# 2.1.1 How can I graph it?

## Transforming Quadratic Functions

In a previous course, you developed several tools that enabled you to transform graphs of parabolas by altering their equations. In this lesson, you will review transformations of functions and review how to sketch graphs of quadratic functions.

Brain Dump:

$$f(x) = a(x-h)^2 + k$$

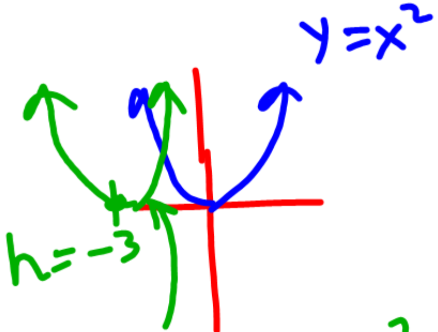
**2-1.** TRANSFORMING PARABOLAS

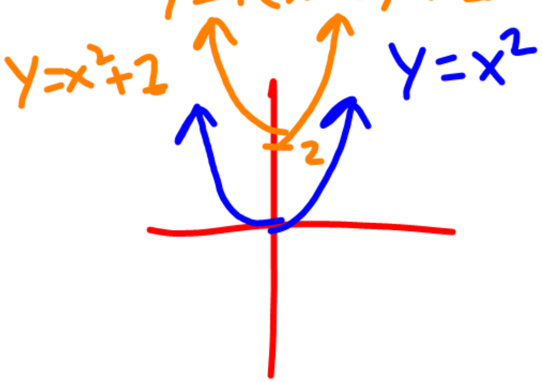
Use your graphing tool or Transforming Parabolas (Desmos) to investigate the impact of the **parameters**, $a$, $h$, and $k$, in the graphing form of a quadratic function $\boxed{y = a(x - h)^2 + k}$:

Click in the lower right corner of the graph to view it in full-screen mode. Desmos Accessibility

- Which parameter translates the graph of $y = x^2$ horizontally (right or left)? What values of the parameter translate $y = x^2$ to the left? To the right?
  $+h$ $h$ $-h$
- Which parameter stretches or compresses the graph of $y = x^2$ vertically? What values of the parameter stretch the graph? What values compress the graph?
  $0<|a|<1$ $a$ $|a|>1$
- What values of which parameter will reflect the graph of $y = x^2$ across the $x$-axis?
  $-a$
- Which parameter translates the graph of $y = x^2$ vertically (up or down)? What values of the parameter translate $y = x^2$ up? Down? Why?
  $k$ $+k$ $-k$
- Are there any points on the graph of a parabola that have a connection to specific parameters in the equation? Explain.

$y=1(x-0)^2+2$




$y=a(x-h)^2+k$

$\boxed{\text{Vertex: } (h,k)}$

$y=1(x--3)^2+0$

$y=(x+3)^2$

Shift 3

**2-2.** For each quadratic function below, predict the coordinates of the vertex, the orientation (whether it opens up or down), and whether the graph will be a vertical stretch or a compression of $y = x^2$. Do not use a graphing calculator. Make a sketch based on your predictions. How can you make an accurate graph without using a table? Be prepared to share your strategies with the class.

$1(x - -9)^2 + 0$

a. $y = (x + 9)^2$ $(-9, 0)$

b. $y = x^2 + 7$

c. $y = 3x^2$

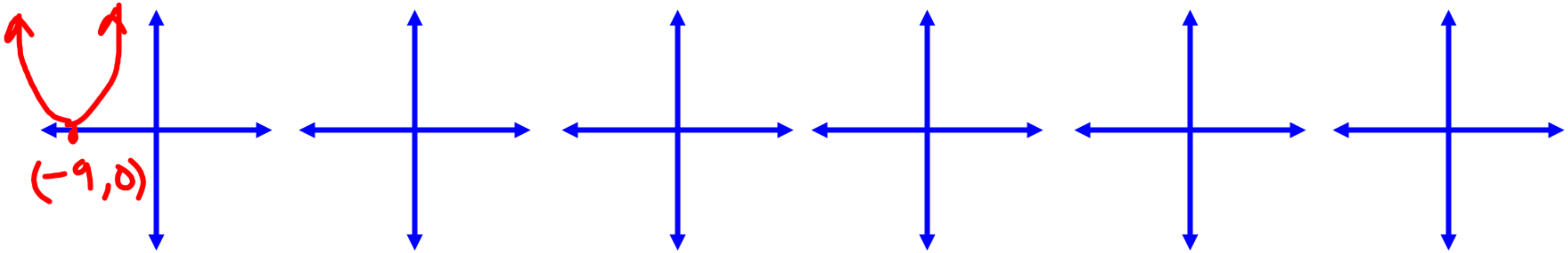
d. $y = \frac{1}{3}(x - 1)^2$

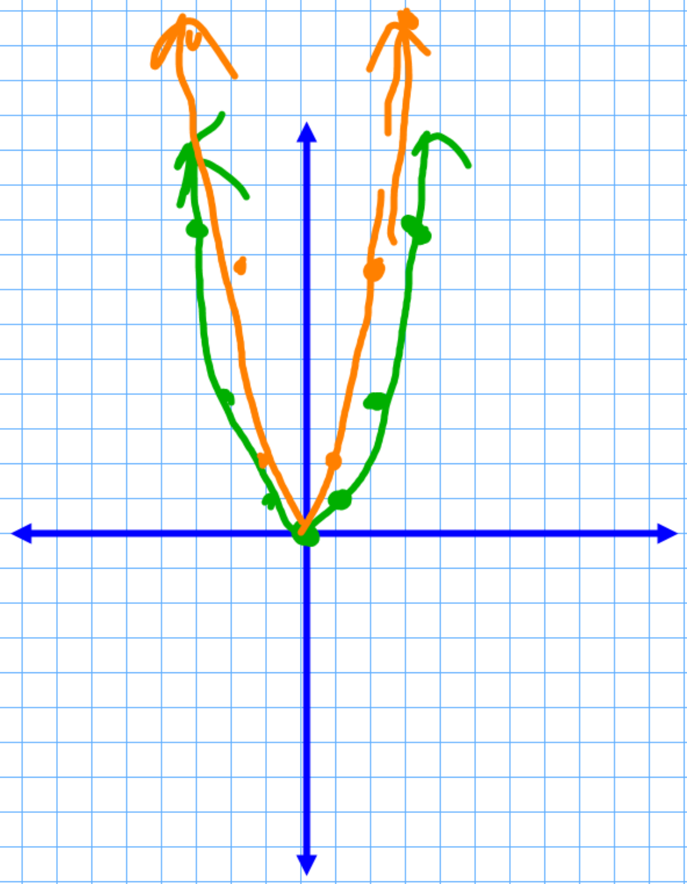
e. $y = -(x - 7)^2 + 6$

f. $y = 2(x + 3)^2 - 8$

g. Use your graphing tool to check your predictions for the functions in parts (a) through (f). How accurate were your predictions? Did you make any mistakes? If so, describe the mistakes and what you need to do to correct them.

h. What information did you need to make a sketch without using a table?

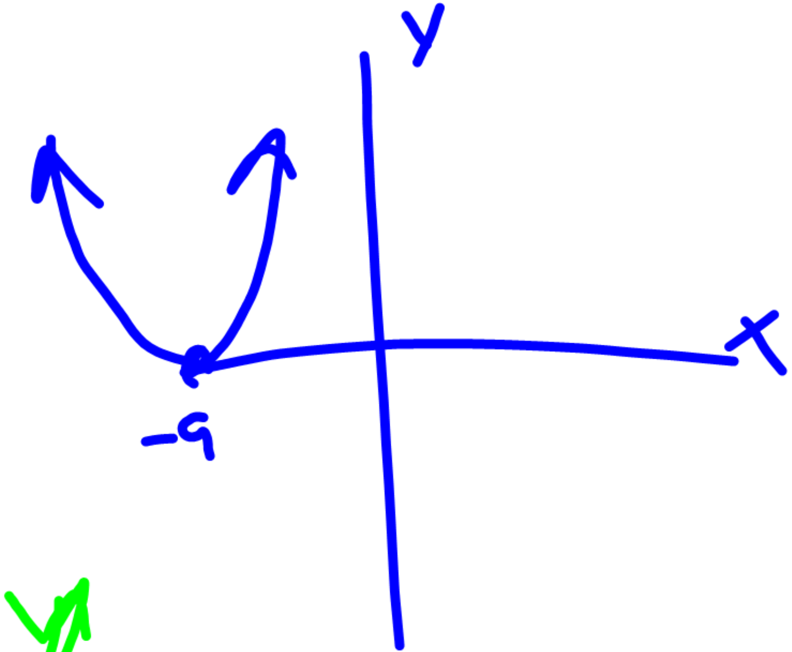




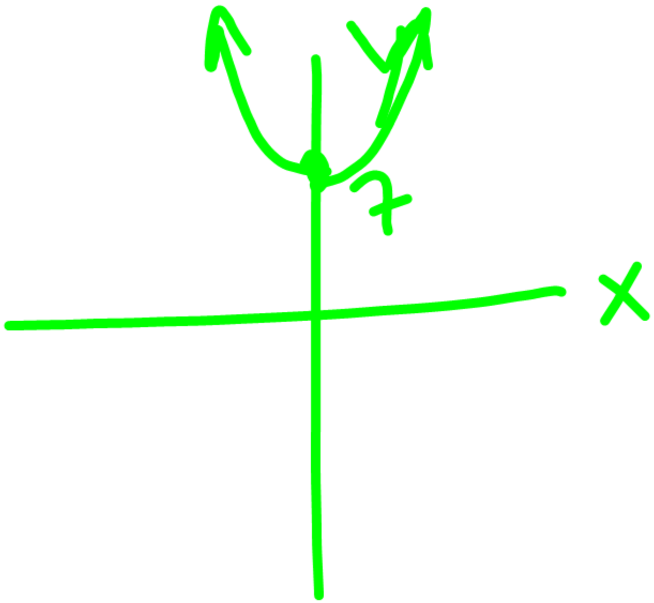
| $x$ | $x^2$ | | $2x^2$ | |
|---|---|---|---|---|
| 0 | 0 | | 0 | |
| | | $+1$ | | $+2$ |
| 1 | 1 | | 2 | |
| | | $+3$ | | $+6$ |
| 2 | 4 | | 8 | |
| | | $+5$ | | $+10$ |
| 3 | 9 | | 18 | |

$$y = (x+9)^2$$

$$(x-(-9))^2$$




$$y = x^2 + 7$$



**2-3.** Graph each equation below without making a table or using your graphing calculator. Look for ways to go directly from the rule to the graph. What information did you need to make a graph without using a table? How did you find that information from the equation? Be ready to share your strategies with the class.

a. $y = (x - 7)^2 - 2$

b. $y = 0.5(x + 3)^2 + 1$

**2-6.** Graph each equation below without making a table or using your graphing calculator. Look for ways to go directly from the rule to the graph. What information did you need to make a graph without using a table? How did you find that information from the equation? Be ready to share your strategies with the class.

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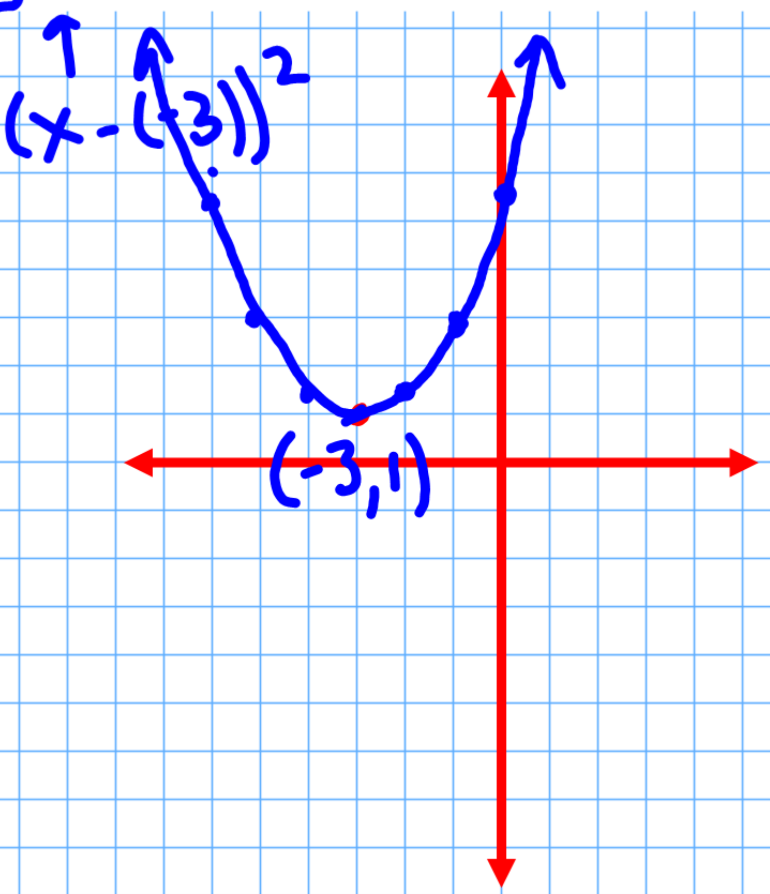


| $x$ | $x^2$ | |
|---|---|---|
| 0 | 0 | $>+1$ |
| 1 | 1 | $>+3$ |
| 2 | 4 | $>+5$ |
| 3 | 9 | $>+7$ |
| 4 | 16 | |

**2-4.** In the previous problem you figured out that having an equation for a parabola in **graphing form** ($y = a(x - h)^2 + k$) allows you to determine the vertex, the orientation, and the stretch factor of the parabola. Furthermore, knowing these attributes allows you to make a graph without having to make a table. How can you make a graph without a table when the equation is given in **standard form** ($y = ax^2 + bx + c$)? Consider the function $y = 2x^2 + 4x - 30$. ← y-int

a. What is the orientation of the graph? That is, does it open upward or open downward? How could you change the equation to make the graph open the opposite way?

UP

b. What is the stretch factor of the graph? Justify your answer. Stretch factor: 2

c. Can you identify the vertex of $y = 2x^2 + 4x - 30$ by looking at the equation? If not, talk with your team about strategies you could use to find the vertex without using a table or graphing calculator and then apply your new strategy to the problem. If your team is stuck consider parts (*i*) through (*iii*) below

*i.* What are the $x$-intercepts of the parabola?

*ii.* Where is the vertex located in relation to the $x$-intercepts? Can you use this relationship to find the $x$-coordinate of the vertex?

*iii.* Use the $x$-coordinate of the vertex to find its $y$-coordinate.

d. Sketch a graph of $y = 2x^2 + 4x - 30$ and write its equation in graphing form.

e. Verify that both forms of your equation are equivalent.

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e. Verify that both forms of your equation are equivalent.

$y = 2x^2 + 4x - 30$

$-60x^2$

$10x \quad -6x$

$4x$

| | $10x$ | $-30$ |
|---|---|---|
| $+10$ / $2x$ | $2x^2$ | $-6x$ |
| | $1x$ | $-3$ |

$0 = (2x+10)(x-3)$

$2x + 10 = 0 \qquad x = -5$

$x - 3 = 0 \qquad x = +3$

Line of Symmetry

$x = \dfrac{-5+3}{2}$

$x = -1 \leftarrow h$

$y = a(x-h)^2 + k$

$y = 2(x - -1)^2 + -32$

$\boxed{y = 2(x+1)^2 - 32}$

$y = 2(-1)^2 + 4(-1) - 30$

$y = -32 \leftarrow k$