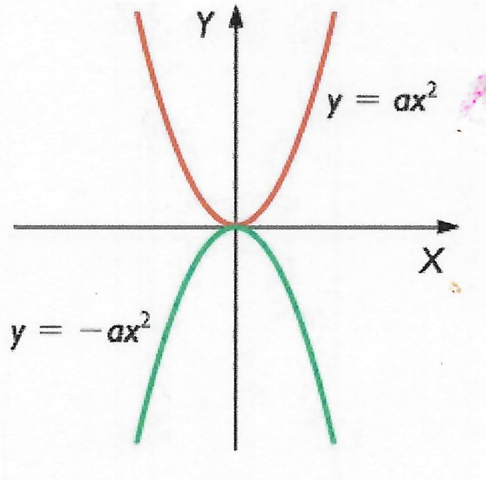
Modeling a Crescent Kick:

An Application of Mathematics in Martial Arts

by Michael O'Leary

A parabola is a type of curve formed by graphing a quadratic equation. A quadratic equation is an equation of the form $y=ax^2+bx+c$ where a, b, and c are real constants and a does not equal 0. However, parabolas also show up in physics. Any projectile that is launched will follow the path of the parabola. Most kicks in Tae-Kwon-Do do not follow this pass because they are not bound by gravity as most projectiles are. However, due to the unique course of a crescent kick, it is possible to approximate the quadratic model of this kick.

But first, let's take a closer look at parabolas. The two most basic examples of a parabola are $y=x^2$ and, more importantly for this particular project, $y=-x^2$.



The vertex of a quadratic equation is the point at which if you draw a vertical line through it, the two halves of the parabola appear to be mirror images of each other. The x value of the vertex is equal to $-b/2a$. The y value of the vertex is the value of y when $x=-b/2a$.

To find the model of a set of data that can be modeled with a quadratic equation, you need three points. It is easier to model this data, however, if you have one or both of two special points. One of these is the vertex. The other is the y-intercept. The y intercept is the point at which $x=0$.

Now we actually get to model the data. The first point of data happens to be the vertex and the y intercept. The point (0,62.5), derived from the fact that I am 5 ft. 2.5 in. tall, which in turn is 62.5 in. tall. For convenience, we assign the x value as 0. Since this is the highest point of the arc of a crescent kick, by definition, it is also the vertex. Since the vertex is a maximum value, we can also infer that a is a negative value. The second point is (16.25,0). I got this because at the end of the crescent kick, my foot ended up 1 ft 4.25 in. away from the axis of symmetry. This becomes 16.25 in. For convenience, we set the y value as 0. The last point I didn't even have to measure for. Since a point that was not the vertex was (16.25,0) we can surely say that another point is (-16.25,0). Now we have three points, which we can use to find the quadratic equation that models the kick. Substituting the x and y values in, we get the three equations…

$62.5=0a+0b+c$ or $62.5=c$

$0=264.0625a+16.25b+c$

$0=264.0625a-16.25b+c$

We now know the value of c, so we can therefore narrow it down to two equations…

$0=264.0625a+16.25b+62.5$

$0=264.0625a-16.25b+62.5$

Now if we subtract 62.5 from both sides we get…

$-62.5=264.0625a+16.25b$

$-62.5=264.0625a-16.25\ b$

Since both of the quantities on the right side of the equations are equal to

-16.25, we can equate them to each other.

$264.0625a+16.25b=264.0625-16.25b$

Now, if we add 16.25b to both sides...

$264.0625a+32.5b=264.0625a$

Now subtracting 264.0625a from both sides…

$32.5b=0$

Now dividing both sides by 32.5 we obtain the value of b…

$b=0$

But we are not done yet, we substitute the values of b and c into one of the primary equations…

$0=264.0625a+62.5$

Then, we subtract 62.5 from both sides…

$-62.5=264.0625a$

And then divide both sides by 264.0625…

$-0.2367\approx a$

So now we know the values of all three constants, so we can find the equation of the crescent kick to be

$y\approx-0.2367x^2+0x+62.5$

Or the more simplified version…

$y\approx-0.2367x^2+62.5$

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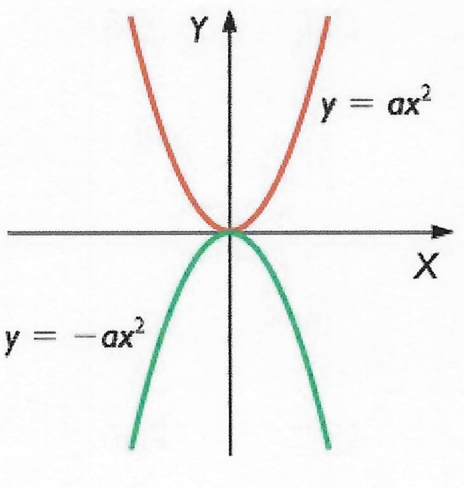

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