Chapter Learning Target:
Understand exponents and rational numbers.

Chapter Success Criteria:
- I can evaluate a power.
- I can evaluate expressions involving whole number bases.
- I can evaluate expressions involving rational number bases.
- I can solve real-life problems involving powers.

Surface   Deep

1.1 Exponents
1.2 Product of Powers Property
1.3 Quotient of Powers Property
1.4 Rational Numbers
1.5 Rational Numbers and Exponents
1. Tony says that there are approximately $10^{24}$ stars in our universe and $10^{11}$ stars in our galaxy. How can this information help you estimate how many other galaxies exist, when you assume other galaxies have about the same number of stars?

2. **ANALYZE A PROBLEM** Scientists have estimated the number of stars and planets in our galaxy.

   a. Describe how estimating the number of stars in our galaxy helps us estimate the number of planets in other galaxies.

   b. How accurate of an estimation do you think we can get? Explain.

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**STEAM Performance Task** The Number of Stars in Galaxies

After completing this chapter, you will be able to use the concepts you learned to answer the questions in the **STEAM Performance Task**. You will be given information about the estimated number of stars in different galaxies.

**Number of Stars**

- **Milky Way galaxy**: $10^{11}$
- **Andromeda galaxy**: $10^{12}$

You will be asked to group the number of stars and compare the number of stars in each galaxy.
Getting Ready for Chapter 1 with CalcChat®

Chapter Exploration

Actively Participate in Effortful Learning Collectively
Work with a partner to prepare for concepts in this chapter.

1. STRUCTURE Write each distance as a whole number. Which numbers do you know how
to write in words? For instance, in words, $10^2$ is equal to one hundred.

a. $10^3$ meters: diameter of a meteor crater

b. $10^9$ meters: diameter of Halley’s Comet

c. $10^7$ meters: diameter of Earth

d. $10^{16}$ meters: diameter of the solar system

e. $10^{21}$ meters: diameter of the Milky Way galaxy

f. $10^{27}$ meters: diameter of the observable universe

2. Write the numbers of wives, sacks, cats, and kits as powers.

As I was going to St. Ives
I met a man with seven wives
Each wife had seven sacks
Each sack had seven cats
Each cat had seven kits
Kits, cats, sacks, wives
How many were going to St. Ives?

Nursery Rhyme, 1730

Vocabulary

The following terms are defined in this chapter. Think about what each might mean
and record your thoughts.

- power: exponent of a power
- base of a power: rational number
The expression $3^5$ is called a power. The base is 3. The exponent is 5.

### Exploration 1 Using Exponent Notation

**Work with a partner.**

**a.** Copy and complete the table.

<table>
<thead>
<tr>
<th>Power</th>
<th>Repeated Multiplication Form</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2^1$</td>
<td>$2$</td>
<td>$2$</td>
</tr>
<tr>
<td>$2^2$</td>
<td>$2 \cdot 2$</td>
<td>$4$</td>
</tr>
<tr>
<td>$2^3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$2^4$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$2^5$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$2^6$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$2^7$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**b.** Describe what is meant by the expression $2^n$. How can you find the value of $2^n$?

### Exploration 2 Using Exponent Notation

**Work with a partner.** On a game show, each small cube is worth $3. The small cubes are arranged to form a large cube. Show how you can use a power to find the total value of the large cube. Then write an explanation to convince a friend that your answer is correct.

**Number Sense and Operations**

- **MA.7.NSO.1.1** Know and apply the Laws of Exponents to evaluate numerical expressions and generate equivalent numerical expressions, limited to whole-number exponents and rational number bases.
- **MA.7.NSO.2.1** Solve mathematical problems using multi-step order of operations with rational numbers including grouping symbols, whole-number exponents and absolute value.
A **power** is a product of repeated factors. The **base** of a power is the repeated factor. The **exponent** of a power indicates the number of times the base is used as a factor.

\[ 2^3 = 2 \cdot 2 \cdot 2 \cdot 2 \]

- **power**
- **base** is used as a factor **5** times.

### Example 1 Writing Expressions Using Exponents

Write each product using exponents.

**a.** \(7 \cdot 7 \cdot 7\)

Because 7 is used as a factor 3 times, its exponent is 3.

\[ \text{So, } 7 \cdot 7 \cdot 7 = 7^3. \]

**b.** \(3 \cdot 3 \cdot 5 \cdot 5 \cdot 5 \)

Because 3 is used as a factor 2 times, its exponent is 2. Because 5 is used as a factor 4 times, its exponent is 4.

\[ \text{So, } 3 \cdot 3 \cdot 5 \cdot 5 \cdot 5 = 3^2 \cdot 5^4. \]

### Try It Write the product using exponents.

1. \(4 \cdot 4 \cdot 4 \cdot 4 \cdot 4\)
2. \(2 \cdot 2 \cdot 2 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3\)

### Example 2 Evaluating Expressions

Evaluate each expression.

**a.** \(5^3\)

\[ \begin{align*}
5^3 &= 5 \cdot 5 \cdot 5 \\
&= 125
\end{align*} \]

- The base is 5.
- **Write as repeated multiplication.**
- **Simplify.**

**b.** \(-2^4\)

\[ \begin{align*}
-2^4 &= -(2 \cdot 2 \cdot 2 \cdot 2) \\
&= -16
\end{align*} \]

- The base is 2.
- **Write as repeated multiplication.**
- **Simplify.**

### Try It Evaluate the expression.

3. \(12^2\)
4. \(2^6\)
5. \(-5^4\)
6. \(-4^3\)
Example 3  Using Order of Operations

Evaluate each expression.

a. \(3 + 2 \cdot 3^4 = 3 + 2 \cdot 81\)
   \[= 3 + 162\]
   \[= 165\]

b. \(3^3 - 8^2 \div 2 = 27 - 64 \div 2\)
   \[= 27 - 32\]
   \[= -5\]

c. \(-3 \cdot (-10^2 + 70) = -3 \cdot (-100 + 70)\)
   \[= -3 \cdot (-30)\]
   \[= 90\]

REFLECT ON YOUR METHOD
Can you use the Distributive Property to evaluate the expression in part (c)? Explain.

Try It  Evaluate the expression.

7. \(9 - 2^5 \cdot 0.5\)
8. \(3^3 \div 9 + 18\)
9. \((7 \cdot 4 - 4^3) \div 6\)

In-Class Practice  

WRITING EXPRESSIONS USING EXPONENTS  Write the product using exponents.

10. \(9 \cdot 9 \cdot 9\)
11. \(8 \cdot 8 \cdot 8 \cdot 8\)
12. \(2 \cdot 2 \cdot 2 \cdot 3 \cdot 3 \cdot 3\)
13. \(5 \cdot 5 \cdot 7 \cdot 7 \cdot 7 \cdot 7\)

EVALUATING EXPRESSIONS  Evaluate the expression.

14. \(11^2\)
15. \(8^3\)
16. \(-6^3\)
17. \(-2^5\)

USING ORDER OF OPERATIONS  Evaluate the expression.

18. \(-24 \div 2^2\)
19. \((3^3 - 6 \cdot 8) \div 7\)

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

\(4^3, 3^4, 8^2, 2^6\)
Example 4 Modeling Real Life

The annual profit $P$ (in thousands of dollars) earned by a technology company $x$ years after opening is represented by the equation $P = 0.1x^3 + 3$. How much more profit is earned in year 5 than in year 4?

Use the equation to find the profits earned in year 4 and year 5. Then subtract the profit in year 4 from the profit in year 5 to determine how much more profit is earned in year 5.

<table>
<thead>
<tr>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P = 0.1x^3 + 3$</td>
<td>$P = 0.1x^3 + 3$</td>
</tr>
<tr>
<td>$= 0.1(4)^3 + 3$</td>
<td>$= 0.1(5)^3 + 3$</td>
</tr>
<tr>
<td>$= 0.1(64) + 3$</td>
<td>$= 0.1(125) + 3$</td>
</tr>
<tr>
<td>$= 9.4$</td>
<td>$= 15.5$</td>
</tr>
</tbody>
</table>

So, the company earns $15.5 - 9.4 = 6.1$, or $6100$ more profit in year 5 than in year 4.

In-Class Practice

21. The annual profit $P$ (in thousands of dollars) earned by a commercial fishing company $x$ years after opening is represented by the equation $P = 1.6x^2 + 2$. How much more profit is earned in year 4 than in year 3?

22. Dig Deeper Consider the three units of time below.

Century: $10^2$ years
Millennium: $10^3$ years
Gigayear: $10^9$ years

a. Write each unit of time as a whole number.

b. A megayear is $\frac{1}{1000}$ the length of a gigayear. Write the length of a megayear as a power.
1.1 Practice WITH CalcChat® AND CalcView®

Review & Refresh

Find the missing value(s) in the ratio table. Then write the equivalent ratios.

1. | Oranges | 5 | 15 |
   | Apples  | 4 | 8  |

2. | Cars   | 3 | 9  |
   | Trucks | 2 | 36 |

Evaluate the expression.

3. $3(15 - 8) + 4$
4. $2 \times 20 - 13$
5. $-7 + (6 - 2) \div 2$

Find the area of each figure.

6. 

7. 

Concepts, Skills, & Problem Solving

USING EXPONENT NOTATION Write the power in repeated multiplication form. Then find the value of the power. (See Exploration 1.)

8. $4^4$
9. $8^2$
10. $5^3$

WRITING EXPRESSIONS USING EXPONENTS Write the product using exponents. (See Example 1.)

11. $3 \cdot 3 \cdot 3 \cdot 3$
12. $6 \cdot 6$
13. $9 \cdot 9 \cdot 9 \cdot 9$
14. $4 \cdot 4 \cdot 4 \cdot 4 \cdot 4$
15. $2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$
16. $5 \cdot 5 \cdot 5 \cdot 5 \cdot 5 \cdot 5$
17. $7 \cdot 7 \cdot 7 \cdot 2 \cdot 2$
18. $8 \cdot 8 \cdot 8 \cdot 6 \cdot 6$
19. $3 \cdot 3 \cdot 3 \cdot 3 \cdot 9 \cdot 9$

EVALUATING EXPRESSIONS Evaluate the expression. (See Example 2.)

20. $5^2$
21. $-11^3$
22. $1^6$
23. $3^4$
24. $13^3$
25. $-9^3$

26. **YOU BE THE TEACHER** Your friend evaluates the power $-6^2$. Is your friend correct? Explain your reasoning.

$-6^2 = (-6) \cdot (-6) = 36$

Section 1.1 Exponents 7
Chapter 1  Exponents and Rational Numbers

**STRUCTURE** Write the prime factorization of the number using exponents.

27. 675  
28. 280  
29. 363

**PATTERNS** The smallest doll is 2 inches tall. The height of each of the other dolls is twice the height of the next smaller doll. Write an expression involving a power that represents the height of the largest doll. What is the height of the largest doll?

**USING ORDER OF OPERATIONS** Evaluate the expression. (See Example 3.)

31. $5 + 3 \cdot 2^3$  
32. $2 + 7 \cdot 3^2$  
33. $(13^2 - 12^2) ÷ 5$

34. $\frac{1}{2} (4^3 - 6 \cdot 3^2)$  
35. $\frac{1}{2} (7 + 5^3)$  
36. $-10 \times (24 - 4^2)$

37. $(9^2 - 15 \cdot 2) ÷ 17$  
38. $-6 \cdot (-5^2 + 20)$  
39. $(-4 + 12 - 6^2) ÷ 7$

**MODELING REAL LIFE** Scientists study two bacteria colonies to learn more about how these bacteria populations grow. The number $P$ of bacteria present in colony A after $h$ hours is represented by the equation $P = 50(3)^h$. The number $B$ of bacteria present in colony B after $h$ hours can be represented by $B = 75(2)^h$. (See Example 4.)

a. Find the amount of bacteria in each colony after 4 hours.

b. Which colony has a greater number of bacteria after 9 hours? Explain.

**STRUCTURE** Copy and complete the table. Compare the values of $2^h - 1$ with the values of $2^h - 1$. Are any of the values the same? If so, which values? If not, explain why not.

<table>
<thead>
<tr>
<th>$h$</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2^h - 1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$2^h - 1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Dig Deeper** You create a social media page for an event you are planning at your school. The number $N$ of people who see the post after $s$ shares is represented by the equation $N = 2(4)^s$.

a. How many people see your event page if 3 of your classmates share your page?

b. How many classmates must share your event page for at least 8100 people to see your page? Explain.
**Section 1.2  Product of Powers Property**

**Learning Target:** Generate equivalent expressions involving products of powers.

**Success Criteria:**
- I can find products of powers that have the same base.
- I can find powers of powers.
- I can find powers of products.

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**Exploration 1  Finding Products of Powers**

**Work with a partner.**

**a.** Copy and complete the table. Use your results to write a *general rule* for finding $a^m \cdot a^n$, a product of two powers with the same base.

<table>
<thead>
<tr>
<th>Product</th>
<th>Repeated Multiplication Form</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2^2 \cdot 2^4$</td>
<td>$2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$</td>
<td></td>
</tr>
<tr>
<td>$7^3 \cdot 7^2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$5^1 \cdot 5^6$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$10^3 \cdot 10^5$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$6^2 \cdot 6^2$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**b.** Show how to use your rule in part (a) to write each expression below as a single power. Then write a *general rule* for finding $(a^m)^n$, a power of a power.

$$(7^3)^2 \quad (6^2)^2 \quad (3^2)^3 \quad (2^2)^4 \quad (5^2)^5$$

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**Exploration 2  Finding Powers of Products**

**Work with a partner.** Copy and complete the table. Use your results to write a *general rule* for finding $(ab)^m$, a power of a product.

<table>
<thead>
<tr>
<th>Power</th>
<th>Repeated Multiplication Form</th>
<th>Product of Powers</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(2 \cdot 3)^3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(2 \cdot 5)^2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$(5 \cdot 4)^3$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Number Sense and Operations**

MA.7.NSO.1.1 Know and apply the Laws of Exponents to evaluate numerical expressions and generate equivalent numerical expressions, limited to whole-number exponents and rational number bases.


**Chapter 1**

**Exponents and Rational Numbers**

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### Key Ideas

#### Product of Powers Property

**Words**  To multiply powers with the same base, add their exponents.

**Numbers**  
\[4^2 \cdot 4^3 = 4^{2+3} = 4^5\]

**Algebra**  
\[a^m \cdot a^n = a^{m+n}\]

#### Power of a Power Property

**Words**  To find a power of a power, multiply the exponents.

**Numbers**  
\[(4^6)^3 = 4^{6\cdot3} = 4^{18}\]

**Algebra**  
\[(a^m)^n = a^{mn}\]

#### Power of a Product Property

**Words**  To find a power of a product, find the power of each factor and multiply.

**Numbers**  
\[(3 \cdot 2)^5 = 3^5 \cdot 2^5\]

**Algebra**  
\[(ab)^m = a^m b^m\]

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### Example 1  Multiplying Powers with the Same Base

**a.**  
\[2^4 \cdot 2^5 = 2^{4+5} = 2^9\]

*Product of Powers Property*

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**b.**  
\[4^3 \cdot 4^7 = 4^{3+7} = 4^{10}\]

*Product of Powers Property*

---

**c.**  
\[5 \cdot 5^6 = 5^1 \cdot 5^6 = 5^{1+6} = 5^7\]

*Rewrite as 5^1.*

**Product of Powers Property**

---

### Try It  Simplify the expression. Write your answer as a power.

1.  
   \[6^2 \cdot 6^4\]

2.  
   \[2^3 \cdot 2^6\]

3.  
   \[3 \cdot 3^{12}\]

---

**10**  
**Chapter 1  Exponents and Rational Numbers**
Example 2  Finding a Power of a Power

a. \((3^4)^3 = 3^{4\cdot3}\)
   \[= 3^{12}\]
   Power of a Power Property
   Simplify.

b. \((8^5)^4 = 8^{5\cdot4}\)
   \[= 8^{20}\]
   Power of a Power Property
   Simplify.

Try It
Simplify the expression. Write your answer as a power.

4. \((4^3)^5\)
5. \((7^2)^4\)
6. \((5^3)^2\)

Example 3  Finding a Power of a Product

a. \((2 \cdot 5)^3 = 2^3 \cdot 5^3\)
   Power of a Product Property

b. \((3 \cdot 4)^2 = 3^2 \cdot 4^2\)
   Power of a Product Property

Try It
Simplify the expression. Write your answer as a product of powers.

7. \((5 \cdot 7)^4\)
8. \((2 \cdot 9)^5\)
9. \((11 \cdot 12)^2\)

In-Class Practice  
FINDING POWERS  Simplify the expression. Write your answer as a power.

10. \(4^7 \cdot 4^4\)
11. \((8^5)^3\)
12. \(3^5 \cdot 3^7\)

FINDING A POWER OF A PRODUCT  Simplify the expression. Write your answer as a product of powers.

13. \((2 \cdot 7)^4\)
14. \((3 \cdot 5)^6\)
15. \((8 \cdot 9)^3\)

16. REASONING  Can you use the Product of Powers Property to simplify \(5^2 \cdot 6^6\)? Explain.

17. OPEN-ENDED  Write an expression that simplifies to \(2^{12}\) using the Product of Powers Property.
Example 4  B.E.S.T. Test Prep: Modeling Real Life

One gigabyte (GB) of computer storage space is $2^{30}$ bytes. The storage details of a computer are shown. How many bytes of total storage space does the computer have?

\[
\begin{align*}
\text{A} & \quad 2^{34} \\
\text{B} & \quad 2^{36} \\
\text{C} & \quad 2^{80} \\
\text{D} & \quad 128^{30}
\end{align*}
\]

The computer has 64 gigabytes of total storage space. Notice that you can write 64 as a power, $2^6$.

Use a verbal model to solve the problem.

\[
\begin{align*}
\text{Total number of bytes} &= \text{Number of bytes in a gigabyte} \cdot \text{Number of gigabytes} \\
&= 2^{30} \cdot 2^6 \quad \text{Substitute.} \\
&= 2^{30+6} \quad \text{Product of Powers Property} \\
&= 2^{36} \quad \text{Simplify.}
\end{align*}
\]

The computer has $2^{36}$ bytes of total storage space. So, the correct answer is (B).

**In-Class Practice**

18. A newborn blue whale weighs $3^7$ kilograms. An adult blue whale weighs 81 times the weight of the newborn. How many kilograms does the adult blue whale weigh?

19. One megabyte of cell phone storage space is $2^{20}$ bytes. An app uses $4^4$ megabytes of storage space. How many bytes of storage space does the app use?

20. **Dig Deeper** The sides of a large square rug are 3 times longer than the sides of a square rug with sides that are 2 feet long. Write an expression for the area of the large rug as a product of powers. Justify your answer.
Practice WITH CalcChat® AND CalcView®

1.2

Review & Refresh

Write the product using exponents.

1. \(11 \cdot 11 \cdot 11 \cdot 11 \cdot 11\)

2. \(6 \cdot 6 \cdot 6 \cdot 3 \cdot 3\)

Evaluate the expression when \(x = 2\) and \(z = -3\).

3. \(-4x\)

4. \(xz\)

5. \(7z + 6x\)

6. Find the area of the triangle.

![Triangle with sides 10 ft and 31 ft]

Concepts, Skills, & Problem Solving

FINDING PRODUCTS OF POWERS Write the expression in repeated multiplication form. Then write the expression as a power. (See Exploration 1.)

7. \(5^6 \cdot 5^3\)

8. \((6^4)^2\)

9. \(8^3 \cdot 8^4\)

FINDING POWERS Simplify the expression. Write your answer as a power. (See Examples 1 and 2.)

10. \(3^2 \cdot 3^2\)

11. \(8^{10} \cdot 8^4\)

12. \((5^4)^3\)

13. \((3^2)^4\)

14. \(4^5 \cdot 4^7\)

15. \(7^6 \cdot 7\)

16. \((1^{12})^3\)

17. \((5^2)^3\)

18. \(6^3 \cdot 6^4\)

HELP A CLASSMATE Your friend wants to simplify the expression \(5^2 \cdot 5^9\). Explain how your friend can complete their work.

\[5^2 \cdot 5^9 = (5)\]

FINDING A POWER OF A PRODUCT Simplify the expression. Write your answer as a product of powers. (See Example 3.)

20. \((6 \cdot 4)^3\)

21. \((3 \cdot 7)^5\)

22. \((2 \cdot 9)^4\)

23. \((8 \cdot 7)^4\)

24. \((1 \cdot 5)^{12}\)

25. \((10 \cdot 3)^2\)

STRUCTURE Is \(3^2 + 3^3\) equal to \(3^5\)? Explain.
27. **PROBLEM SOLVING** A display case for the artifact shown is in the shape of a cube. Each side of the display case is three times longer than the base length of the artifact.

a. Write a power of a product that represents the volume of the case.

b. What is the volume of the case?

28. **NUMBER SENSE** Show that 
\[(3 \cdot 8 \cdot 5)^7 = 6^7 \cdot 4^7 \cdot 5^7.\]

29. **MODELING REAL LIFE** The lowest altitude of an altocumulus cloud is about $3^8$ feet. The highest altitude of an altocumulus cloud is about 3 times the lowest altitude. What is the highest altitude of an altocumulus cloud? Write your answer as a power. (See Example 4.)

30. **INVESTIGATE** Each galaxy in the universe has a different number of stars. Astronomers estimate that the Milky Way galaxy has about $10^{11}$ stars. The Andromeda galaxy has about $10^6$ as many stars as the Milky Way.

a. How many total stars are in the Andromeda galaxy?

b. Research the number of stars in another galaxy. Write a power that relates the number of stars in this galaxy to the number of stars in the Milky Way.

31. **MODELING REAL LIFE** The United States Postal Service delivers about $2^4 \cdot 3 \cdot 5^3$ pieces of mail each second. There are $2^8 \cdot 3^4 \cdot 5^2$ seconds in 6 days. How many pieces of mail does the United States Postal Service deliver in 6 days? Write your answer as an expression involving three powers.

32. **REASONING** The row numbers $y$ and column numbers $x$ of a chessboard are shown. Each position on the chessboard has a stack of pennies. (Only the first row is shown.) The number of pennies in each stack is $2^x \cdot 2^y$.

a. Which locations have 32 pennies in their stacks?

b. How much money (in dollars) is in the location with the tallest stack?

c. A penny is about 0.06 inch thick. About how tall is the tallest stack?

33. **NUMBER SENSE** Find the value of $x$ in the equation without evaluating the power.

\[2^5 \cdot 2^x = 256\]
1.3 Quotient of Powers Property

Learning Target: Generate equivalent expressions involving quotients of powers.

Success Criteria:
- I can find quotients of powers that have the same base.
- I can simplify expressions using the Quotient of Powers Property.
- I can solve real-life problems involving quotients of powers.

Exploration 1 Finding Quotients of Powers

Work with a partner.

a. Copy and complete the table. Use your results to write a general rule for finding $\frac{a^m}{a^n}$, a quotient of two powers with the same base.

<table>
<thead>
<tr>
<th>Quotient</th>
<th>Repeated Multiplication Form</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{2^4}{2^2}$</td>
<td>$\frac{2 \cdot 2 \cdot 2 \cdot 2}{2 \cdot 2}$</td>
<td></td>
</tr>
<tr>
<td>$\frac{7^7}{7^3}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{10^8}{10^5}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b. Use your rule in part (a) to simplify the quotients in the first column of the table above. Does your rule give the results in the third column?

c. Copy and complete the table. Use your rule in part (a) to complete the third column. Use your results to define $a^0$, where $a \neq 0$.

<table>
<thead>
<tr>
<th>Quotient</th>
<th>Value</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{4^3}{4^3}$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>$\frac{3^5}{3^5}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{2^6}{2^6}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number Sense and Operations
MA.7.NSO.1.1 Know and apply the Laws of Exponents to evaluate numerical expressions and generate equivalent numerical expressions, limited to whole-number exponents and rational number bases.
1.3 Lesson

**Key Ideas**

**Quotient of Powers Property**

Words  To divide powers with the same base, subtract their exponents.

Numbers  \( \frac{4^5}{4^2} = 4^{5-2} = 4^3 \)

Algebra  \( \frac{a^m}{a^n} = a^{m-n} \), where \( a \neq 0 \)

**Zero Exponents**

Words  For any nonzero number \( a \), \( a^0 = 1 \). The power \( 0^0 \) is **undefined**.

Numbers  \( 4^0 = 1 \)

Algebra  \( a^0 = 1 \), where \( a \neq 0 \)

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**Example 1** Dividing Powers with the Same Base

Simplify \( \frac{2^6}{2^4} \). Write your answer as a power.

\[
\frac{2^6}{2^4} = 2^{6-4} = 2^2
\]

**Try It**

Simplify the expression. Write your answer as a power.

1. \( \frac{9^7}{9^4} \)

2. \( \frac{4^6}{4^3} \)

3. \( \frac{8^8}{8^4} \)

4. \( \frac{5^3}{5^3} \)

---

**Example 2** Simplifying an Expression

Simplify \( \frac{3^4 \cdot 3^2}{3^3} \). Write your answer as a power.

\[
\frac{3^4 \cdot 3^2}{3^3} = \frac{3^{4+2}}{3^3} = \frac{3^6}{3^3} = 3^{6-3} = 3^3
\]

**Try It**

Simplify the expression. Write your answer as a power.

5. \( \frac{6^7 \cdot 6^3}{6^5} \)

6. \( \frac{2^{15}}{2^3 \cdot 2^2} \)

7. \( \frac{4^8 \cdot 4^6}{4^5} \)
Example 3  Simplifying Expressions

a. \( \frac{4^9}{4^5} \cdot \frac{4^6}{4^2} = \frac{4^{9-5} \cdot 4^{6-2}}{1} \)
   = \(4^4 \cdot 4^6 = 4^{4+6} = 4^{10}\)

b. \( \frac{9^{10}}{9^6} \cdot \frac{9^7}{9^4} = \frac{9^{10-6} \cdot 9^{7-4}}{1} \)
   = \(9^4 \cdot 9^3 = 9^{4+3} = 9^7\)

c. \(5^3 \cdot 3^0 = 5^3 \cdot 1\)
   = \(5^3\)

Try It

Simplify the expression. Write your answer as a power.

8. \(\frac{5^7 \cdot 5^6}{5^5 \cdot 5^2}\)
9. \(\frac{7^5 \cdot 7^9}{7^7}\)
10. \(2^5 \cdot 8^0\)

In-Class Practice

SIMPLIFYING EXPRESSIONS  Simplify the expression.
Write your answer as a power.

11. \(\frac{3^9}{3^2}\)
12. \(\frac{8^6 \cdot 8^2}{8^3}\)
13. \(\frac{7^{11}}{7^4 \cdot 7^6}\)
14. \(\frac{5^6 \cdot 5^3}{5^5 \cdot 5^2}\)
15. \(\frac{2^9 \cdot 2^4}{2^4 \cdot 2^4}\)
16. \(8^4 \cdot 6^0\)

17. WHICH ONE DOESN'T BELONG?  Which quotient does not belong with the other three? Explain your reasoning.

\[\frac{10^7}{10^2}, \frac{6^3}{6^2}, \frac{4^8}{3^4}, \frac{5^6}{5^3}\]
### Example 4  
**Modeling Real Life**

A warehouse is shipping boxes of cube-shaped puzzles to a store. The volume of a puzzle is $2^3$ cubic inches. The puzzles can fit in a box with no space left over. The volume of the box is $8 \cdot 2^6$ cubic inches. How many puzzles can fit in the box?

You can find the number of puzzles that can fit in the box by dividing the volume of the box by the volume of a puzzle.

\[
\frac{\text{Volume of the box}}{\text{Volume of a puzzle}} = \frac{8 \cdot 2^6}{2^3}
\]

Substitute.

\[
= 8 \cdot 2^3
\]

Rewrite.

\[
= 8 \cdot 2^3
\]

Quotient of Powers Property

\[
= 8 \cdot 8
\]

Evaluate the power.

\[
= 64
\]

Simplify.

So, 64 cube-shaped puzzles can fit in the box.

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### In-Class Practice

18. A warehouse is shipping boxes of cube-shaped puzzles. The volume of a box is $2^6$ cubic inches. The boxes can fit in a box with no space left over. The volume of the box is $8 \cdot 2^6$ cubic inches. How many puzzles can fit in the box?

19. You want to purchase a cat tracker. Tracker A detects your cat within a distance of $4 \cdot 10^2$ feet of your home. Tracker B detects your cat within a distance of $10^4$ feet of your home. Which tracker covers a greater distance from your home? How many times greater?

20. **Dig Deeper** An earthquake of magnitude 3.0 is $10^2$ times stronger than an earthquake of magnitude 1.0. An earthquake of magnitude 8.0 is $10^7$ times stronger than an earthquake of magnitude 1.0. How many times stronger is an earthquake of magnitude 8.0 than an earthquake of magnitude 3.0?
1.3 Practice with CalcChat® and CalcView®

Review & Refresh

Simplify the expression. Write your answer as a power.

1. \(4^2 \cdot 4^3\)  
2. \((8^5)^5\)  
3. \((5 \cdot 6)^7\)

Find the volume of the prism.

4.  
5.  
6. 

Find the mean of the data.

7. 21, 23, 24, 24, 27, 19  
8. 44, 37, 45, 38, 42, 40, 36, 46

Concepts, Skills, & Problem Solving

FINDING QUOTIENTS OF POWERS  Write the quotient as repeated multiplication. Then write the quotient as a power. (See Exploration 1.)

9. \(\frac{7^9}{7^6}\)  
10. \(\frac{4^6}{4^2}\)  
11. \(\frac{9^{10}}{9^5}\)

DIVIDING POWERS WITH THE SAME BASE  Simplify the expression. Write your answer as a power. (See Example 1.)

12. \(\frac{8^9}{8^7}\)  
13. \(\frac{6^{10}}{6^4}\)  
14. \(\frac{3^4}{3^1}\)  
15. \(\frac{4^5}{4^3}\)

16. \(\frac{64^4}{64^3}\)  
17. \(\frac{17^5}{17^2}\)  
18. \(\frac{72^8}{72^6}\)  
19. \(\frac{29^{11}}{29^7}\)

20. YOU BE THE TEACHER  Your friend simplifies the quotient. Is your friend correct? Explain your reasoning.

SIMPLIFYING AN EXPRESSION  Simplify the expression. Write your answer as a power. (See Example 2.)

21. \(\frac{6^{13}}{6^4 \cdot 6^2}\)  
22. \(\frac{7^5 \cdot 7^3}{7^2}\)  
23. \(\frac{8^{11}}{8^7 \cdot 8^2}\)

24. \(\frac{9^{10}}{9^{18} \cdot 9^8}\)  
25. \(\frac{5^{22}}{5^8 \cdot 5^9}\)  
26. \(\frac{11^8 \cdot 11^6}{11^8}\)
27. **MODELING REAL LIFE** The sound intensity of a normal conversation is $10^6$ times greater than the quietest noise a person can hear. The sound intensity of a jet at takeoff is $10^{14}$ times greater than the quietest noise a person can hear. How many times more intense is the sound of a jet at takeoff than the sound of a normal conversation?

28. Simplify the expression. Write your answer as a power. (See Example 3.)

$$4^6 \cdot 4^3$$
$$\frac{4^4 \cdot 4^2}{4^4 \cdot 4^2}$$

29. $$\frac{3^2 \cdot 3^6}{3^2 \cdot 3}$$

30. $$\frac{6^2 \cdot 6^{12}}{6 \cdot 6^8}$$

31. $$\frac{7^7 \cdot 7^6}{7 \cdot 7^2}$$

32. $$\frac{8^5 \cdot 8^{13}}{8^3 \cdot 8^8}$$

33. $$\frac{9^8 \cdot 9^2 \cdot 9^4}{9^7 \cdot 9 \cdot 9^2}$$

34. **PATTERNS** The storage capacities and prices of five devices are shown in the table.

<table>
<thead>
<tr>
<th>Device</th>
<th>Storage (GB)</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$2^5$</td>
<td>$30$</td>
</tr>
<tr>
<td>B</td>
<td>$2^6$</td>
<td>$50$</td>
</tr>
<tr>
<td>C</td>
<td>$2^7$</td>
<td>$70$</td>
</tr>
<tr>
<td>D</td>
<td>$2^8$</td>
<td>$90$</td>
</tr>
<tr>
<td>E</td>
<td>$2^9$</td>
<td>$110$</td>
</tr>
</tbody>
</table>

35. **Dig Deeper** Consider the equation $\frac{9^m}{9^n} = 9^2$.

a. Find two numbers $m$ and $n$ that satisfy the equation. Explain your reasoning.

b. Describe the number of solutions that satisfy the equation. Explain your reasoning.

36. **MODELING REAL LIFE** A scientist estimates that there are about $10^{24}$ stars in the universe and that each galaxy has, on average, approximately the same number of stars as the Milky Way galaxy: $10 \cdot 10^{10}$ stars. About how many galaxies are in the universe? (See Example 4.)

37. **NUMBER SENSE** Find the value of $x$ that makes $\frac{8^{14}}{8^{2x+1}} = 8^9$ true. Explain how you found your answer.
Rational Numbers

Learning Target: Understand how to compare rational numbers.

Success Criteria:
- I can graph rational numbers on a number line.
- I can find the absolute value of a rational number.
- I can use a number line to compare rational numbers.

Recall that integers are the set of whole numbers and their opposites. A rational number is a number that can be written as $\frac{a}{b}$, where $a$ and $b$ are integers and $b \neq 0$.

Exploration 1

Using a Number Line

Work with a partner. Make a number line on the floor. Include both negative numbers and positive numbers.

a. Stand on an integer. Then have your partner stand on the opposite of the integer. How far are each of you from 0? What do you call the distance between a number and 0 on a number line?

b. Stand on a rational number that is not an integer. Then have your partner stand on any other number. Which number is greater? How do you know?

c. Stand on any number other than 0 on the number line. Can your partner stand on a number that is

- greater than your number and farther from 0?
- greater than your number and closer to 0?
- less than your number and the same distance from 0?
- less than your number and farther from 0?

For each case in which it was not possible to stand on a number as directed, explain why it is not possible. In each of the other cases, how can you decide where your partner can stand?
1.4 Lesson

Key Idea

Absolute Value

Words The absolute value of a number is the distance between the number and 0 on a number line. The absolute value of a number \(a\) is written as \(|a|\).

Numbers

\(|-4| = 4\) \hspace{1cm} \(|4| = 4\)

Example 1 Finding Absolute Values of Integers

a. Find the absolute value of \(-3\).

Graph \(-3\) on a number line.

The distance between \(-3\) and 0 is 3.

\(\therefore\) So, \(|-3| = 3\).

b. Find the absolute value of 5.

Graph 5 on a number line.

The distance between 5 and 0 is 5.

\(\therefore\) So, \(|5| = 5\).

Try It Find the absolute value.

1. \(|-2|\) 2. \(|-6|\) 3. \(|7|\)
Example 2  Finding Absolute Values of Rational Numbers

a. Find the absolute value of $-0.2$.

Graph $-0.2$ on a number line.

The distance between $-0.2$ and $0$ is $0.2$.

So, $|-0.2| = 0.2$.

b. Find the absolute value of $\frac{1}{4}$.

Graph $\frac{1}{4}$ on a number line.

The distance between $\frac{1}{4}$ and $0$ is $\frac{1}{4}$.

So, $|\frac{1}{4}| = \frac{1}{4}$.

c. Find the absolute value of $-\frac{1}{2}$.

Graph $-\frac{1}{2}$ on a number line.

The distance between $-\frac{1}{2}$ and $0$ is $\frac{1}{2}$.

So, $|-\frac{1}{2}| = \frac{1}{2}$.

Try It  Find the absolute value.

4. $|-2.6|$

5. $|\frac{1}{2}|$

6. $|\frac{5}{3}|$
Example 3  Comparing Rational Numbers

a. Compare $| -0.4 |$ and $| 0.2 |$.

Graph $| 0.2 | = 0.2$ on a number line.  
Graph $| -0.4 | = 0.4$ on a number line.

$| -0.4 |$ is to the right of $| 0.2 |$.

So, $| -0.4 | > | 0.2 |$.

b. Compare $| -2.5 |$ and $\frac{3}{2}$.

Graph $\frac{3}{2}$ on a number line.  
Graph $| -2.5 | = 2.5$ on a number line.

$| -2.5 |$ is to the right of $\frac{3}{2}$.

So, $| -2.5 | > \frac{3}{2}$.

Try It  Copy and complete the statement using $<$, $>$, or $=$.  

7. $| 9 |$ $| -9 |$  

8. $-\frac{1}{2} |$ $-\frac{1}{4} |$  

9. $7 |$ $| -4.5 |$

In-Class Practice  

10. VOCABULARY  Which of the following numbers are integers?

$9, 3.2, -1, \frac{1}{2}, -0.25, 15$

Comparing Rational Numbers  Copy and complete the statement using $<$, $>$, or $=$.  

Use a number line to justify your answer.

11. $\frac{2}{5} |$ $\frac{3}{5} |$  

12. $3.5 |$ $\frac{7}{2} |$  

13. $\frac{11}{4} |$ $| -2.8 |$

14. WRITING  You compare two numbers, $a$ and $b$.  Explain how $a > b$ and $| a | < | b |$ can both be true statements.
Example 4  Modeling Real Life

A moon has an ocean underneath its icy surface. Scientists run tests above and below the surface. The table shows the elevations of each test. Which test is deepest? Which test is closest to the surface?

<table>
<thead>
<tr>
<th>Test</th>
<th>Temperature</th>
<th>Salinity</th>
<th>Atmosphere</th>
<th>Organics</th>
<th>Ice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation</td>
<td>−3.8</td>
<td>−5.15</td>
<td>0.3</td>
<td>−4.5</td>
<td>−0.25</td>
</tr>
</tbody>
</table>

To determine which test is deepest, find the least elevation. Graph the elevations on a vertical number line.

The number line shows that the salinity test is deepest. The number line also shows that the atmosphere test and the ice test are closest to the surface. To determine which is closer to the surface, identify which elevation has a lesser absolute value.

**Atmosphere:**  $|0.3| = 0.3$

**Ice:**  $|-0.25| = 0.25$

So, the salinity test is deepest and the ice test is closest to the surface.

In-Class Practice

15. An airplane is at an elevation of 5.5 miles. A submarine is at an elevation of $-10.9$ kilometers. Which is closer to sea level? Explain.

16. A sailfish is at an elevation of $-\frac{1}{5}$ kilometer. A heron is at an elevation of 0.4 kilometer. Which is closer to sea level? Explain.

17. The image shows the corrective powers (in diopters) of contact lenses for eight people. The farther the number of diopters is from 0, the greater the power of the lens. Positive diopters correct farsightedness and negative diopters correct nearsightedness. Who is the most nearsighted? the most farsighted? Who has the best eyesight?

<table>
<thead>
<tr>
<th>Patient</th>
<th>Power (diopters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>−1.25</td>
</tr>
<tr>
<td>2</td>
<td>0.75</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>4</td>
<td>−3.75</td>
</tr>
<tr>
<td>5</td>
<td>−2.5</td>
</tr>
<tr>
<td>6</td>
<td>−4.75</td>
</tr>
<tr>
<td>7</td>
<td>−7.5</td>
</tr>
<tr>
<td>8</td>
<td>1.5</td>
</tr>
</tbody>
</table>
1.4 Practice with CalcChat® and CalcView®

Review & Refresh

Simplify the expression. Write your answer as a power.

1. \( \frac{10^8}{10^4} \)  
2. \( \frac{2^9}{2^3} \)  
3. \( \frac{3^8 \cdot 3^3}{3^2} \)

Find the GCF of the numbers.

4. 8, 20  
5. 12, 30  
6. 7, 28  
7. 48, 72  
8. What is the ratio of dogs to cats?

Concepts, Skills, & Problem Solving

NUMBER SENSE  Determine which number is greater and which number is farther from 0. Explain your reasoning. (See Exploration 1.)

9. 4, −6  
10. −3.25, \( \frac{7}{2} \)  
11. \( \frac{-4}{5}, -1.3 \)

FINDING ABSOLUTE VALUES  Find the absolute value. (See Examples 1 and 2.)

12. |8|  
13. |−2|  
14. |−10|  
15. |10|

16. |0|  
17. \( \frac{1}{3} \)  
18. \( \frac{7}{8} \)  
19. \( \frac{-5}{9} \)

20. \( \frac{11}{8} \)  
21. 3.8  
22. |−5.3|  
23. \( \frac{-15}{4} \)

24. 7.64  
25. |−18.26|  
26. \( \frac{2}{5} \)  
27. \( -\frac{5}{6} \)

COMPARING RATIONAL NUMBERS  Copy and complete the statement using <, >, or =. (See Example 3.)

28. 2 |−5|  
29. |−1| |−8|  
30. |5| |−5|

31. |−2| |0|  
32. 0.4 |−\( \frac{7}{8} \)|  
33. \( 4.9 \) |−5.3|

34. |−4.7| \( \frac{1}{2} \)  
35. \( −\frac{3}{4} \) |−\( \frac{3}{4} \)|  
36. −|\( \frac{1}{4} \)| |−\( \frac{3}{8} \)|
YOU BE THE TEACHER  Your friend compares two rational numbers. Is your friend correct? Explain your reasoning.

37. \(|-10| = -10\)

38. \(\left| -\frac{4}{5} \right| > \left| -\frac{1}{2} \right|\)

39. **B.E.S.T. Test Prep** Which number has an absolute value greater than 3?

   - A  -4
   - B  -2.5
   - C  2
   - D  3

40. **MODELING REAL LIFE** The *summit elevation* of a volcano is the elevation of the top of the volcano relative to sea level. The summit elevation of Kilauea, a volcano in Hawaii, is 1277 meters. The summit elevation of Loihi, an underwater volcano in Hawaii, is \(-969\) meters. Which summit is higher? Which summit is closer to sea level?

41. **MODELING REAL LIFE** The *freezing point* of a liquid is the temperature at which the liquid becomes a solid. (See Example 4.)

   a. Which liquid in the table has the lowest freezing point?
   
   b. Is the freezing point of mercury or butter closer to the freezing point of water, 0°C?

<table>
<thead>
<tr>
<th>Liquid</th>
<th>Freezing Point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter</td>
<td>35</td>
</tr>
<tr>
<td>Airplane fuel</td>
<td>-53</td>
</tr>
<tr>
<td>Honey</td>
<td>-3</td>
</tr>
<tr>
<td>Mercury</td>
<td>-39</td>
</tr>
<tr>
<td>Candle wax</td>
<td>53</td>
</tr>
</tbody>
</table>

42. \(8, |3|, -5, |-2|, -2\)

43. \(|-6.3|, -7.2, 8, |5|, -6.3\)

44. \(|3.5|, |-1.8|, 4.6, 3\frac{2}{5}, 2.7|\)

45. \(|-\frac{3}{4}|, \frac{5}{8}, \frac{1}{4}, |\frac{1}{2}|, |\frac{-7}{8}|\)

46. **INVESTIGATE** The table shows the distances (in astronomical units) of several NASA spacecraft from Earth in 2020.

   a. Order the spacecraft by distance from Earth from closest to farthest.

   b. Research the distance these spacecrafts are from Earth now. Did the order in part (a) change?

<table>
<thead>
<tr>
<th>Spacecraft</th>
<th>Distance (AU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Horizons</td>
<td>46.8</td>
</tr>
<tr>
<td>Voyager 1</td>
<td>149.2</td>
</tr>
<tr>
<td>Voyager 2</td>
<td>123.6</td>
</tr>
<tr>
<td>Juno</td>
<td>0.4</td>
</tr>
</tbody>
</table>
47. **PROBLEM SOLVING** The table shows golf scores, relative to par.

<table>
<thead>
<tr>
<th>Player</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+5</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>−4</td>
</tr>
<tr>
<td>4</td>
<td>−1</td>
</tr>
<tr>
<td>5</td>
<td>+2</td>
</tr>
</tbody>
</table>

a. The player with the lowest score wins. Which player wins?
b. Which player is closest to par?
c. Which player is farthest from par?

48. **Dig Deeper** You use the table below to record the temperature at the same location each hour for several hours. At what time is the temperature coldest? At what time is the temperature closest to the freezing point of water, 0°C?

<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00 A.M.</td>
<td>−2.6</td>
</tr>
<tr>
<td>11:00 A.M.</td>
<td>−2.7</td>
</tr>
<tr>
<td>12:00 P.M.</td>
<td>−0.15</td>
</tr>
<tr>
<td>1:00 P.M.</td>
<td>1.6</td>
</tr>
<tr>
<td>2:00 P.M.</td>
<td>−1.25</td>
</tr>
<tr>
<td>3:00 P.M.</td>
<td>−3.4</td>
</tr>
</tbody>
</table>

49. **Dig Deeper** A construction company demolishes a brick patio and builds a new one. Trucks deliver and remove bricks from the construction site. Trucks delivering bricks carry 150 new bricks per truckload, and trucks removing bricks carry 100 bricks per truckload.

a. Two truckloads of old bricks are removed, and three truckloads of new bricks are delivered to the site. Use the expression \(2|−100| + 3(150)\) to find the total number of bricks that are moved.

b. Describe a situation where the sum of bricks the company removes and delivers is −250 bricks.

**DISCUSS MATHEMATICAL THINKING** Determine whether the statement is true or false. Explain your reasoning.

50. If \(x < 0\), then \(|x| = −x\).

51. The absolute value of every rational number is positive.

52. **ADAPT A PROCEDURE** You, your friend, and your cousin visit the Calle Ocho Walk of Fame in Miami. The stars are in order from 1 to 20. You decide that everyone must stop at each star they pass and can visit a star more than once. You start at star 1, your friend starts at star 3, and your cousin starts at star 13.

<table>
<thead>
<tr>
<th>Star</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

a. You and your cousin walk toward each other and meet at star 5. Who saw more stars? Explain.

b. Your friend made 23 stops and ended on star 10. What is a possible order of stars your friend visited? Explain how you found your answer.
Exploration 1
Finding Powers of Quotients

Work with a partner. Copy and complete the table. Use your results to write a general rule for finding \( \left( \frac{a}{b} \right)^m \), a power of a quotient.

<table>
<thead>
<tr>
<th>Expression</th>
<th>Repeated Multiplication Form</th>
<th>Rewritten Form</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \left( \frac{1}{2} \right)^2 )</td>
<td>( \frac{1}{2} \cdot \frac{1}{2} )</td>
<td>( \frac{1 \cdot 1}{2 \cdot 2} = \frac{1^2}{2^2} )</td>
<td>( \frac{1}{4} )</td>
</tr>
<tr>
<td>( \left( \frac{3}{4} \right)^3 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \left( \frac{5}{2} \right)^4 )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Exploration 2
Writing Equivalent Expressions

Work with a partner. Copy and complete the table. Apply the properties of exponents to rewrite each expression as a single power. State the property used.

<table>
<thead>
<tr>
<th>Expression</th>
<th>Simplified Expression</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \left( \frac{1}{3} \right)^2 \cdot \left( \frac{1}{3} \right)^6 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( 0.4^4 \cdot 0.4^5 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \left( \frac{1}{4} \right)^3 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \frac{1.5^9}{1.5^4} )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number Sense and Operations
MA.7.NSO.1.1 Know and apply the Laws of Exponents to evaluate numerical expressions and generate equivalent numerical expressions, limited to whole-number exponents and rational number bases.
1.5 Lesson

Example 1 Writing Expressions Using Exponents

Write each product using exponents.

a. \(\left(-\frac{1}{2}\right) \cdot \left(-\frac{1}{2}\right) \cdot \left(-\frac{1}{2}\right)\)

Because \(-\frac{1}{2}\) is used as a factor 3 times, its exponent is 3.

So, \(\left(-\frac{1}{2}\right) \cdot \left(-\frac{1}{2}\right) \cdot \left(-\frac{1}{2}\right) = \left(-\frac{1}{2}\right)^3\).

b. \(0.5 \cdot 0.5 \cdot 0.5 \cdot 0.5\)

Because 0.5 is used as a factor 4 times, its exponent is 4.

So, \(0.5 \cdot 0.5 \cdot 0.5 \cdot 0.5 = 0.5^4\).

Try It Write the product using exponents.

1. \(\frac{1}{4} \cdot \frac{1}{4} \cdot \frac{1}{4} \cdot \frac{1}{4}\)

2. \((-0.3) \cdot (-0.3) \cdot (-0.3)\)

You can use repeated multiplication or the Power of a Quotient Property to evaluate expressions involving powers with rational number bases.

Key Idea

Power of a Quotient Property

Words To find a power of a quotient, divide the power of the numerator by the power of the denominator.

Numbers

\[\left(\frac{3}{2}\right)^2 = \frac{3^2}{2^2} = \frac{9}{4}\]

Algebra

\[\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}, \text{ where } b \neq 0\]

Example 2 Evaluating Expressions

Evaluate each expression.

a. \(-0.1^2 = -(0.1 \cdot 0.1)\)

Write as repeated multiplication.

\[= -0.01\]

Simplify.

USE ANOTHER METHOD

Evaluate the expression in part (a) by rewriting the decimal as a fraction and using the Power of a Quotient Property.

b. \(\left(\frac{5}{4}\right)^3 = \frac{5^3}{4^3}\)

Power of a Quotient Property

\[= \frac{125}{64}\]

Simplify.

Try It Evaluate the expression.

3. \(0.5^2\)

4. \((-0.2)^3\)

5. \(\left(\frac{7}{6}\right)^2\)

6. \(-\left(\frac{2}{3}\right)^4\)
Example 3  Simplifying Expressions

a. \((-\frac{1}{4})^4 \cdot (-\frac{1}{4})^3 = (-\frac{1}{4})^{4+3}\)  
   \[= (-\frac{1}{4})^7\]  
   Product of Powers Property  
   Simplify.

b. \((0.5^2)^3 = 0.5^{2 \cdot 3}\)  
   \[= 0.5^6\]  
   Power of a Power Property  
   Simplify.

c. \((-2.7)^8 \div (-2.7)^5 = (-2.7)^{8-5}\)  
   \[= (-2.7)^3\]  
   Quotient of Powers Property  
   Simplify.

d. \(\left(\frac{1}{5}\right)^3 \cdot \left(\frac{1}{6}\right)^0 = \left(\frac{1}{5}\right)^3 \cdot 1\)  
   \[= \left(\frac{1}{5}\right)^3\]  
   Definition of a zero exponent  
   Multiplicative Identity Property of One

Try It  Simplify the expression. Write your answer as a power.

7. \(0.8^6 \cdot 0.8^7\)  
8. \(\frac{6.5^7}{6.5^4}\)  
9. \(\left(\frac{1}{8}\right)^3 \cdot \left(\frac{1}{4}\right)^0\)

In-Class Practice

WRITING EXPRESSIONS USING EXPONENTS  Write the product using exponents.

10. \((-0.9) \cdot (-0.9) \cdot (-0.9)\)  
11. \(\frac{1}{8} \cdot \frac{1}{8} \cdot \frac{1}{8} \cdot \frac{1}{8}\)

EVALUATING EXPRESSIONS  Evaluate the expression.

12. \(0.4^3\)  
13. \(\left(\frac{3}{2}\right)^3\)  
14. \(-\left(\frac{1}{2}\right)^5\)

SIMPLIFYING EXPRESSIONS  Simplify the expression. Write your answer as a power.

15. \(\left(-\frac{1}{8}\right)^5 \cdot \left(-\frac{1}{8}\right)^7\)  
16. \((0.2^3)^4\)  
17. \(\frac{1.8^6}{1.8^7}\)

18. WHICH ONE DOESN’T BELONG? Which expression does not belong with the other three? Explain your reasoning.

\[1.2^2 \cdot 1.2^3\]  
\[\frac{1.2^8}{1.2^3}\]  
\[(1.2^3)^2\]  
\[1.2^5 \cdot 1.2^0\]
Example 4  Modeling Real Life

The projected population of Florida in 2040 is about $4 \cdot 7.2^8$. Predict the average number of people per square kilometer in Florida in 2040.

You are given the projected population of Florida in 2040 and the land area of Florida. You are asked to predict the average number of people per square kilometer in Florida in 2040.

You can find the average number of people per square kilometer in 2040 by dividing the projected population of Florida in 2040 by the land area.

\[
\text{People per square kilometer} = \frac{\text{Population in 2040}}{\text{Land area}}
\]

\[
= \frac{4 \cdot 7.2^8}{7.2^6}
\]

\[= 4 \cdot \frac{7.2^8}{7.2^6}\]

\[= 4 \cdot 7.2^2\]

\[= 207.36\]

So, you can predict that there will be about 207 people per square kilometer in Florida in 2040.

Check Reasonableness
Use estimation.
\[4 \cdot \frac{7^8}{7^6} = 4 \cdot 7^2\]
\[= 4 \cdot 49\]
\[= 200, \text{ which is close to 207.} \checkmark\]

In-Class Practice

19. The edges of a cube are $1.4^5$ centimeters long. Find the volume of the cube. Write your answer as a power.

20. **Dig Deeper** A scientist has 32 grams of a radioactive isotope. The amount is halved every minute due to radioactive decay.
   a. Write an expression involving a power for the amount remaining after 3 minutes.
   b. Write an expression for the amount remaining after $t$ minutes. Justify your answer.
   c. Use the expression in part (b) to find the amount remaining after 5 minutes.
### Review & Refresh

Copy and complete the statement using <, >, or =.

1. \(5 \quad \underline{\quad} \quad | -7 | \)  
2. \(-2.6 \quad \underline{\quad} \quad | -2.06 | \)  
3. \(-\frac{3}{5} \quad \underline{\quad} \quad -\frac{5}{8} \)

Make a box-and-whisker plot for the data.

4. Time spent studying (in minutes): 35, 41, 45, 43, 33, 24, 56, 49, 37, 47, 45  
5. Points scored in a basketball game: 73, 65, 64, 71, 52, 63, 74, 68, 66, 72, 59, 78

Find the numbers of faces, edges, and vertices of the solid.

6.  
7.  
8.  

### Concepts, Skills, & Problem Solving

**WRITING EQUIVALENT EXPRESSIONS** Apply the properties of exponents to rewrite the expression as a single power. State the property used. (See Exploration 2.)

9. \(0.6^3 \cdot 0.6^7\)  
10. \(\frac{3.78^8}{3.75^5}\)  
11. \([\left(\frac{2}{3}\right)^3]^3\)

**WRITING EXPRESSIONS USING EXPONENTS** Write the product using exponents. (See Example 1.)

12. \(0.2 \cdot 0.2 \cdot 0.2 \cdot 0.2\)  
13. \(\frac{1}{3} \cdot \frac{1}{3} \cdot \frac{1}{3}\)  
14. \((-\frac{1}{2}) \cdot (-\frac{1}{2}) \cdot (-\frac{1}{2})\)  
15. \((-0.6) \cdot (-0.6) \cdot (-0.6) \cdot (-0.6)\)  
16. \(1.5 \cdot 1.5 \cdot 1.5 \cdot 1.5 \cdot 1.5\)  
17. \((-\frac{2}{5}) \cdot (-\frac{2}{5}) \cdot (-\frac{2}{5})\)  
18. \((-\frac{3}{4}) \cdot (-\frac{3}{4}) \cdot (-\frac{3}{4}) \cdot (-\frac{3}{4})\)  
19. \(-\frac{1}{4} \cdot \frac{1}{4} \cdot \frac{1}{4} \cdot \frac{1}{4}\)

**EVALUATING EXPRESSIONS** Evaluate the expression. (See Example 2.)

20. \(0.3^3\)  
21. \(\left(\frac{3}{4}\right)^4\)  
22. \(-0.5^5\)  
23. \(\left(\frac{2}{7}\right)^3\)  
24. \((1.2)^2\)  
25. \(\left(\frac{1}{2}\right)^6\)  
26. \(\left(\frac{1}{12}\right)^2\)  
27. \((-\frac{2}{9})^3\)  
28. \(-\left(\frac{3}{2}\right)^4\)
29. **YOU BE THE TEACHER** Your friend evaluates the expression. Is your friend correct? Explain your reasoning.

SIMPLIFYING EXPRESSIONS  Simplify the expression. Write your answer as a power. (See Example 3.)

30. \(0.7^5 \cdot 0.7^0\)  

31. \(\frac{(-6.4)^8}{(-6.4)^6}\)

32. \(4.5^5\)

33. \((\frac{2}{3})^2 \cdot \frac{2}{3}\)

34. \(\left(-\frac{3}{4}\right)^2\)

35. \((-\frac{5}{7})^8 \cdot (-\frac{5}{7})^9\)

36. **B.E.S.T. Test Prep** Which expression is equivalent to 0.47³?  

(A) 0.47³ · 0.47³  

(B) ((0.47)³)⁶  

(C) \(\frac{0.47^0}{0.47^9}\)  

(D) \(\frac{0.47^{12}}{0.47^3}\)

37. **MODELING REAL LIFE** The Haitian Compas Festival in Miami, Florida, is one of the largest outdoor festivals in the United States. The projected number of people for next year attending the first day of the festival is about \(6 \cdot \left(\frac{8}{5}\right)^{15}\) people. The projected total number of people who will attend the whole festival is \(\left(\frac{8}{5}\right)^2\) times the number of people who attended the first day. Predict the total number of people who will attend the festival. (See Example 4.)

38. **GEOMETRY** The area of a rectangle is \(\left(\frac{5}{8}\right)^{12}\) square feet. Find the width of the rectangle.

39. **NUMBER SENSE** Find the value of \(x\) in the equation without evaluating the power.

   a. \(\left(\frac{1}{2}\right)^{15} \cdot \left(\frac{1}{2}\right)^x = \frac{1}{256}\)

   b. \(\left(\frac{1}{3}\right)^2 \cdot \left(\frac{1}{3}\right)^x = \frac{1}{729}\)

40. **ASSESS REASONABleness** The approximate frequency (in vibrations per second) of a note on a piano is represented by the equation \(F = 440(1.059)^n\), where \(n\) is the number of notes above A440. Each black or white key represents one note.

   a. Compare the frequency of A to the frequency of A440.

   b. Estimate the frequency of D#. Is your answer reasonable? Explain.
1. **ANALYZE A PROBLEM** The runway shown has an area of $2.14^{16}$ square yards. Find the perimeter (in feet) of the runway.

Using the Problem-Solving Plan

You know the area of the rectangular runway in square yards and the width of the runway in yards. You want to know the perimeter of the runway in feet.

Use the formula for the area of a rectangle to write an equation in one variable, then solve for the length of the runway (in yards) and find the perimeter of the runway. Finally, use a measurement conversion to write the perimeter in terms of feet.

Use the plan to solve the problem. Then check your solution.

2. Two memory cards are shown. How many times more bytes can card A hold than card B? At what percentage of maximum capacity is each card?
1

Chapter Review WITH CalcChat®

Review Vocabulary

Write the definition and give an example of each vocabulary term.

- **power**, p. 4
- **exponent**, p. 4
- **base**, p. 4
- **rational number**, p. 21
- **integers**, p. 21
- **absolute value**, p. 22

Graphic Organizers

You can use a Definition and Example Chart to organize information about a concept. Here is an example of a Definition and Example Chart for the vocabulary term **power**.

```
Power: product of repeated factors

Example
5 \cdot 5 \cdot 5 = 5^3

Example
\frac{1}{4} \cdot \frac{1}{4} = \left(\frac{1}{4}\right)^2

Example
(-2)^5
```

Choose and complete a graphic organizer to help you study the concept.

1. Product of Powers Property
2. Power of a Power Property
3. Power of a Product Property
4. Quotient of Powers Property
5. **rational number**
6. **absolute value**
Chapter Learning Target: Understand exponents and rational numbers.
Chapter Success Criteria:
- I can evaluate a power.
- I can evaluate expressions involving whole number bases.
- I can evaluate expressions involving rational number bases.
- I can solve real-life problems involving powers.

Rate your understanding after each section.

1. I don’t understand yet.
2. I can do it with help.
3. I can do it on my own.
4. I can teach someone else.

1.1 Exponents (pp. 3–8)
Learning Target: Use exponents to write and evaluate expressions.

Write the product using exponents.
1. \(9 \cdot 9 \cdot 9 \cdot 9 \cdot 9\)
2. \(2 \cdot 2 \cdot 2 \cdot 4 \cdot 4\)

Evaluate the expression.
3. \(11^3\)
4. \(-7^5\)
5. \(-12^4\)

6. The profit \(P\) (in dollars) earned by a local merchant selling \(x\) items is represented by the equation \(P = 0.2x^3 - 10\). How much more profit does he earn selling 15 items than 5 items?

1.2 Product of Powers Property (pp. 9–14)
Learning Target: Generate equivalent expressions involving products of powers.

Simplify the expression. Write your answer as a power.
7. \(3^5 \cdot 3^2\)
8. \((8^{11})^2\)
9. \((4 \cdot 6)^4\)

10. Simplify \(- (2 \cdot 5)^4\).

11. Write an expression that simplifies to \(11^{24}\) using the Power of a Power Property.

12. You send an email with a file size of 4 kilobytes. One kilobyte is \(2^{10}\) bytes. What is the file size of your email in bytes?

13. Explain how to use properties of exponents to simplify the expression \(27 \cdot 3^2\).
1.3 Quotient of Powers Property (pp. 15–20)

Learning Target: Generate equivalent expressions involving quotients of powers.

Simplify the expression. Write your answer as a power.

14. \( \frac{8^6}{8^3} \)
15. \( \frac{5^2 \cdot 5^9}{5} \)
16. \( \frac{7^6 \cdot 7^5}{7^6} \)
17. \( \frac{3^9 \cdot 3^{10} \cdot 3^0}{3^2} \)

18. Write an expression that simplifies to \( 9^3 \) using the Quotient of Powers Property.

19. At the end of a fiscal year, a company has made \( 5 \cdot 7^7 \) dollars in profit. The company employs \( 7^3 \) people. How much will each person receive if the company divides the profit equally among its employees?

20. A professional video game tournament has a \( 4^{13} \) dollar cash prize. Any player who beats the game is a winner, and the prize is split evenly among the winners.
   
   a. How many people win when each winner receives \( 4^9 \) dollars?
   
   b. How much money will each winner receive when \( 4^3 \) people win?

1.4 Rational Numbers (pp. 21–28)

Learning Target: Understand how to compare rational numbers.

Find the absolute value.

21. \( |3| \)
22. \( |-9| \)
23. \( |\frac{3}{4}| \)
24. \( |-5.2| \)
25. \( |\frac{-6}{7}| \)
26. \( |4.15| \)

Copy and complete the statement using <, >, or =.

27. \( |-2| \quad -2 \)
28. \( \frac{1}{3} \quad \frac{5}{6} \)
29. \( -1.7 \quad -1.7 \)
30. Order \( 2.25 \), \( -1.5 \), \( \frac{1}{4} \), \( -2 \), and \( -2 \) from least to greatest.
31. Your friend is in Death Valley, California, at an elevation of −282 feet. You are near the Mississippi River in Illinois at an elevation of 279 feet. Who is closer to sea level?

32. Give values for a and b so that \(a < b\) and \(|a| > |b|\).

33. The map shows the longitudes (in degrees) for Salvador, Brazil, and Nairobi, Kenya. Which city is closer to the prime meridian?

![Map showing latitudes and longitudes of different cities.](Image)

34. \((0.7)^4\)

35. \(-\left(\frac{1}{2}\right)^0\)

36. \(\left(\frac{3}{5}\right)^2\)

37. \(\frac{1}{8} \cdot \frac{1}{8} \cdot \frac{1}{8} \cdot \frac{1}{8}\)

38. \((-\frac{3}{7}) \cdot (-\frac{3}{7}) \cdot (-\frac{3}{7})\)

39. \((-\frac{2}{5})^3 \cdot (-\frac{2}{5})^2\)

40. A blue crab is 1.67 feet away from a trap on the ocean floor. The crab pauses every 1.65 feet while walking to check for predators. Write an expression using exponents that represents how many times the crab pauses before reaching the trap.

41. \(\frac{3.6^7}{3.6^4}\)

42. \(\left(\frac{2}{9}\right)^3 \cdot \left(\frac{2}{9}\right)^5\)

43. \(\frac{1.2^5}{1.2^0}\)
Chapter 1  Exponents and Rational Numbers

Practice Test with CalcChat®

Write the product using exponents.
1. \((-15) \cdot (-15) \cdot (-15)\)
2. \(\frac{1}{6} \cdot \frac{1}{6} \cdot \frac{1}{6} \cdot \frac{1}{6} \cdot \frac{1}{6}\)

Evaluate the expression.
3. \(10 + 3^2 \div 9\)
4. \(3^3 - 3^4 \div 3^3\)

Simplify the expression. Write your answer as a power.
5. \(9^{10} \cdot 9\)
6. \((6^5)^5\)
7. \(\frac{(-3.5)^{13} \cdot (-3.5)^2}{(-3.5)^9}\)
8. Is \((5^2)^3\) the same as \((5^3)^2\)? Explain.
9. One scoop of rice weighs about 3^9 milligrams.
   a. Write an expression to find the weight of \(s\) scoops of rice. Use your expression to find the weight of 5 scoops of rice.
   b. A grain of rice weighs about 3^3 milligrams. About how many grains of rice are in 1 scoop?

Find the absolute value.
10. \(\left| \frac{-4}{5} \right|\)
11. \(|6.43|\)
12. \(|-22|\)

Copy and complete the statement using \(<, >, or =\).
13. \(4 \quad \_ \quad -8\)
14. \(\_ \quad -7 \quad \_ \quad -12\)
15. \(\_ \quad -7 \quad \_ \quad 3\)

16. The average temperature in Rapid City, South Dakota, is 45.2°F. In 2019, the lowest temperature in Rapid City was \(-19^\circ F\) and the highest temperature was \(92^\circ F\). Which of the extreme temperatures is closer to the average? Explain.

17. A snail begins to cross a road that is 1.3 feet wide. The snail is moving at a pace of 1.33 feet per minute. How many minutes does it take the snail to cross the road? Write your answer using exponents.

18. A cube has the dimensions shown.
   a. Write a power that represents the surface area of the cube.
   b. Write a power that represents the volume of the cube.
Use the Distributive Property to evaluate the expression. Explain each step.

1. \(9 \cdot (5 - 3)\)   
2. \((7 + 11) \cdot 3\)   
3. \(-6 \cdot (-4 + 1)\)

Write the product using exponents.

4. \(3 \cdot 3 \cdot 3 \cdot 3 \cdot 3\)   
5. \((-8) \cdot (-8) \cdot (-8)\)

Write a positive or negative integer that represents the situation.

6. A bird flies from the top of a 25-foot-tall tree to the ground.
7. You walk up 18 stairs.
8. A charity receives a $340 donation.
9. A teacher uses a spinner to call on students in class. How many times more likely is it that the student called on has a name beginning with \(M\) than \(L\)? Explain.
10. You and a friend are biking down your street. You are traveling 8 miles per hour, and your friend is traveling 716 feet per minute. Who is traveling faster? Explain.

Simplify the expression. Write your answer as a power.

11. \(4^7 \cdot 4^6\)   
12. \((-2)^8 \cdot (-2)^3\)   
13. \(\frac{7^6 \cdot 7^7}{7^4}\)
14. You are flipping a fair coin. When the coin lands on heads, you add 7 points to your score. Your score at the end of the game is 91 points.
   a. Write an equation in one variable that represents the number of times the coin lands on heads.
   b. Use your equation to find the number of times the coin lands on heads.

Write the ratio of the objects.

15. worms to fish   
16. bottles to cans

Review & Refresh while Building Fluency
1. Which of the following expressions are equivalent to 36?

A. $1 + 3 \cdot 9$
B. $44 - 4 \cdot 2$
C. $9 \cdot 2^3 / 2$
D. $72 \div 9 - 7$
E. $-8 + 11 \cdot 12$
F. $4^2 \cdot 3 + (-16)$

2. What is the value of $8^3 \div 8^0$?

3. Which expression is equivalent to the expression $2^4 \cdot 2^3$?

A. $2^{12}$
B. $4^7$
C. 48
D. 128

4. When evaluating $40 - 4 \cdot 3^2$ the first step is to

A. subtract 40 and 4
B. multiply 4 and 3
C. evaluate $3^2$
D. multiply 3 and 2

and the value of the expression is

A. $-104$
B. 4
C. 16
D. 360

5. What is the distance between the two numbers on the number line?

A. $-2\frac{1}{8}$
B. $-1\frac{3}{8}$
C. $1\frac{3}{8}$
D. $2\frac{1}{8}$
6. Which expression is not equivalent to 16?
   A) \(2^4 \cdot 2^0\)  
   B) \(4^6 \div 4^4\)  
   C) \(\frac{2^5}{2}\)  
   D) \(16^8 \cdot 16^7\)

7. Which expressions simplify to 6^5?
   A) \(6^7 \cdot 6^2\)  
   B) \(\frac{6^8}{6^3}\)  
   C) \(6^3 \cdot 6^2\)  
   D) \(6^9 \cdot 6^4\)  
   E) \(\frac{6^6}{6^0}\)  
   F) \(\frac{6^4 \cdot 6^6}{6^5}\)

8. A privacy wall is constructed using the brick shown. How many bricks does it take to complete one row of the wall when the wall is 57.6 feet long?
   A) 48 bricks  
   B) 72 bricks  
   C) 144 bricks  
   D) 150 bricks

9. What is the missing exponent?
   \[ \frac{1}{8} = \frac{1}{8} \cdot \frac{1}{8} \cdot \frac{1}{8} \]

10. The table shows the height (in inches) of 12 students in a class.

<table>
<thead>
<tr>
<th>Students’ Heights (inches)</th>
<th>61</th>
<th>74</th>
<th>66</th>
<th>59</th>
<th>63</th>
<th>72</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>60</td>
<td>68</td>
<td>70</td>
<td>62</td>
<td>61</td>
<td></td>
</tr>
</tbody>
</table>

What is the mean height of the class?
   A) 61 in.  
   B) 63.5 in.  
   C) 65 in.  
   D) 74 in.