






2-1

Vertex Form of a Quadratic Function

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EXPLORE & REASON

The table represents $A(x)$, the area of a square as a function of side length x units, where x is a positive real number.

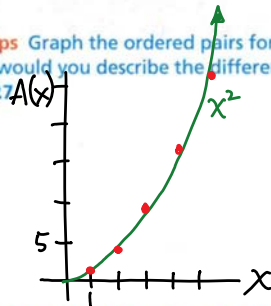
Side Length (units)	x	1	2	3	4
Model					
Area (sq. units)	$A(x)$	1	4	9	16

A. Consider the function where the areas in the table are doubled. Write the equation of a function that represents this.

$$A(x) = x \cdot x = x^2$$

for $x \geq 1$

B. **Look for Relationships** Graph the ordered pairs for both $A(x)$ and your new function. How would you describe the differences in the locations of these points? **MP.7**



C. Find the equation for a function whose x -values are the same as $A(x)$ but whose y -values lie 2 units greater than each y -value in $A(x)$.

$$A(x) + 2$$

y-values are 2 units greater

- vertical shift/translation

HABITS OF MIND

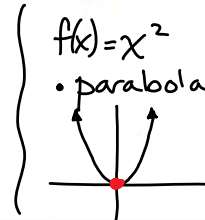
Communicate Precisely Do you think the effect of altering $A(x)$ in the two ways you did would work for any function you start with? Explain. **MP.6**

Quadratic Function $\rightarrow f(x) = ax^2 + bx + c$

- standard

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

- vertex: (h, k)



Transformations

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

Vert. refl / Stretch / Shrink (Compression)
 Horiz. Shift
 Vert. Shift

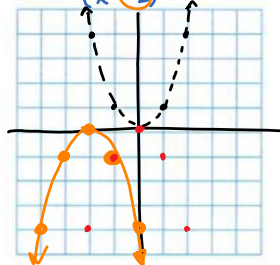
EXAMPLE 1 Try It! Transform a Quadratic Function

PE
MD
AS

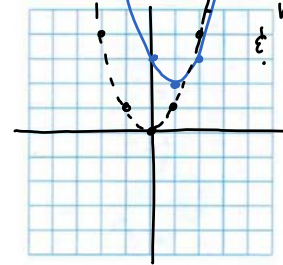
vert refl
Shift left 2

Describe the transformations of the parent function $f(x) = x^2$. Then graph the function.

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



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

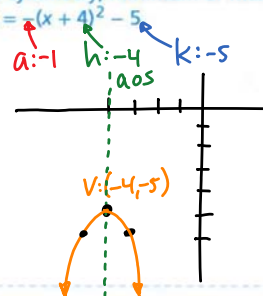


Shift right 1 & up 2

EXAMPLE 2 Try It! Determine Key Features of a Quadratic Function

2. Identify the vertex, axis of symmetry, minimum or maximum, domain, and range of the function $f(x) = -(x+4)^2 - 5$.

- $V: (h, k) = (-4, -5)$
- AOS: $x = h \rightarrow x = -4$
- maximum $\rightarrow -5$
- Domain: \mathbb{R}
- Range: $y \leq -5$



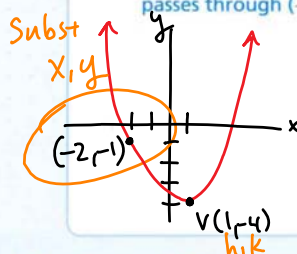
HABITS OF MIND

Make Sense and Persevere In what order should you apply the transformations shown in the Try It! for Example 2? **MP.1**

PE
MD \rightarrow "a"
AS \rightarrow "h, k"

EXAMPLE 3 Try It! Write an Equation of a Parabola

3. What is the equation of a parabola with a vertex of $(1, -4)$ and which passes through $(-2, -1)$?



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

$$y = a(x-1)^2 - 4$$

$$-1 = a(-2-1)^2 - 4$$

$$-1 = a(-3)^2 - 4$$

$$3 = 9a$$

$$\frac{1}{3} = a$$

$$\therefore y = \frac{1}{3}(x-1)^2 - 4$$

EXAMPLE 4 Try It! Write an Equation of a Parabola Given the Graph

4. The graph shows the height of the flying disk with respect to time. What is the equation of the function? Write the equation in vertex form. Then write the equation in the form $y = ax^2 + bx + c$.

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

$$4 = a(0-2)^2 + 10$$

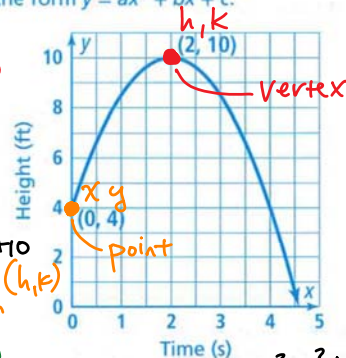
$$4 = a(4) + 10$$

$$-6 = 4a$$

$$-\frac{3}{2} = a$$

$$\therefore y = -\frac{3}{2}(x-2)^2 + 10$$

• vertex (h, k)
form



→ Convert to standard form

$$-\frac{3}{2}(x-2)(x-2) + 10$$

$$-\frac{3}{2}(x^2 - 2x - 2x + 4) + 10$$

$$-\frac{3}{2}(x^2 - 4x + 4) + 10$$

$$-\frac{3}{2}x^2 + 6x - 6 + 10$$

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

EXAMPLE 5 Try It! Write an Equation of a Transformed Function

5. What is the equation of j ? Write the equation in vertex form and in the form $y = ax^2 + bx + c$.

a. Let j be a quadratic function whose graph is a translation 2 units right and 5 units down of the graph of f .

b. Let j be a function whose graph is a reflection of the graph of f in the x -axis followed by a translation 1 unit down.

$$y = x^2$$

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

**

$$a=1$$

$$(x-2)^2 \neq x^2 - 4$$

$$h: 2$$

$$y = 1(x-2)^2 + -5$$

$$y = (x-2)(x-2) - 5$$

$$= x^2 - 2x - 2x + 4 - 5$$

$$y = x^2 - 4x - 1$$

$$k: -5$$

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

$$y = -x^2 - 1$$

HABITS OF MIND

Generalize What information do you need to write the equation of a transformed quadratic function in vertex form? © MP8

Do You UNDERSTAND?

1. **ESSENTIAL QUESTION** How does the equation of a quadratic function in vertex form highlight key features of the function's graph?




2. **Error Analysis** Given the function $g(x) = (x + 3)^2$ Martin says the graph should be translated right 3 units from the parent graph $f(x) = x^2$. Explain his error. **MP.3**

left 3

$$\rightarrow g(x) = (x - (-3))^2$$

3. **Vocabulary** What shape does a quadratic function have when graphed?

Parabola ... 

4. **Communicate Precisely** How are the graphs of $f(x) = x^2$ and $g(x) = -(x + 2)^2 - 4$ related? **MP.6**



- vert refl
- left 2
- down 4

Do You KNOW HOW?

Describe the transformation of the parent function $f(x) = x^2$.

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

$a: -1$ → Vert reflection
 $h: -5$ → shift left 5
 $k: 2$ → shift up 2

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

$h: -2$ → shift left 2
 $k: -7$ → shift down 7

Write the equation of each parabola in vertex form.

7. Vertex: $(-3, 7)$; Point: $(-2, -5)$

$y = a(x-h)^2 + k$
 $-5 = a(-2 - (-3))^2 + 7$
 $-5 = a(1)^2 + 7$
 $-12 = a$

$y = -12(x+3)^2 + 7$

8. Vertex: $(1, 3)$; Point: $(2, 5)$

$y = a(x-h)^2 + k$
 $5 = a(2-1)^2 + 3$
 $5 = a + 3$
 $2 = a$

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

9. Vertex: $(-4, 6)$; Point: $(-2, -2)$



10. Vertex: $(7, 4)$; Point: $(5, 16)$

