Name______________________________________________________ Date__________

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

**For use with Exploration 8.4**

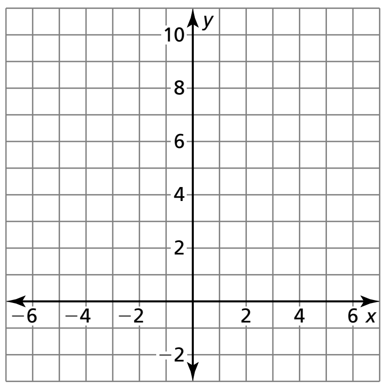
**Essential Question** How can you describe the graph of $f(x) = a(x - h)^2$?

## 1 EXPLORATION: Graphing $y = a(x - h)^2$ When $h > 0$

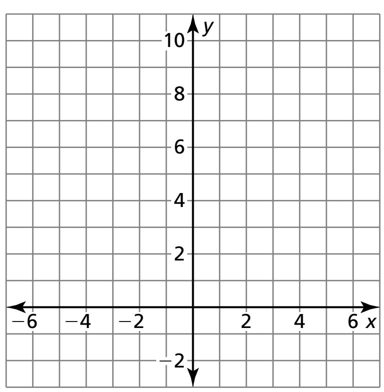
**Go to *BigIdeasMath.com* for an interactive tool to investigate this exploration.**

**Work with a partner.** Sketch the graphs of the functions in the same coordinate plane. How does the value of $h$ affect the graph of $y = a(x - h)^2$?

**a.** $f(x) = x^2$ and $g(x) = (x - 2)^2$




**b.** $f(x) = 2x^2$ and $g(x) = 2(x - 2)^2$

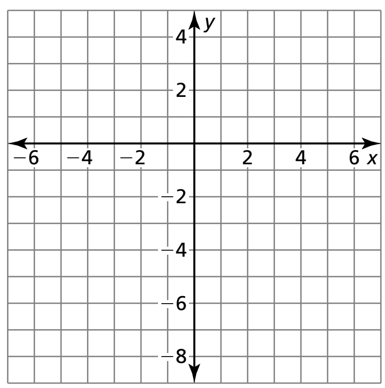


## 2 EXPLORATION: Graphing $y = a(x - h)^2$ When $h < 0$

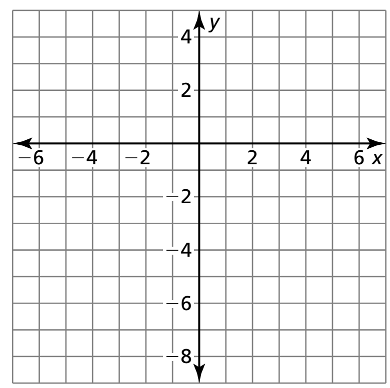
**Go to *BigIdeasMath.com* for an interactive tool to investigate this exploration.**

**Work with a partner.** Sketch the graphs of the functions in the same coordinate plane. How does the value of $h$ affect the graph of $y = a(x - h)^2$?

**a.** $f(x) = -x^2$ and $g(x) = -(x + 2)^2$



**b.** $f(x) = -2x^2$ and $g(x) = -2(x + 2)^2$



## Communicate Your Answer

**3.** How can you describe the graph of $f(x) = a(x - h)^2$?

**4.** Without graphing, describe the graph of each function. Use a graphing calculator to check your answer.

**a.** $y = (x - 3)^2$

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

**c.** $y = -(x - 3)^2$

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# 8.4 Practice

**For use after Lesson 8.4**

## Core Concepts

### Even and Odd Functions

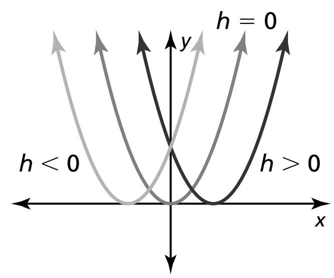
A function $y = f(x)$ is **even** when $f(-x) = f(x)$ for each $x$ in the domain of $f$. The graph of an even function is symmetric about the $y$-axis.

A function $y = f(x)$ is **odd** when $f(-x) = -f(x)$ for each $x$ in the domain of $f$. The graph of an odd function is symmetric about the origin. A graph is *symmetric about the origin* when it looks the same after reflections in the $x$-axis and then in the $y$-axis.

**Notes:**

### Graphing $f(x) = a(x - h)^2$

- When $h > 0$, the graph of $f(x) = a(x - h)^2$ is a horizontal translation $h$ units right of the graph $f(x) = ax^2$.
- When $h < 0$, the graph of $f(x) = a(x - h)^2$ is a horizontal translation $|h|$ units left of the graph of $f(x) = ax^2$.

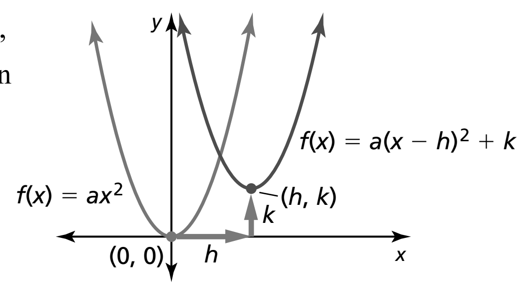



The vertex of the graph of $f(x) = a(x - h)^2$ is $(h, 0)$, and the axis of symmetry is $x = h$.

**Notes:**

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

The **vertex form** of a quadratic function is $f(x) = a(x - h)^2 + k$, where $a \neq 0$. The graph of $f(x) = a(x - h)^2 + k$ is a translation $h$ units horizontally and $k$ units vertically of the graph of $f(x) = ax^2$.




The vertex of the graph of $f(x) = a(x - h)^2 + k$ is $(h, k)$, and the axis of symmetry is $x = h$.

**Notes:**

## Worked-Out Examples

### Example #1

**Determine whether the function is even, odd, or neither.**

$f(x) = 4x + 3$

$f(-x) = 4(-x) + 3$

$= -4x + 3$

Because $f(x) = 4x + 3$ and $-f(x) = -4x - 3$, you can conclude that $f(-x) \neq f(x)$ and $f(-x) \neq -f(x)$. So, the function is neither odd nor even.

### Example #2

**Find the vertex and the axis of symmetry of the graph of the function.**

$f(x) = 3(x + 1)^2$

For $f(x) = 3(x + 1)^2$, because $h = -1$, the axis of symmetry is $x = -1$, and the vertex is $(-1, 0)$.

# Practice A

**In Exercises 1–4, determine whether the function is *even, odd,* or *neither.***

**1.** $f(x) = 5x$

**2.** $f(x) = -4x^2$

**3.** $h(x) = \frac{1}{2}x^2$

**4.** $f(x) = -3x^2 + 2x + 1$

**In Exercises 5–8, find the vertex and the axis of symmetry of the graph of the function.**

**5.** $f(x) = 5(x - 2)^2$

**6.** $f(x) = -4(x + 8)^2$

## 8.4 Practice (continued)

**7.** $p(x) = -\frac{1}{2}(x - 1)^2 + 4$

**8.** $g(x) = -(x + 1)^2 - 5$

**In Exercises 9 and 10, graph the function. Compare the graph to the graph of $f(x) = x^2$.**

**9.** $m(x) = 3(x + 2)^2$

**10.** $g(x) = -\frac{1}{4}(x - 6)^2 + 4$

**In Exercises 11 and 12, graph *g*.**

**11.** $f(x) = 3(x + 1)^2 - 1;\ g(x) = f(x + 2)$

**12.** $f(x) = \frac{1}{2}(x - 3)^2 - 5;\ g(x) = -f(x)$

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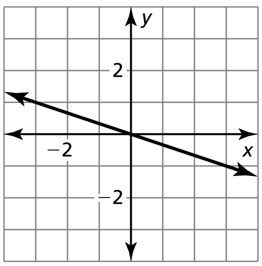
# Practice B

**In Exercises 1–3, determine whether the function is *even*, *odd*, or *neither*.**

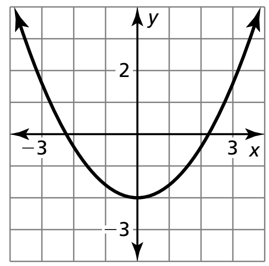
**1.** $f(x) = 3x^2 + 2x$ **2.** $g(x) = \frac{2}{3}x$ **3.** $h(x) = \frac{1}{3}x^2 - 2$

**In Exercises 4 and 5, determine whether the function represented by the graph is *even*, *odd*, or *neither*.**

**4.**




**5.**




**In Exercises 6–8, find the vertex and the axis of symmetry of the graph of the function.**

**6.** $f(x) = -\frac{1}{3}(x + 6)^2$ **7.** $f(x) = 9(x - 4)^2$ **8.** $y = -10(x + 9)^2$

**In Exercises 9–11, graph the function. Compare the graph to the graph of $f(x) = x^2$.**

**9.** $g(x) = 4(x + 2)^2$ **10.** $g(x) = \frac{1}{3}(x - 5)^2$ **11.** $g(x) = \frac{1}{6}(x - 1)^2$

**In Exercises 12–14, find the vertex and the axis of symmetry of the graph of the function.**

**12.** $y = 6(x - 4)^2 - 3$ **13.** $f(x) = -4(x + 1)^2 + 5$ **14.** $y = -(x + 3)^2 - 2$

**In Exercises 15 and 16, graph the function. Compare the graph to the graph of $f(x) = x^2$.**

**15.** $g(x) = 3(x + 2)^2 - 1$ **16.** $g(x) = -\frac{1}{2}(x - 1)^2 + 3$

**In Exercises 17 and 18, rewrite the quadratic function in vertex form.**

**17.** $y = 5x^2 - 10x + 2$ **18.** $f(x) = -2x^2 + 8x + 5$

**19.** The graph of $y = x^2$ is reflected in the $x$-axis and translated 3 units right and 2 units up. Write an equation for the function in vertex form and in standard form. Describe advantages of writing the function in each form.