Ah, Doom. Truly a product of its age, when games were games and first-person shooters were all about action. Doom was limited by its technology, but that didn’t stop it from being a masterpiece that changed the face of gaming forever.

Doom came well before the advent of fully three-dimensional games. Instead of 3D models, Doom used sprites to represent characters in the game world. These sprites would change depending on the angle that you viewed them from, giving the illusion that you’re walking around a three-dimensional object. How could they have pulled off this effect? Well, I’m here to talk about one possible solution.

Math is an important part of game development. So, before we can talk about Doom, first we have to talk about trigonometry.

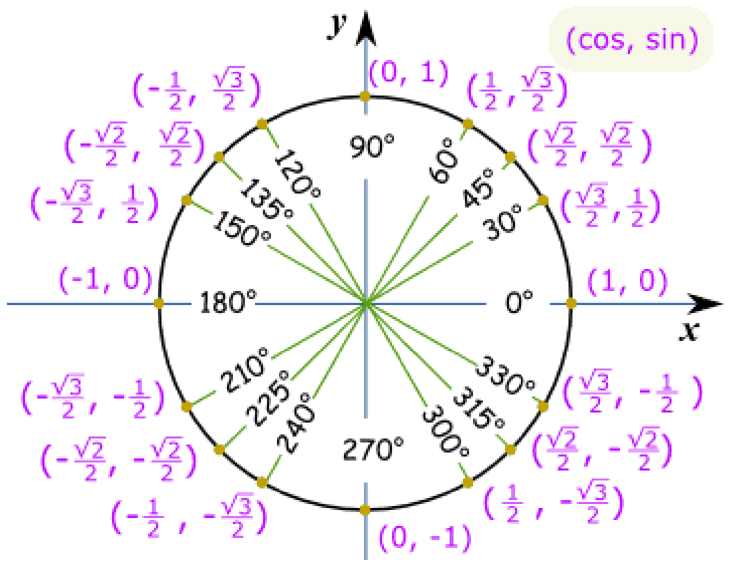
Trigonometry may sound big and scary, but all it really is is a way of looking at angles. That’s a simplification if there ever was one, but for now we’ll just be sticking to the very basics.

Trigonometry says that every angle has two values associated with it: the sine and the cosine. While two angles may have the same sine or the same cosine, the combination of the two will always be unique.
For example, 45 degrees and 135 degrees have the same sine, but the cosine of 45 degrees is positive; the cosine of 135 degrees is negative.

If you combine these two values, you get the ratio of the sine to the cosine: the tangent. The tangent is unique for every possible angle between 0 and 360 degrees.

Sine ÷ Cosine = Tangent

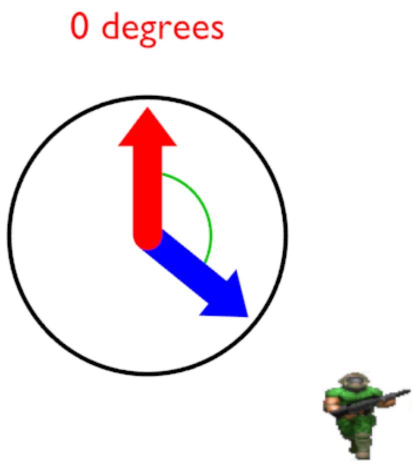
All of this can be laid out in a diagram called the Unit Circle, which lays out angles from 0 to 360 degrees and lists the value of their sines, cosines and sometimes tangents as well. Related to this are the inverse functions: given a sine, the inverse sine function will tell you which angle has that sine. Same for the cosine and inverse cosine function, as well as the tangent and the inverse tangent function.



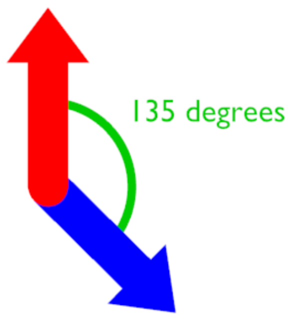
(cos, sin)
y
x
(0, 1)
$(\frac{1}{2}, \frac{\sqrt{3}}{2})$
$(\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2})$
$(\frac{\sqrt{3}}{2}, \frac{1}{2})$
(1, 0)
$(\frac{\sqrt{3}}{2}, -\frac{1}{2})$
$(\frac{\sqrt{2}}{2}, -\frac{\sqrt{2}}{2})$
$(\frac{1}{2}, -\frac{\sqrt{3}}{2})$
(0, -1)
$(-\frac{1}{2}, -\frac{\sqrt{3}}{2})$
$(-\frac{\sqrt{2}}{2}, -\frac{\sqrt{2}}{2})$
$(-\frac{\sqrt{3}}{2}, -\frac{1}{2})$
(-1, 0)
$(-\frac{\sqrt{3}}{2}, \frac{1}{2})$
$(-\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2})$
$(-\frac{1}{2}, \frac{\sqrt{3}}{2})$
90°
60°
45°
30°
0°
330°
315°
300°
270°
240°
225°
210°
180°
150°
135°
120°

The Unit Circle

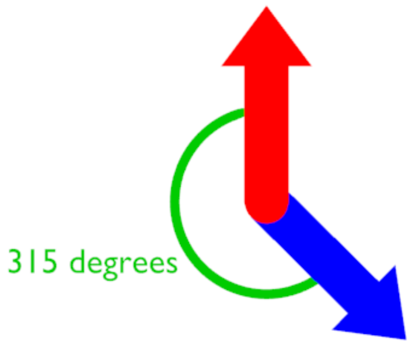
If we set the forward direction of our enemy as the starting angle (0 degrees) and use an inverse function to find the angle between our hero and the enemy, we can tell what image we need to be showing for any given angle.



I imagine you have a question right now. 'Why do we need all that about trigonometry? Wouldn't it be simpler to have the computer check the angle for us?' You're right about one thing: efficiency is always a good thing when designing a computer program, especially a video game. But there's a problem with that solution: *Your computer is actually kind of bad at trigonometry.* For example, take this angle:



Is it really 135 degrees? If you simply had the computer calculate this angle using the inverse tangent function, it would say yes: this angle is 135 degrees. However, in our system, we need the computer to realize that this is actually *315* degrees, not 135. Using basic trig functions, your computer will only ever return an angle between 0 and 180 degrees.



Why does it do that? Shouldn't a computer be better at math? Well, let's take a closer look at the tangent.

I said earlier that the tangent is the sine divided by the cosine. What makes the difference between the tangent of 135 degrees and the tangent of 315 degrees is the sign of these values.

Let’s take a scenario. Say we have two fractions:

$$-\frac{\sqrt{2}}{2} \qquad \frac{\sqrt{2}}{-2}$$

<u>These aren’t actual tangent values, but let’s pretend for the sake of this explanation.</u>

When you tell your computer (or calculator, or any other digital math tool) to perform an operation on these fractions, it will simplify both of them to the same value, which is correct in basic arithmetic. However, *<u>this is incorrect for the purposes of trigonometry.</u>*

$$-\frac{\sqrt{2}}{2} \neq \frac{\sqrt{2}}{-2}$$

The presence and position of the minus sign is significant. If an angle has a positive sine and a negative cosine, that angle is different from one which has a negative sine and a positive cosine. However, if you were to put the tangent of that angle into your calculator, it would simplify the value so that the angle returned is between 0 and 180 degrees.

NOT FINISHED BECAUSE I’M LAZY AND LAAAAME