Parent function: \( y = x^2 \)

Vertex form: \( y = a(x - h)^2 + k \)

Vertex: \((h, k)\)

Just as our other functions, the x-element of the vertex translates the parabola horizontally left or right. The y-element translates the parabola vertically up or down.

**Note:** While we like to graph using the calculator, using the vertex form in some cases may even be faster than using a graphing calculator.

<table>
<thead>
<tr>
<th>When ( y = x^2 ) or ( y = a(x - h)^2 + k ):</th>
<th></th>
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</thead>
</table>
| 1. \( y = -ax^2 \) | reflection across the x-axis (flips upside down)  
*Negative is a sad face.* |
| 2. \( a > 1 \) | the graph stretches (gets skinny) |
| 3. \( 0 < a < 1 \) (a fraction) | the graph will shrink (gets broad or wide) |
| 4. \( h > 0 \) or \( h < 0 \)  
*remember the equation form!*  
\((x - h)^2\) | positive \( h \) shift right  
negative \( h \) graph shifts left |
| 5. \( k > 0 \) or \( k < 0 \) | positive \( k \) shift up  
negative \( k \) shift down |
| 6. \text{vertex} = (h, k) |  |
| 7. axis of symmetry: line \( x = h \) |  |

Graph each equation, notice what happens with \( k \):

- \( y = x^2 + 3 \)
- \( y = x^2 \)
- \( y = x^2 - 5 \)
graph each equation, notice what happens with $h$:

\[
y = (x + 3)^2
\]
\[
y = x^2
\]
\[
y = (x - 5)^2
\]

**Translation:**

**Graph:** $f(x) = (x - 2)^2 + 3$

The vertex is:

Notice that the graph has both a vertical and a horizontal shift. The graph moves ________2 units and ________3 units.

**Reflection:**

**Graph:** $g(x) = -(x - 2)^2 + 3$?

The vertex is:

This is called a reflection along the horizontal axis. We can generalize by saying that any quadratic equation with a negative sign in front of the $x^2$ term will open downward or be upside down.

**Leading Coefficient:**

**Graph** $y = 3x^2$

Notice the effect of a number in front of a quadratic equation: the graph got skinnier (compressed).

**Graph** $y = \frac{1}{4}x^2$,

The graph gets fatter (stretches).

In general, if the constant, "a", is larger than 1 the graph will get skinny.

For values between 0 and 1 the graph will get wider.
Write an equation of a parabola in vertex form from a graph

Graph, state domain and range

\[ y = 2(x + 1)^2 - 4 \]

\[ y = \frac{1}{2}(x - 2)^2 + 3 \]

Convert an equation to vertex form:

\[ y = -3x^2 + 12x + 5 \]

\[ y = x^2 - 8x + 21 \]