Inverse Trig Functions

Objectives

1. Find the values of inverse trig functions
2. Find the values of the compositions of inverse trig functions
3. Write an algebraic expression for the compositions of inverse trig functions

Trig Functions and the Horizontal Line Test

Recall that for a function to have an inverse, any horizontal line can only hit the function at most once.

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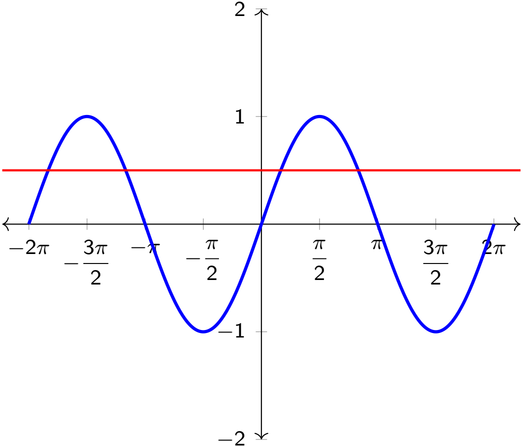
This creates a problem with periodic functions such as $y = \sin x$.

Graph of $y = \sin x$ and $y = \frac{1}{2}$



Passing the Horizontal Line Test

If we limit the graph to a smaller domain, then the Horizontal Line Test will demonstrate the function $y = \sin x$ will have an inverse:

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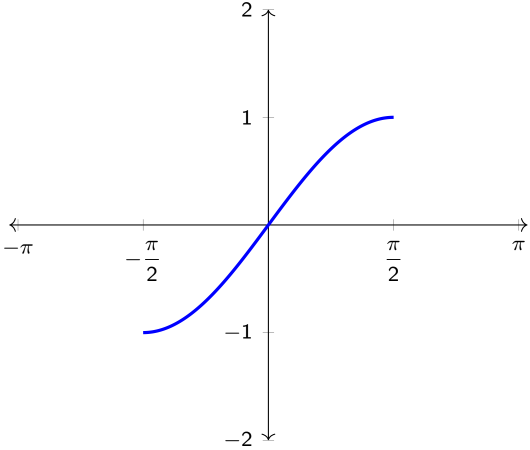

Graph of $y = \sin^{-1} x$

The inverse of $y = \sin x$ is

$$y = \sin^{-1} x \qquad \text{or} \qquad y = \arcsin x$$

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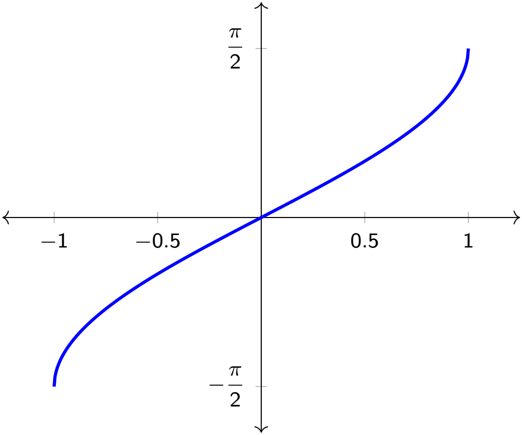

Domains and Ranges for Inverse Trig Functions

Inverse Function	Domain (Input)	Range (Output)

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$y = \csc^{-1} x$	$(-\infty, -1] \cup [1, \infty)$	$\left[-\frac{\pi}{2}, 0\right) \cup \left(0, \frac{\pi}{2}\right]$

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$y = \sec^{-1} x$	$(-\infty, -1] \cup [1, \infty)$	$\left[0, \frac{\pi}{2}\right) \cup \left(\frac{\pi}{2}, \pi\right]$

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$y = \cot^{-1} x$	$(-\infty, \infty)$	$(0, \pi)$

Example 1

Find the exact value of each.

(a) $\sin^{-1}\left(\frac{\sqrt{2}}{2}\right)$

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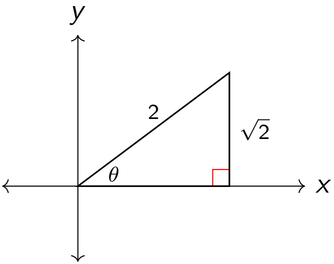

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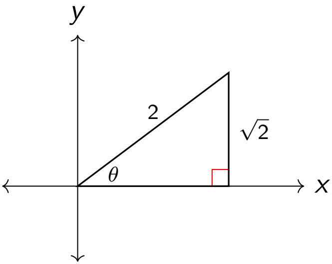

$$\theta = \sin^{-1}\left(\frac{\sqrt{2}}{2}\right)$$

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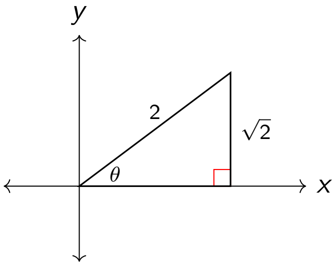

$$\theta = \sin^{-1}\left(\frac{\sqrt{2}}{2}\right)$$

$$\theta = 45^\circ$$

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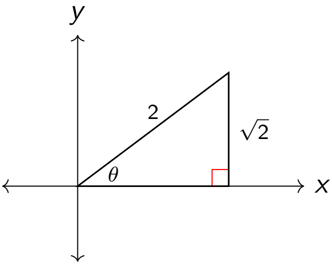

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$$\theta = \frac{\pi}{4}$$

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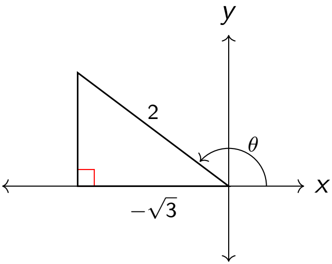

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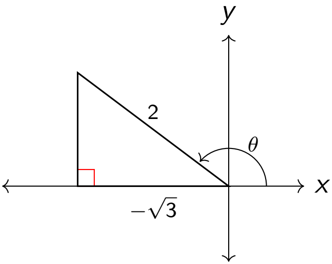

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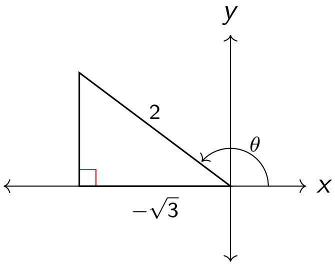

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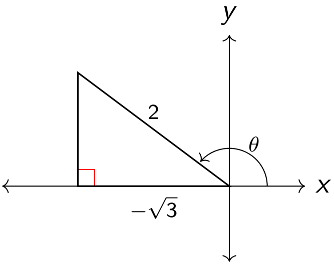

$$\theta = \cos^{-1}\left(\frac{-\sqrt{3}}{2}\right)$$

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$$\theta = -\frac{5\pi}{6}$$

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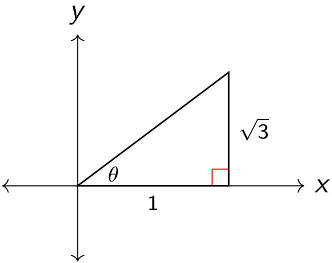

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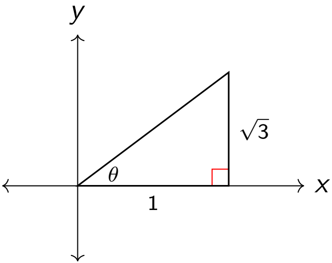

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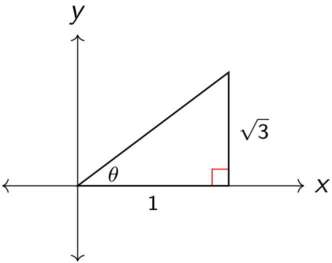

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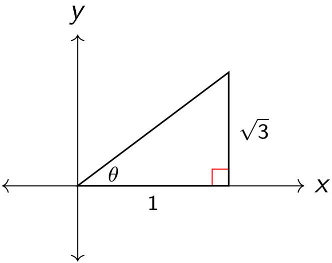

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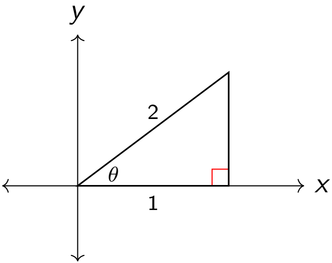

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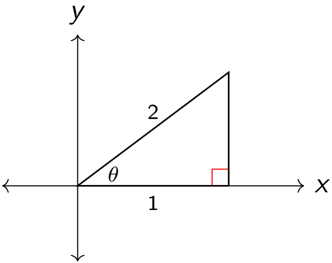

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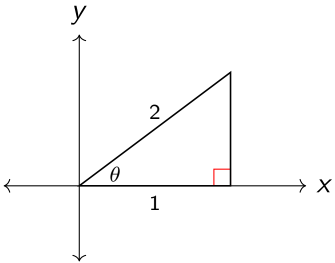

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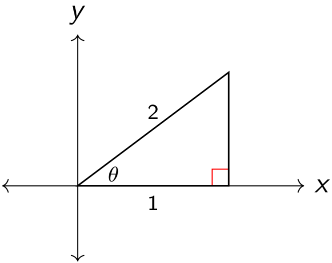

$$\theta = \sec^{-1}(2)$$

$$\theta = 60^\circ$$

$$\theta = \frac{\pi}{3}$$

Objectives

1. Find the values of inverse trig functions
2. Find the values of the compositions of inverse trig functions
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Compositions of Inverse Trig Functions

When dealing with problems like these, it helps to sketch a right triangle, much like in the previous example.

You may need to use the Pythagorean Theorem.

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Find the exact values of each (if possible).

(a) $\cos\left(\cos^{-1}\left(\frac{1}{3}\right)\right)$

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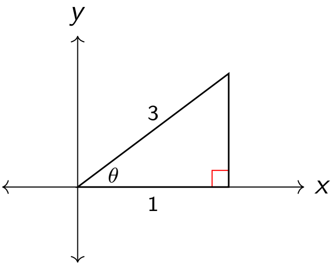

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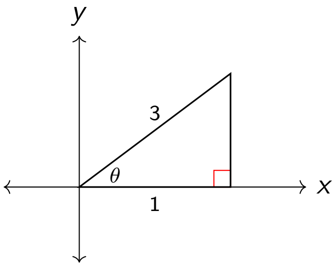

$$\theta = \cos^{-1}\left(\frac{1}{3}\right)$$

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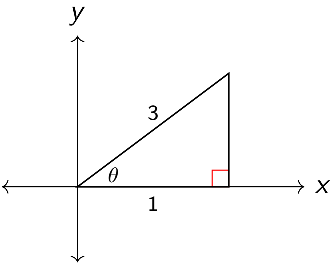

$$\theta = \cos^{-1}\left(\frac{1}{3}\right)$$

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

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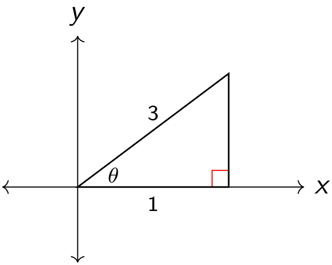

$$\theta = \cos^{-1}\left(\frac{1}{3}\right)$$

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(b) $\sin\left(\arcsin\left(-\frac{3}{7}\right)\right)$

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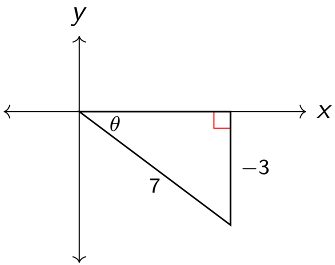

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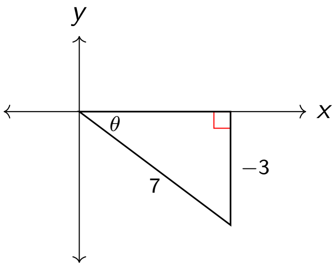

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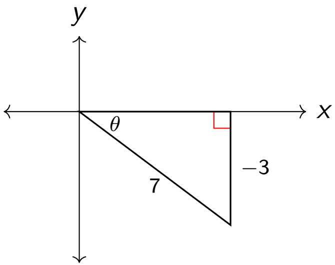

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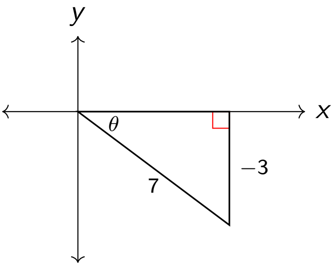

$$\theta = \arcsin\left(-\frac{3}{7}\right)$$

$$\sin\theta = \frac{y}{r}$$

$$\sin\theta = -\frac{3}{7}$$

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(c) $\cos\left(\arccos\left(\frac{5}{4}\right)\right)$

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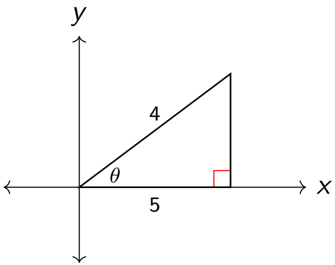

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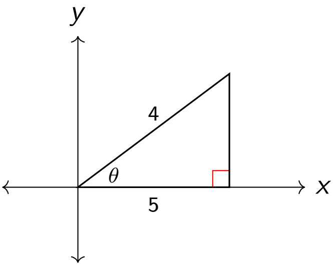
(c) $\cos\left(\arccos\left(\dfrac{5}{4}\right)\right)$



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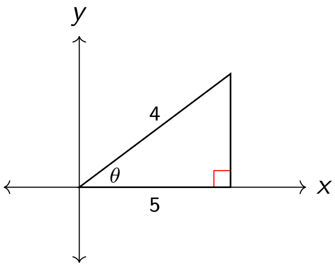

$$\theta = \arccos\left(\frac{5}{4}\right)$$

Domain error.

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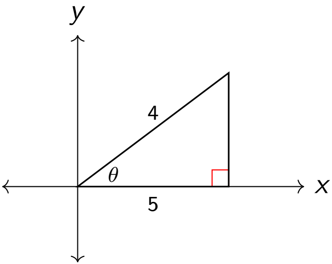

$$\theta = \arccos\left(\frac{5}{4}\right)$$

Domain error.

$\varnothing$

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(d) $\cos\left(\arctan\left(\frac{5}{12}\right)\right)$

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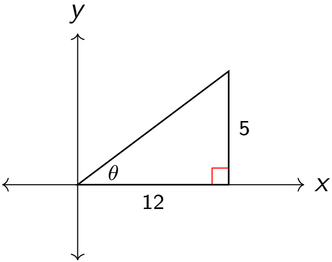

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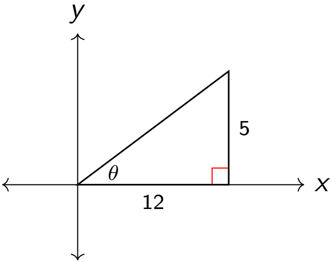

$$\theta = \arctan\left(\frac{5}{12}\right)$$

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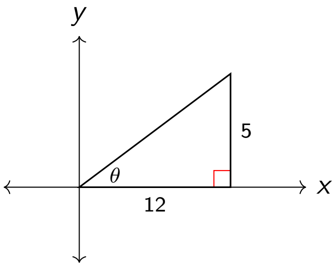

$$\theta = \arctan\left(\frac{5}{12}\right)$$

$$12^2 + 5^2 = r^2$$

Example 2

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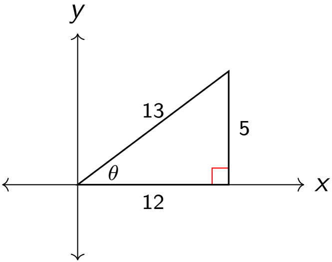

$$\theta = \arctan\left(\frac{5}{12}\right)$$

$$12^2 + 5^2 = r^2$$

$$r = \sqrt{169} = 13$$

Example 2

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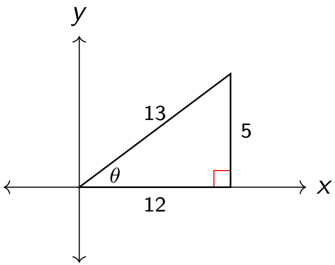

$$\theta = \arctan\left(\frac{5}{12}\right)$$

$$12^2 + 5^2 = r^2$$

$$r = \sqrt{169} = 13$$

$$\cos\theta = \frac{12}{13}$$

Example 2

(e) $\sin\left(\arctan\left(\frac{3}{4}\right)\right)$

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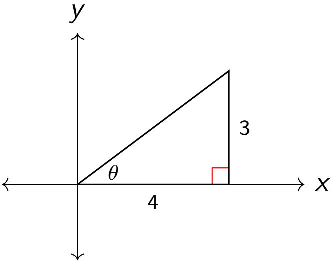

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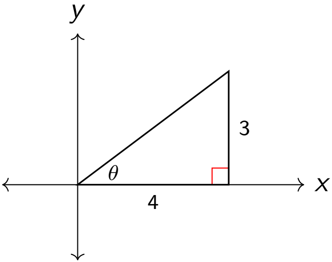

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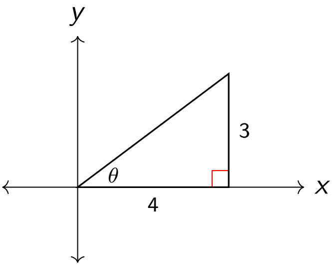
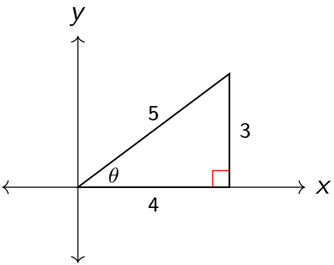


$$\theta = \arctan\left(\frac{3}{4}\right)$$

$$3^2 + 4^2 = r^2$$

Example 2

(e) $\sin\left(\arctan\left(\frac{3}{4}\right)\right)$



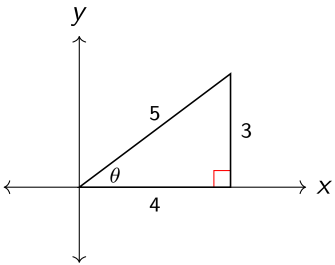
$$\theta = \arctan\left(\frac{3}{4}\right)$$

$$3^2 + 4^2 = r^2$$

$$r = \sqrt{25} = 5$$

Example 2

(e) $\sin\left(\arctan\left(\frac{3}{4}\right)\right)$



$$\theta = \arctan\left(\frac{3}{4}\right)$$

$$3^2 + 4^2 = r^2$$

$$r = \sqrt{25} = 5$$

$$\sin\theta = \frac{3}{5}$$

Example 2

(f) $\cot\left(\arcsin\left(-\frac{1}{3}\right)\right)$

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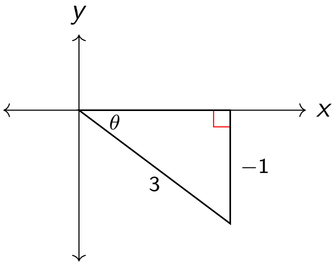

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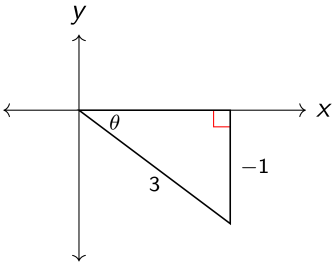

$$\theta = \arcsin\left(-\frac{1}{3}\right)$$

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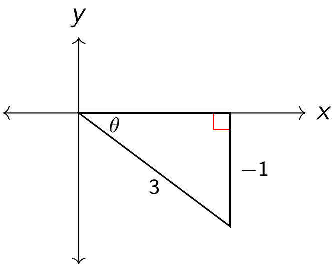

$$\theta = \arcsin\left(-\frac{1}{3}\right)$$

$$x^2 + 1^2 = 3^2$$

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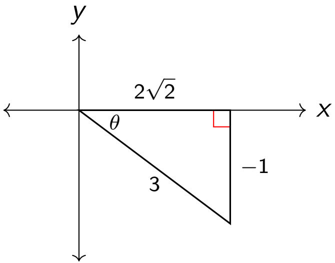

$$\theta = \arcsin\left(-\frac{1}{3}\right)$$

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$$x = \sqrt{8} = 2\sqrt{2}$$

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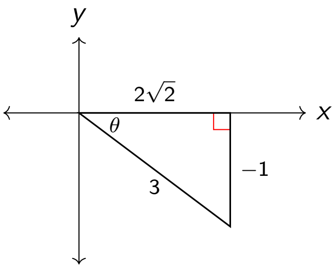

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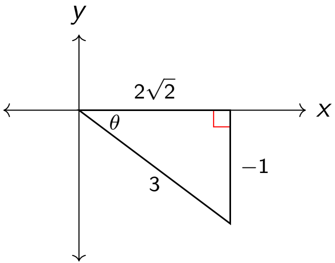

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$$\cot\theta = \frac{x}{y}$$

$$\cot\theta = \frac{2\sqrt{2}}{-1} = -2\sqrt{2}$$

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(g) $\sec\left(\arccos\left(\dfrac{3}{4}\right)\right)$

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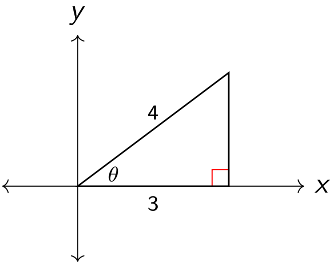

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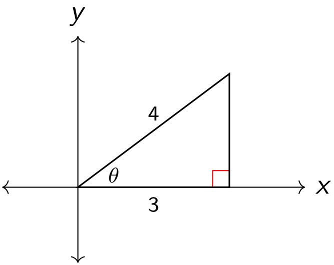

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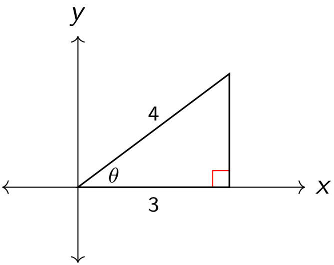

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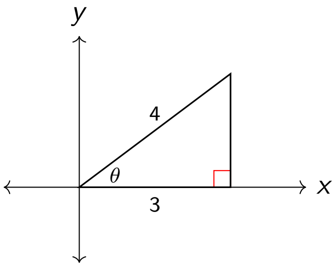

$$\theta = \arccos\left(\frac{3}{4}\right)$$

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$$\sec\theta = \frac{4}{3}$$

Objectives

1. Find the values of inverse trig functions
2. Find the values of the compositions of inverse trig functions
3. Write an algebraic expression for the compositions of inverse trig functions

Algebraic Inverse Trig

In calculus, inverse trigonometric functions will be expressed algebraically (i.e. in terms of x).

Set up a right triangle and use the Pythagorean Theorem to write the missing side in terms of x.

Example 3

Write each as an algebraic expression of x.

(a) $\cos\left(\sin^{-1} x\right)$

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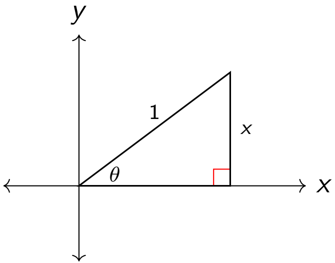

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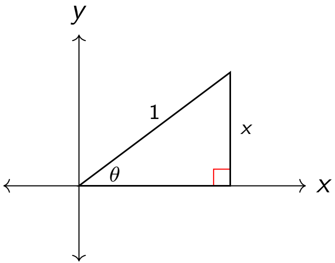

$\theta = \arcsin(x)$

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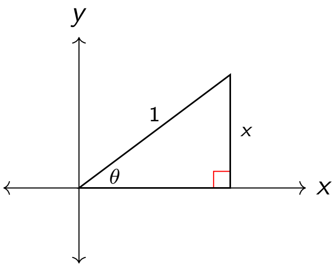

$$\theta = \arcsin(x)$$

$$a^2 + x^2 = 1^2$$

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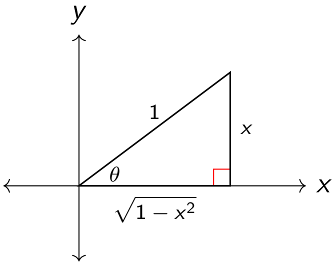

$$\theta = \arcsin(x)$$

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$$a = \sqrt{1-x^2}$$

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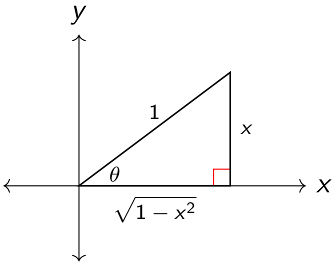

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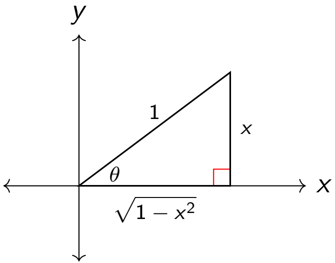

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(b) $\sec\left(\tan^{-1} x\right)$

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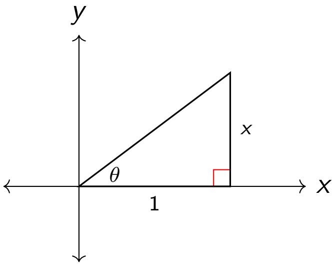

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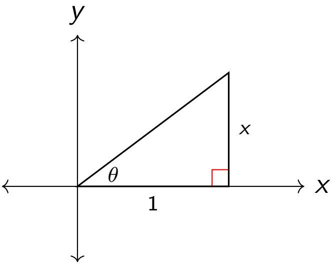

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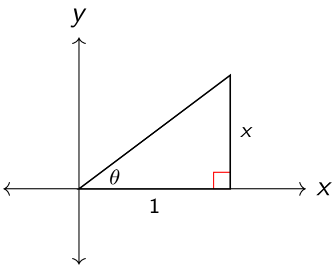

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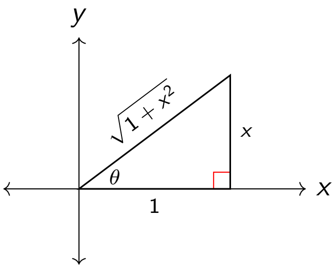

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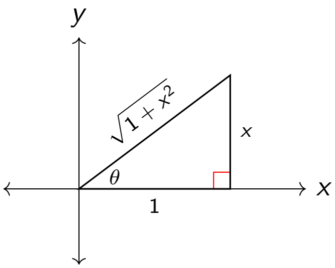

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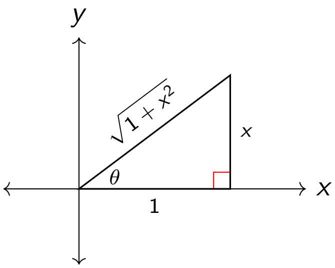

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$$\sec\theta = \frac{\sqrt{1+x^2}}{1} = \sqrt{1+x^2}$$

Example 3

(c) $\tan\left(\sin^{-1}(2x)\right)$

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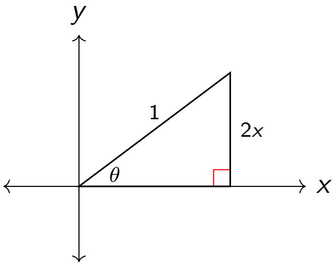

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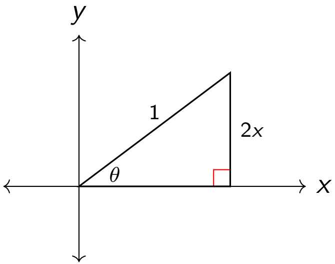

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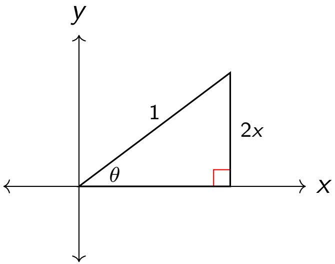

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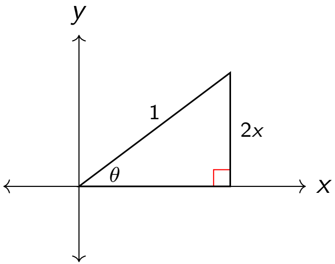

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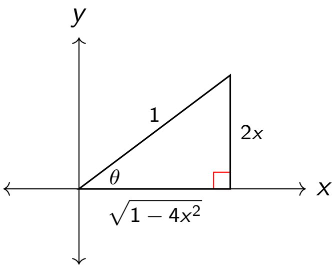

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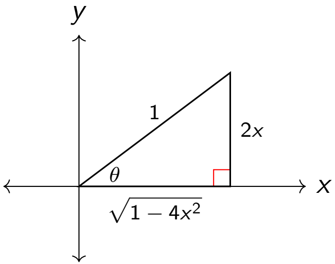

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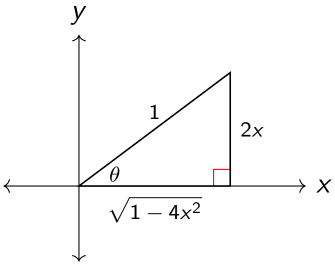

$$\tan\theta = \frac{\text{opp}}{\text{adj}}$$

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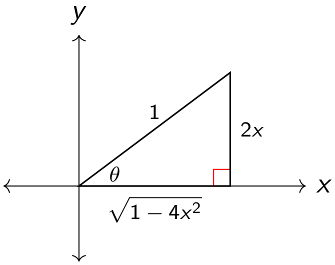

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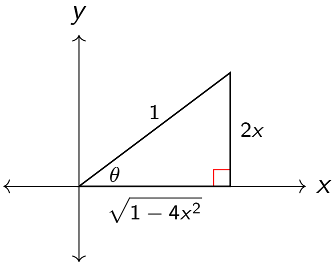

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$$\tan\theta = \frac{2x}{\sqrt{1-4x^2}}$$

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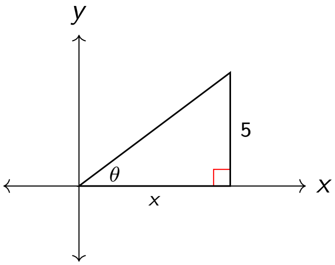

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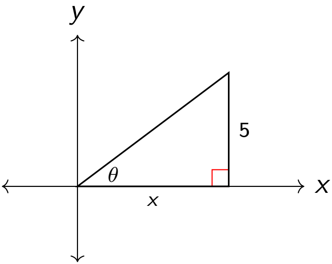

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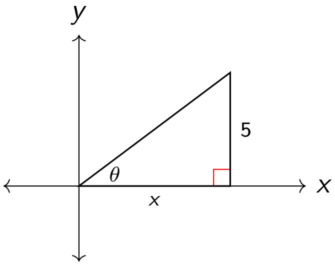

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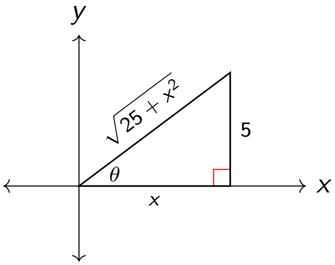

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$$c = \sqrt{25 + x^2}$$

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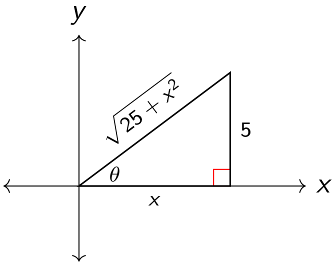

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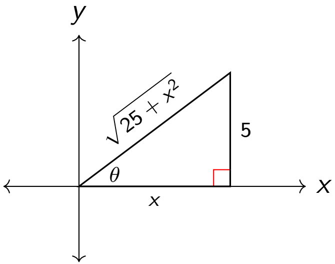

$$\sec\theta = \frac{\text{hyp}}{\text{adj}}$$

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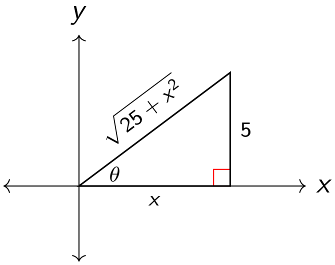

$$\sec\theta = \frac{\text{hyp}}{\text{adj}}$$

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