

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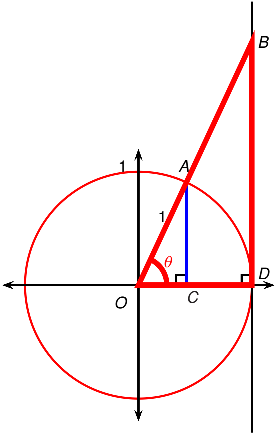
Geometric interpretation of all trigonometric functions



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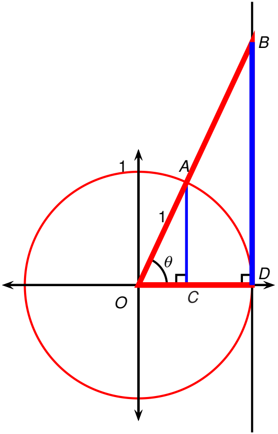
\tan\theta &= \frac{\text{opp}}{\text{adj}} \\
\cot\theta & \\
\sec\theta & \\
\csc\theta &
\end{aligned}
$$

Geometric interpretation of all trigonometric functions



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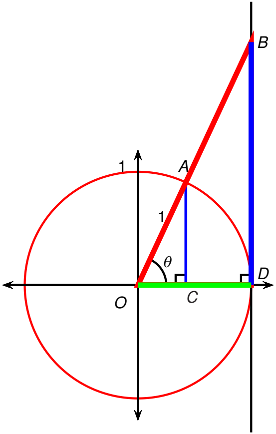
\tan\theta &= \frac{\text{opp}}{\text{adj}} = \frac{|BD|}{|OD|} \\
\cot\theta & \\
\sec\theta & \\
\csc\theta &
\end{aligned}
$$

Geometric interpretation of all trigonometric functions



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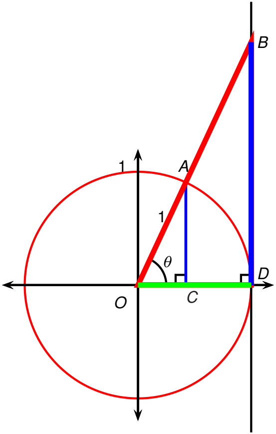
\cot\theta & \\
\sec\theta & \\
\csc\theta &
\end{aligned}
$$

Geometric interpretation of all trigonometric functions



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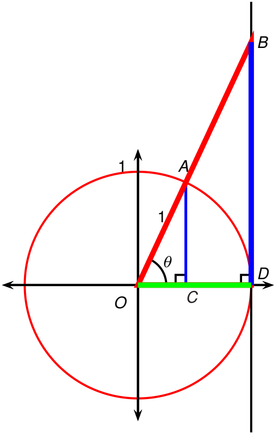
\tan\theta &= \frac{\text{opp}}{\text{adj}} = \frac{|BD|}{|OD|} = \frac{|BD|}{1} \\
\cot\theta & \\
\sec\theta & \\
\csc\theta &
\end{aligned}$$

Geometric interpretation of all trigonometric functions



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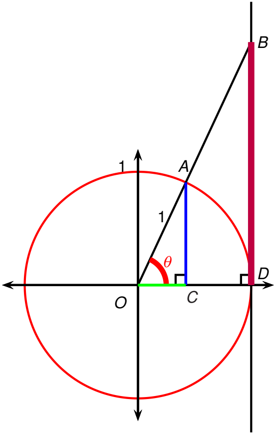
\cot\theta & \\
\sec\theta & \\
\csc\theta &
\end{aligned}
$$

Geometric interpretation of all trigonometric functions



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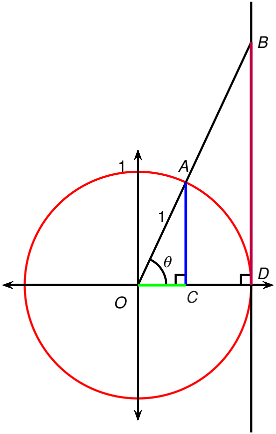
$\cot\theta$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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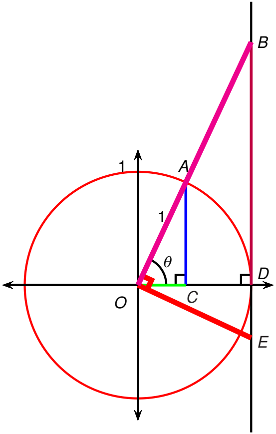
\tan\theta &= \frac{\text{opp}}{\text{adj}} = \frac{|BD|}{|OD|} = \frac{|BD|}{1} = |BD| \\
\cot\theta &= \frac{\text{adj}}{\text{opp}} \\
\sec\theta & \\
\csc\theta &
\end{aligned}
$$

Geometric interpretation of all trigonometric functions



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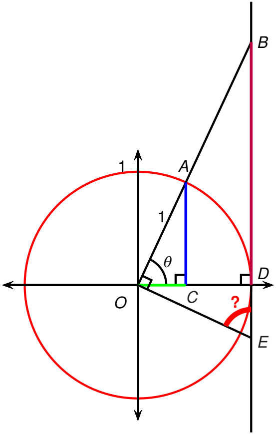
\cot\theta &= \frac{\text{adj}}{\text{opp}} \\
\sec\theta & \\
\csc\theta &
\end{aligned}$$

Geometric interpretation of all trigonometric functions



$\angle OED = \mathbf{?}$

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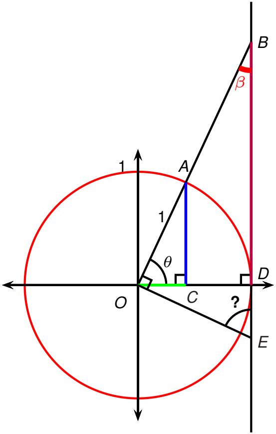
$$\cot\theta = \frac{\text{adj}}{\text{opp}}$$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



$\beta = \textbf{?}$

$\angle OED = \textbf{?}$

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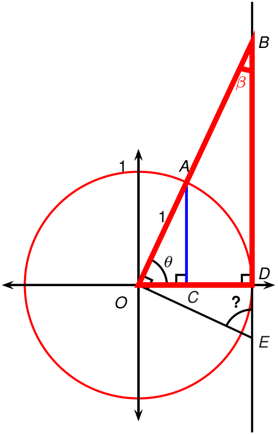
\tan\theta &= \frac{\text{opp}}{\text{adj}} = \frac{|BD|}{|OD|} = \frac{|BD|}{1} = |BD| \\
\cot\theta &= \frac{\text{adj}}{\text{opp}} \\
\sec\theta & \\
\csc\theta &
\end{aligned}
$$

Geometric interpretation of all trigonometric functions



$\beta = 180^\circ - 90^\circ - \theta$

$\angle OED = \mathbf{?}$

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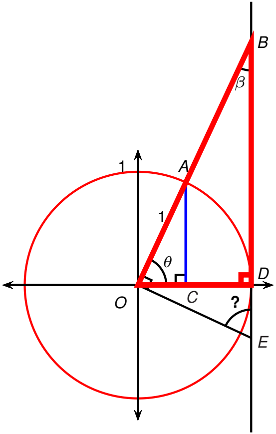
\cot\theta &= \frac{\text{adj}}{\text{opp}} \\
\sec\theta & \\
\csc\theta &
\end{aligned}$$

Geometric interpretation of all trigonometric functions



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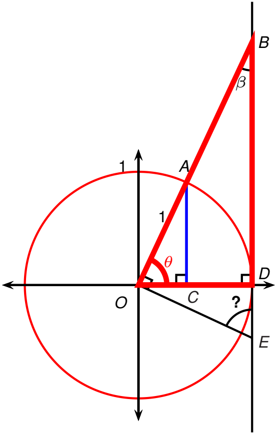
\sec\theta & \\
\csc\theta &
\end{aligned}$$

Geometric interpretation of all trigonometric functions



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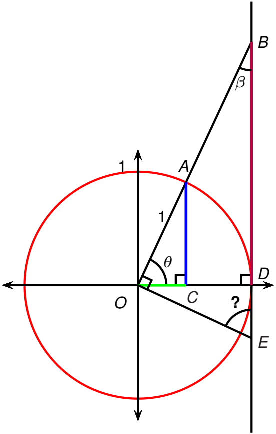
\cot\theta &= \frac{\text{adj}}{\text{opp}} \\
\sec\theta & \\
\csc\theta &
\end{aligned}
$$

Geometric interpretation of all trigonometric functions



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$= 90^\circ - \theta$

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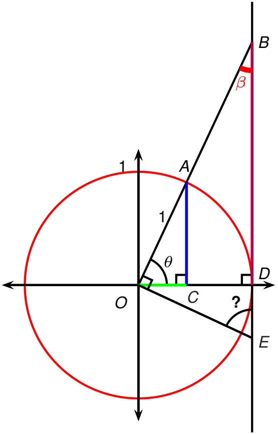
$$\cot\theta = \frac{\text{adj}}{\text{opp}}$$

$\sec\theta$

$\csc\theta$

Geometric interpretation of all trigonometric functions



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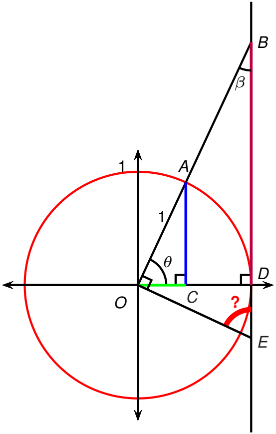
\cot\theta &= \frac{\text{adj}}{\text{opp}} \\
\sec\theta & \\
\csc\theta &
\end{aligned}$$

Geometric interpretation of all trigonometric functions



$$\begin{aligned}\beta &= 180^\circ - 90^\circ - \theta\\ &= 90^\circ - \theta\end{aligned}$$

$\angle OED =$ **?**

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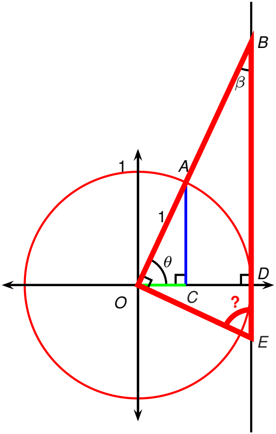
\tan\theta &= \frac{\text{opp}}{\text{adj}} = \frac{|BD|}{|OD|} = \frac{|BD|}{1} = |BD|\\
\cot\theta &= \frac{\text{adj}}{\text{opp}}\\
\sec\theta &\\
\csc\theta &
\end{aligned}$$

Geometric interpretation of all trigonometric functions



$$\beta = 180^\circ - 90^\circ - \theta$$
$$= 90^\circ - \theta$$
$$\angle OED = 180^\circ - 90^\circ - \beta$$

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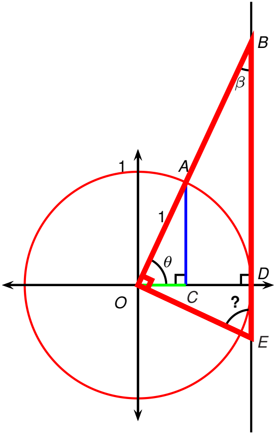
$$\sec\theta$$
$$\csc\theta$$

Geometric interpretation of all trigonometric functions



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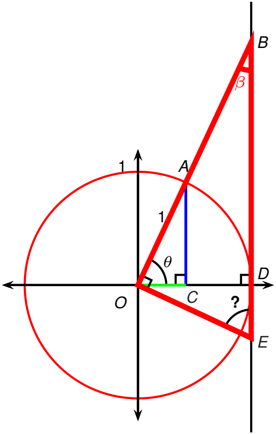
Geometric interpretation of all trigonometric functions



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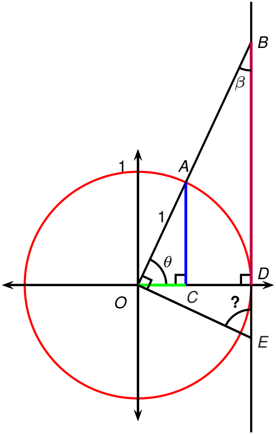

$$\begin{aligned}\beta &= 180^\circ - 90^\circ - \theta\\ &= 90^\circ - \theta\\ \angle OED &= {\color{red}180^\circ - 90^\circ} - \beta\\ &= {\color{red}90^\circ} - (90^\circ - \theta)\end{aligned}$$

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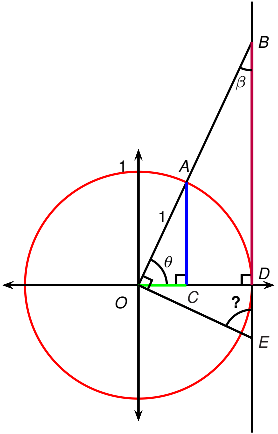

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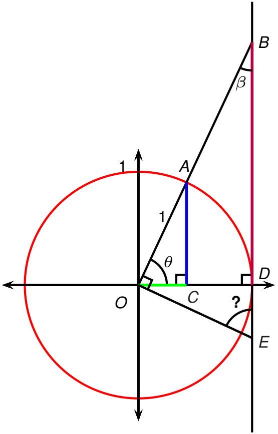

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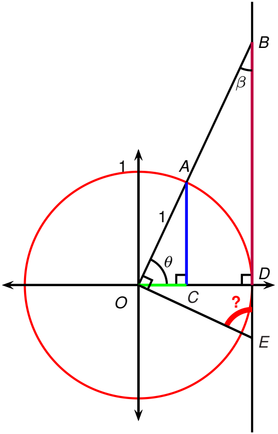

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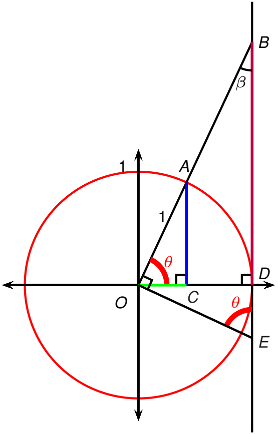

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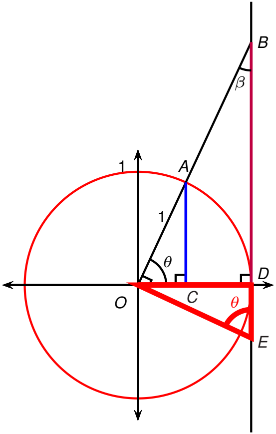

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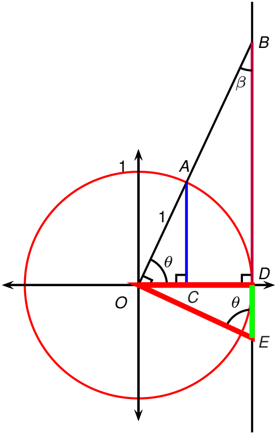
Geometric interpretation of all trigonometric functions



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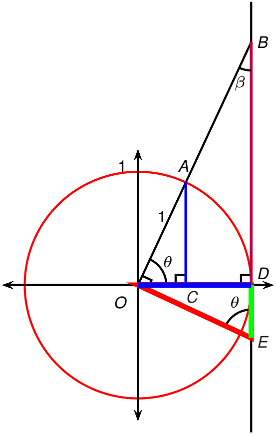

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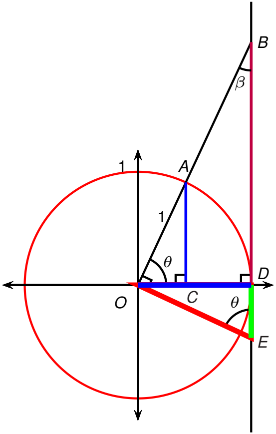

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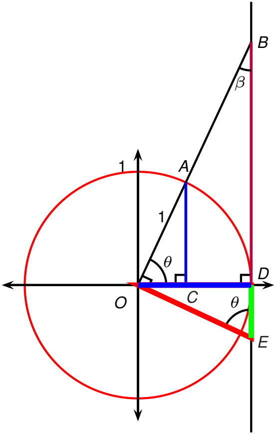

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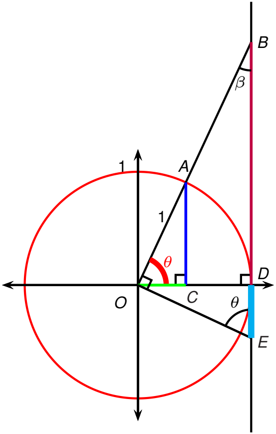

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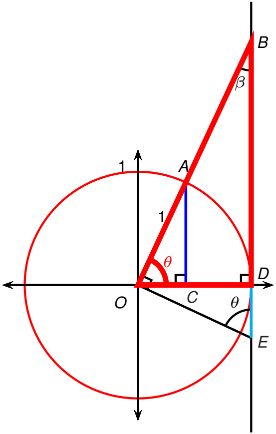

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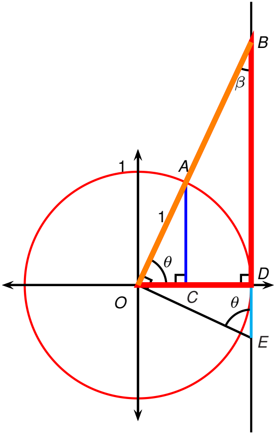

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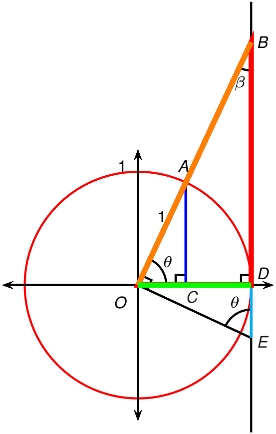
Geometric interpretation of all trigonometric functions



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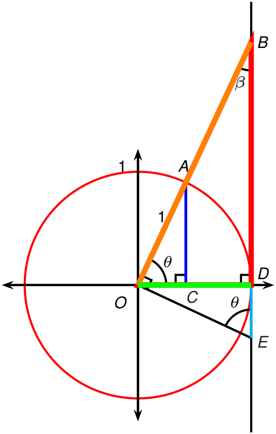
Geometric interpretation of all trigonometric functions



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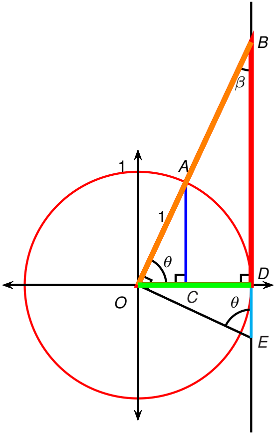
Geometric interpretation of all trigonometric functions



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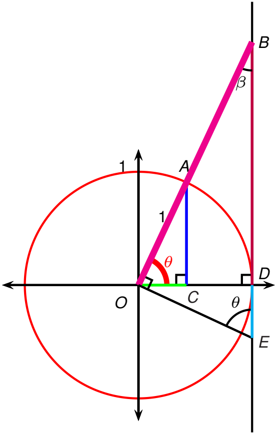
Geometric interpretation of all trigonometric functions



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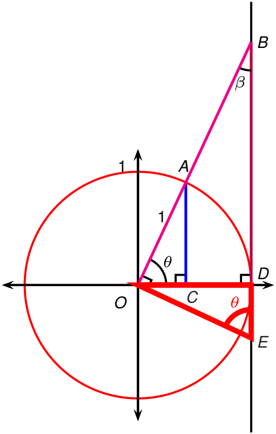
Geometric interpretation of all trigonometric functions



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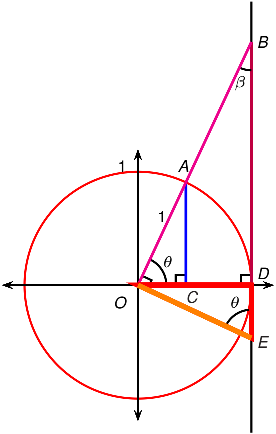
Geometric interpretation of all trigonometric functions



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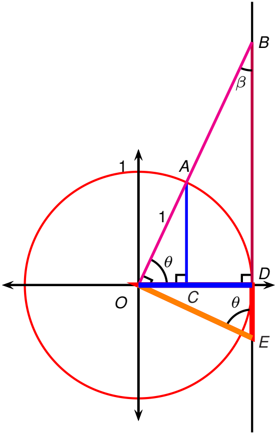

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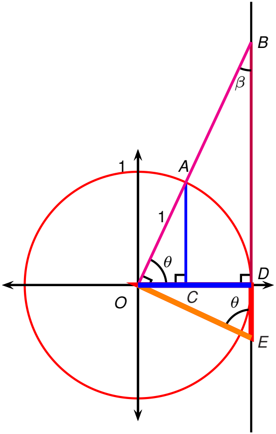

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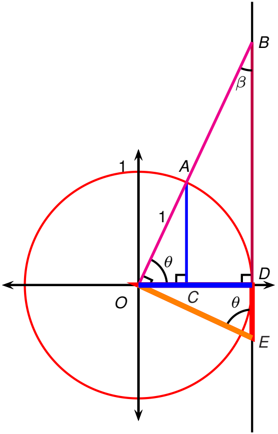

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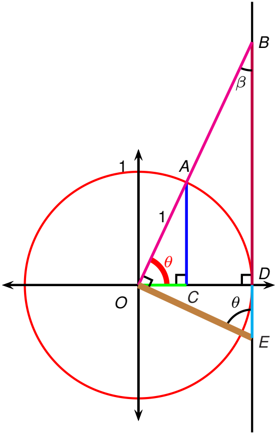

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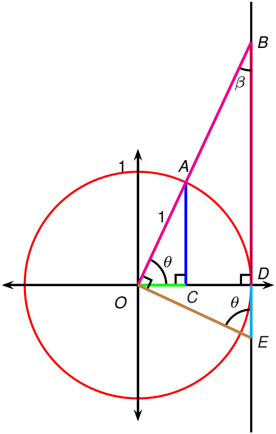

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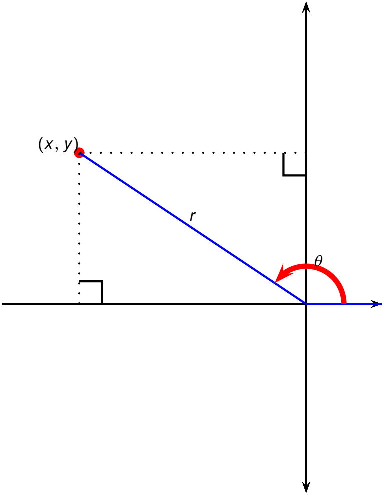

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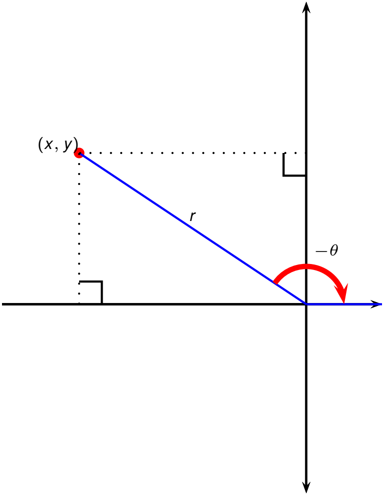
- Positive angles are obtained by rotating counterclockwise.



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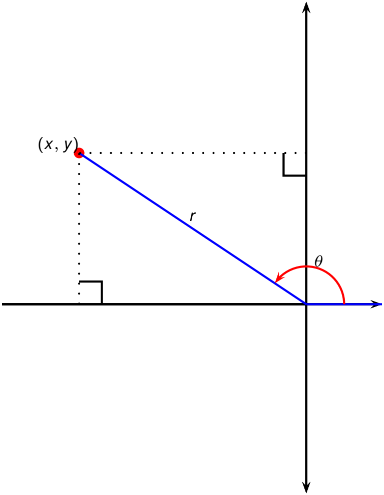

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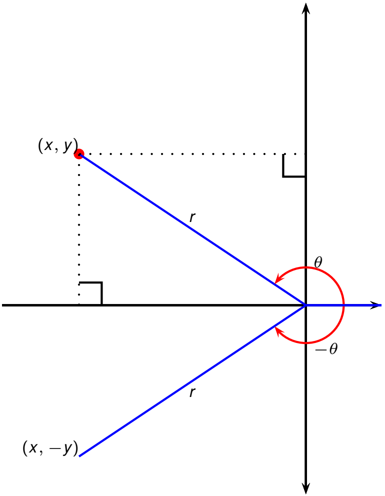

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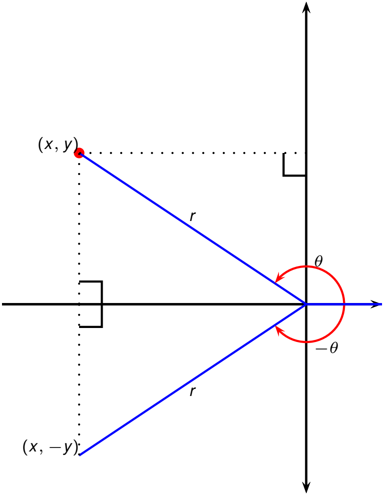

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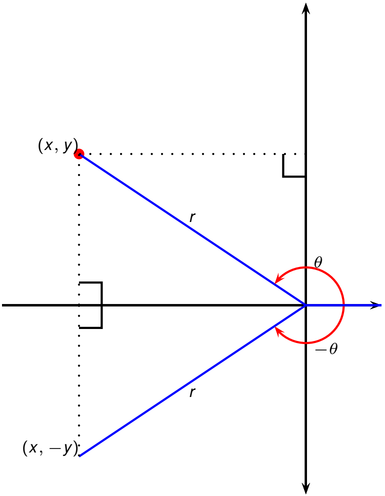

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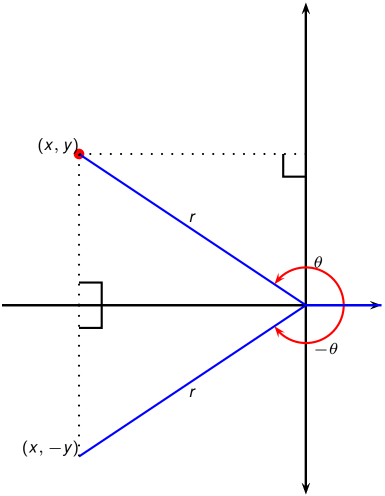

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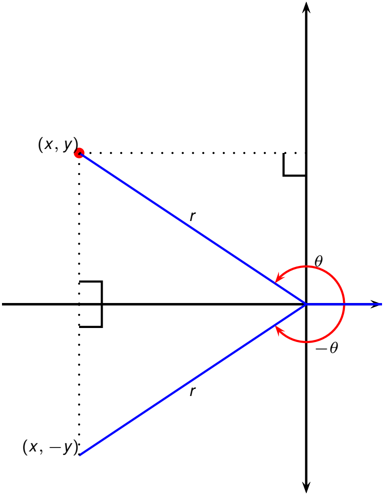

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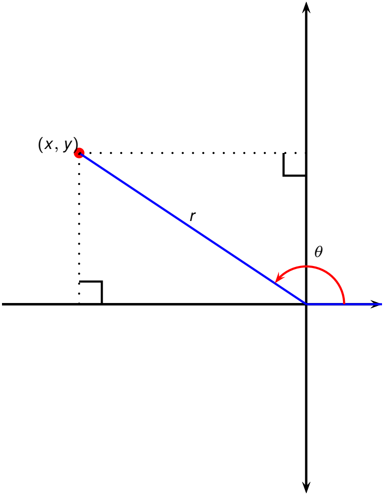

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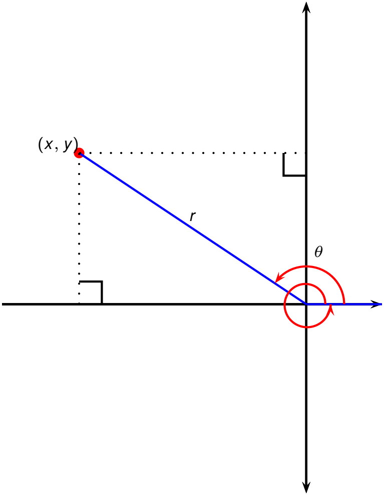

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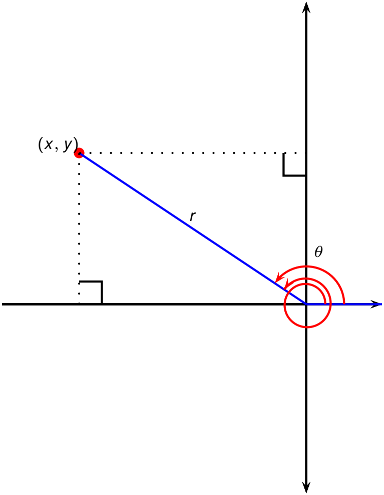

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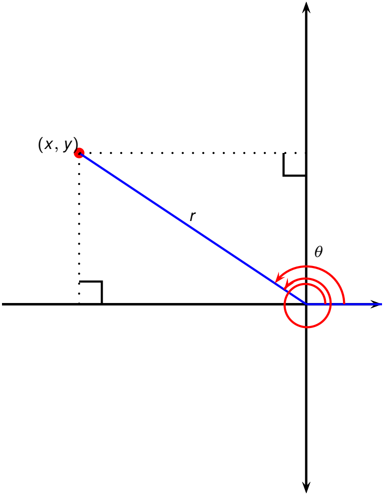

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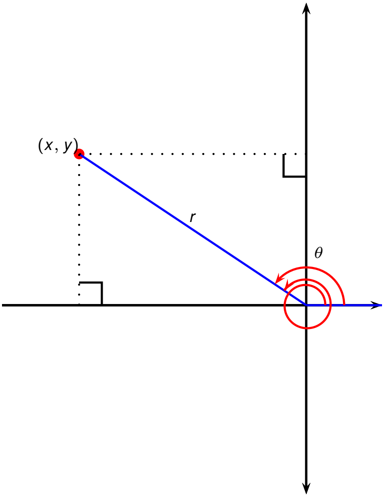

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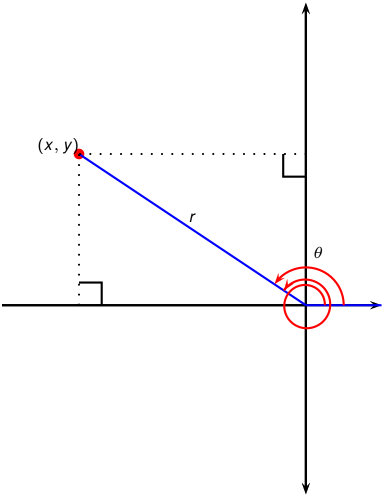

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- We say $\sin$ and $\cos$ are 2π-periodic.

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Definition (Trigonometric Identity)

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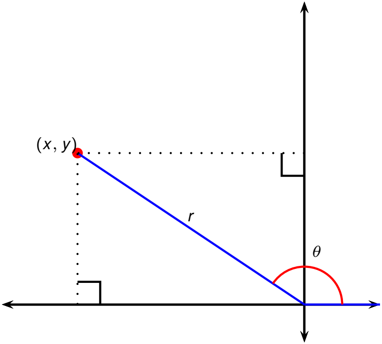
- By convention, when dealing with trigonometric identities we do not account for the domains of the involved expressions.
- For example, $\frac{\sin\theta}{\sin\theta} = 1$ is considered a valid trigonometric identity, although, when considered as a function, the left hand side is not defined for $\theta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



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- $\cot\theta = \dfrac{1}{\tan\theta}$
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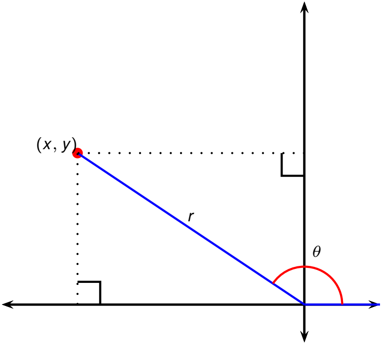

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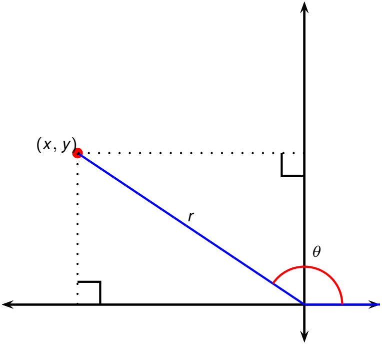
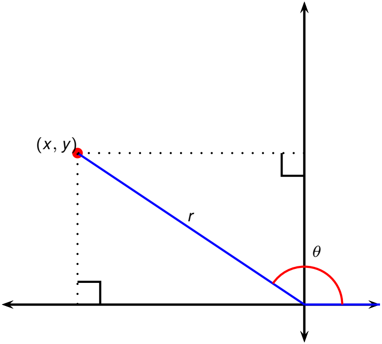


$$\begin{array}{ll} \sin\theta = \frac{y}{r} & \csc\theta = \frac{r}{y} \\ \cos\theta = \frac{x}{r} & \sec\theta = \frac{r}{x} \\ \tan\theta = \frac{y}{x} & \cot\theta = \frac{x}{y} \end{array}$$

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



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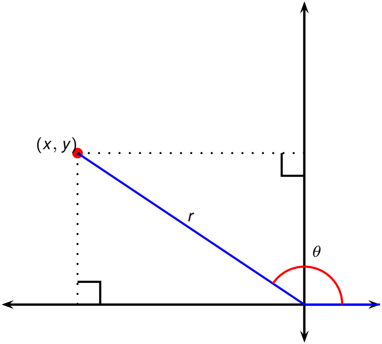

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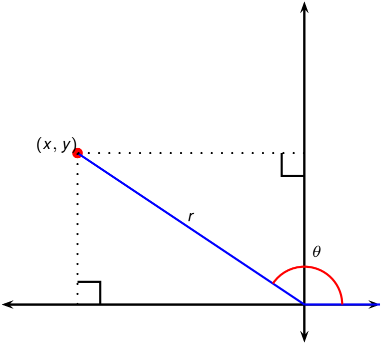

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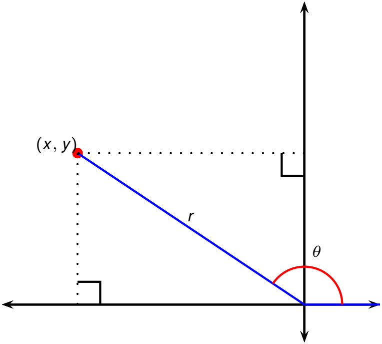
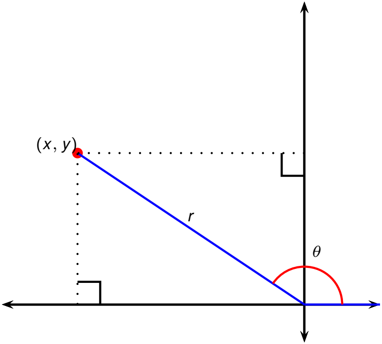
$$\begin{aligned} & \sin^2\theta + \cos^2\theta \\ = \quad & \frac{y^2}{r^2} + \frac{x^2}{r^2} \\ = \quad & \frac{y^2 + x^2}{r^2} \\ = \quad & \frac{r^2}{r^2} \end{aligned}$$



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

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



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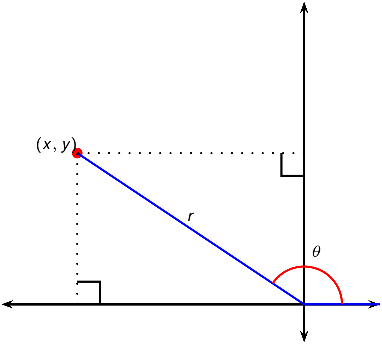
$$\begin{aligned} & \sin^2\theta + \cos^2\theta \\ = \ & \frac{y^2}{r^2} + \frac{x^2}{r^2} \\ = \ & \frac{y^2 + x^2}{r^2} \\ = \ & \frac{r^2}{r^2} \\ = \ & 1 \end{aligned}$$

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



$$\sin\theta = \frac{y}{r} \quad \csc\theta = \frac{r}{y}$$
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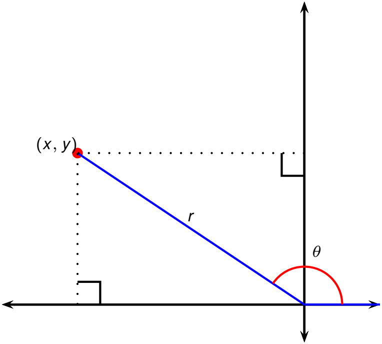
Example ($\tan^2\theta + 1 = \sec^2\theta$)

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



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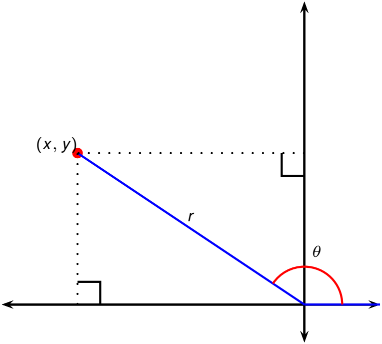
$$\tan\theta = \frac{y}{x} \quad \cot\theta = \frac{x}{y}$$

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

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

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



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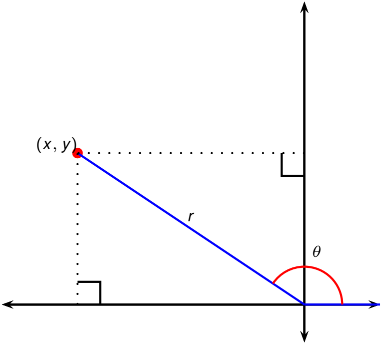
$$\tan\theta = \frac{y}{x} \quad \cot\theta = \frac{x}{y}$$

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

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

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



$$\sin\theta = \frac{y}{r} \quad \csc\theta = \frac{r}{y}$$
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Example ($\tan^2\theta + 1 = \sec^2\theta$)

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

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