

1

Relationships Matter

Evaluating Numeric Expressions

WARM UP

Write each power of ten as a product of factors. Then calculate the product.

1. $10^2 = \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$

2. $10^5 = \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$

3. $10^3 = \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$

4. $10^4 = \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$

5. $10^7 = \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$

LEARNING GOALS

- Interpret a number raised to a positive integer power as a repeated product.
- Identify perfect square numbers and perfect cube numbers.
- Write and evaluate numeric expressions involving whole-number exponents.
- Model numeric expressions with two- and three-dimensional figures.
- Evaluate numeric expressions using the Order of Operations.

KEY TERMS

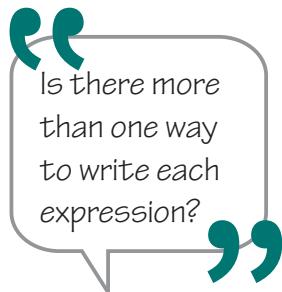
- power
- base
- exponent
- perfect square
- perfect cube
- evaluate a numeric expression
- Order of Operations

You have written and evaluated expressions equivalent to given numbers. Besides the four operations—addition, subtraction, multiplication, and division—are there other structures that can be used in numeric expressions?

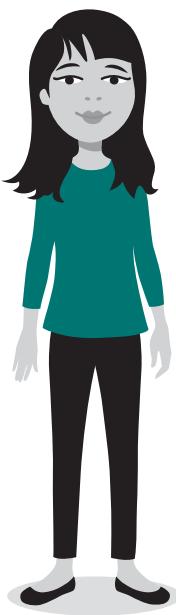
Expression Challenge

Recall that an expression in mathematics is a number or a combination of numbers and operations. The number 8 is an expression, and $2 \times 2 + 4$ is also an expression. Both of these expressions are equal to 8.

1. Write an expression that is equal to 10 using only four 2s and any number of math symbols.



2. Write an expression that is equal to 8 using only four 3s and any number of math symbols.



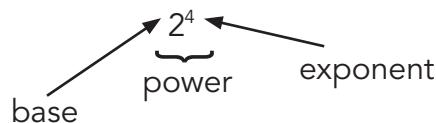
3. Write an expression that is equal to 20 using only one 2 and two 4s and any number of math symbols.





Just as repeated addition can be represented as a multiplication problem, repeated multiplication can be represented as a **power**. A **power** has two elements: the base and the exponent.

$$2 \times 2 \times 2 \times 2 = 2^4$$



The **base** of a power is the factor that is multiplied repeatedly in the power, and the **exponent** of the power is the number of times the base is used as a factor.

You can read a power in different ways:

- "2 to the fourth power"
 - "2 raised to the fourth power"
-

1. Identify the base and exponent in each power. Then, write each power in words.

a. 7^5

b. 4^8

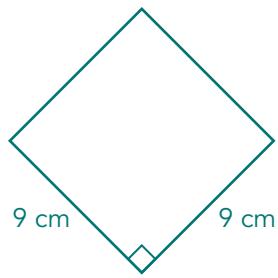
Remember that the area of a rectangle is calculated by multiplying its length by its width. Because all sides of a square have the same length, the area of a square, A , is calculated by multiplying the length of the side, s , by itself. The formula for the area of a square, $A = s \times s$, can be written as $A = s^2$.

In the power s^2 , the base is the side length, s , and the exponent is 2.

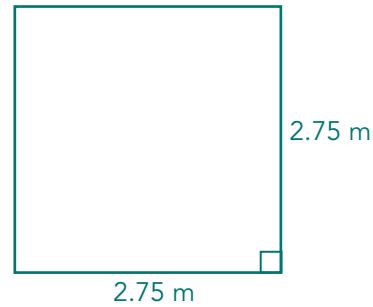
In the same way, to calculate the square of a number, you multiply the number by itself.

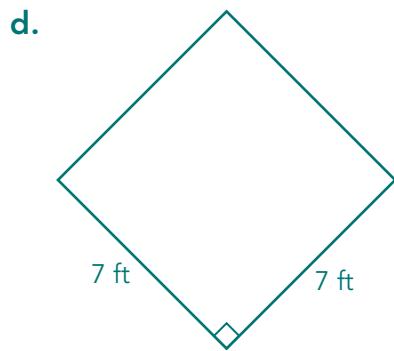
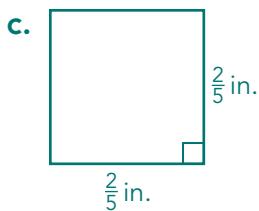
2. Write the area of each square as a repeated product, as a square number, and as an area in square units.

a.



b.





You can read 3^2 as
"3 squared."

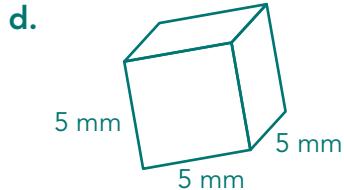
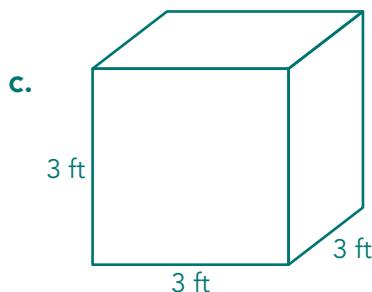
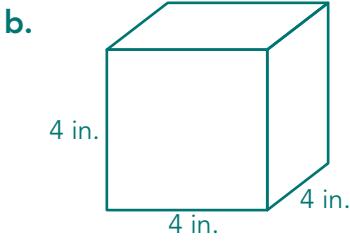
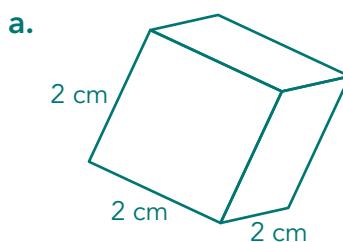
In the power s^3 ,
the base is the side
length, s , and the
exponent is 3.

Some of the areas that you wrote in Question 1 are called **perfect squares** because they are squares of an integer. For example, 9 is a perfect square because $3 \times 3 = 9$. Another way you can write this mathematical sentence is $3^2 = 9$.

Recall that the volume of a cube is calculated by multiplying its length by its width and its height. Since the length, width, and height of a cube are all the same, the formula for the volume, V , of a cube can be written as $V = s \times s \times s$, or $V = s^3$.

In the same way, to calculate the cube of a number, you use the number as a factor three times.

3. Write the volume of each cube as a repeated product, as the cube of a number, and as a volume in cubic units.



You can read 6^3 as
"6 cubed."

A **perfect cube** is the cube of an integer. For example, 216 is a perfect cube because 6 is a whole number and $6 \times 6 \times 6 = 216$.



Previously, you may have thought about expressions as recipes. For example, the expression $2 + 2$ might have meant “start with 2 and add 2 more.” But as a relationship, $2 + 2$ means “2 combined with 2.”

The Expression Cards at the end of this lesson contain a variety of numeric expressions and models that represent numeric expressions. Cut out the Expression Cards.

Remember, a numeric expression is a mathematical phrase that contains numbers and operations.

1. Consider the different structures of the expressions and the models.

- a. Sort the models in a mathematically meaningful way.
- b. Sort the expressions in a mathematically meaningful way.
- c. Explain how you sorted the Expression Cards.

2. Match the numeric expressions with the models. Select two pairs of cards and explain why each expression matches the model.

Now it's your turn!

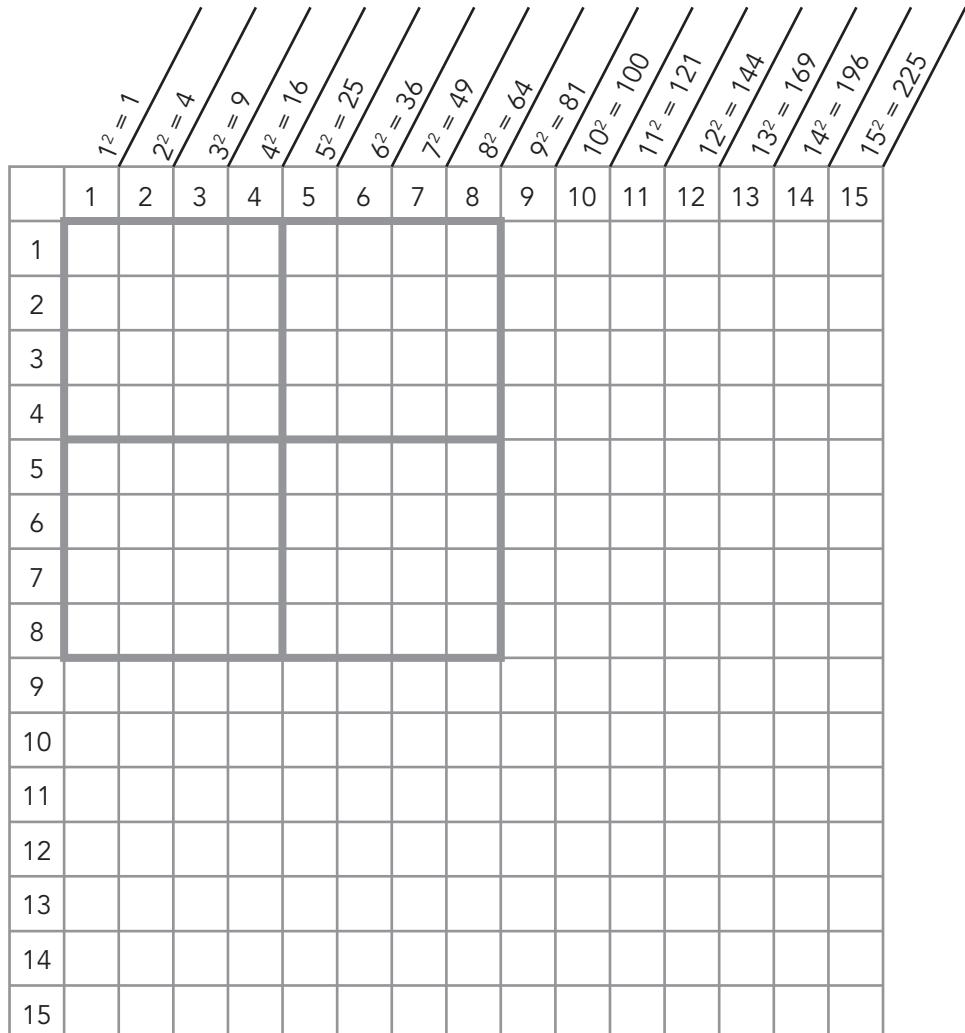
3. Think of a numeric expression. Draw a model to represent that expression. Trade your model with a classmate and write the numeric expression that represents their model. When you both have written your answers, trade back and check your work!

ACTIVITY
1.3

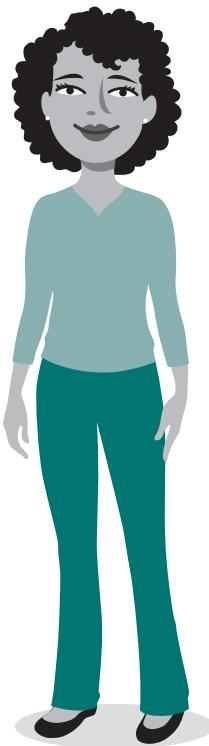
Writing Equivalent Expressions



The diagram can be used to determine perfect squares. Daniel drew on the diagram to show that the expression $(4 + 4)^2$ is equivalent to 8^2 .



“How can you use the grid to determine the square of any number from 1 to 15?”



1. Explain why $(4 + 4)^2$ is equivalent to 8^2 and not equivalent to $4^2 + 4^2$. Then use the diagram to write other expressions that are equivalent to 8^2 .

2. Write an equivalent numeric expression for each perfect square.

NOTES

a. 6^2

b. 12^2

To **evaluate a numeric expression** means to simplify the expression to a single numeric value.

3. Use the diagram to rewrite the expression $(7 - 3)^2 + (10 - 7)^2$ with fewer terms. Explain your work.

4. Use the diagram to write four numeric expressions. Then explain how to evaluate each expression.

The table shows the cubes of the first 10 whole numbers.

$1^3 = 1$	$2^3 = 8$	$3^3 = 27$	$4^3 = 64$	$5^3 = 125$
$6^3 = 216$	$7^3 = 343$	$8^3 = 512$	$9^3 = 729$	$10^3 = 1000$

5. Write two more equivalent expressions for each. Show how to evaluate the expressions.

a. 5^3

b. 2^3



Consider the numeric expression $2 \cdot 5^2$.

- Shae drew a model to represent the expression.

Explain how Shae's model represents the expression. Then evaluate the expression.



- Doug and Miguel each evaluated the expression differently.

Miguel

$$2 \cdot 5^2$$

$$5^2 = 25$$

$$2 \cdot 25 = 50$$



Doug

$$2 \cdot 5^2$$

$$2 \cdot 5 = 10$$

$$10^2 = 100$$



- What does Miguel's solution tell you about how to evaluate a numeric expression with both multiplication and exponents?

- Draw a model to represent Doug's solution. Explain how the model is different from Shae's.

Parentheses are symbols used to group numbers and operations. You can think about expressions inside parentheses as a single value.

- This model represents the expression $(6 + 4) \cdot 3$.

- Evaluate the expression represented by the model.

6	4
6	4
6	4

- b. Draw a model that would represent the expression $6 + (4 \cdot 3)$ and evaluate the expression.
- c. Compare the models and the expressions. How does moving the parentheses change how you draw the model and how you evaluate the expression?

4. Consider the numeric expression $(5 + 3)^2$.

- a. Draw a model to represent this expression.

- b. The numeric expression was evaluated in two different ways, resulting in two different values. Determine which solution is correct. Explain why one solution is correct and state the error that was made in the other solution.

Solution A

$$\begin{aligned}(5 + 3)^2 \\ = 8^2 \\ = 64\end{aligned}$$

Solution B

$$\begin{aligned}(5 + 3)^2 \\ = 25 + 9 \\ = 34\end{aligned}$$



5. Consider the numeric expression $3 \cdot (7 - 2)$.

- a. Draw a model to represent this expression.

- b. The numeric expression was evaluated in two different ways, resulting in two different values. Determine which solution is correct. Explain why one solution is correct and state the error that was made in the other solution. Cross out the incorrect solution.

Solution A

$$\begin{aligned}3 \cdot (7 - 2) \\ = 21 - 2 \\ = 19\end{aligned}$$

Solution B

$$\begin{aligned}3 \cdot (7 - 2) \\ = 3(5) \\ = 15\end{aligned}$$



6. A band is playing at a local restaurant for a total of 8 Fridays and will be paid after their last performance. The band advertises their 8 appearances in the local newspaper for a total cost of \$400. If the band makes \$500 for each appearance, which numeric expression correctly shows the amount of money each of the four members will earn? Explain your reasoning.

Expression A

$$(8 \cdot 500 - 400) \div 4$$

Expression B

$$8 \cdot 500 - 400 \div 4$$

ACTIVITY

1.5

The Order of Operations



We can use "Please Excuse My Dear Aunt Sally" to remember Parentheses, Exponents, Multiplication and Division, and Addition and Subtraction, right?

There is an *Order of Operations*, an order in which operations are performed when evaluating any numeric expression. The **Order of Operations** is a set of rules that ensures the same result every time an expression is evaluated.

Order of Operations Rules

1. Evaluate expressions inside parentheses or grouping symbols.
2. Evaluate exponents.
3. Multiply and divide from left to right.
4. Add and subtract from left to right.

Keep in mind that multiplication and division are of equal importance and evaluated in order from left to right. The same is true for addition and subtraction.



I like "Pink
Elephants
Must Dance
Around
Snakes" better.
Is that OK?



A mnemonic
may help you
remember
the order. The
important
thing is to
understand
WHY the order
of operations
works.



Evaluate each expression using the Order of Operations.

1. $28 \div 2^2 - 36 \div 3^2$

2. $12 + (25 \div 5)^2$

3. $(12^2 - 48) \times 2$

4. $168 \div 2^3 + 3^3 - 20$

5. $10 \div (5 - 3) + 2^3$

TALK the TALK

Order of Operations

Determine whether or not each expression was evaluated correctly. Show the correct work for any incorrect answers.

1. $18 \div 2 \cdot 3^2$

18 ÷ 2 · 9

18 ÷ 18

1

2. $(15 + 10 \div 5) + 8$

(15 + 2) + 8

17 + 8

25

3. $60 - (10 - 6 + 1)^2 \cdot 2$

$60 - (10 - 7)^2 \cdot 2$

$60 - (3)^2 \cdot 2$

$60 - 9 \cdot 2$

$60 - 18$

42

Each numeric expression has been evaluated correctly and incorrectly. For those that have been evaluated correctly, state how the Order of Operations was used to evaluate the expression. For those expressions that have been evaluated incorrectly, determine the error that was made.

4. $2(10 - 1) - 3 \cdot 2$

$2(9) - 3 \cdot 2$

$18 - 3 \cdot 2$

$15 \cdot 2$

30

$2(10 - 1) - 3 \cdot 2$

$2(9) - 3 \cdot 2$

$18 - 6$

12

5. $4 + 3^2$

$4 + 9$

13

$4 + 3^2$

7^2

49

6. $(2 + 6)^2$

8^2

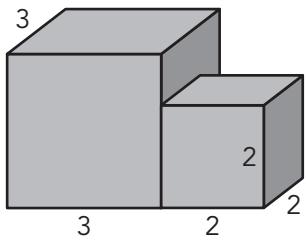
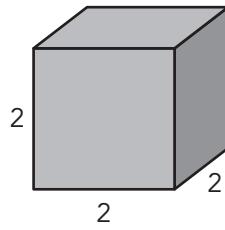
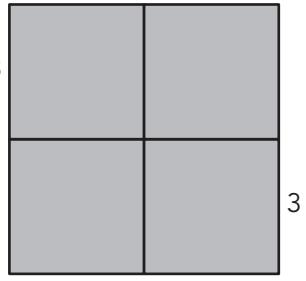
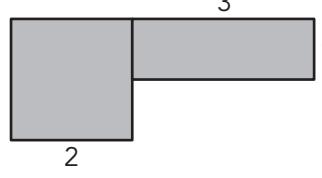
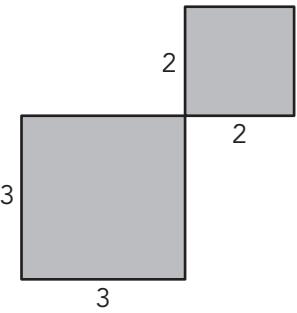
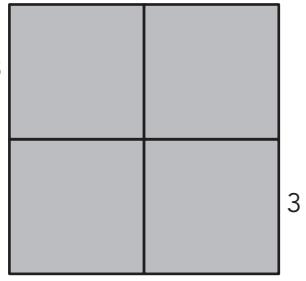
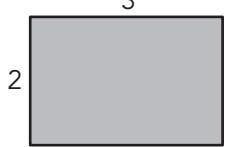
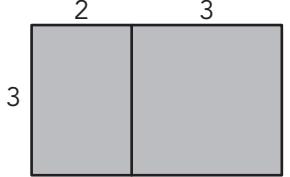
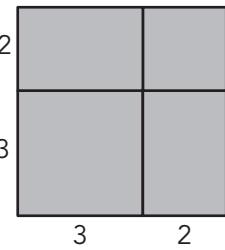
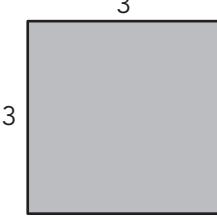
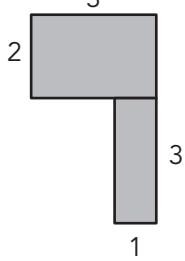
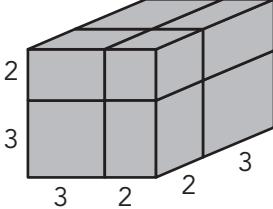
64

$(2 + 6)^2$

$4 + 36$

40

Expression Cards

3×2	$(3 \times 2)^2$		$(3 + 2)^3$
	3^2		
$3 + 2^2$			$(3 + 2)^2$
$3^3 + 2^3$			
	$3 \times 2 + 3$	$3^2 + 2^2$	
2^3			

Assignment

Write

Write your own mnemonic for the Order of Operations.

Remember

Memorize the first 15 squares and 10 cubes.

Perfect Squares

$1^2 = 1$	$2^2 = 4$	$3^2 = 9$	$4^2 = 16$	$5^2 = 25$
$6^2 = 36$	$7^2 = 49$	$8^2 = 64$	$9^2 = 81$	$10^2 = 100$
$11^2 = 121$	$12^2 = 144$	$13^2 = 169$	$14^2 = 196$	$15^2 = 225$

Perfect Cubes

$1^3 = 1$	$2^3 = 8$	$3^3 = 27$	$4^3 = 64$	$5^3 = 125$
$6^3 = 216$	$7^3 = 343$	$8^3 = 512$	$9^3 = 729$	$10^3 = 1000$

Practice

Use the Order of Operations to evaluate each numeric expression.

1. $4^2 \cdot 3$
2. $3^3 - 14 \div 2 + 5$
3. $17 - 2^3$
4. $144 \div 6^2 \cdot 8 + 2^2$
5. $32 \div 4^2$
6. $2^4 - 3 \cdot 5 + 9$
7. $9 + 5^2 - 2 \cdot 3^2$
8. $11^2 - 7 \cdot 6 - 4^3 \div 2$

Stretch

Evaluate each power raised to a power.

1. $(3^2)^2$
2. $(5^2)^4$
3. $(4^3)^2$

Review

Graph each rate in the given pair on a coordinate plane. Explain whether or not the rates are equivalent.

1. $\frac{15 \text{ cups flour}}{8.25 \text{ cups sugar}}, \frac{5 \text{ cups flour}}{2.75 \text{ cups sugar}}$

2. $\frac{245 \text{ mi}}{3.5 \text{ h}}, \frac{150 \text{ mi}}{2 \text{ h}}$

Calculate each conversion.

3. 4 grams = ____ milligrams

4. 6400 ounces = ____ pounds

Determine each sum.

5. $\frac{6}{7} + 3\frac{1}{5}$

6. $1\frac{2}{3} + 4\frac{1}{4}$