a. $y = x^2 + 6x - 5$

$y = x^2 + 6x - 5$	Original function
$y = (x^2 + 6x + 9) - 5 - 9$	Complete the square.
$y = (x + 3)^2 - 14$	Simplify.

Example 1 **Write each function in vertex form.** 1. $y = (x+3)^2 - 7$ 2. $y = -2(x-2)^2 + 3$

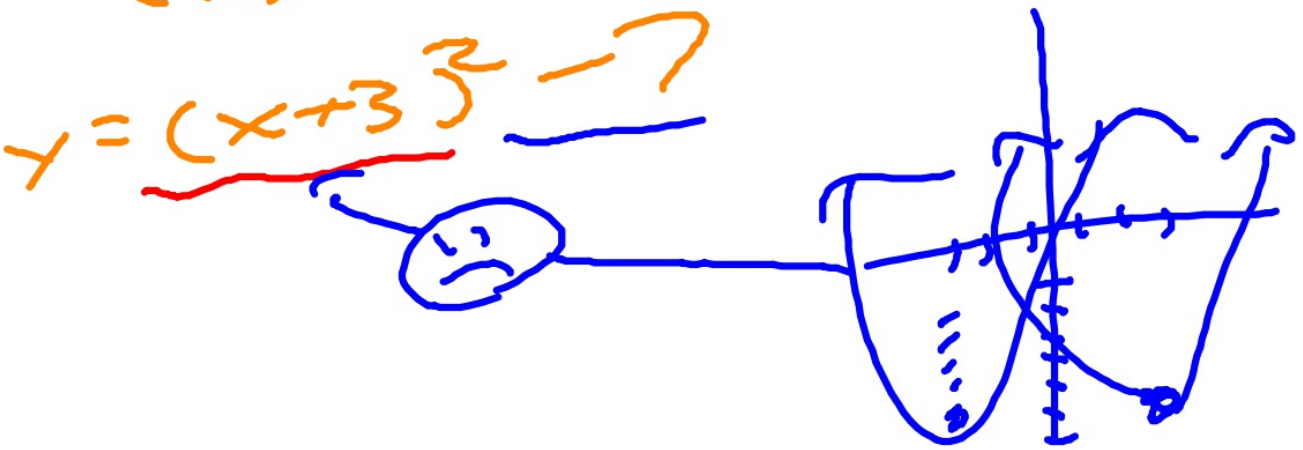
1. $y = x^2 + 6x + 2$ **2.** $y = -2x^2 + 8x - 5$ **3.** $y = 4x^2 + 24x + 24$

S

$\left(\frac{6}{2}\right)^2 = 9$

(1) $y = \frac{x^2 + 6x + 9}{(x+3)(x+3)} + 2 - 9$

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



2. $y = -2x^2 + 8x - 5$

3. $y = 4x^2 + 24x + 24$

(2) $y = -2(x^2 - 4x + 4) - 5 + 8$

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

(3) $y = 4(x^2 + 6x + 9) + 24 - 36$

$y = 4(x+3)^2 - 12$

vertex $(-3, -12)$

Solve the Test Item

The vertex of the parabola is at $(3, 2)$, so $h = 3$ and $k = 2$. Since $(-1, -2)$ is a point on the graph, let $x = -1$ and $y = -2$. Substitute these values into the vertex form of the equation and solve for a.

$y = a(x - h)^2 + k$	Vertex form
$-2 = a(-1 - 3)^2 + 2$	Substitute -2 for y, -1 for x, 3 for h and 2 for k.
$-2 = a(16) + 2$	Simplify.
$-4 = 16a$	Subtract 2 from each side.
$-\frac{1}{4} = a$	Divide each side by 16.

The equation of the parabola in vertex form is $y = -\frac{1}{4}(x - 3)^2 + 2$.

The answer is B.

Example 2

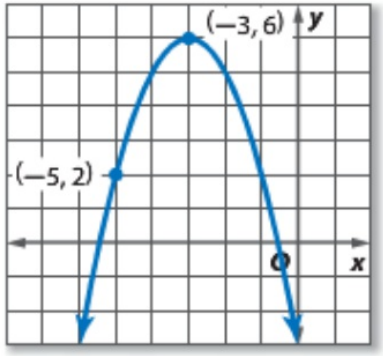
4. MULTIPLE CHOICE Which function is shown in the graph? **A**

A $y = -(x + 3)^2 + 6$

B $y = -(x - 3)^2 - 6$

C $y = -2(x + 3)^2 + 6$

D $y = -2(x - 3)^2 - 6$



p. 277

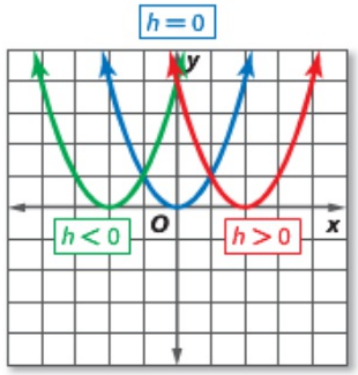
ConceptSummary Transformations of Quadratic Functions

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

h, Horizontal Translation

h units to the right if *h* is positive

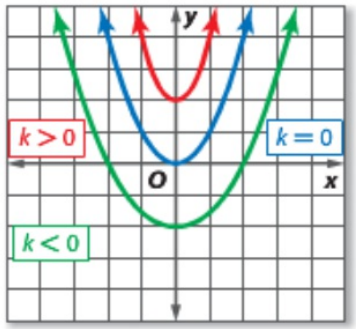
| *h* | units to the left if *h* is negative



k, Vertical Translation

k units up if *k* is positive

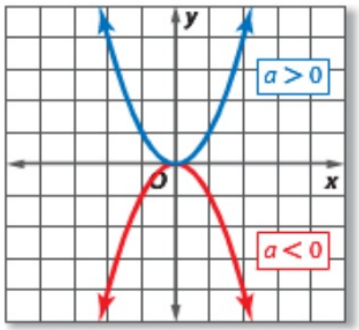
| *k* | units down if *k* is negative



a, Reflection

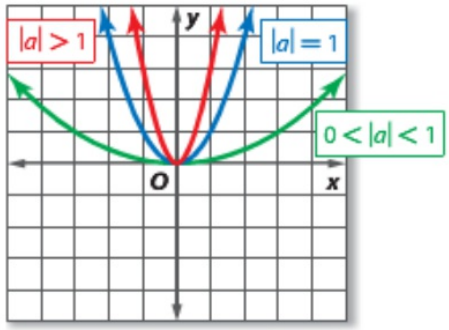
If $a > 0$, the graph opens up.

If $a < 0$, the graph opens down.



a, Dilation

If $|a| > 1$, the graph is stretched vertically. If $0 < |a| < 1$, the graph is compressed vertically.



StudyTip

Absolute Value

$0 < |a| < 1$ means that *a* is a rational number between 0 and 1, such as $\frac{3}{4}$, or a rational number between -1 and 0, such as -0.3.

Example 3 Graph Equations in Vertex Form

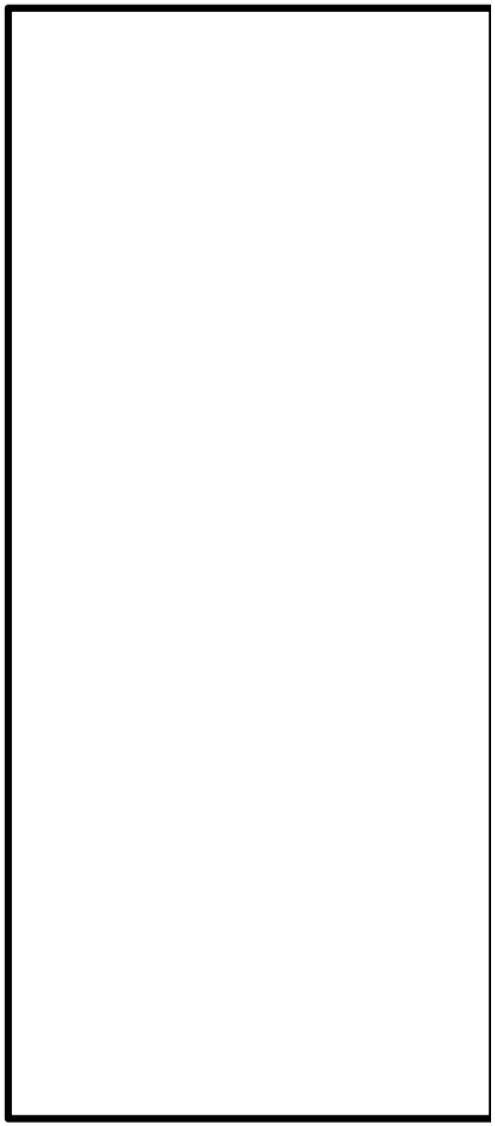
Graph $y = 4x^2 - 16x - 40$.

Example 3 Graph each function. **5–7. See margin.**

5. $y = (x - 3)^2 - 4$

6. $y = -2x^2 + 5$

7. $y = \frac{1}{2}(x + 6)^2 - 8$



Practice and Problem Solving

Extra Practice is on page R4.

Example 1 Write each function in vertex form.

8. $y = x^2 + 9x + 8$

9. $y = x^2 - 6x + 3$

10. $y = -2x^2 + 5x$

11 $y = x^2 + 2x + 7$

12. $y = -3x^2 + 12x - 10$ $y = -3(x - 2)^2 + 2$

13. $y = x^2 + 8x + 16$ $y = (x + 4)^2$

14. $y = 2x^2 - 4x - 3$ $y = 2(x - 1)^2 - 5$

15. $y = 3x^2 + 10x$

16. $y = x^2 - 4x + 9$ $y = (x - 2)^2 + 5$

17. $y = -4x^2 - 24x - 15$ $y = -4(x + 3)^2 + 21$

18. $y = x^2 - 12x + 36$ $y = (x - 6)^2$

19. $y = -x^2 - 4x - 1$ $y = -(x + 2)^2 + 3$

Example 2

20. FIREWORKS During an Independence Day fireworks show, the height h in meters of a specific rocket after t seconds can be modeled by $h = -4.9(t - 4)^2 + 80$. Graph the function. See margin.

21. FINANCIAL LITERACY A bicycle rental shop rents an average of 120 bicycles per week and charges \$25 per day. The manager estimates that there will be 15 additional bicycles rented for each \$1 reduction in the rental price. The maximum income the manager can expect can be modeled by $y = -15x^2 + 255x + 3000$, where y is the weekly income and x is the number of bicycles rented. Write this function in vertex form. Then graph.

$y = -15(x - 8.5)^2 + 4083.75$; See Chapter 4 Answer Appendix for graph.

Example 3 Graph each function. 22–33. See Chapter 4 Answer Appendix.

22. $y = (x - 5)^2 + 3$

23. $y = 9x^2 - 8$

24. $y = -2(x - 5)^2$

25. $y = \frac{1}{10}(x + 6)^2 + 6$

26. $y = -3(x - 5)^2 - 2$

27. $y = -\frac{1}{4}x^2 - 5$

28. $y = 2x^2 + 10$

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

30. $y = \frac{1}{6}(x - 3)^2 - 10$

31. $y = (x - 9)^2 - 7$

32. $y = -\frac{5}{8}x^2 - 8$

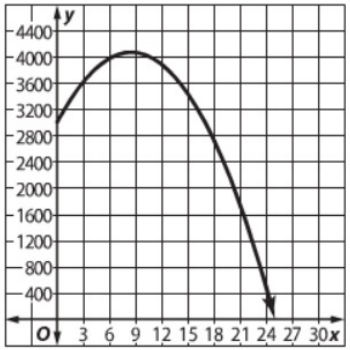
33. $y = -4(x - 10)^2 - 10$

27. $y = -\frac{1}{4}x^2 - 5$

$y = -\frac{1}{4}(x-0)^2 - 5$

Lesson 4-7

21.



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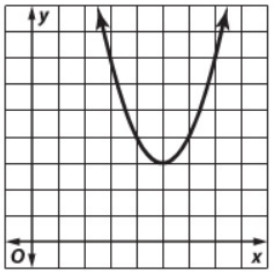

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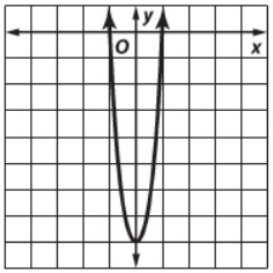

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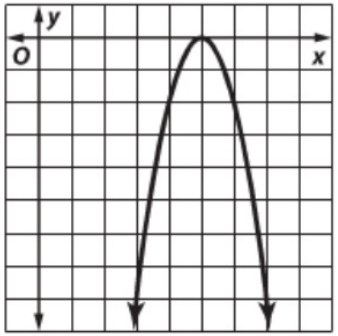

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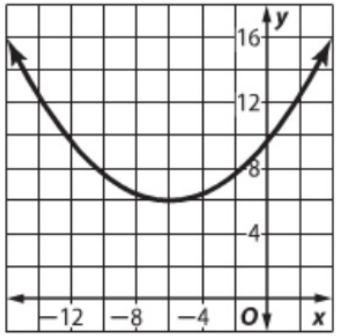

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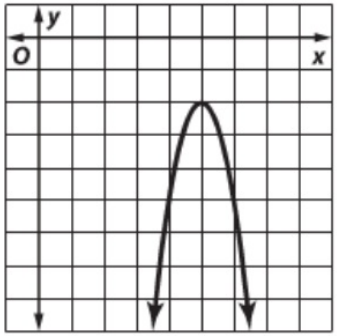

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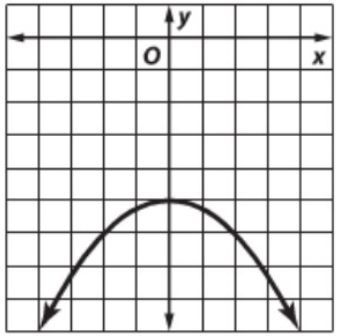

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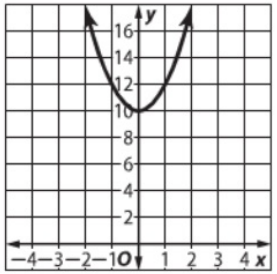

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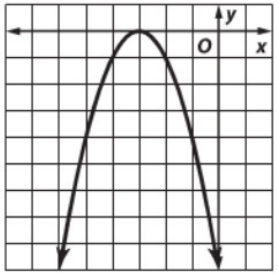

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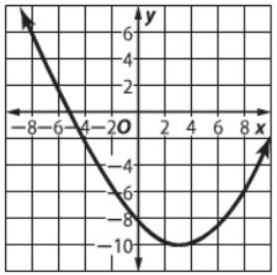

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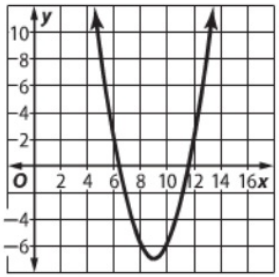

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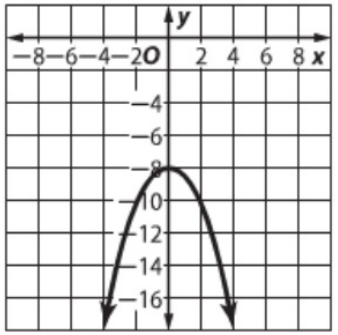

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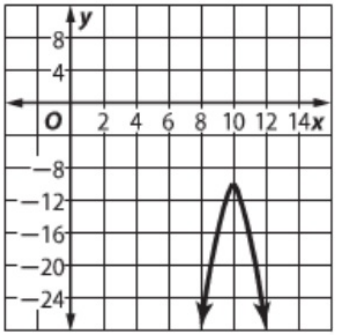

Lesson 4-7

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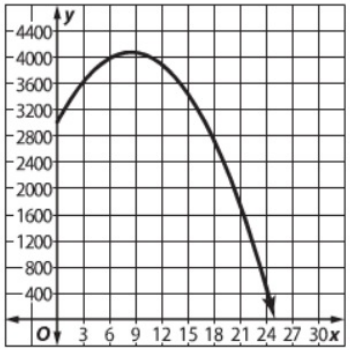

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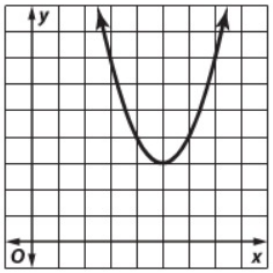

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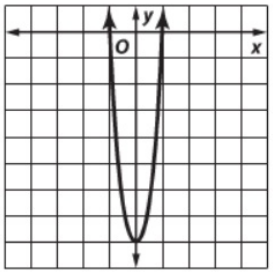

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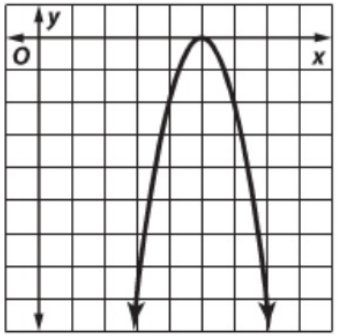

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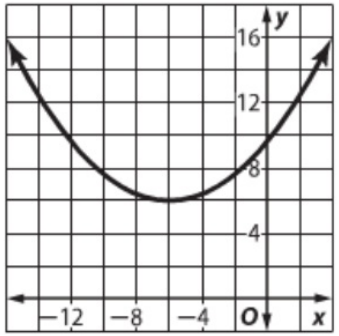

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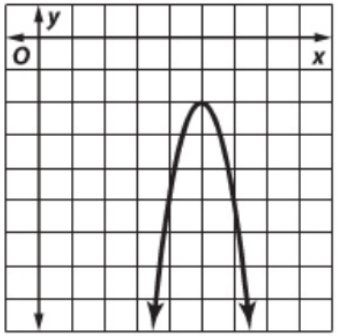

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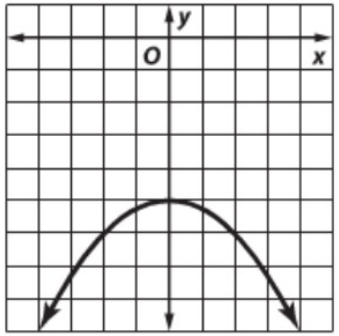

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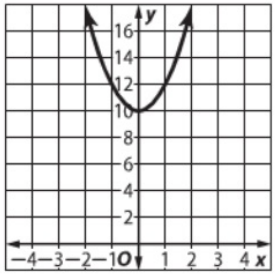

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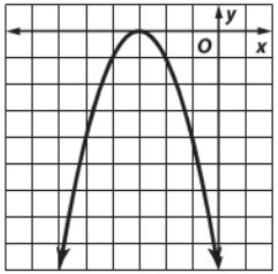

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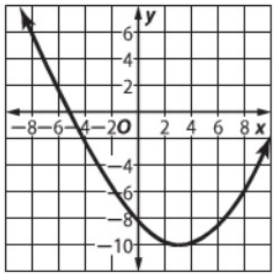

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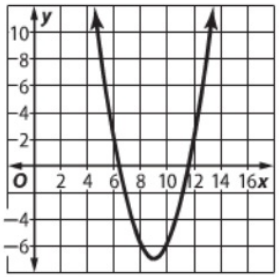

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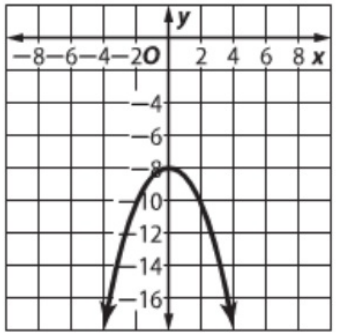

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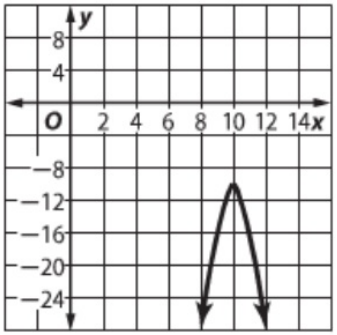

Lesson 4-7

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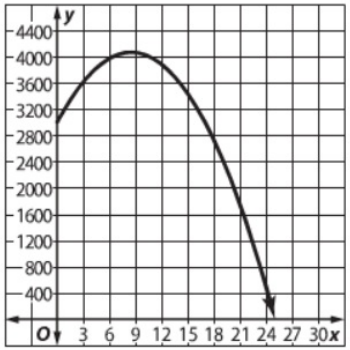

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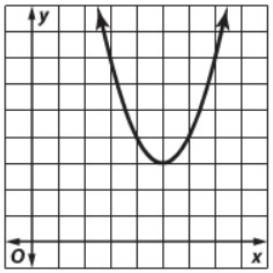

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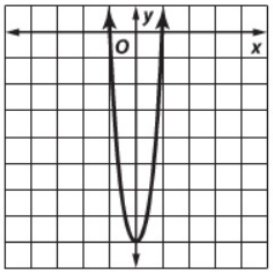

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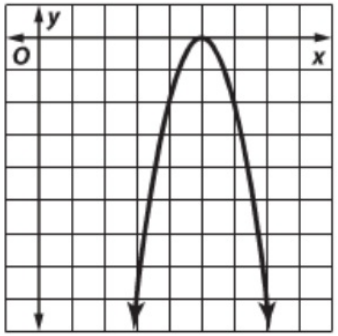

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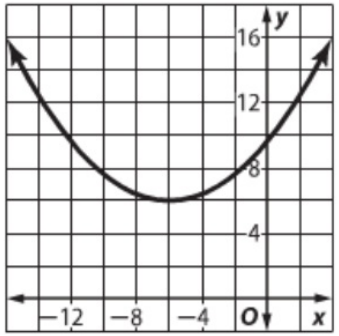

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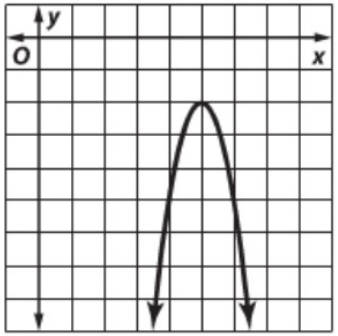

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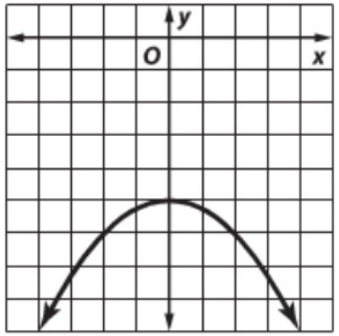

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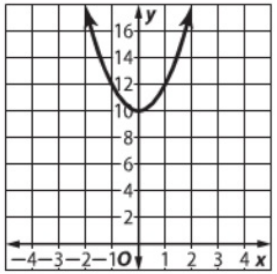

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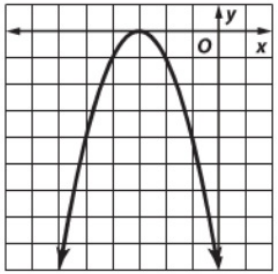

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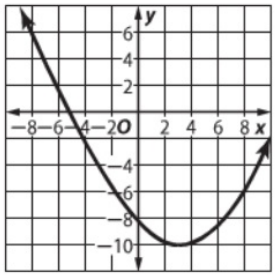

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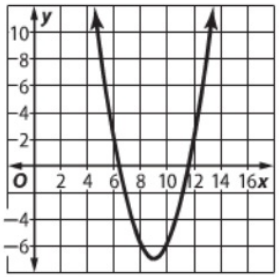

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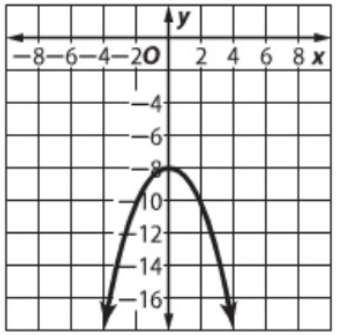
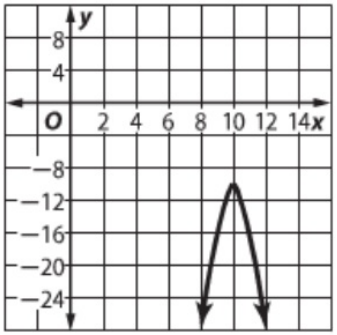
33.