

10.1

Adding and Subtracting Polynomials

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Guided Practice

CRITICAL THINKING about the Lesson

- Describe a polynomial in one variable.
- Name the terms of $-3x^3 - 2x^2 + 4x - 5$.
- Name the coefficients in $-7x^3 + 12x - 31$.
 $-7, 0, 12, -31$
- Write $15y - 6 + 10y^3 - 3y^2$ in standard form. $10y^3 - 3y^2 + 15y - 6$
- What is the degree of $2x^2 - 4x^3 + 7$? **3**
- Subtract $(2x^2 - 4x + 1)$ from $(x^2 + 8)$.
 $-x^2 + 4x + 7$

1. See page 508.

Independent Practice

In Exercises 7–10, classify the polynomial by degree and by number of terms.

- $-5x - 4$ **Linear, binomial**
- -7 **Constant, monomial**
- $16 - 4x + 3x^2 - x^4$ **Quadratic, polynomial**
- $3x^2 + 6x + 1$ **Quadratic, trinomial**

In Exercises 11–16, add the polynomials. (Use a horizontal format.)

- $x^2 - 3$; $3x^2 + 5$ **$4x^2 + 2$**
- $-3y + 2$; $y^2 + 3y + 2$ **$y^2 + 4$**
- $2x^2 + 3x + 1$; $x^2 - 2x + 2$ **$3x^2 + x + 3$**
- $2x^2 - x + 3$; $3x^2 - 4x + 7$ **$5x^2 - 5x + 10$**
- $12x^3 + 2x^2 - 4$; $9x^2 + 3x - 8$
- $-4x^3 - 2x^2 + x - 5$; $2x^3 + 3x + 4$
 $12x^3 + 11x^2 + 3x - 12$
- $-2x^3 - 2x^2 + 4x - 1$**

In Exercises 17–20, add the polynomials. (Use a vertical format.)

- $2z - 8z^2 - 3$; $z^2 + 5z$ **$-7z^2 + 7z - 3$**
- $6x^2 + 5$; $3 - 2x^2$ **$4x^2 + 8$**
- $5x^4 - 2x + 7$; $-3x^4 + 6x^2 - 5$
- $4x^2 - 7x + 2$; $-x^2 + x - 2$ **$3x^2 - 6x$**
- $2x^4 + 6x^2 - 2x + 2$**

In Exercises 21–24, subtract the second polynomial from the first. (Use a horizontal format.)

- $z^3 + z^2 + 1$; z^2 **$z^3 + 1$**
- 10 ; $u^2 + 5$ **$-u^2 + 5$**
- $2x^2 + 3x - 4$; $x^2 + x - 1$ **$x^2 + 2x - 3$**
- $3x^3 - 4x^2 + 3$; $x^3 + 3x^2 - x - 4$
 $2x^3 - 7x^2 + x + 7$

In Exercises 25–28, subtract the second polynomial from the first. (Use a vertical format.)

25. $10x^3 + 15$; $17x^3 - 4x + 5$ $-7x^3 + 4x + 10$

26. $y^2 + 3y^4$; $y^5 - y^4$ $-y^6 + 4y^4 + y^2$

27. $-2x^3 + 5x^2 - x + 8$; $-2x^3 + 3x - 4$

28. $3x^2 + 7x - 6$; $3x^2 + 7x - 6$

$5x^2 - 4x + 12$

In Exercises 29–34, perform the indicated operations. Use either a horizontal or vertical format and explain why you chose the method you used. *Reasons will vary.*

29. $(6x - 5) - (8x + 15) + (3x - 4)$ $x - 24$

30. $(2x^2 + 1) + (x^2 - 2x + 1) - (2x^2 + 8)$ $x^2 - 2x - 6$

31. $-(x^3 - 2) + (4x^3 - 2x) - (2x^2 + 3)$

32. $-(5x^2 - 1) - (-3x^2 + 5) - (x^2 - x)$

33. $2(t^2 + 5) - 3(t^2 + 5) + 5(t^2 + 5)$ $4t^2 + 20$

34. $-10(u + 1) + 8(u - 1) - 3(u + 6)$

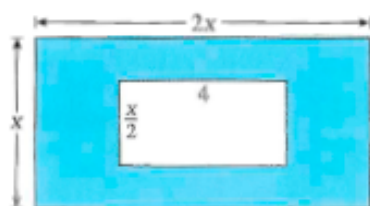
31. $3x^3 - 2x^2 - 2x - 1$ $-5u - 36$

32. $-3x^2 + x - 4$

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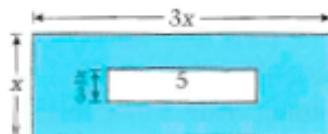
Geometry In Exercises 35 and 36, find the area of the shaded region.

35.



$2x^2 - 2x$

36.



$3x^2 - \frac{5}{3}x$

10.2

Multiplying Polynomials



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EXERCISES

Guided Practice

► **CRITICAL THINKING about the Lesson** See below.

1. Show how the Distributive Properties can be used to multiply $(2x - 3)$ and $(x + 4)$.
2. Multiply: $(x + 1)(x^2 - x + 1)$. Explain your use of the Distributive Property.
3. Multiply: $(x - 3)(2x + 5)$. $2x^2 - x - 15$
4. What does FOIL represent?

Independent Practice

In Exercises 5–10, multiply.

5. $(3x - 7)(-2x)$ $-6x^2 + 14x$
6. $3x^2(5x - x^3 + 2)$ $15x^3 - 3x^5 + 6x^2$
7. $(-x)(2x^2 - 3x)$ $-2x^3 + 3x^2$
8. $2x(3x^2 - 4x + 1)$ $6x^3 - 8x^2 + 2x$
9. $4x^2(5x^3 - 2x^2 + x)$ $20x^5 - 8x^4 + 4x^3$
10. $-x^2(6x^3 - 14x + 9)$ $-6x^5 + 14x^3 - 9x^2$

In Exercises 11–16, use the FOIL pattern to multiply.

11. $(3x - 2)(5x + 7)$ $15x^2 + 11x - 14$
12. $(3x + 5)(2x + 1)$ $6x^2 + 13x + 5$
13. $(x - 4)(x + 4)$ $x^2 - 16$
14. $(2x - 3)(x + 3)$ $2x^2 + 3x - 9$
15. $(x - 5)(2x + 10)$ $2x^2 - 50$
16. $(3x - 5)(2x + 1)$ $6x^2 - 7x - 5$

In Exercises 17–22, use an area model (or algebra tiles) to multiply. See Additional Answers.

17. $(x + 1)(x + 5)$ $x^2 + 6x + 5$
18. $(x + 2)(x + 6)$ $x^2 + 8x + 12$
19. $(x + 1)(x + 2)$ $x^2 + 3x + 2$
20. $(3x + 1)(2x + 2)$ $6x^2 + 8x + 2$
21. $(x + 2)(2x + 3)$ $2x^2 + 7x + 6$
22. $(2x + 1)(x + 3)$ $2x^2 + 7x + 3$

In Exercises 23–28, use the Distributive Property to multiply.

23. $(x - 3)(3x + 1)$ $3x^2 - 8x - 3$
24. $(2x + 1)(3x + 1)$ $6x^2 + 5x + 1$
25. $(3x^2 + x - 5)(2x - 1)$ $6x^3 - x^2 - 11x + 5$
26. $(2x^2 - 7x + 1)(4x + 3)$ $8x^3 - 22x^2 - 17x + 3$
27. $(x^2 + 9)(x^2 - x - 4)$ $x^4 - x^3 + 5x^2 - 9x - 36$
28. $(x + 3)(x^2 - 6x + 2)$ $x^3 - 3x^2 - 16x + 6$

In Exercises 23–28, use the Distributive Property to multiply.

23. $(x - 3)(3x + 1)$ $3x^2 - 8x - 3$ 24. $(2x + 1)(3x + 1)$ $6x^2 + 5x + 1$ 25. $(3x^2 + x - 5)(2x - 1)$

26. $(2x^2 - 7x + 1)(4x + 3)$ 27. $(x^2 + 9)(x^2 - x - 4)$ 28. $(x + 3)(x^2 - 6x + 2)$
 $8x^3 - 22x^2 - 17x + 3$ $x^4 - x^3 + 5x^2 - 9x - 36$ $x^3 - 3x^2 - 16x + 6$

In Exercises 29–37, multiply.

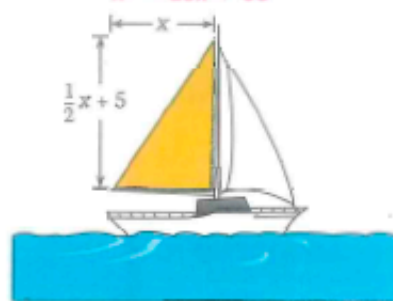
29. $(x + 3)(x - 4)$ $x^2 - x - 12$ 30. $(2x - 1)(x + 9)$ $2x^2 + 17x - 9$ 31. $(2x - 5)(x + 6)$
 32. $(3x - 4)(\frac{1}{3}x + 1)$ $x^2 + \frac{5}{3}x - 4$ 33. $(x + \frac{6}{5})(4x - 5)$ $4x^2 - \frac{1}{5}x - 6$ 34. $(x + \frac{1}{4})(x - \frac{5}{4})$
 35. $(\frac{1}{2}x + 3)(\frac{1}{2}x - 2)$ $\frac{1}{4}x^2 + \frac{1}{2}x - 6$ 36. $(-3x^2 + x - 1)(x + 3)$ 37. $(x^2 + 4x - 9)(x - 4)$
 $x^3 - 25x + 36$

38. **Area of a Sail** The base of a triangular sail is x feet and its height is $\frac{1}{2}x + 5$ feet. Find an expression for the area, A , of the sail. $A = \frac{1}{4}x^2 + \frac{5}{2}x$

39. Use the expression in Exercise 38 to complete the table.

Base, x	5	6	7	8	9	10
Area, A	?	?	?	?	?	?

$18\frac{3}{4}, 24, 29\frac{3}{4}, 36, 42\frac{3}{4}, 50$



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34. $x^2 - x - \frac{5}{16}$

1. $(2x - 3)(x + 4) = 2x(x + 4) - 3(x + 4)$
 $= 2x^2 + 8x - 3x - 12 = 2x^2 + 5x - 12$ 2. $(x^3 + 1), x(x^2 - x + 1) + 1(x^2 - x + 1)$
 $= x^3 - x^2 + x + x^2 - x + 1$

10.3

Multiplying Polynomials: Two Special Cases

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I'VE DECIDED TO SIMPLIFY MY LIFE, ROY. YOU'RE OUT.
MY iPhone IS IN."

Guided Practice

CRITICAL THINKING about the Lesson

1. True or False? The product of $(a - b)$ and $(a - b)$ is $a^2 - b^2$. Explain. **False. See margin.** $(a + b)^2 = a^2 + \boxed{?} + b^2$, $2ab$
2. Find the missing term:
 $(x - 3)(x + 3) = x^2 - 9$; $(x + 3)^2 = x^2 + 6x + 9$;
 $(x - 3)^2 = x^2 - 6x + 9$
3. Write two expressions for the area of a square whose sides are each $x - 4$.
 $(x - 4)^2$, $x^2 - 8x + 16$
4. Give an example of each of the types of special products in this lesson.

Answer

$$\begin{aligned} 1. \text{ False } (a - b)(a - b) \\ &= a^2 - ab - ab + b^2 \\ &= a^2 - 2ab + b^2 \neq a^2 - b^2 \end{aligned}$$

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Independent Practice

In Exercises 5–10, use an area model (or algebra tiles) to write the square as a trinomial. **See Additional Answers.**

5. $(x + 2)^2$ $x^2 + 4x + 4$
6. $(x + 3)^2$ $x^2 + 6x + 9$
7. $(2n + 1)^2$ $4n^2 + 4n + 1$
8. $(3a + 2)^2$ $9a^2 + 12a + 4$
9. $(2x + 2)^2$ $4x^2 + 8x + 4$
10. $(3x + 1)^2$ $9x^2 + 6x + 1$

In Exercises 11–16, write the square as a trinomial.

11. $(n + 6)^2$ $n^2 + 12n + 36$
12. $(x + 4)^2$ $x^2 + 8x + 16$
13. $(2x + 1)^2$ $4x^2 + 4x + 1$
14. $(2m - 3)^2$ $4m^2 - 12m + 9$
15. $(3t - 2)^2$ $9t^2 - 12t + 4$
16. $(x - 9)^2$ $x^2 - 18x + 81$

In Exercises 17–22, multiply.

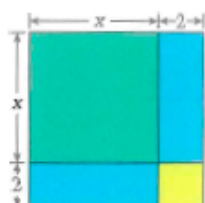
17. $(x + 5)(x - 5)$ $x^2 - 25$
18. $(x - 2)(x + 2)$ $x^2 - 4$
19. $(2x - 2)(2x + 2)$ $4x^2 - 4$
20. $(5x - 6)(5x + 6)$ $25x^2 - 36$
21. $(a + 2b)(a - 2b)$ $a^2 - 4b^2$
22. $(4x - 7y)(4x + 7y)$ $16x^2 - 49y^2$

In Exercises 23–28, write the square as a trinomial.

23. $(x + 6)^2$ $x^2 + 12x + 36$
24. $(x + 10)^2$ $x^2 + 20x + 100$
25. $(a - 2)^2$ $a^2 - 4a + 4$
26. $(2x - 5)^2$ $4x^2 - 20x + 25$
27. $(2x - 5y)^2$ $4x^2 - 20xy + 25y^2$
28. $(4s + 3t)^2$ $16s^2 + 24st + 9t^2$

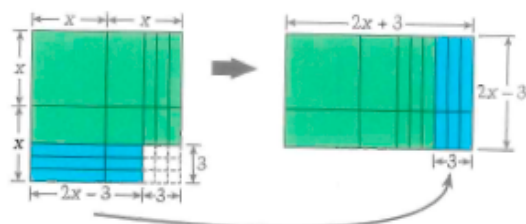
Area Model (or Algebra Tiles) In Exercises 29 and 30, write two different expressions for the area of the figure. Describe the special-product pattern that is represented.

29.



$(x + 2)^2$, $x^2 + 4x + 4$; square of a binomial

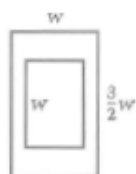
30.



$4x^2 - 9$, $(2x + 3)(2x - 3)$;
Product of a sum and difference of two terms

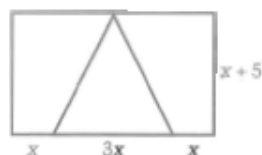
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33. **Geometry** The ratio of the height and width of the smaller rectangle is equal to the ratio of the height and width of the larger rectangle. Find expressions for the perimeters and areas of both.



Large: $P = 5w$, $A = \frac{3}{2}w^2$. Small: $P = \frac{10}{3}w$, $A = \frac{2}{3}w^2$ Triangle: $A = \frac{3}{2}x^2 + \frac{15}{2}x$. Rectangle: $A = 5x^2 + 25x$

34. **Geometry** Find the area of the rectangle and the area of the triangle.



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10.4

Factoring: Special Products



Guided Practice

CRITICAL THINKING about the Lesson

- Describe the relationship between multiplying polynomials and factoring a polynomial. **Each is the reverse process of the other.**
- Factor out the greatest common monomial factor: $3x^3 - 6x^2 + 9$.
 $3(x^3 - 2x^2 + 3)$
- Show how the Distributive Property can be used to factor $2x(2x - 3) + 3(2x - 3)$.
3., 4. See margin.
- Give an example of each of the three special-product factoring patterns in the lesson.

Independent Practice

In Exercises 5–10, find the greatest common factor of the given terms.

- $6x^5, 30x^4, 12x^3$ **$6x^3$**
- $7x^3, 28x, 14x^4$ **$7x$**
- $24x^3, 32x^2$ **$8x^2$**
- $99x^6, 45x^3$ **$9x^3$**
- $16x^2y, 84xy^2, 36x^2y^2$ **$4xy$**
- $10xy^2, 25x^3y^2, 80x^2y$ **$5xy$**

In Exercises 11–19, factor out the greatest common monomial factor. *(difficult!)*

- $2x^2 - 4$ **$2(x^2 - 2)$**
- $3x + 6$ **$3(x + 2)$**
- $4a - 12$ **$4(a - 3)$**
- $14z^3 + 21$ **$7(2z^3 + 3)$**
- $24x^2 - 18$ **$6(4x^2 - 3)$**
- $-a^3 - 4a$ **$-a(a^2 + 4)$**
- $21u^2 - 14u$ **$7u(3u - 2)$**
- $36y^4 + 24y^2$ **$12y^2(3y^2 + 2)$**
- $4x^2 - 8x + 8$ **$4(x^2 - 2x + 2)$**

In Exercises 20–28, factor the expression. **25. $(u + \frac{1}{4})(u - \frac{1}{4})$**

- $x^2 - 64$ **$(x + 8)(x - 8)$**
- $y^2 - 144$ **$(y + 12)(y - 12)$**
- $2x^2 + 16x + 32$
- $9x^2 - 30xy + 25y^2$ **$(3x - 5y)^2$**
- $4y^2 + 20yz + 25z^2$ **$(2y + 5z)^2$**
- $u^2 - \frac{1}{16}$
- $v^2 - \frac{9}{25}$ **$(v + \frac{3}{5})(v - \frac{3}{5})$**
- $81 - (z + 5)^2$ **$(4 - z)(14 + z)$**
- $3(x - 3)^2 - 12$ **$3(x - 5)(x - 1)$**

10.5

Factoring Quadratic Trinomials

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REVOLUTIONIZE THE WAY
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EXERCISES

Guided Practice

CRITICAL THINKING about the Lesson

- Factor $x^2 - 4x + 3$. When testing possible factorizations, why is it unnecessary to test $(x - 1)(x + 3)$ and $(x + 1)(x - 3)$?
 - Factor $x^2 + 2x - 3$. When testing possible factorizations, why is it unnecessary to test $(x - 1)(x - 3)$ and $(x + 1)(x + 3)$?
 - What is the discriminant of $ax^2 + bx + c$?
 $b^2 - 4ac$
 - If the discriminant of $ax^2 + bx + c$ is 35, can the trinomial be factored with integer coefficients? Explain.
No. The discriminant must be the square of an integer.
- 1., 2. See margin.

Independent Practice

In Exercises 5–10, choose the correct factorization. (If neither is correct, find the correct factorization.)

- | | | |
|-----------------------------|-----------------------------|--|
| 5. $x^2 + x - 20$ a | 6. $x^2 + 8x + 16$ b | 7. $x^2 - 10x + 24$ a |
| a. $(x - 4)(x + 5)$ | a. $(x + 2)(x + 8)$ | a. $(x - 6)(x - 4)$ |
| b. $(x + 4)(x - 5)$ | b. $(x + 4)(x + 4)$ | b. $(x - 12)(x + 2)$ |
| 8. $3x^2 - 7x - 6$ a | 9. $6x^2 - 7x - 5$ b | 10. $2x^2 - 7x - 9$ |
| a. $(x - 3)(3x + 2)$ | a. $(6x + 1)(x - 5)$ | a. $(x - 1)(2x + 9)$ |
| b. $(x + 3)(3x - 2)$ | b. $(2x + 1)(3x - 5)$ | b. $(2x - 1)(x + 9)$ |
| | | Neither, $(x + 1)(2x - 9)$ |

In Exercises 11–28, factor the trinomial.

- | | | |
|--|--|-----------------------|
| 11. $x^2 + 3x - 4$ $(x + 4)(x - 1)$ | 12. $x^2 - 5x + 6$ $(x - 2)(x - 3)$ | 13. $x^2 + 3x - 18$ |
| 14. $y^2 - 16y - 36$ $(y - 18)(y + 2)$ | 15. $x^2 - 10x + 24$ $(x - 6)(x - 4)$ | 16. $x^2 + 13x + 22$ |
| 17. $x^2 + 15x + 50$ $(x + 10)(x + 5)$ | 18. $y^2 + 30y + 216$ $(y + 12)(y + 18)$ | 19. $y^2 - 35y + 300$ |
| 20. $t^2 - 4t - 21$ $(t - 7)(t + 3)$ | 21. $3x^2 + 8x + 5$ $(3x + 5)(x + 1)$ | 22. $6x^2 + 5x - 4$ |
| 23. $2x^2 - x - 21$ $(2x - 7)(x + 3)$ | 24. $3x^2 + 11x + 10$ $(3x + 5)(x + 2)$ | 25. $48 - 16y + y^2$ |
| 26. $32 + 12x + x^2$ $(x + 4)(x + 8)$ | 27. $2x^2 - x - 6$ $(2x + 3)(x - 2)$ | 28. $5 + 34x - 7x^2$ |

In Exercises 29–34, use the discriminant to decide whether the polynomial can be factored with integer coefficients. If it can be factored, then find the factors:

29. $12x^2 - 11x + 3$ **Cannot**

30. $2x^2 - 5x - 12$ $(2x + 3)(x - 4)$

31. $6x^2 - 10x + 4$ $2(3x - 2)(x - 1)$

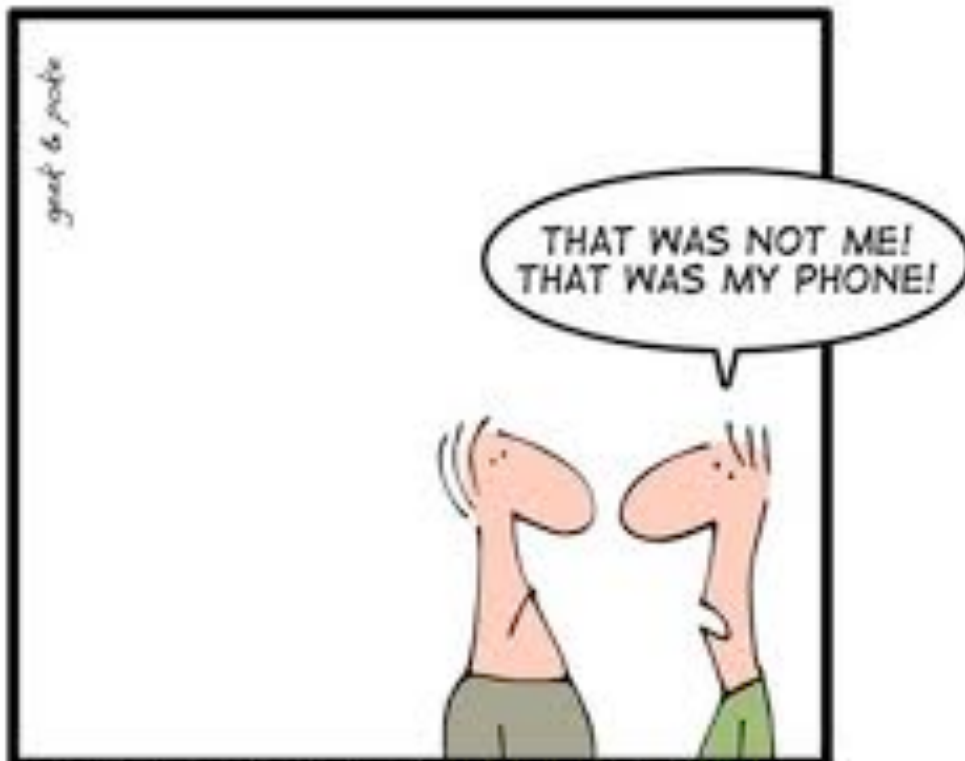
32. $10x^2 - 9x + 6$ **Cannot**

33. $14x^2 - 19x - 40$ $(7x + 8)(2x - 5)$

34. $24x^2 + 3x - 11$ **Cannot**

35. **Geometry** The area of a rectangle is given by $A = x^2 + 4x - 5$. Find expressions for possible lengths and widths of the rectangle. $x + 5, x - 1$

36. **Geometry** The area of a circle is given by $A = \pi(4x^2 + 12x + 9)$. Find an expression for the radius of the circle. $2x + 3$



THE RELEASE OF "IFART MOBILE" MADE IT CLEAR:
A PHONE IS NOT ONLY FOR PHONING

10.6

Solving Quadratic Equations by Factoring



Guided Practice

CRITICAL THINKING about the Lesson

1. Use the Zero-Product Property to complete the statement. If $ab = 0$, then $\boxed{?}$.
2. Solve the equation: $(x - 2)(x + 1) = 0$.
 $2, -1$
3. Solve the equation: $3x^2 + 4x = 0$. $0, -\frac{4}{3}$
4. Which two numbers satisfy the statement, "The sum of a number and its square is zero."? $0, -1$
5. True or False? If $(5x - 1)(x + 3) = 1$, then $5x - 1 = 1$ or $x + 3 = 1$. Explain.
False. The product of any number and its reciprocal is 1; so neither factor has to equal 1.
6. True or False? If $(x + 3)(x - 3) = 0$, then $x + 3 = 0$ or $x - 3 = 0$. Explain.
True. A product cannot equal 0, unless one of the factors is 0.

Independent Practice

In Exercises 7–10, solve the equation.

7. $(x + 1)(x + 2) = 0$ $-1, -2$
8. $(x - 3)(x + 7) = 0$ $3, -7$
9. $(x + 3)(x + 4) = 0$ $-3, -4$
10. $(x + 6)(x - 5) = 0$ $-6, 5$

In Exercises 11–16, solve the equation by factoring.

11. $x^2 + 5x - 6 = 0$ $-6, 1$
12. $3x^2 + 11x - 4 = 0$ $\frac{1}{3}, -4$
13. $2x^2 + 5x + 3 = 0$ $-\frac{3}{2}, -1$
14. $6x^2 + 13x + 5 = 0$ $-\frac{1}{2}, -\frac{5}{3}$
15. $3x^2 + 7x + 2 = 0$ $-\frac{1}{3}, -2$
16. $12x^2 - 5x - 3 = 0$ $\frac{3}{4}, -\frac{1}{3}$

In Exercises 17–24, match the equation with its solutions.

17. $x^2 - 5x + 6 = 0$ **f** 18. $x^2 + 5x + 6 = 0$ **b** 19. $x^2 - 7x + 6 = 0$ **g** 20. $x^2 + 7x + 6 = 0$ **a**
 21. $x^2 - 5x - 6 = 0$ **d** 22. $x^2 + 5x - 6 = 0$ **c** 23. $x^2 + x - 6 = 0$ **e** 24. $x^2 - x - 6 = 0$ **h**
 a. $-1, -6$ b. $-2, -3$ c. $1, -6$ d. $-1, 6$
 e. $2, -3$ f. $2, 3$ g. $1, 6$ h. $-2, 3$

In Exercises 25–33, solve the equation by finding square roots, by the quadratic formula, or by factoring.

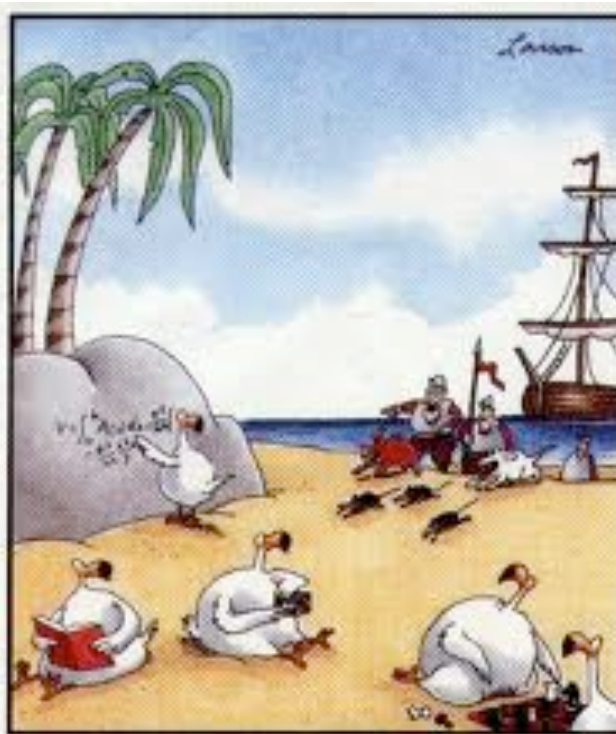
25. $x(x - 9) = 0$ **0, 9** 26. $2y(y + 6) = 0$ **0, -6** 27. $y^2 - 7y + 6 = -6$ **3, 4**
 28. $x^2 - 12 = -3$ **± 3** 29. $x^2 - 8x = -16$ **4** 30. $x^2 + 4x + 7 = 3$ **-2**
 31. $4x^2 + 2x = 0$ **0, $-\frac{1}{2}$** 32. $4y^2 - 18y = 0$ **0, $\frac{9}{2}$** 33. $x^2 - 12x + 40 = 4$ **6**

In Exercises 34 and 35, multiply both sides of the equation by an appropriate power of ten to obtain integer coefficients. Then solve by factoring.

- ★ 34. $0.8x^2 + 3.2x + 2.4 = 0$ **-1, -3** ★ 35. $0.23x^2 - 0.54x + 0.16 = 0$ **$\frac{8}{23}, 2$**

9.2

Solving Quadratic Equations by Finding Square Roots



Unbeknownst to most ornithologists, the dodo was actually a very advanced species, living alone quite peacefully until, in the 17th century, it was annihilated by men, rats, and dogs. As usual.

Guided Practice

CRITICAL THINKING about the Lesson

1. Which of the following are quadratic equations?

a. $-3x + 5 = 0$

b. $x^2 - 1 = 0$

c. $x^2 - 3x^3 = 0$

d. $-3 + 4x + x^2 = 0$

In Exercises 2–4, write in standard form and find the leading coefficient.

2. $-3x^2 + 5 = 0$ As is, -3

3. $\frac{1}{2}x^2 + 9x - 3 = 0$ As is, $\frac{1}{2}$

4. $-8x - x^2 + 4 = 0$
 $-x^2 - 8x + 4 = 0$, -1

In Exercises 5–8, solve the equation. If there are no solutions, state the reason.

5. $x^2 = 17 \pm \sqrt{17}$

6. $x^2 = 0$ 0

7. $x^2 = -4$
No real solution

8. $x^2 = 6 \pm \sqrt{6}$

Independent Practice

In Exercises 9–20, solve the equation.

9. $x^2 = 9 \pm 3$

10. $h^2 = 25 \pm 5$

11. $6x^2 = 600 \pm 10$

16. ± 12

12. $\frac{1}{5}x^2 = 5 \pm 5$

13. $3x^2 = 363 \pm 11$

14. $2b^2 = 98 \pm 7$

15. $t^2 + 2 = 11 \pm 3$

16. $t^2 - 57 = 87$

17. $\frac{1}{2}x^2 - 1 = 7 \pm 4$

18. $4y^2 + 7 = 8 \pm \frac{1}{2}$

19. $2s^2 - 5 = 27 \pm 4$

20. $81x^2 - 5 = 20 \pm \frac{5}{9}$

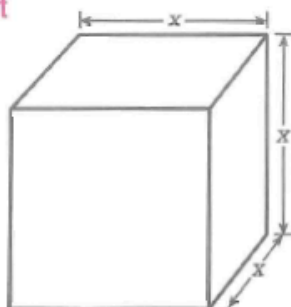
Technology In Exercises 21–28, use a calculator to solve the equation.
Round the results to two decimal places.

21. $3x^2 + 2 = 56$ ± 4.24 22. $7y^2 - 12 = 23$ ± 2.24 23. $2x^2 - 5 = 7$ ± 2.45 24. $\frac{2}{3}n^2 - 6 = 2$ ± 3.46
25. $\frac{1}{2}x^2 + 3 = 8$ ± 3.16 26. $4x^2 + 9 = 41$ ± 2.83 27. $6s^2 - 2 = 0$ ± 0.58 28. $5a^2 + 10 = 20$ ± 1.41

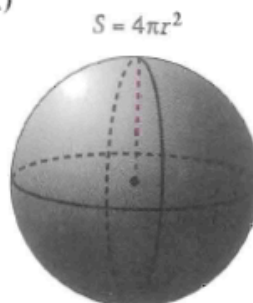
In Exercises 29–32, an object is dropped from a height h . How long does it take to reach the ground? (Assume there is no air resistance.)

29. $h = 64$ feet 2 seconds 30. $h = 144$ feet 3 seconds 31. $h = 500$ feet 32. $h = 600$ feet
31. ≈ 5.59 seconds
32. ≈ 6.12 seconds

- ★ 33. **Geometry** The surface area of a cube is 150 square feet. Find the length of each edge. 5 ft



- ★ 34. **Geometry** The surface area of a sphere is 80 square meters. Find the radius. (Use $\pi \approx 3.14$.) ≈ 2.52 m



9.3

Graphs of Quadratic Equations



"Your room is right in here, Maestro."

Guided Practice

CRITICAL THINKING about the Lesson

- Write the equation $y = -3 + 4x - x^2$ in standard form. $y = -x^2 + 4x - 3$
- How can you use a to decide whether the graph of $y = ax^2 + bx + c$ opens up or down? If $a > 0$, graph opens up; if $a < 0$, graph opens down.
- Find the vertex of the graph of $y = 2x^2 + 4x - 2$. $(-1, -4)$
- The graph of a quadratic equation is called a $\boxed{?}$. *parabola*
- True or False? The axis of symmetry of the graph of $y = ax^2 + bx + c$ is parallel to the y -axis (or is the y -axis). *True*
- Find the axis of symmetry of the graph of $y = -3x^2 + 3x + 1$. $x = \frac{1}{2}$

Independent Practice

In Exercises 7–12, decide whether the graph of the equation opens up or down. Then find the coordinates of the vertex.

- $y = 2x^2 + 4$ Up, $(0, 4)$
- $y = -5x^2$ Down, $(0, 0)$
- $y = -x^2 - 4$ Down, $(0, 0)$
- $y - 3x^2 = -2x$ Up, $(\frac{1}{3}, -\frac{1}{3})$
- $y + 5x^2 = -x + 10$ Down, $(-\frac{1}{10}, \frac{201}{20})$
- $y = x^2 - 8x + 12$ Up, $(4, -8)$

In Exercises 13–18, find the coordinates of the vertex and the equation of the axis of symmetry. See below.

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

14. $y = 2x^2 + 3x + 6$

15. $y = -4x^2 - 4x + 8$

16. $y = 3x^2 - 9x - 12$

17. $y = 2x^2 + 7x - 21$

18. $y = -x^2 + 4x + 16$

In Exercises 19–36, sketch the graph of the equation. Label the vertex. See Additional Answers.

19. $y = x^2 + x + 2$

20. $y = -x^2 + 2x - 1$

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

22. $y = 2x^2 - 3x + 4$

23. $y = 6x^2 - 3x + 4$

24. $y = 5x^2 + 4x - 5$

25. $y = 4x^2 - x + 6$

26. $y = -3x^2 - x + 7$

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

28. $y = 6x^2 - 4x - 1$

29. $y = -3x^2 - 5x + 3$

30. $y = -2x^2 - 3x + 2$

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

32. $y = -4x^2 - 3x + 6$

★ 33. $y = -\frac{1}{2}x^2 - 3x + 4$

34. $y = \frac{1}{3}x^2 + 3x - 2$

★ 35. $y = -2x^2 + \frac{1}{3}x - 1$

★ 36. $y = 3x^2 - \frac{1}{2}x + 4$

You've Got to Have the Right Angle In Exercise 37, use the information given in Example 3.

37. Natalya Lisovskaya's winning throw in the shot put was at a 45° angle. If the shot had been thrown at a 40° angle or 50° angle, would it have gone farther? Explain. See margin.

Throw at 40° angle: $y = -0.0125x^2 + 0.84x + 5$

Throw at 50° angle: $y = -0.0177x^2 + 1.19x + 5$

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13. $x = -\frac{1}{3}; (-\frac{1}{3}, \frac{11}{3})$

14. $x = -\frac{3}{4}; (-\frac{3}{4}, \frac{39}{8})$

15. $x = -\frac{1}{2}; (-\frac{1}{2}, 9)$

16. $x = \frac{3}{2}; (\frac{3}{2}, -\frac{75}{4})$

17. $x = -\frac{7}{4}; (-\frac{7}{4}, -\frac{217}{8})$

18. $x = 2; (2, 20)$

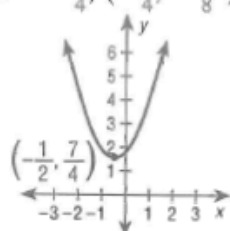
■ 9.3 Independent Practice pp. 468–469

7. Up (0, 4) 9. Down, (0, 0) 11. Down, $(-\frac{1}{10}, \frac{201}{20})$

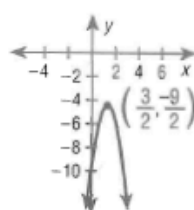
13. $x = -\frac{1}{3}, (-\frac{1}{3}, \frac{11}{3})$ 15. $x = -\frac{1}{2}, (-\frac{1}{2}, 9)$

17. $x = -\frac{7}{4}, (-\frac{7}{4}, -\frac{217}{8})$

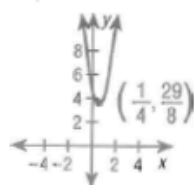
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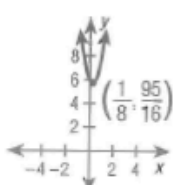
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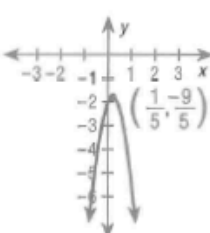
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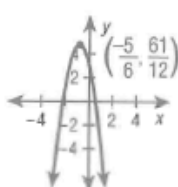
25.



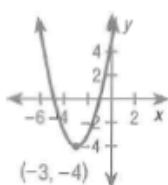
27.



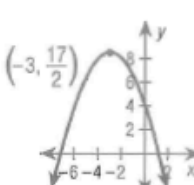
29.



31.



33.



9.4

The Quadratic Formula



Knowing how it could change the lives of canines everywhere, the dog scientists struggled diligently to understand the Doorknob Principle.

Guided Practice

CRITICAL THINKING about the Lesson

1. **True or False?** The quadratic formula states that the solutions of the equation $ax^2 + bx + c = 0$ are "the opposite of b , plus or minus the square root of b minus $4ac$, all divided by $2a$." **False**
2. Describe the two models for vertical motion. **See top of page 474.**
3. State the values of a , b , and c from the standard form of the equation $5 = 6 + 9x - x^2$. **$a = -1$, $b = 9$, $c = 1$**
4. Solve $x^2 + x - 2 = 0$. **$1, -2$**
5. Sketch the graph of $y = x^2 + x - 2$ and label the x -intercepts. **See Additional Answers.**
6. Describe the relationship between the x -intercepts found in Exercise 5 and the solutions found in Exercise 4. **They are the same.**

Independent Practice

In Exercises 7–10, write the quadratic equation in standard form.

7. $-3x^2 + 5x = 9$ **$-3x^2 + 5x - 9 = 0$**
8. $5 - 2x + x^2 = 0$ **$x^2 - 2x + 5 = 0$**
9. $-4 + 3x + x^2 = 5$ **$x^2 + 3x - 9 = 0$**
10. $9x - 7x^2 = 16$ **$-7x^2 + 9x - 16 = 0$**

In Exercises 11–14, find the value of $b^2 - 4ac$ for the equation.

11. $2x^2 - 3x - 1 = 0$ **17**
 12. $4x^2 + 4x + 1 = 0$ **0**
 13. $3x^2 - 2x - 5 = 0$ **64**
 14. $x^2 - 11x + 30 = 0$ **1**
- 18. $3 + \sqrt{2} \approx 4.41$, $3 - \sqrt{2} \approx 1.59$**

$$18. 3 + \sqrt{2} \approx 4.41, 3 - \sqrt{2} \approx 1.59$$

In Exercises 15–20, use the quadratic formula to solve the equation.

$$15. 4x^2 - 13x + 3 = 0 \quad 3, \frac{1}{4}$$

$$16. 3y^2 + 11y + 10 = 0 \quad -\frac{5}{3}, -2$$

$$17. 2x^2 + 7x + 3 = 0 \quad -\frac{1}{2}, -3$$

$$18. x^2 - 6x + 7 = 0$$

$$19. 5y^2 + 2y - 2 = 0$$

$$20. 2x^2 + 4x - 3 = 0$$

19.–20. See below.

In Exercises 21–26, solve the quadratic equation by the most convenient method (finding square roots or the quadratic formula). Explain why you chose your method.

$$\sqrt{27} \approx 5.20, -\sqrt{27} \approx -5.20$$

$$21. \frac{-10 + \sqrt{70}}{6} \approx -0.27$$

$$\frac{-10 - \sqrt{70}}{6} \approx -3.06$$

$$21. 6x^2 + 20x + 5 = 0$$

$$22. t^2 = 27$$

$$23. x^2 - 625 = 0 \quad 25, -25$$

$$24. 4u^2 - 49 = 0 \quad \frac{7}{2}, -\frac{7}{2}$$

$$25. -2x^2 + 6x + 1 = 0$$

$$26. x^2 + 14x + 49 = 0 \quad -7$$

In Exercises 27–32, find the x -intercepts of the graph of the equation.

$$27. y = x^2 + 2x + 15 \quad \text{None}$$

$$28. y = x^2 - 6x - 7 \quad 7, -1$$

$$29. y = x^2 + x - 20 \quad 4, -5$$

$$30. y = x^2 + 8x + 12 \quad -2, -6$$

$$31. y = x^2 + x - \frac{3}{4} \quad \frac{1}{2}, -\frac{3}{2}$$

$$32. y = x^2 + \frac{7}{3}x - 2 \quad \frac{2}{3}, -3$$

$$25. \frac{3 + \sqrt{11}}{2} \approx 3.16, \frac{3 - \sqrt{11}}{2} \approx -0.16$$

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$$19. \frac{-1 + \sqrt{11}}{5} \approx 0.46; \frac{-1 - \sqrt{11}}{5} \approx -0.86 \quad 20. \frac{-2 + \sqrt{10}}{2} \approx 0.58; \frac{-2 - \sqrt{10}}{2} \approx -2.58$$

Isolating what I mean



Math phobic's nightmare