

# Build Quadratics from Roots

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Score: \_\_\_\_\_ / 35

## Quick Review

The relationship to memorize: **if  $r$  is a root of a quadratic, then  $(x - r)$  is a factor.** That's the key to running the construction in reverse — given roots, build the quadratic. Roots  $r_1$  and  $r_2$  give the factored form  $a(x - r_1)(x - r_2)$ , where  $a$  is any nonzero leading coefficient (it doesn't change the roots, only the steepness and direction of opening). Watch the signs: root  $-3$  gives the factor  $(x - (-3)) = (x + 3)$ , not  $(x - 3)$ .

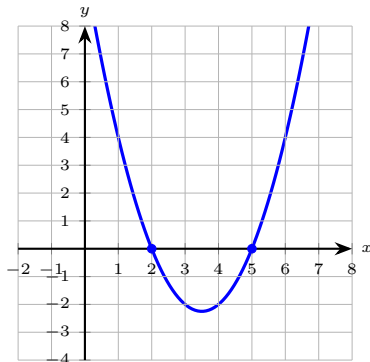
**Vieta's shortcut.** For a monic quadratic  $x^2 + bx + c$ , the sum of the roots is  $-b$  and the product is  $c$ . So roots  $r_1, r_2$  build the monic quadratic  $x^2 - (r_1 + r_2)x + r_1r_2$ .

**Irrational and complex conjugates:** if a quadratic has rational coefficients and one root is  $p + q\sqrt{n}$ , the other root must be the conjugate  $p - q\sqrt{n}$ . Same idea for complex coefficients: if real-coefficient and one root is  $a + bi$ , the other is  $a - bi$ . This is what forces the irrational/imaginary parts to cancel when you multiply the factors out.

## PRACTICE

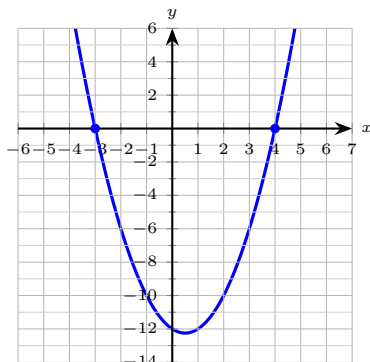
Build the requested quadratic.

1. This monic parabola ( $a = 1$ ) has the  $x$ -intercepts shown. Write it in factored form. \_\_\_\_\_



2. Expand:  $(x - 3)(x + 4)$  \_\_\_\_\_

3. The monic parabola ( $a = 1$ ) below crosses the  $x$ -axis at the marked points. Write it in standard form. \_\_\_\_\_



4. Leading coefficient 2; roots 1 and  $-3$ . \_\_\_\_\_

5. Monic quadratic: root sum 7, root product 12. \_\_\_\_\_

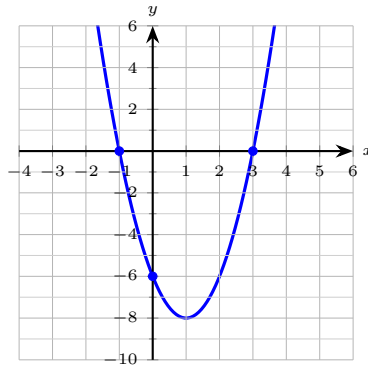
6. What is the other root if one root is  $3 + \sqrt{2}$  (rational coefficients)? \_\_\_\_\_

7. Monic standard form: roots  $-2$  and  $5$ . \_\_\_\_\_



8. Which expression has roots 1 and 4? Choose:  $(x - 1)(x - 4)$  or  $(x + 1)(x + 4)$ . \_\_\_\_\_

9. The parabola below has the marked  $x$ -intercepts and passes through the labelled point on the  $y$ -axis. Write its equation in factored form (find  $a$ ). \_\_\_\_\_



10. Monic quadratic with roots  $2 + \sqrt{5}$  and  $2 - \sqrt{5}$ . \_\_\_\_\_

11. Monic; roots  $-1$  and  $-6$ . \_\_\_\_\_

12. Monic; double root at  $4$ . \_\_\_\_\_

13. What is the other root if one is  $2 - 3i$  (real coefficients)? \_\_\_\_\_

14. Monic standard form: roots  $0$  and  $5$ . \_\_\_\_\_

15. Quadratic with leading  $3$ ; roots  $\frac{1}{3}$  and  $-2$ . \_\_\_\_\_

16. Quadratic with leading  $-1$ ; roots  $-4$  and  $1$ . \_\_\_\_\_

17. Monic; roots  $1 + i$  and  $1 - i$ . \_\_\_\_\_

18. Monic quadratic: root sum  $-2$ , root product  $-15$ . \_\_\_\_\_

19. Monic; double root at  $-\frac{3}{2}$ . \_\_\_\_\_

20. Standard form: roots  $-3$  and  $7$ ; leading coefficient  $1$ . \_\_\_\_\_

**◆ Word Problems**

21. A parabola has  $x$ -intercepts at  $-2$  and  $6$  and passes through the point  $(0, -12)$ . Write the quadratic in standard form. \_\_\_\_\_

22. A water-balloon launcher's trajectory has zeros (ground contact) at  $x = 0$  and  $x = 8$  meters. The balloon clears a  $4$ -meter wall at  $x = 4$  meters. Find the leading coefficient  $a$  and write the quadratic in factored form. \_\_\_\_\_

23. Find a monic quadratic with rational coefficients that has  $1 + \sqrt{3}$  as one of its roots. \_\_\_\_\_

24. A quadratic has zeros at  $x = -4$  and  $x = 3$  and a  $y$ -intercept of  $24$ . Find the leading coefficient  $a$ . \_\_\_\_\_

**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  $x^2 + 7x + 10$ . \_\_\_\_\_

30. Find the discriminant of  $x^2 - 4x + 8 = 0$ . \_\_\_\_\_

31. Solve  $2x^2 - 8 = 0$ . \_\_\_\_\_

32. Write roots  $-1$  and  $6$  as a quadratic. \_\_\_\_\_

33. Find the  $y$ -intercept of  $y = x^2 - 3x - 10$ . \_\_\_\_\_

34. Find zeros of  $y = (x - 4)(x + 2)$ . \_\_\_\_\_

35. Solve  $x^2 - 9 < 0$ . \_\_\_\_\_



## Answer Keys

<ol style="list-style-type: none"> <li>1. <math>(x - 2)(x - 5)</math></li> <li>2. <math>x^2 + x - 12</math></li> <li>3. <math>x^2 - x - 12</math></li> <li>4. <math>2x^2 + 4x - 6</math></li> <li>5. <math>x^2 - 7x + 12</math></li> <li>6. <math>3 - \sqrt{2}</math></li> <li>7. <math>x^2 - 3x - 10</math></li> <li>8. <math>(x - 1)(x - 4)</math></li> <li>9. <math>f(x) = 2(x + 1)(x - 3)</math></li> <li>10. <math>x^2 - 4x - 1</math></li> <li>11. <math>x^2 + 7x + 6</math></li> <li>12. <math>x^2 - 8x + 16</math></li> </ol> <p><b>Additional Practice Answers</b></p> <ol style="list-style-type: none"> <li>25. <math>x = 2, 3</math></li> <li>26. <math>x = -7, 7</math></li> <li>27. <math>(3, -4)</math></li> <li>28. <math>x = -3</math></li> <li>29. <math>(x + 5)(x + 2)</math></li> <li>30. <math>-16</math></li> </ol>	<ol style="list-style-type: none"> <li>13. <math>2 + 3i</math></li> <li>14. <math>x^2 - 5x</math></li> <li>15. <math>3x^2 + 5x - 2</math></li> <li>16. <math>-x^2 - 3x + 4</math></li> <li>17. <math>x^2 - 2x + 2</math></li> <li>18. <math>x^2 + 2x - 15</math></li> <li>19. <math>x^2 + 3x + \frac{9}{4}</math></li> <li>20. <math>x^2 - 4x - 21</math></li> <li>21. <math>f(x) = x^2 - 4x - 12</math></li> <li>22. <math>a = -\frac{1}{4}; y = -\frac{1}{4}x(x - 8)</math></li> <li>23. <math>x^2 - 2x - 2</math></li> <li>24. <math>a = -2</math></li> </ol> <ol style="list-style-type: none"> <li>31. <math>x = -2, 2</math></li> <li>32. <math>(x + 1)(x - 6)</math></li> <li>33. <math>(0, -10)</math></li> <li>34. <math>x = 4, -2</math></li> <li>35. <math>-3 &lt; x &lt; 3</math></li> </ol>
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**Additional Practice:** Answers for all numbered items, including the added practice, are shown in the grid above.

### Step-by-Step Explanations

1. Read the crossings:  $x = 2$  and  $x = 5$ . Each root  $r$  gives factor  $(x - r)$ . So  $(x - 2)(x - 5)$ . (Don't write  $(x + 2)(x + 5)$  — the signs flip from root to factor.)
2. FOIL each pair: First  $x \cdot x = x^2$ , Outer  $x \cdot 4 = 4x$ , Inner  $-3 \cdot x = -3x$ , Last  $-3 \cdot 4 = -12$ . Combine the middle terms  $4x - 3x = x$ :  $x^2 + x - 12$ .
3. The intercepts are  $x = -3$  and  $x = 4$ . Factors:  $(x + 3)(x - 4)$ . Expand:  $x^2 - 4x + 3x - 12 = x^2 - x - 12$ .
4. Factors  $2(x - 1)(x + 3)$ . Expand the inner pair:  $(x - 1)(x + 3) = x^2 + 2x - 3$ . Multiply by 2:  $2x^2 + 4x - 6$ .
5. A careful way to see it: Vieta's shortcut:  $x^2 - (\text{sum})x + (\text{product}) = x^2 - 7x + 12$ . (Factors:  $(x - 3)(x - 4)$ .) That gives a quick check on the answer.
6. With rational coefficients, irrational roots come in conjugate pairs. Conjugate of  $3 + \sqrt{2}$  is  $3 - \sqrt{2}$ .
7. Each root  $r$  gives factor  $(x - r)$ : root  $-2$  gives  $(x + 2)$ , root  $5$  gives  $(x - 5)$ . Expand:  $x^2 - 5x + 2x - 10 = x^2 - 3x - 10$ .
8. Roots map to factors with flipped signs:  $1 \rightarrow (x - 1)$ ,  $4 \rightarrow (x - 4)$ . The other choice has roots  $-1$  and  $-4$ .
9. The zeros are  $-1$  and  $3$ , so start with  $a(x + 1)(x - 3)$ . Use the labelled point  $(0, -6)$ :  $-6 = a(1)(-3) = -3a$ , so  $a = 2$ . Final:  $2(x + 1)(x - 3)$ .
10. Difference of squares pattern:  $(x - (2 + \sqrt{5}))(x - (2 - \sqrt{5})) = (x - 2)^2 - (\sqrt{5})^2 = x^2 - 4x + 4 - 5 = x^2 - 4x - 1$ .
11. Roots  $-1$  and  $-6$  give factors  $(x + 1)(x + 6)$  — a negative root flips to a plus sign inside. Expand:  $x^2 + 6x + x + 6 = x^2 + 7x + 6$ .
12. A double root at  $4$  means the factor  $(x - 4)$  appears twice:  $(x - 4)^2$ . Expand using  $(a - b)^2 = a^2 - 2ab + b^2$ :  $x^2 - 8x + 16$ .
13. With real coefficients, complex roots always come in conjugate pairs — that's what makes the imaginary parts cancel when you multiply the factors. So flip the

- sign on the imaginary part: the partner of  $2 - 3i$  is  $2 + 3i$ .
14. Root  $0$  gives factor  $(x - 0) = x$ , and root  $5$  gives  $(x - 5)$ . Multiply:  $x(x - 5) = x^2 - 5x$ . Zero is a valid root — its factor is just  $x$ .
15. One steady path is: Factored:  $3(x - \frac{1}{3})(x + 2) = (3x - 1)(x + 2)$ . Expand:  $3x^2 + 6x - x - 2 = 3x^2 + 5x - 2$ . That gives a quick check on the answer.
16. Factored:  $-(x + 4)(x - 1)$ . Expand the pair:  $(x + 4)(x - 1) = x^2 + 3x - 4$ . Negate:  $-x^2 - 3x + 4$ .
17. A careful way to see it:  $(x - (1 + i))(x - (1 - i)) = (x - 1)^2 - i^2 = x^2 - 2x + 1 + 1 = x^2 - 2x + 2$ . (Recall  $-i^2 = +1$ .) That gives a quick check on the answer.
18. Keep the rule visible:  $x^2 - (\text{sum})x + (\text{product}) = x^2 + 2x - 15$ . (Factors:  $(x + 5)(x - 3)$ .) That gives a quick check on the answer.
19. One steady path is:  $(x + \frac{3}{2})^2 = x^2 + 3x + \frac{9}{4}$ . Equivalently,  $4x^2 + 12x + 9$  after clearing the fraction. That gives a quick check on the answer.
20. Start with the key idea: Factors:  $(x + 3)(x - 7)$ . Expand:  $x^2 - 7x + 3x - 21 = x^2 - 4x - 21$ . That gives a quick check on the answer.
21. Factored:  $f(x) = a(x + 2)(x - 6)$ . Use  $(0, -12)$ :  $-12 = a(2)(-6) = -12a$ , so  $a = 1$ . Then  $(x + 2)(x - 6) = x^2 - 4x - 12$ .
22. Factored:  $y = a \cdot x(x - 8)$ . At the wall,  $x = 4$  gives  $y = 4$ :  $4 = a(4)(-4) = -16a$ , so  $a = -\frac{1}{4}$ . Final:  $y = -\frac{1}{4}x(x - 8)$ . Verify the zeros:  $x = 0$  and  $x = 8$  both make  $y = 0$ . ✓
23. Conjugate root must be  $1 - \sqrt{3}$ . Then  $(x - (1 + \sqrt{3}))(x - (1 - \sqrt{3})) = (x - 1)^2 - (\sqrt{3})^2 = x^2 - 2x + 1 - 3 = x^2 - 2x - 2$ .
24. Factored:  $f(x) = a(x + 4)(x - 3)$ . At  $x = 0$ :  $f(0) = a(4)(-3) = -12a = 24$ , so  $a = -2$ . The parabola opens down and is steep enough to hit  $y = 24$  at the  $y$ -axis.



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