Graphing Quadratic Functions

Name: _____	Date: _____	Score: _____ / 29

Quick Review

A quadratic graphs as a **parabola**. Two forms make life easy. **Vertex form** $f(x) = a(x-h)^2 + k$ tells you the vertex (h, k) directly, and the sign of a tells you which way it opens (up if $a > 0$, down if $a < 0$). Watch the sign on h: $(x-3)^2$ has vertex at $h = 3$, while $(x+5)^2 = (x-(-5))^2$ has vertex at $h = -5$. Tempting wrong move: writing the vertex with the positive sign from inside the parentheses.

Standard form $f(x) = ax^2 + bx + c$ takes one more step: $x_{\text{vertex}} = -\dfrac{b}{2a}$, then plug back to get the y-coordinate. The y-intercept is always $(0, c)$ in standard form — substitute $x = 0$.

To convert standard to vertex form, **complete the square**. For $x^2 + bx + c$, half the linear coefficient is $\frac{b}{2}$, and squaring gives $\left(\frac{b}{2}\right)^2$ — add and subtract that constant. The vertex is the maximum (downward parabola) or minimum (upward) of the function. The axis of symmetry passes vertically through the vertex: $x = h$.

Three quick examples of the same parent parabola shifted:

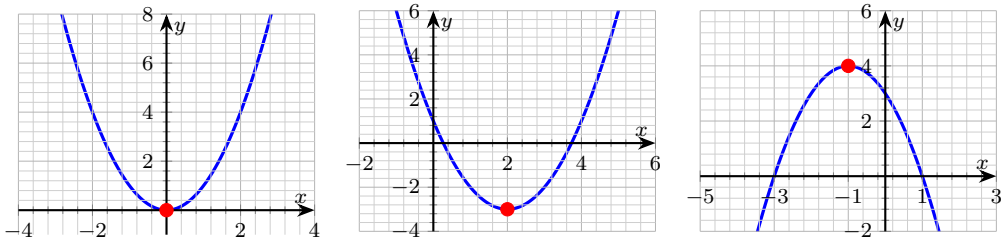


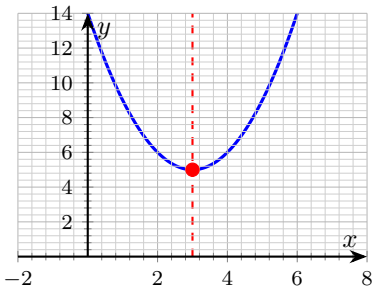
Table-to-graph check. A quadratic table is symmetric around the vertex. Equal y-values on both sides of the middle help you catch a misplaced vertex before graphing.

x	-2	-1	0	1	2
$f(x)$	8	3	0	-1	0

PRACTICE

Find the requested feature or write the equation.

1. Find the vertex of $f(x) = (x-3)^2 + 5$ from the graph. _____



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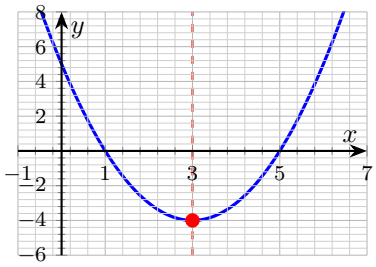
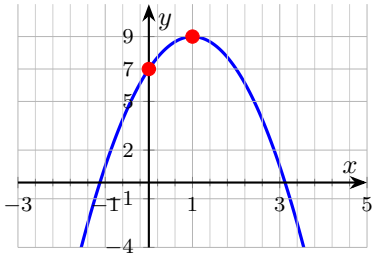
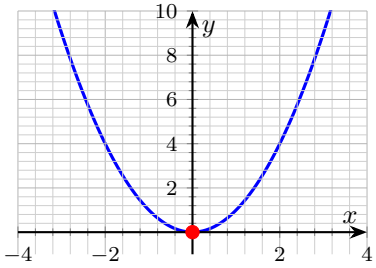
2. Find the vertex of $f(x) = x^2 - 6x + 5$. _____



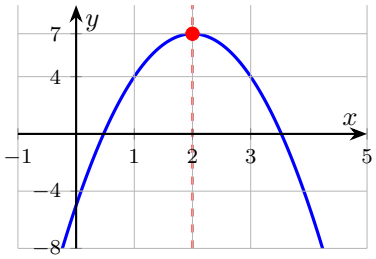
3. Find the y-intercept of $f(x) = -2x^2 + 4x + 7$. _____



4. Direction and vertex of the parent parabola $f(x) = x^2$. _____



5. Find the maximum of $f(x) = -3x^2 + 12x - 5$ and the x-value where it occurs. _____



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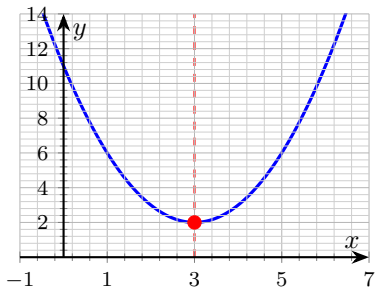
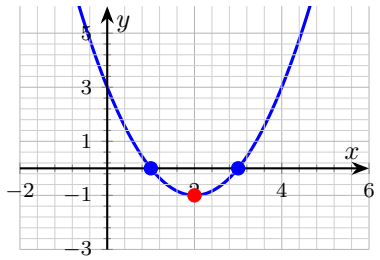
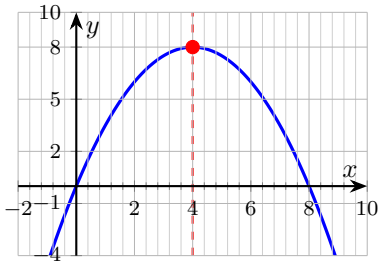
6. Convert $f(x) = x^2 - 6x + 11$ to vertex form. _____



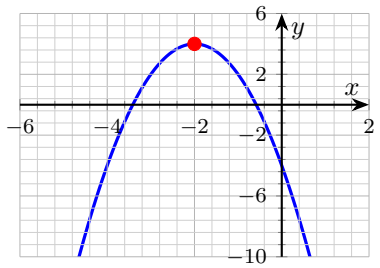
7. Find the vertex of $f(x) = x^2 - 4x + 3$. _____



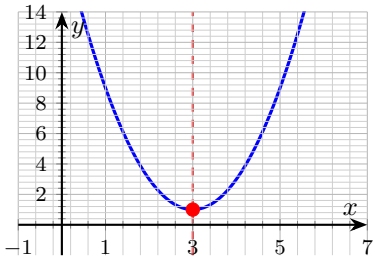
8. Find the vertex of $g(x) = -\frac{1}{2}(x-4)^2 + 8$. _____



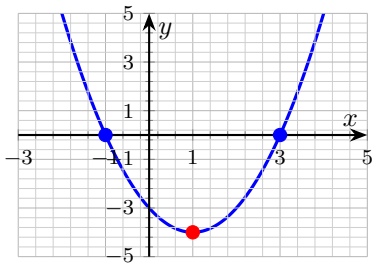
9. Write the equation in vertex form: vertex $(-2, 4)$, opens down, $|a| = 2$. _____



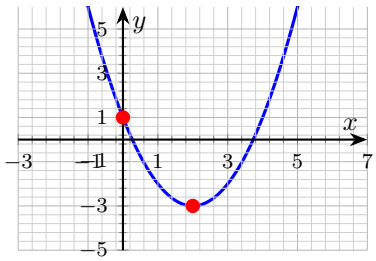
10. Convert to vertex form: $f(x) = 2x^2 - 12x + 19$, then locate the vertex on the graph. _____



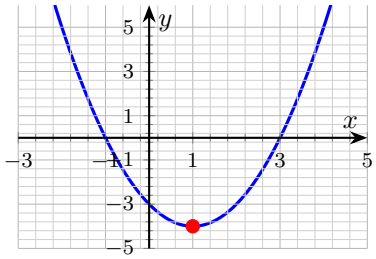
11. From the graph, find the vertex of $f(x) = (x-1)^2 - 4$. _____



12. A parabola has vertex $(2, -3)$ and passes through $(0, 1)$. Write its equation in vertex form. _____



13. Maximum or minimum value of $f(x) = (x-1)^2 - 4$? State the extreme value. _____



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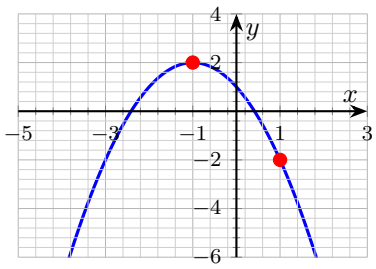
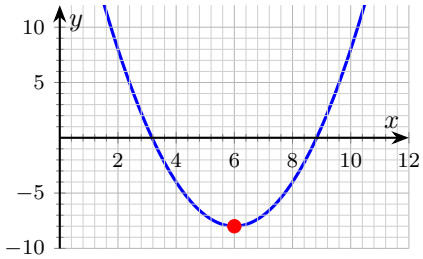
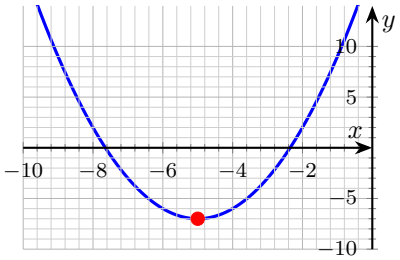
14. A parabola has vertex $(-1, 2)$ and passes through $(1, -2)$. Write its equation in vertex form. _____



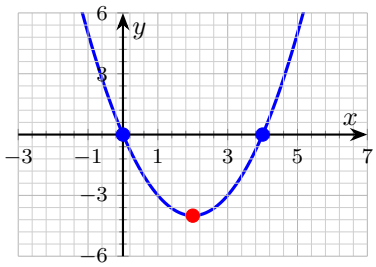
15. Write $x^2 - 12x + 28$ in vertex form. (Graph confirms.) _____



16. Write $x^2 + 10x + 18$ in vertex form. _____



17. Read the equation in vertex form from the graph. _____



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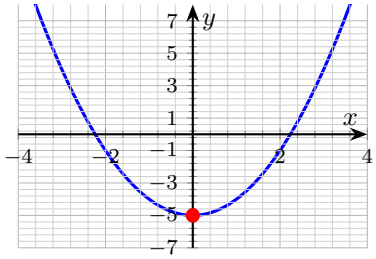
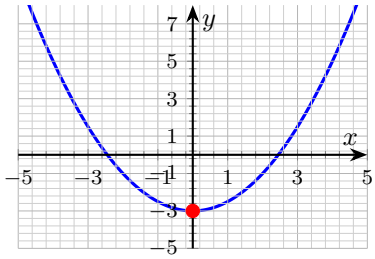
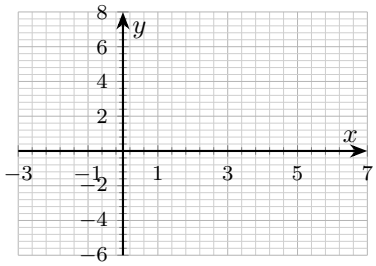
18. Match the graph: opens up, vertex below the x-axis. _____



19. Identify the graph of $f(x) = \frac{1}{2}x^2 - 3$. _____



20. Sketch $f(x) = -x^2 + 4x + 1$ on the plane and label the vertex. _____



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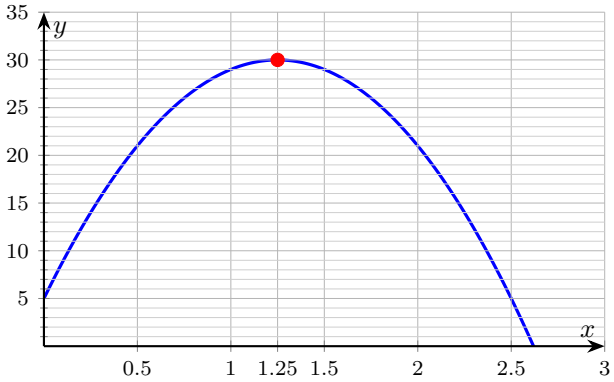
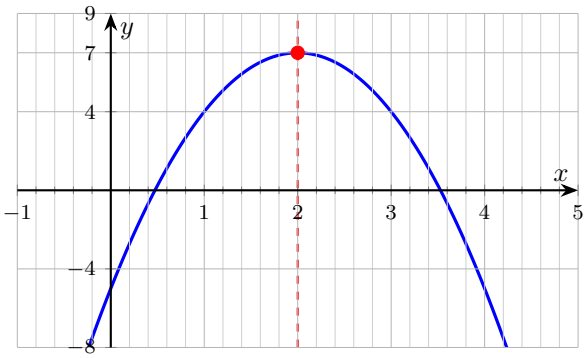
Word Problems

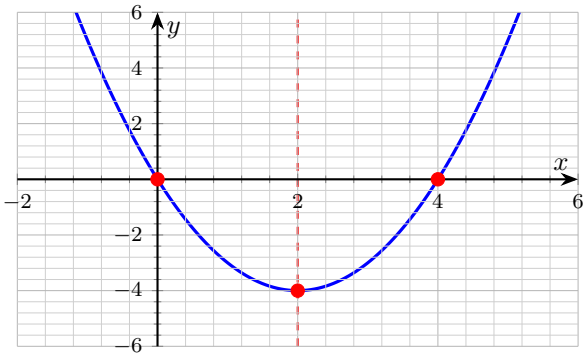
21. A ball is thrown upward from a height of 5 feet with an initial velocity of 40 ft/s. Its height is modeled by $h(t) = -16t^2 + 40t + 5$. What is the maximum height reached? ____



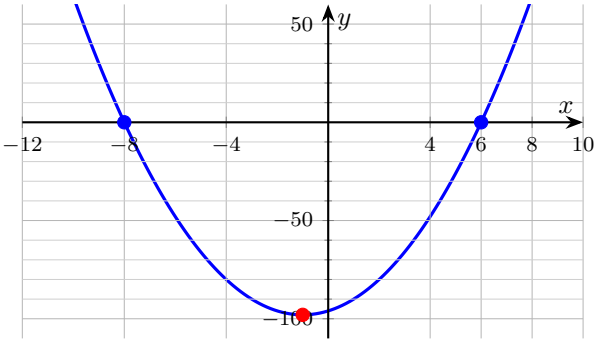
22. Revenue (in hundreds of dollars) follows $R(x) = -3x^2 + 12x - 5$, where x is the number of price increases. Find the maximum revenue and the x that produces it. ____



23. A parabola passes through the points $(0, 0)$, $(4, 0)$, and has its vertex on the line $x = 2$. Find the equation in vertex form if it also passes through $(2, -4)$. ____



24. A rectangular garden has length 4 feet more than twice its width, and its area is 96 ft^2. Find the width by setting up the area function and using its quadratic vertex form. ____



Additional Practice

25. Solve $x^2 - 5x + 6 = 0$. _____

26. Solve $x^2 = 49$. _____

27. Find the vertex of $y = (x - 3)^2 - 4$. _____

28. Find the axis of symmetry of $y = x^2 + 6x + 1$. _____

29. Factor $x^2 + 7x + 10$. _____

Answer Keys

1. $(3, 5)$
2. $(3, -4)$
3. $(0, 7)$
4. up; $(0, 0)$
5. 7 at $x = 2$
6. $f(x) = (x - 3)^2 + 2$
7. $(2, -1)$
8. $(4, 8)$
9. $f(x) = -2(x + 2)^2 + 4$
10. $f(x) = 2(x - 3)^2 + 1$
11. $(1, -4)$
12. $f(x) = (x - 2)^2 - 3$
13. minimum value -4
14. $f(x) = -(x + 1)^2 + 2$
15. $(x - 6)^2 - 8$
16. $(x + 5)^2 - 7$
17. $f(x) = (x - 2)^2 - 4$
18. one possible: $f(x) = x^2 - 5$
19. vertex $(0, -3)$, opens up, wide
20. vertex $(2, 5)$, opens down
21. 30 feet
22. \$700 at $x = 2$ price increases
23. $f(x) = (x - 2)^2 - 4$
24. 6 feet

Additional Practice Answers

25. $x = 2,\ 3$
26. $x = -7,\ 7$
27. $(3, -4)$
28. $x = -3$
29. $(x + 5)(x + 2)$

Additional Practice: Answers for all numbered items, including the added practice, are shown in the grid above.

Step-by-Step Explanations

1. Vertex form $a(x - h)^2 + k$ hands you the vertex (h, k) for free. Match it up: $h = 3$ (the number subtracted inside) and $k = 5$, so the vertex is $(3, 5)$. The dashed line $x = 3$ is the axis of symmetry running through it.

2. From standard form the vertex's x is $-\frac{b}{2a} = -\frac{-6}{2(1)} = 3$ (watch that $-b$ flips the sign of -6 to $+6$). Plug back for the height: $f(3) = 9 - 18 + 5 = -4$. Vertex $(3, -4)$.

3. Set $x = 0$: $f(0) = 7$. The constant term in standard form *is* the y-intercept. The graph crosses the y-axis at 7.

4. This is the parent parabola $y = x^2$. Since $a = 1 > 0$, it opens up, and with no shifts the vertex sits right at the origin $(0, 0)$.

5. Because $a = -3 < 0$ the parabola opens down, so the vertex is the highest point — a maximum. Find its x: $-\frac{b}{2a} = -\frac{12}{2(-3)} = 2$. Then $f(2) = -3(4) + 12(2) - 5 = -12 + 24 - 5 = 7$, so the max value is 7 at $x = 2$.

6. Half of -6 is -3, and $(-3)^2 = 9$. So $x^2 - 6x + 11 = (x^2 - 6x + 9) + 2 = (x - 3)^2 + 2$. Vertex $(3, 2)$, matching the graph.

7. One steady path is: $x_v = -\frac{-4}{2} = 2$. $f(2) = 4 - 8 + 3 = -1$. Vertex: $(2, -1)$. The graph also shows the two x-intercepts at 1 and 3. That gives a quick check on the answer.

8. Read the vertex straight off $a(x - h)^2 + k$: $(x - 4)$ gives $h = 4$ and the $+8$ gives $k = 8$, so the vertex is $(4, 8)$. The $-\frac{1}{2}$ only flips it open-down and widens it — coefficients never move the vertex.

9. Vertex $(-2, 4)$ gives $(x + 2)^2 + 4$. Opens down with $|a| = 2$, so $a = -2$. Final: $-2(x + 2)^2 + 4$.

10. Factor the 2 out of the variable terms: $2(x^2 - 6x) + 19$. Half of -6 is -3, square is 9: $2[(x - 3)^2 - 9] + 19 = 2(x - 3)^2 + 1$. Vertex $(3, 1)$.

11. Vertex form reveals the vertex: $h = 1$, $k = -4$. Reading the graph confirms it. (Intercepts: $(x - 1)^2 = 4$ gives $x = -1$ or $x = 3$.)

12. Vertex form: $f(x) = a(x-2)^2 - 3$. Use $(0, 1)$: $1 = a(0-2)^2 - 3 = 4a - 3$, so $4a = 4$ and $a = 1$. Equation: $(x - 2)^2 - 3$.

13. Since $a = 1 > 0$ the parabola opens up, so its vertex is the lowest point and the function has a minimum (not a maximum). Vertex form shows the vertex at $(1, -4)$, so the minimum value is -4, reached at $x = 1$.

14. Vertex form: $a(x + 1)^2 + 2$. Plug $(1, -2)$: $-2 = a(2)^2 + 2 = 4a + 2$, so $4a = -4$ and $a = -1$. Equation: $-(x + 1)^2 + 2$.

15. Complete the square: half of -12 is -6, and $(-6)^2 = 36$. Write $x^2 - 12x + 28 = (x^2 - 12x + 36) + 28 - 36 = (x - 6)^2 - 8$ — you add 36 to build the square, then subtract it back so nothing changes. Vertex $(6, -8)$.

16. Half of 10 is 5, and $5^2 = 25$. So $x^2+10x+18 = (x^2+10x+25)+18-25 = (x + 5)^2 - 7$. Since $(x + 5)^2 = (x - (-5))^2$, the vertex is $(-5, -7)$, matching the graph.

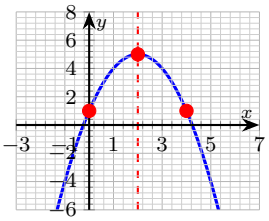
17. Vertex at $(2, -4)$, opens up. With intercepts at $x = 0$ and $x = 4$, a must be 1: check $(0 - 2)^2 - 4 = 0$. Match.

18. Positive leading coefficient ⇒ opens up. Constant term negative ⇒ vertex sits below the x-axis. The graph $f(x) = x^2 - 5$ fits exactly.

19. Since $a = \frac{1}{2} > 0$ the parabola opens up, and a coefficient between 0 and 1 flattens it — wider than $y = x^2$. With no x-term and a -3 constant, the vertex sits at $(0, -3)$.

20. Start with the key idea: $x_v = -\frac{4}{-2} = 2$, and $f(2) = -4 + 8 + 1 = 5$. Vertex: $(2, 5)$. $a = -1$ opens down. Plot the vertex, then a couple of symmetric points like $(0, 1)$ and $(4, 1)$ to anchor the curve. That gives a quick check on the answer.

Answer graph



21. Vertex of a downward parabola gives the max. $t_v = -\frac{40}{-32} = 1.25$ seconds. Then $h(1.25) = -16(1.5625) + 40(1.25) + 5 = -25 + 50 + 5 = 30$ feet.

22. Opens down, so the vertex is a maximum. $x_v = -\frac{12}{-6} = 2$, and $R(2) = -12 + 24 - 5 = 7$. The model is in hundreds of dollars, so the max revenue is \$700 at $x = 2$ price increases.

23. Vertex $(2, -4)$ gives $a(x - 2)^2 - 4$. Use $(0, 0)$: $0 = a(4) - 4$, so $a = 1$. Equation: $(x - 2)^2 - 4$. Check $(4, 0)$: $(2)^2 - 4 = 0$ ✓.

24. Let width be w; length is $2w+4$. Area: $w(2w+4) = 96$, so $2w^2+4w-96 = 0$, then $w^2 + 2w - 48 = 0$. Factor: $(w + 8)(w - 6) = 0$, so $w = 6$ (toss the negative). Width $= 6$ ft, length $= 16$ ft, area $= 96$. Check.

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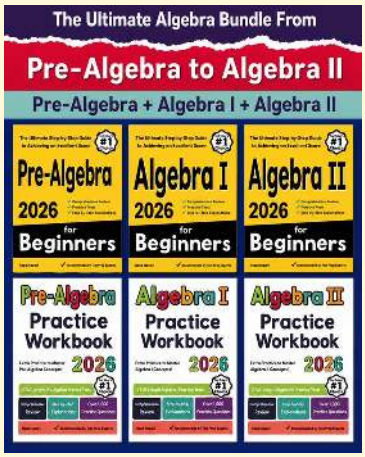

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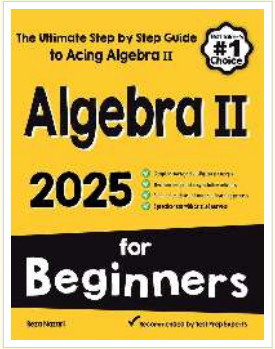

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