1.2 Order of Operations

Learning Target: Write and evaluate numerical expressions using the order of operations.

Success Criteria:
- I can explain why there is a need for a standard order of operations.
- I can evaluate numerical expressions involving several operations, exponents, and grouping symbols.
- I can write numerical expressions involving exponents to represent a real-life problem.

EXPLORATION 1 Comparing Different Orders

Work with a partner. Find the value of each expression by using different orders of operations. Are your answers the same?

a. Add, then multiply. Multiply, then add.

$3 + 2 \times 2$ $3 + 2 \times 2$

b. Subtract, then multiply. Multiply, then subtract.

$18 - 3 \cdot 3$ $18 - 3 \cdot 3$

c. Multiply, then subtract. Subtract, then multiply.

$8 \times 8 - 2$ $8 \times 8 - 2$

d. Multiply, then add. Add, then multiply.

$6 \cdot 6 + 2$ $6 \cdot 6 + 2$

EXPLORATION 2 Determining Order of Operations

Work with a partner.

a. Scientific calculators use a standard order of operations when evaluating expressions. Why is a standard order of operations needed?

b. Use a scientific calculator to evaluate each expression in Exploration 1. Enter each expression exactly as written. For each expression, which order of operations is correct?

c. What order of operations should be used to evaluate $3 + 2^2$, $18 - 3^2$, $8^2 - 2$, and $6^2 + 2$?

d. Do $18 \div 3 \cdot 3$ and $18 \div 3^2$ have the same value? Justify your answer.

e. How does evaluating powers fit into the order of operations?

Math Practice

Use Technology to Explore

How does a scientific calculator help you explore order of operations?

1.2 Lesson

Key Vocabulary

numerical expression, *p. 10*

evaluate, *p. 10*

order of operations, *p. 10*

A **numerical expression** is an expression that contains numbers and operations. To **evaluate**, or find the value of, a numerical expression, use a set of rules called the **order of operations**.

Key Idea

Order of Operations

1. Perform operations in grouping symbols.
2. Evaluate numbers with exponents.
3. Multiply and divide from left to right.
4. Add and subtract from left to right.

EXAMPLE 1 Using Order of Operations

a. Evaluate $12 - 2 \times 4$.

$12 - 2 \times 4 = 12 - 8$ Multiply 2 and 4.

$= 4$ Subtract 8 from 12.

b. Evaluate $60 \div [(4 + 2) \times 5]$.

$60 \div [(4 + 2) \times 5] = 60 \div [6 \times 5]$ Perform operation in parentheses.

$= 60 \div 30$ Perform operation in brackets.

$= 2$ Divide 60 by 30.

Try It **Evaluate the expression.**

1. $7 \cdot 5 + 3$ **2.** $(28 - 20) \div 4$ **3.** $[6 + (15 - 10)] \times 5$

EXAMPLE 2 Using Order of Operations with Exponents

Evaluate $30 \div (7 + 2^3) \times 6$.

$30 \div (7 + 2^3) \times 6 = 30 \div (7 + 8) \times 6$ Evaluate power in parentheses.

$= 30 \div 15 \times 6$ Perform operation in parentheses.

$= 2 \times 6$ Divide 30 by 15.

$= 12$ Multiply 2 and 6.

Remember to multiply and divide from left to right. In Example 2, you should divide before multiplying because the division symbol comes first when reading from left to right.

Try It **Evaluate the expression.**

4. $6 + 2^4 - 1$ **5.** $4 \cdot 3^2 + 18 - 9$ **6.** $16 + (5^2 - 7) \div 3$

1.2 Lesson

Key Vocabulary

numerical expression, *p. 10*

evaluate, *p. 10*

order of operations, *p. 10*

A **numerical expression** is an expression that contains numbers and operations. To **evaluate**, or find the value of, a numerical expression, use a set of rules called the **order of operations**.

Key Idea

Order of Operations

1. Perform operations in grouping symbols.
2. Evaluate numbers with exponents.
3. Multiply and divide from left to right.
4. Add and subtract from left to right.

EXAMPLE 1 Using Order of Operations

a. Evaluate $12 - 2 \times 4$.

$12 - 2 \times 4 = 12 - 8$ Multiply 2 and 4.

$= 4$ Subtract 8 from 12.

b. Evaluate $60 \div [(4 + 2) \times 5]$.

$60 \div [(4 + 2) \times 5] = 60 \div [6 \times 5]$ Perform operation in parentheses.

$= 60 \div 30$ Perform operation in brackets.

$= 2$ Divide 60 by 30.

Try It **Evaluate the expression.**

1. $7 \cdot 5 + 3$ **2.** $(28 - 20) \div 4$ **3.** $[6 + (15 - 10)] \times 5$

EXAMPLE 2 Using Order of Operations with Exponents

Evaluate $30 \div (7 + 2^3) \times 6$.

$30 \div (7 + 2^3) \times 6 = 30 \div (7 + 8) \times 6$ Evaluate power in parentheses.

$= 30 \div 15 \times 6$ Perform operation in parentheses.

$= 2 \times 6$ Divide 30 by 15.

$= 12$ Multiply 2 and 6.

Remember to multiply and divide from left to right. In Example 2, you should divide before multiplying because the division symbol comes first when reading from left to right.

Try It **Evaluate the expression.**

4. $6 + 2^4 - 1$ **5.** $4 \cdot 3^2 + 18 - 9$ **6.** $16 + (5^2 - 7) \div 3$

The symbols $\times$ and $\cdot$ are used to indicate multiplication. You can also use parentheses to indicate multiplication. For example, $3(2 + 7)$ is the same as $3 \times (2 + 7)$.

EXAMPLE 3 Using Order of Operations

Remember

You can interpret a fraction as division of the numerator by the denominator.

$$\frac{a}{b} = a \div b$$

a. Evaluate $9 + \frac{8 - 2}{3}$.

$9 + \frac{8 - 2}{3} = 9 + (8 - 2) \div 3$ Rewrite fraction as division.

$= 9 + 6 \div 3$ Perform operation in parentheses.

$= 9 + 2$ Divide 6 by 3.

$= 11$ Add 9 and 2.

b. Evaluate $10 - 8(13 + 7) \div 4^2$.

$10 - 8(13 + 7) \div 4^2 = 10 - 8(20) \div 4^2$ Perform operation in parentheses.

$= 10 - 8(20) \div 16$ Evaluate 4^2.

$= 10 - 160 \div 16$ Multiply 8 and 20.

$= 10 - 10$ Divide 160 by 16.

$= 0$ Subtract 10 from 10.

Try It **Evaluate the expression.**

7. $50 + 6(12 \div 4) - 8^2$ **8.** $5^2 - \frac{1}{5}(10 - 5)$ **9.** $\frac{8(2 + 5)}{7}$

Self-Assessment for Concepts & Skills

Solve each exercise. Then rate your understanding of the success criteria in your journal.

USING ORDER OF OPERATIONS **Evaluate the expression.**

10. $7 + 2 \cdot 4$ **11.** $8 \div 4 \times 2$ **12.** $3(5 + 1) \div 3^2$

13. WRITING Why does $12 - 8 \div 2 = 8$, but $(12 - 8) \div 2 = 2$?

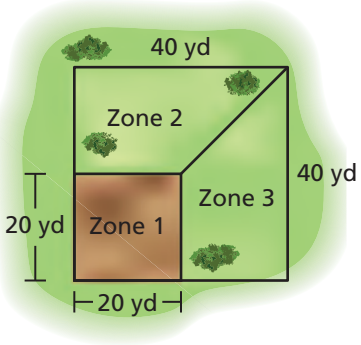
14. MP REASONING Describe the steps in evaluating the expression $8 \div (6 - 4) + 3^2$.

15. WHICH ONE DOESN'T BELONG? Which expression does *not* belong with the other three? Explain your reasoning.

$5^2 - 8 \times 2$ $5^2 - (8 \times 2)$ $5^2 - 2 \times 8$ $(5^2 - 8) \times 2$

EXAMPLE 4 Modeling Real Life

The diagram shows landing zones for skydivers. Zone 1 is for experts. The remaining space is divided in half and designated as Zones 2 and 3 for tandem divers. What is the area of Zone 2?



Understand the problem.

You are given the dimensions of landing zones and that the areas of Zones 2 and 3 are equal. You are asked to find the area of Zone 2.

Make a plan.

Use a verbal model to write an expression. Subtract the area of Zone 1 from the total area to find the combined area of Zones 2 and 3. Then multiply the combined area by one-half.

Solve and check.

Verbal Model One-half (Total area − Area of Zone 1)

Expression $\frac{1}{2}$ (40^2 − 20^2)

$$\frac{1}{2}(40^2 - 20^2) = \frac{1}{2}(1600 - 400) \quad \text{Evaluate powers in parentheses.}$$

$$= \frac{1}{2}(1200) \quad \text{Perform operation in parentheses.}$$

$$= 600 \quad \text{Multiply } \frac{1}{2} \text{ and } 1200.$$

▶ The area of Zone 2 is 600 square yards.

Check Verify that the areas of the three zones have a sum equal to the total area.

$400 + 600 + 600 \stackrel{?}{=} 1600$

$1600 = 1600$ ✓

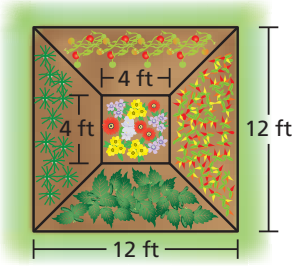
Self-Assessment for Problem Solving

Solve each exercise. Then rate your understanding of the success criteria in your journal.

16. A square plot of land has side lengths of 40 meters. An archaeologist divides the land into 64 equal parts. What is the area of each part?

17. A glass block window is made of two different-sized glass squares. The window has side lengths of 40 inches. The large glass squares have side lengths of 10 inches. Find the total area of the small glass squares.

18. DIG DEEPER! A square vegetable garden has side lengths of 12 feet. You plant flowers in the center portion as shown. You divide the remaining space into 4 equal sections and plant tomatoes, onions, zucchini, and peppers. What is the area of the onion section?



1.2 Practice

Go to **BigIdeasMath.com** to get HELP with solving the exercises.

Review & Refresh

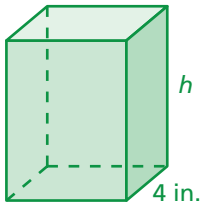
Write the product as a power.

1. $11 \times 11 \times 11 \times 11$

2. $13 \times 13 \times 13 \times 13 \times 13$

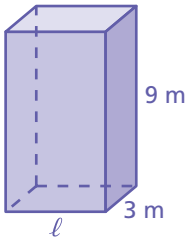
Find the missing dimension of the rectangular prism.

3.



Volume = 192 in.^{3}

4.



Volume = 135 m^3

Tell whether the number is prime or composite.

5. 9

6. 11

7. 23

Concepts, Skills, & Problem Solving

COMPARING DIFFERENT ORDERS **Find the value of the expression by using different orders of operations. Are your answers the same?** (See Exploration 1, p. 9.)

8. Add, then multiply. $4 + 6 \times 6$ Multiply, then add. $4 + 6 \times 6$

9. Subtract, then multiply. $5 \times 5 - 3$ Multiply, then subtract. $5 \times 5 - 3$

USING ORDER OF OPERATIONS **Evaluate the expression.**

10. $5 + 18 \div 6$

11. $(11 - 3) \div 2 + 1$

12. $45 \div 9 \times 12$

13. $6^2 - 3 \cdot 4$

14. $42 \div (15 - 2^3)$

15. $4^2 \cdot 2 + 8 \cdot 7$

16. $(5^2 - 2) \times 1^5 + 4$

17. $4 + 2 \times 3^2 - 9$

18. $8 \div 2 \times 3 + 4^2 \div 4$

19. $3^2 + 12 \div (6 - 3) \times 8$

20. $(10 + 4) \div (26 - 19)$

21. $(5^2 - 4) \cdot 2 - 18$

22. $2 \times [(16 - 8) \times 2]$

23. $12 + 8 \times 3^3 - 24$

24. $6^2 \div [(2 + 4) \times 2^3]$

YOU BE THE TEACHER **Your friend evaluates the expression. Is your friend correct? Explain your reasoning.**

25.

$9 + 3 \times 3^2 = 12 \times 9$
$= 108$

26.

$19 - 6 + 12 = 19 - 18$
$= 1$

27. MP **PROBLEM SOLVING** You need to read 20 poems in 5 days for an English project. Each poem is 2 pages long. Evaluate the expression $20 \times 2 \div 5$ to find how many pages you need to read each day.

USING ORDER OF OPERATIONS **Evaluate the expression.**

28. $12 - 2(7 - 4)$

29. $4(3 + 5) - 3(6 - 2)$

30. $6 + \frac{1}{4}(12 - 8)$

31. $9^2 - 8(6 + 2)$

32. $4(3 - 1)^3 + 7(6) - 5^2$

33. $8\left[\left(1\frac{1}{6} + \frac{5}{6}\right) \div 4\right]$

34. $7^2 - 2\left(\frac{11}{8} - \frac{3}{8}\right)$

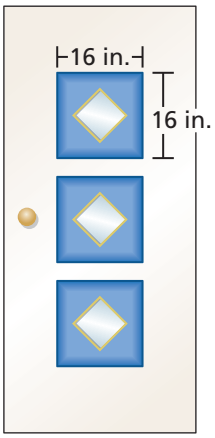
35. $8(7.3 + 3.7 - 8) \div 2$

36. $2^4(5.2 - 3.2) \div 4$

37. $\frac{6^2(3 + 5)}{4}$

38. $\frac{12^2 - 4(6) + 1}{11^2}$

39. $\frac{26 \div 2 + 5}{3^2 - 3}$

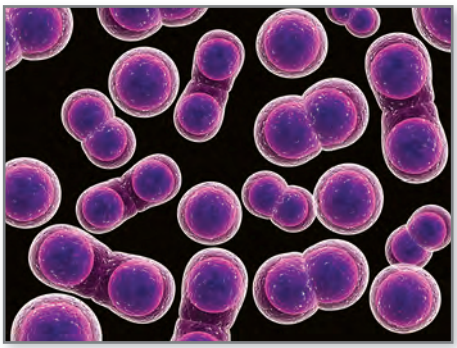


40. **PROBLEM SOLVING** Before a show, there are 8 people in a theater. Five groups of 4 people enter, and then three groups of 2 people leave. Evaluate the expression $8 + 5(4) - 3(2)$ to find how many people are in the theater.

41. **MODELING REAL LIFE** The front door of a house is painted white and blue. Each window is a square with a side length of 7 inches. What is the area of the door that is painted blue?

42. **PROBLEM SOLVING** You buy 6 notebooks, 10 folders, 1 pack of pencils, and 1 lunch box for school. After using a $10 gift card, how much do you owe? Explain how you solved the problem.

43. **OPEN-ENDED** Use all four operations and at least one exponent to write an expression that has a value of 100.



44. **REPEATED REASONING** A Petri dish contains 35 cells. Every day, each cell in the Petri dish divides into 2 cells in a process called *mitosis*. How many cells are there after 14 days? Justify your answer.

45. **REASONING** Two groups collect litter along the side of a road. It takes each group 5 minutes to clean up a 200-yard section. How long does it take both groups working together to clean up 2 *miles*? Explain how you solved the problem.

46. **NUMBER SENSE** Copy each statement. Insert $+$, $-$, $\times$, or $\div$ symbols to make each statement true.

a. $27 \square 3 \square 5 \square 2 = 19$

b. $9^2 \square 11 \square 8 \square 4 \square 1 = 60$

c. $5 \square 6 \square 15 \square 9 = 24$

d. $14 \square 2 \square 7 \square 3 \square 9 = 10$