Bellwork!

If d varies inversely as t, and $d = 20$ when $t = 2$, what is the value of t when $d = -5$?

(1) 8   (3) −8

(2) 2   (4) −2

Lesson 4 – 1   **Date:**_____

AGENDA

Bellwork:

Homework Review:

Lesson: Quadratic Functions and Transformation

Objective: To identify and graph quadratic functions.

Essential Understanding: The graph of any quadratic function is a transformation of the graph of the parent quadratic function, $y = x^2$.

Problem 1 Graphing a Function of the Form $f(x) = ax^2$
Problem 2 Graphing Translations of $f(x) = x^2$
Problem 3 Interpreting Vertex Form
Problem 4 Using Vertex Form
Problem 5 Writing a Quadratic Function in Vertex Form

Teacher Directed: Problems 1, 2, 3, 4, 5

Student Centered: Lesson Quiz

Homework: Problem Set G "select problems"

In the Solve It, you used the *parabolic* shape of the horse's jump. A **parabola** is the graph of a **quadratic function**, which you can write in the form $f(x) = ax^2 + bx + c$, where $a \neq 0$.

Essential Understanding The graph of any quadratic function is a transformation of the graph of the parent quadratic function, $y = x^2$.

The **vertex form** of a quadratic function is $f(x) = a(x - h)^2 + k$, where $a \neq 0$. The **axis of symmetry** is a line that divides the parabola into two mirror images. The equation of the axis of symmetry is $x = h$. The **vertex of the parabola** is (h, k), the intersection of the parabola and its axis of symmetry.

Lesson Vocabulary
- parabola
- quadratic function
- vertex form
- axis of symmetry
- vertex of the parabola
- minimum value
- maximum value

Key Concept   The Parent Quadratic Function

The parent quadratic function is $f(x) = x^2$. Its graph is the parabola shown. The axis of symmetry is $x = 0$. The vertex is $(0, 0)$.

Vertex (0, 0)   Axis of Symmetry $x = 0$
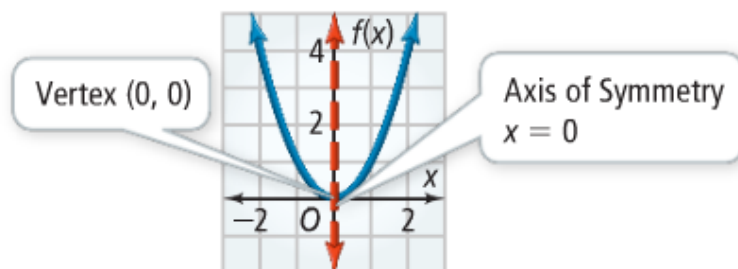
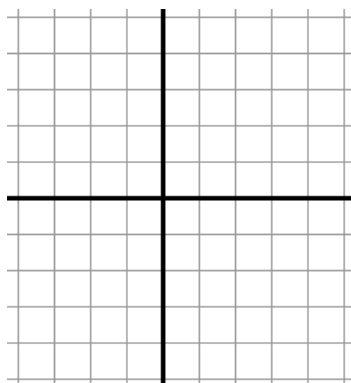## Problem 1 Graphing a Function of the Form $f(x) = ax^2$

What is the graph of $f(x) = \frac{1}{2}x^2$?

Step 1 Plot the vertex $(0, 0)$. Draw the axis of symmetry, $x = 0$.

Step 2 Find and plot two points on one side of the axis of symmetry.

**Step 3** Plot the corresponding points on the other side of the axis of symmetry.
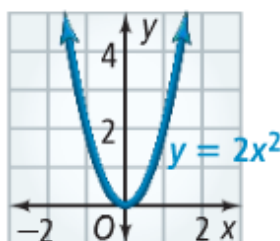
Step 4 Sketch the curve.

Graphs of $y = ax^2$ and $y = -ax^2$ are reflections of each other across the x-axis. Increasing $|a|$ stretches the graph vertically and narrows it horizontally. Decreasing $|a|$ compresses the graph vertically and widens it horizontally.
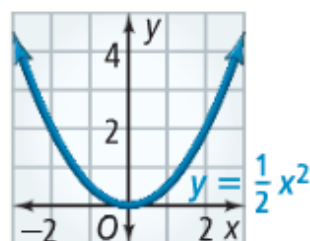

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Key Concept Reflection, Stretch, and Compression
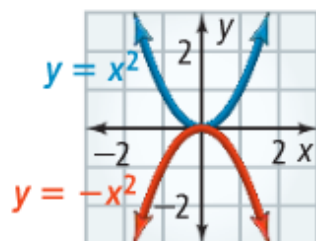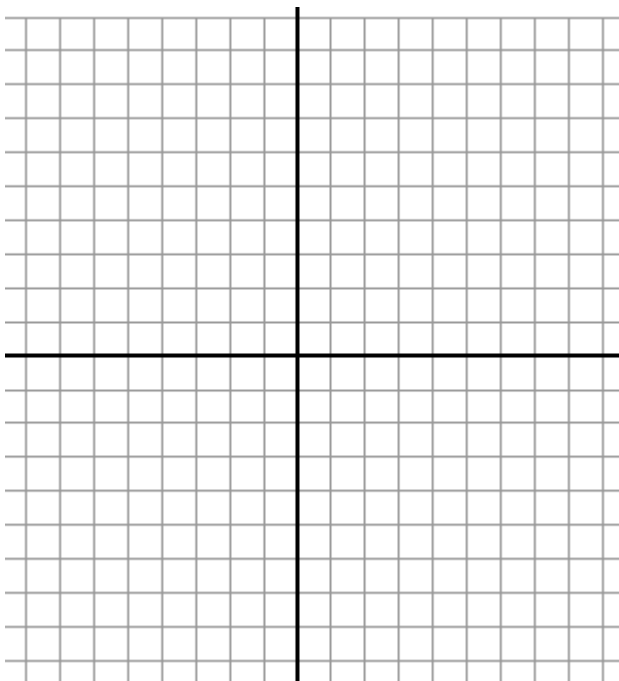
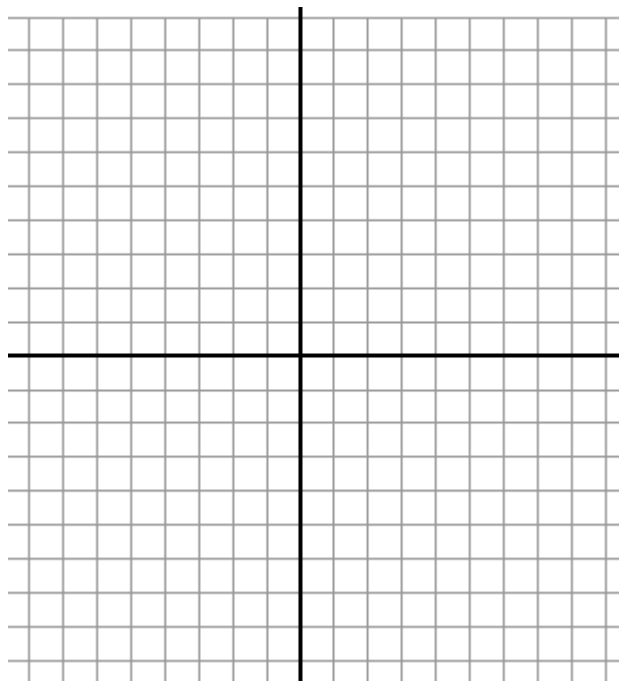Reflection,
a and −a

Stretch,
a > 1

Compression,
0 < a < 1

Problem 2 Graphing Translations of $f(x) = x^2$

Graph each function. How is each graph a translation of $f(x) = x^2$?

A $g(x) = x^2 - 5$

B $h(x) = (x - 4)^2$

Got It? 2. Graph each function. How is it a translation of $f(x) = x^2$?

    a. $g(x) = x^2 + 3$ **b.** $h(x) = (x + 1)^2$

For $y = 3(x - 4)^2 - 2$, what are the vertex, the axis of symmetry, the maximum or minimum value, the domain and the range?

Step 1 Compare: $y = 3(x - 4)^2 - 2$
$y = a(x - h)^2 + k$

Step 2 The vertex is $(h, k) = (4, -2)$.

Step 3 The axis of symmetry is $x = h$, or $x = 4$.

Step 4 Since $a > 0$, the parabola opens upward. $k = -2$ is the minimum value.

Step 5 Domain: All real numbers. There is no restriction on the value of x.
Range: All real numbers ≥ -2, since the minimum value of the function is -2.
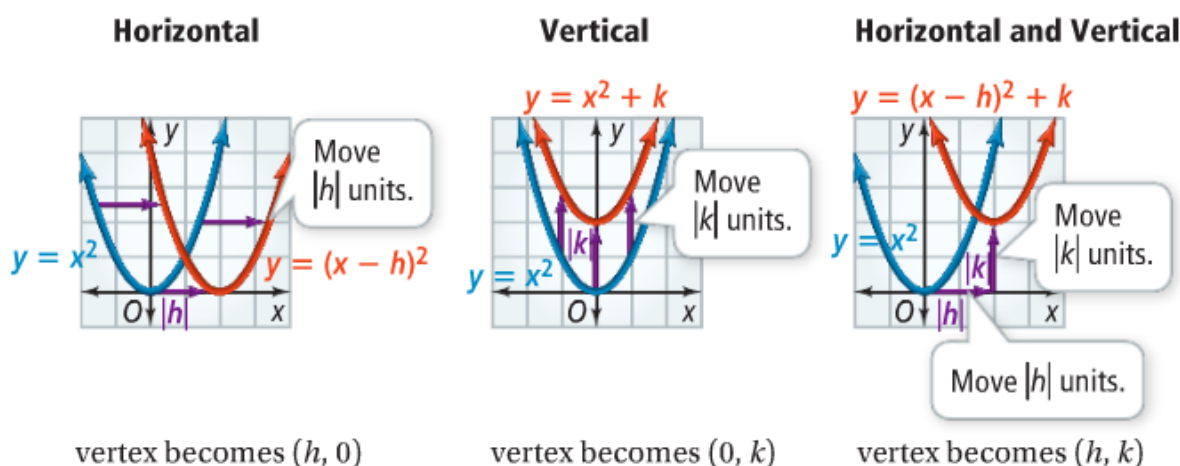
Got It? 3. What are the vertex, axis of symmetry, minimum or maximum, and domain and range of the function $y = -2(x + 1)^2 + 4$?

You can use the vertex form of a quadratic function, $f(x) = a(x - h)^2 + k$, to transform the graph of the parent function $f(x) = x^2$.
- Stretch or compress the graph of $f(x) = x^2$ vertically by the factor $|a|$.
- If $a < 0$, reflect the graph across the x-axis.
- Shift the graph $|h|$ units horizontally and $|k|$ units vertically.

ake note

## Key Concept   Translation of the Parabola

Horizontal

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

Move $|h|$ units.

vertex becomes $(h, 0)$

Vertical

$y = x^2 + k$

$y = x^2$

Move $|k|$ units.

vertex becomes $(0, k)$

Horizontal and Vertical

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

$y = x^2$

Move $|k|$ units.

Move $|h|$ units.

vertex becomes (h, k)

A What is the graph of $f(x) = -2(x - 1)^2 + 3$?

Step 1 Identify the constants $a = -2$, $h = 1$, and $k = 3$. Because $a < 0$, the parabola opens downward.

Step 2 Plot the vertex $(h, k) = (1, 3)$ and draw the axis of symmetry $x = 1$.

$f(x) = -2(x - 1)^2 + 3$
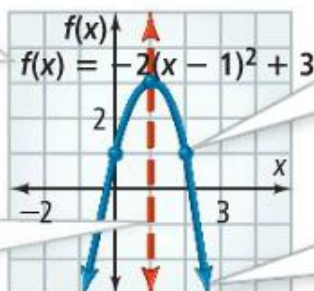
Step 3 Plot two points. $f(2) = -2(2 - 1)^2 + 3 = 1$. Plot $(2, 1)$ and the symmetric point $(0, 1)$.

Step 4 Sketch the curve.

B Multiple Choice What steps transform the graph of $y = x^2$ to $y = -2(x + 1)^2 + 3$?

Ⓐ Reflect across the x-axis, stretch by the factor 2, translate 1 unit to the right and 3 units up.

Ⓑ Stretch by the factor 2, translate 1 unit to the right and 3 units up.

Ⓒ Reflect across the x-axis, translate 1 unit to the left and 3 units up.

Ⓓ Stretch by the factor 2, reflect across the x-axis, translate 1 unit to the left and 3 units up.

Got It? 4. What steps transform the graph of $y = x^2$ to $y = 2(x + 2)^2 - 5$?

Problem 5 Writing a Quadratic Function in Vertex Form

Nature The picture shows the jump of a dolphin. What quadratic function models the path of the dolphin's jump?

Think

What is the vertex?

Choose another point, $(9, 4)$, from the path. Substitute in the vertex form.

Solve for a.

Substitute in the vertex

Write

The vertex is $(3, 7)$.
$h = 3, k = 7$

$f(x) = a(x - h)^2 + k$
$4 = a(9 - 3)^2 + 7$
$4 = 36a + 7$
$-3 = 36a$
$a = -\frac{1}{12}$

$f(x) = -\frac{1}{12}(x - 3)^2 + 7$
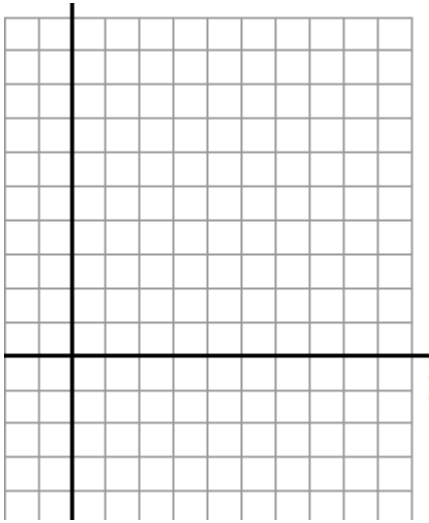
4-1 Lesson Quiz

1. What are the vertex, the axis of symmetry, the minimum or the maximum, the domain, and the range of $y = -5(x + 2)^2 - 8$?

2. What is the graph of $f(x) = \frac{1}{3}(x - 4)^2 - 1$?

3. Do you UNDERSTAND? A frog leaps 2 feet. The highest point in the jump is 6 inches. Assume the frog starts at $(0, 0)$. What quadratic function models the path of the jump? Specify the units you use.