Find the coordinates of the vertex.

1. $y = x^2$
2. $y = x^2 + 2$
3. $y = -\frac{2}{3}x^2$
4. $y = x^2 - 5x$
5. $y = -x^2$
6. $y = 3x^2 + x + 2$

Warm Up

axis of symmetry

$$x = \frac{-b}{2a}$$

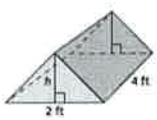
use solution from x to sub in and solve for y to find vertex

vertex: the point where the graph changes direction

Tell whether the volume of the solid is a linear or nonlinear function of the missing dimension(s). Explain.

1.


2.


3.


4.


Cumulative Warm Up

Skip for review lesson

Essential Question

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

Essential Question

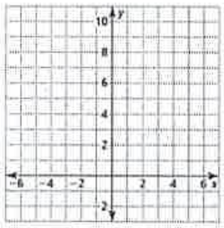
what you will learn:
- Identify even and odd functions
- Graph quadratic functions of the form $f(x) = a(x-h)^2$
- Graph $f(x) = a(x-h)^2 + k$

model real life w/ $f(x) = a(x-h)^2 + k$

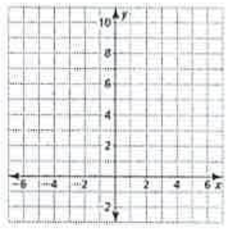
· review parent function

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 $g(x) = 2(x - 2)^2$



* use software to review

Exploration 1

· $f(x) = x^2$ (parent function)

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

$f(x) = (x - 2)^2$

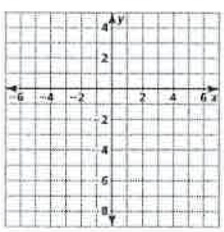
b.) $f(x) = 2x^2$

$g(x) = 2(x - 2)^2$

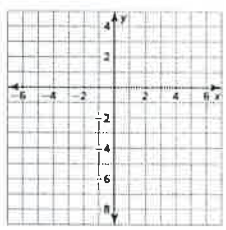
discuss transformations

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 $g(x) = -2(x + 2)^2$



* use software to review

Exploration 2

· discuss transformations and changes

Core Concept

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.

Core Concept

even function: a function $y = f(x)$ is even when $f(-x) = f(x)$ for each domain of f.

odd function: a function $y = f(x)$ is odd when $f(-x) = -f(x)$ for each x in the domain of f.

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

a. $f(x) = 2x$ **b.** $g(x) = x^2 - 2$ **c.** $h(x) = 2x^2 + x - 2$

$f(-x) = 2(-x)$ ← substitute $-x$ for x

$= -2x$ ← simplify

$= -f(x)$ substitute $f(x)$ for $2x$.

the function is odd

$g(x) = x^2 - 2$

$g(-x) = (-x)^2 - 2$

$g(-x) = x^2 - 2$

$= g(x)$

$g(-x) = g(x)$ even

$h(x) = 2x^2 + x - 2$

$h(-x) = 2(-x^2) + (-x) - 2$

$= 2x^2 - x - 2$

$h(x) = 2x^2 + x - 2$ and $-h(x) = -2x^2 - x + 2$

$h(-x) \neq h(x)$ and $h(-x) \neq -h(x)$

neither even or odd.

Example 1

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

1. $f(x) = 5x$ **2.** $g(x) = 2^x$ **3.** $h(x) = 2x^2 + 3$

$f(-x) = 5(-x)$

$f(-x) = -5x$

$f(-x) = -f(x)$

odd

$g(x) = 2^x$

$g(-x) = 2^{-x}$

$g(-x) = \frac{1}{2^x}$

Neither

3.) $h(x) = 2x^2 + 3$

$h(-x) = 2(-x)^2 + 3$

$h(-x) = 2x^2 + 3$

even

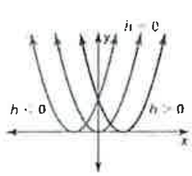
Monitoring Progress 1-3

Core Concept

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 of $f(x) = ax^2$.
- 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 $x = h$.



Core Concept

* use graphing software to show translations

Create graphic organizer to help show changes to parent function

•Graphic organizer setup

Graph $g(x) = \frac{1}{2}(x-4)^2$. Compare the graph to the graph of $f(x) = x^2$.

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

↑ axis of symmetry

$g(0) = \frac{1}{2}(0-4)^2$
$= 8$
$(0,8)$

$g(2) = \frac{1}{2}(2-4)^2$
$= 2$
$(2,2)$

Example 2

Step 1: axis of sym = $h = 4$
$x = 4$

Step 2: vertex: $h = 0$ $(h,0)$
$(4,0)$

Step 3: plot 2 more points
•choose 2 x values solve for $g(x)$ or y

Step 4: reflect the points over axis of symmetry

Step 5: draw smooth curve

Graph the function. Compare the graph to the graph of $f(x) = x^2$.

4. $g(x) = 2(x+5)^2$

axis = $h = -5$

vertex = $(-5,0)$

5. $h(x) = -(x-2)^2$

axis = 2

vertex = 2, 0

Monitoring Progress 4-5

*Student practice

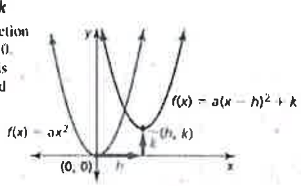
encourage students to use list (steps) from example 2

Core Concept

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 $x = h$.



Core Concept

Graph $g(x) = -2(x + 2)^2 + 3$. Compare the graph to the graph of $f(x) = x^2$.

$g(-4) = -2(-4+2)^2 + 3$
$= -2(-2)^2 + 3$
$= -2(4) + 3$
$= -8 + 3$ $(-4, -5)$
$= -5$

$g(-3) = -2(-3+2)^2 + 3$
$= -2(1) + 3$
$= -2 + 3$ $(-3, -1)$
$= 1$

Example 3

Step 1: axis of symm: $h = -2$
$x = -2$

Step 2: vertex: $h = -2$ $k = 3$
$(-2, 3)$

Step 3: find 2 more points to plot: $-4, -3$

Step 4: reflect points across the x-axis

Step 5: Draw a smooth curve

Consider function g in Example 3. Graph $f(x) = g(x + 5)$.

Example 4

the function in the form $y = g(x-h)$ where $h = -5$

· Creates a horizontal translation 5 units left of the graph of g.

Graph the function. Compare the graph to the graph of $f(x) = x^2$.

6. $g(x) = 3(x - 1)^2 + 6$

vertex $= (1, 6)$
axis $= 1$
vert. stretch
1 unit right
6 units up

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

axis $= -4$
vertex $= (-4, -2)$
vert. shrink
4 units left
2 units down

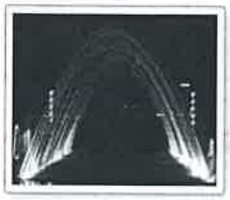
8. Consider function g in Example 3. Graph $f(x) = g(x) - 3$.

Monitoring Progress 6-8

* Student practice *

Always start w/ parent function

Water fountains are usually designed to give a specific visual effect. For example, the water fountain shown consists of streams of water that are shaped like parabolas. Notice how the streams are designed to land on the underwater spotlights. Write and graph a quadratic function that models the path of a stream of water with a maximum height of 5 feet, represented by a vertex of (3, 5), landing on a spotlight 6 feet from the water jet, represented by (6, 0).



Example 5

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

$f(x) = a(x-3)^2 + 5$

$0 = a(6-3)^2 + 5$

$0 = 9a + 5$

$a = -5/9$

$f(x) = -5/9\,(x-3)^2 + 5$

axis = 3 vertex = (3, 5)

find 2 points for x between x = 3 and x = 6

graph (answers/points vary)

9. WHAT IF? The vertex is (3, 6). Write and graph a quadratic function that models the path.

Monitoring Progress 9

Exit Ticket: Given $f(x) = \frac{1}{2}(x+8)^2 + 4$, tell what you know about the function and sketch its graph.

Closure