### 11.1 Squares and Square Roots
- Use numbers and pictures to understand the inverse relationship between squaring a number and finding the square root of a number.
- Approximate a square root by locating it between two consecutive integers.
- Use fractions and decimals to approximate square roots.
- Locate square roots on a number line.

### 11.2 Conjectures About Exponents
- Use patterns to make conjectures about multiplication and division rules for exponentials.
- Understand the meaning of zero and negative exponents.
- Use exponent definitions and rules to rewrite and simplify expressions.

### 11.3 Large and Small Numbers
- Read and write large and small numbers.
- Use different notations, including scientific notation, to write numbers and solve problems.

### 11.4 Skill Builder, Vocabulary, and Review

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*MathLinks*: Grade 8 (Student Packet 11)
## WORD BANK

<table>
<thead>
<tr>
<th>Word or Phrase</th>
<th>Definition or Explanation</th>
<th>Picture or Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>conjecture</td>
<td></td>
<td></td>
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<tr>
<td>exponential notation</td>
<td></td>
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<td>factor</td>
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<td>radicand</td>
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<td>scientific notation</td>
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<td>square of a number</td>
<td></td>
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<tr>
<td>square root of a number</td>
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</tr>
</tbody>
</table>
SQUARES AND SQUARE ROOTS

Summary (Ready)
We will find squares and square roots of numbers. We will approximate and compare square roots of numbers that are not perfect squares.

Goals (Set)
- Use numbers and pictures to understand the inverse relationship between squaring a number and finding the square root of a number.
- Approximate a square root by locating it between two consecutive integers.
- Use fractions and decimals to approximate square roots.
- Locate square roots on a number line.

Warmup (Go)

1. Draw several squares of different sizes on the grid paper below. Record the side length (s, in linear units) and area (A, in square units) for each square. One example is given.

   \[
   \begin{array}{c}
   \text{s = 5 units} \\
   \text{A = 25 units}^2
   \end{array}
   \]

2. Why do you think we use the word “squared” to refer to a number to the second power?
PERFECT SQUARES

1. Complete the table.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$1^2$</td>
<td>$2^2$</td>
<td>$3^2$</td>
<td>$4^2$</td>
<td>$5^2$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$6^2$</td>
<td>$7^2$</td>
<td>$8^2$</td>
<td>$9^2$</td>
<td>$10^2$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$11^2$</td>
<td>$12^2$</td>
<td>$13^2$</td>
<td>$14^2$</td>
<td>$15^2$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$16^2$</td>
<td>$17^2$</td>
<td>$18^2$</td>
<td>$19^2$</td>
<td>$20^2$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$21^2$</td>
<td>$22^2$</td>
<td>$23^2$</td>
<td>$24^2$</td>
<td>$25^2$</td>
</tr>
</tbody>
</table>

2. Based on the given example on the previous page, we write: $5^2 = _____$ (read “5 to the second power is _____” or “5 squared is _____”) and $\sqrt{25} = _____$ (read “the square root of 25 is _____”). This example illustrates the inverse relationship between squares and square roots.

Use the table above as needed, and the inverse relationship between squares and square roots, to simplify each expression.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sqrt{1}$</td>
<td>$\sqrt{36}$</td>
<td>$\sqrt{81}$</td>
<td>$\sqrt{121}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sqrt{225}$</td>
<td>$\sqrt{324}$</td>
<td>$\sqrt{400}$</td>
<td>$\sqrt{625}$</td>
<td></td>
</tr>
</tbody>
</table>

11. Alice was working with her group and said to them, “There is no square root of 13.” Explain what you think she meant by this.
ESTIMATING SQUARE ROOTS

1. Locate the following numbers on the number line below:

   \[0 \quad 1 \quad 4 \quad 9 \quad 16 \quad 25 \quad 36 \quad 49 \quad 64 \quad 81 \quad 100\]

   \[\sqrt{1} \quad \sqrt{4} \quad \sqrt{9} \quad \sqrt{16} \quad \sqrt{25} \quad \sqrt{36} \quad \sqrt{49} \quad \sqrt{64} \quad \sqrt{81} \quad \sqrt{100}\]

   \[0 \quad 1 \quad 2 \quad 8\]

2. Use the values on the number line above to estimate the location of \(\sqrt{27}\).

   Square root form: \(\sqrt{25} < \sqrt{27} < \sqrt{36}\), so \(\sqrt{27}\) is closer to ______.

   Whole numbers: \(5 < \sqrt{27} < _____\), so \(\sqrt{27}\) is closer to ______.

   Estimate the fractional part of \(\sqrt{27}\) as a fraction. \(\frac{27 - 25}{36 - 25} = \frac{2}{11} = \frac{2}{11}\)

   Therefore, \(\sqrt{27}\) is about \(5\frac{2}{11}\). (Calculator check: _____)

A linear estimation of the fractional part of \(\sqrt{27}\)
ESTIMATING SQUARE ROOTS (Continued)

3. Determine an estimate of $\sqrt{40}$ and then locate it on the number line below.

Square root form: ______ $<$ $\sqrt{40}$ $<$ ______, so $\sqrt{40}$ is closer to ______.

Whole numbers: ______ $<$ $\sqrt{40}$ $<$ ______, so $\sqrt{40}$ is closer to ______.

Estimate the fractional part of $\sqrt{40}$ as a fraction. $\frac{40-36}{\text{_____}} = \frac{\text{_____}}{\text{_____}}$

Therefore, $\sqrt{40}$ is about ______. (Calculator check: ______)

![Number line diagram]

4. Determine an estimate of $\sqrt{77}$ and then locate it on the number line below.

Square root form: ______ $<$ $\sqrt{77}$ $<$ ______, so $\sqrt{77}$ is closer to ______.

Whole numbers: ______ $<$ $\sqrt{77}$ $<$ ______, so $\sqrt{77}$ is closer to ______.

Estimate the fractional part of $\sqrt{77}$ as a fraction. $\frac{\text{_____}}{\text{_____}} = \frac{\text{_____}}{\text{_____}}$

Therefore, $\sqrt{77}$ is about ______. (Calculator check: ______)

![Number line diagram]
MORE SQUARE ROOT ESTIMATES

- Use fractions and decimals to approximate each square root.
- Use your table of squares from earlier in the lesson to help if needed.

<table>
<thead>
<tr>
<th></th>
<th>A Number in square root form</th>
<th>B Between roots of perfect squares:</th>
<th>C Between 2 consecutive integers:</th>
<th>D About (fraction):</th>
<th>E About (decimal):</th>
<th>F Calculator check (to nearest tenth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>(\sqrt{5})</td>
<td>(\sqrt{4}) and ____</td>
<td>2 and ____</td>
<td>2</td>
<td></td>
<td>2. ____</td>
</tr>
<tr>
<td>2.</td>
<td>(\sqrt{20})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>(\sqrt{78})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>(\sqrt{220})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>(\sqrt{303})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For their house, Greg and Lauren bought a square rug with an area of 20 square feet.

6. If the dimensions of their front entry are 5 feet by 5 feet, will the rug fit? Explain.

7. Greg decides he would rather put the rug in front of the kitchen sink, which is a space 4 feet wide. Will the rug fit in that space? Explain.

8. Lauren thinks the rug will look great in the hallway, which is 4 \(\frac{1}{2}\) feet wide. Will the rug fit? Explain.

9. Greg measured the hallway again, and discovered it is actually 4 feet 4 inches wide. Will the rug fit? Explain.
Exponents and Roots

11.2 Conjectures About Exponents

CONJECTURES ABOUT EXPONENTS

Summary (Ready)
We will use patterns to make conjectures about rules for multiplying expressions involving exponents.

Goals (Set)
- Use patterns to make conjectures about multiplication and division rules for exponentials.
- Understand the meaning of zero and negative exponents.
- Use exponent definitions and rules to rewrite and simplify expressions.

Warmup (Go)

Exponential Notation

\( b^n \) (read as “ \( b \) to the power \( n \)”) is used to express the product of \( n \) factors of \( b \). That is,

\[
b^n = (b)(b)(b)\ldots(b).
\]

(\( n \) factors)

The number \( b \) is the base, and the number \( n \) is the exponent. We will refer to an expression in the form \( b^n \) as in “exponent form.”

1. The expression \( 3^4 \) is in exponent form. The base is ____ and the exponent is ____.
2. The expression \( x^5 \) is in exponent form. The base is ____ and the exponent is ____.
3. Five to the second power is written as ____ , which is equal to ____ • ____ = ____
4. \( x \) to the third power is written as ____ , which is equal to ____ • ____ • ____ = ____

Write an expression in exponent form to represent each of the following.

5. The area of a square with side length equal to \( x \).

6. The volume of a cube with edge length equal to \( x \).
EXPONENT PRODUCT PATTERNS

Write each exponential expression as a product of factors. Then write it in exponent form \((b^n)\).

1. \(2^3 \cdot 2^5 = (____ \cdot ____ \cdot ____)(____ \cdot ____ \cdot ____ \cdot ____ \cdot ____)(____) \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____)(____) = ____

2. \(x^3 \cdot x^5 = (____ \cdot ____ \cdot ____)(____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____ \cdot ____)(____) = ____

3. \(3^2 \cdot 3^6 = \) ________________

4. \(x^2 \cdot x^6 = \) ________________

5. For problems 1-4, what do you notice about the bases in the original expressions compared to the bases in the result?

6. For problems 1-4, what do you notice about the exponents in the original expressions compared to the exponents in the result?

7. \((8^2)^3 = (____)(____)(____) = (____)(____)(____)(____) = ____

8. \((x^2)^3 = (____)(____)(____) = (____)(____)(____)(____) = ____

9. \((3^4)^2 = \) ________________

10. \((x^4)^2 = \) ________________

11. For problems 7-10, what do you notice about the exponents in the original expressions compared to the exponents in the result?
THE PRODUCT RULE FOR EXPONENTS

Complete problems 1-4 and write observations in the space provided about exponent relationships. Then use these observations to make a conjecture in words and symbols.

1. \((3^2)(3^4) = (\_\_\_\_\_\_) (\_\_\_\_\_\_\_\_) = 3^6\)
   Are the bases the same? \_
   How do the exponents in the original expression relate to the exponent in the product? In other words, how do 2 and 4 relate to 6?

2. \((2^3)(2^4) = (\_\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_\_) = 2\)

3. \((4^3)(4^5) = (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_\_) = 4\)
   (Remember that: \(4^2 = 4\))

4. \((x^2)(x^5) = (\_\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_\_) = x\)

5. Write a conjecture in words related to the multiplication in problems 1-4 above:

6. Write a conjecture in symbols: \((x^a)(x^b) = x\)

   We will call this conjecture the Product Rule for Exponentials.
THE POWER RULE FOR EXPONENTIALS

Complete problems 1-3 and write observations in the space provided about exponent relationships. Then use these observations to make a conjecture in words and symbols.

1. \( (3^2)^4 = (3^2) \cdot (\_\_\_\_\_\_) \cdot (\_\_\_\_\_) \cdot (\_\_\_\_\_) \)
   \[ = (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) = 3^8 \]

   How is this expression different from the expression in problem 1 on the previous page?

   How do the exponents in the original expression relate to the exponent in the product? In other words, how do 2 and 4 relate to 8?

2. \( (2^3)^4 = (\_\_\_\_\_) \cdot (\_\_\_\_\_) \cdot (\_\_\_\_\_) \cdot (\_\_\_\_\_) \)
   \[ = (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) = 2^4 \]

3. \( (x^2)^5 = (\_\_\_\_\_) \cdot (\_\_\_\_\_) \cdot (\_\_\_\_\_) \cdot (\_\_\_\_\_) \cdot (\_\_\_\_\_) \)
   \[ = (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) (\_\_\_\_\_\_\_) = x^5 \]

   4. Write a conjecture in words related to the multiplication in problems 1-3 above:

   5. Write a conjecture in symbols: \( (x^a)^b = x^{ab} \)

   We will call this conjecture the **Power Rule for Exponentials**.
**EXPONENT PRACTICE 1**

Write each expression in exponent form \((b^n)\). Circle the rule used (Exponent Product Rule or Exponent Power Rule.)

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>(5^6 \cdot 5^3 = 5^{[ ]} = 5^{[ ]})</td>
<td>2.</td>
<td>((5^6)^3 = 5^{[ ]} = 5^{[ ]})</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Product Rule</td>
<td>Power Rule</td>
<td>Product Rule</td>
<td>Power Rule</td>
</tr>
<tr>
<td>3.</td>
<td>((7^2)(7^4))</td>
<td>4.</td>
<td>((7^2)^4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Product Rule</td>
<td>Power Rule</td>
<td>Product Rule</td>
<td>Power Rule</td>
</tr>
<tr>
<td>5.</td>
<td>(19^8 \cdot 19^6)</td>
<td>6.</td>
<td>((19^8)^6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Product Rule</td>
<td>Power Rule</td>
<td>Product Rule</td>
<td>Power Rule</td>
</tr>
<tr>
<td>7.</td>
<td>(10 \cdot 10^4)</td>
<td>8.</td>
<td>((10^1)^4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Product Rule</td>
<td>Power Rule</td>
<td>Product Rule</td>
<td>Power Rule</td>
</tr>
<tr>
<td>9.</td>
<td>(10^4 \cdot 10)</td>
<td>10.</td>
<td>((10^4)^1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Product Rule</td>
<td>Power Rule</td>
<td>Product Rule</td>
<td>Power Rule</td>
</tr>
<tr>
<td>11.</td>
<td>(y^{10} \cdot y^{10})</td>
<td>12.</td>
<td>((y^{10})^{10})</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Product Rule</td>
<td>Power Rule</td>
<td>Product Rule</td>
<td>Power Rule</td>
</tr>
<tr>
<td>13.</td>
<td>((x^5)(x^6))</td>
<td>14.</td>
<td>((x^5)^6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Product Rule</td>
<td>Power Rule</td>
<td>Product Rule</td>
<td>Power Rule</td>
</tr>
<tr>
<td>15.</td>
<td>(x \cdot x^8)</td>
<td>16.</td>
<td>((x^1)^8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Product Rule</td>
<td>Power Rule</td>
<td>Product Rule</td>
<td>Power Rule</td>
</tr>
</tbody>
</table>
# Exponent Practice 1 (Continued)

Compute. Results should contain no exponents.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>17.</td>
<td>( \left( \frac{1}{4} \right)^2 )</td>
<td>18.</td>
</tr>
<tr>
<td>19.</td>
<td>( \left( \frac{1}{4} \right)^2 \cdot \left( \frac{1}{4} \right)^3 )</td>
<td>20.</td>
</tr>
<tr>
<td>21.</td>
<td>( 3^2 + 2^3 )</td>
<td>22.</td>
</tr>
<tr>
<td>23.</td>
<td>( 2^3 + 2^5 )</td>
<td>24.</td>
</tr>
</tbody>
</table>

25. Why does the product rule NOT apply to problem 22?

26. Why does the power rule NOT apply to problem 24?

27. Write three different expressions equivalent to \( 2^8 \) that include exponents. (Computing \( 2^8 \) is not necessary.)

28. If \( \left( \frac{1}{4} \right)^3 = \left( \frac{1}{2} \right)^n \), what is the value of \( n \)?

For each equation below, find all integer values for \( x \) that make the equations true.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>29.</td>
<td>( x^2 = 16 )</td>
</tr>
<tr>
<td>31.</td>
<td>( x^3 = 8 )</td>
</tr>
</tbody>
</table>
### PAPER FOLDING EXPERIMENT

1. Record the results from folding a piece of paper.

<table>
<thead>
<tr>
<th>Number of Folds</th>
<th>Number of Sections</th>
<th>Number of Sections as $2$ to a Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>$2^1$</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. The paper folding experiment suggests that $2^0 = ____$

3. Rule: $x^0 = ____$, $x \neq 0$,
EXPONENTIAL QUOTIENT PATTERNS

Complete the table. Following patterns down each column may be helpful.

<table>
<thead>
<tr>
<th></th>
<th>I. Expression</th>
<th>II. Expanded Form</th>
<th>III. Power of 10 (fractions okay)</th>
<th>IV. Power of 10 (no fractions)</th>
<th>V. Value (fractions okay)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( \frac{10^3}{10^0} )</td>
<td></td>
<td>( 10^3 )</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>( \frac{10^3}{10^1} )</td>
<td>( 10 \cdot 10 \cdot 10 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>( \frac{10^3}{10^2} )</td>
<td></td>
<td>( 10^1 )</td>
<td>( 10^1 )</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>( \frac{10^3}{10^5} )</td>
<td>( 10 \cdot 10 \cdot 10 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>( \frac{10^3}{10^4} )</td>
<td>( \frac{1}{10^1} )</td>
<td></td>
<td>( \frac{1}{10} )</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>( \frac{10^3}{10^5} )</td>
<td></td>
<td>( 10^{-2} )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. The expressions in column I are quotients with the same bases. The expressions in column IV are in exponent form. What about the exponents in column I determine when the exponents in column IV will be…

   a. Positive?

   b. Negative?

   c. Zero?

8. How is \( 10^{-2} \) related to \( 10^2 \)?

9. Do any of the expressions above with negative exponents result in a negative value?
EXPONENT QUOTIENT PATTERNS (Continued)

Complete the table. Following patterns down each column may be helpful.

<table>
<thead>
<tr>
<th>I. Expression</th>
<th>II. Expanded Form</th>
<th>III. Power of 10 (fractions okay)</th>
<th>IV. Power of 10 (no fractions)</th>
<th>V. Value (fractions okay)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\frac{3^1}{3^0})</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(\frac{3^1}{3^2})</td>
<td></td>
<td></td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>(\frac{3^1}{3^3})</td>
<td></td>
<td>1</td>
<td>(\frac{1}{3})</td>
<td></td>
</tr>
<tr>
<td>(\frac{3 \cdot 3 \cdot 3 \cdot 3}{3 \cdot 3 \cdot 3 \cdot 3})</td>
<td>3</td>
<td>1</td>
<td>(\frac{1}{27})</td>
<td></td>
</tr>
</tbody>
</table>

16. Patti thinks that a base number to a negative power must result in a negative value. Is Patti correct? Explain.

17. How is \(3^{-1}\) related to \(3^1\)?

18. Make conjectures: If \(x \neq 0\) and \(a > 0\), then

\[x^0 = ___________ \quad x^{-1} = ___________ \quad x^{-a} = ___________\]
THE QUOTIENT RULE FOR EXPONENTS

Complete problems 1-4 and write observations in the space provided about exponent relationships. Then use these observations to make a conjecture in words and symbols.

1. \[
\frac{4^5}{4^3} = \frac{\bullet \bullet \bullet \bullet \bullet}{\bullet \bullet \bullet} = 4^2
\]
   Are the bases the same? _____
   How do the exponents in the original expression relate to the exponent in the quotient? In other words, how do 5 and 3 relate to 2?

2. \[
\frac{4^3}{4^5} = \frac{\bullet \bullet \bullet}{\bullet \bullet \bullet \bullet \bullet} = \frac{1}{4} = 4
\]

3. \[
\frac{x^5}{x^2} = \frac{\bullet \bullet \bullet \bullet \bullet}{\bullet \bullet} = x
\]

4. \[
\frac{x^2}{x^5} = \frac{\bullet \bullet \bullet \bullet}{\bullet \bullet \bullet \bullet \bullet} = \frac{1}{x} = x
\]

5. Write a conjecture in words related to the division in problems 1-4 above:

   If \( x \neq 0 \), then \[
   \frac{x^a}{x^b} = x
   \]

We will call this conjecture the **Exponent Quotient Rule**.
EXPONENT PRACTICE 2

1. A number to a negative power is the same as the ________________ of the number to a positive power. In other words:

\[ b^{-n} = \frac{1}{b^n} = \left( \frac{1}{b} \right)^n \]

2. Using the quotient rule, write \( \frac{5^4}{5^8} \) as 5 to a single power. _________

Now write this expression with a positive exponent. _________

Compute.

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

4. \( 3^4 \cdot \frac{1}{3^4} \)

5. \( 3^4 \cdot 3^{-4} \)

Compute. Fractions are okay.

6. \( \frac{(5^2)^2}{5^3} \)

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

8. \( \frac{5^3 \cdot 5^2}{5^4 \cdot 5^2} \)

9. \( \frac{(5^2)^3}{5^6} \)

10. \( 2^{-3} \cdot 2^5 \)

11. \( 2^3 \cdot 2^{-5} \)

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

13. \( \frac{2^3 \cdot 2^{-3}}{2^{-2}} \)
EXPONENTIAL PRACTICE 2 (Continued)

Compute.

14. \((-2)^2\)  
15. \((-2)^3\)  
16. \((-2)^4\)  
17. \((-2)^5\)

18. \((-2)^{-2}\)  
19. \((-2)^{-3}\)  
20. \((-2)^{-4}\)  
21. \((-2)^{-5}\)

22. Karin thinks that a negative number to a negative power must be negative. Is she correct? Explain.

Write each expression in exponent form \((b^n\text{ where } b > 1)\). The exponent need not be positive.

23. \(\frac{6^5}{6}\)  
24. \(\frac{(5^2)^3}{5^6}\)  
25. \(\frac{2 \cdot 3^{15}}{6 \cdot 3^{17}}\)  
26. \(\frac{1}{2}^{-3}\) (hint: negative exponent → reciprocal)

Write each expression in exponent form. The base \(b\) is given.

27. \(\frac{9^6}{9^4}\)  
28. \(\frac{9^4}{9^6}\)  
29. \(\frac{9^6}{9^4} = 3\)  
30. \(\frac{9^4}{9^6} = 3\)

MathLinks: Grade 8 (Student Packet 11)
LARGE AND SMALL NUMBERS

Summary (Ready)
We will write large and small numbers using a variety of notations, including scientific notation. We will solve problems involving large numbers.

Goals (Set)
• Read and write large and small numbers.
• Use different notations, including scientific notation, to write numbers and solve problems.

Warmup (Go)

1. Fill in the place value chart below and locate the decimal point.

<table>
<thead>
<tr>
<th>trillions</th>
<th></th>
<th></th>
<th></th>
<th>hundred thousands</th>
<th></th>
<th></th>
<th></th>
<th>hundreds</th>
<th></th>
<th></th>
<th></th>
<th>ones</th>
<th></th>
<th></th>
<th></th>
<th>hundredths</th>
</tr>
</thead>
</table>

Write in words:

2. 1,020,300,004,500 __________________________________________

3. 0.078 ______________________________________________________

4. 0.0006 ____________________________________________________

Round to two significant digits.

5. 9,564 ____________________________ 6. 5.0309 ____________________________

Round to one significant digit.

7. 20,345,678 ______________________ 8. 0.000494 ________________________
**LARGE NUMBERS**

Scientific notation is a system that can be used for writing large numbers. In scientific notation, a number is written as a decimal that is greater than or equal to 1 and less than 10, multiplied by a power of 10.

<table>
<thead>
<tr>
<th>Ex.</th>
<th>Standard notation</th>
<th>Product of a number between 1 and 10, and a multiple of 10</th>
<th>Scientific notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>5,200</td>
<td>5.2 × 1,000</td>
<td>5.2 × 10^3</td>
</tr>
<tr>
<td>2.</td>
<td>479,000,000</td>
<td>4.79 × 100,000,000</td>
<td>4.79 × 10^7</td>
</tr>
<tr>
<td>3.</td>
<td>2,000</td>
<td>2 × 10</td>
<td>2 × 10^3</td>
</tr>
<tr>
<td>4.</td>
<td>68,000,000</td>
<td>× 10</td>
<td>× 10^7</td>
</tr>
<tr>
<td>5.</td>
<td>4.58 × 10,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>2.6 × 1,000,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>5.1 × 10^4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>3.07 × 10^5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. Explain why 41.2 × 10^5 is NOT in scientific notation. Then rewrite it in scientific notation.
### SMALL NUMBERS

Scientific Notation is also useful for writing very small numbers. In scientific notation, a number is written as a decimal greater than or equal to 1 and less than 10, multiplied by a power of 10.

<table>
<thead>
<tr>
<th></th>
<th>Standard notation</th>
<th>Product of a number between 1 and 10, and a multiple of 10</th>
<th>Scientific notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex.</td>
<td>0.007</td>
<td>$7 \times 0.001$</td>
<td>$7 \times \frac{1}{1000}$</td>
</tr>
<tr>
<td>1.</td>
<td>0.023</td>
<td>$2.3 \times 0.01$</td>
<td>$2.3 \times \boxed{}$</td>
</tr>
<tr>
<td>2.</td>
<td>0.000459</td>
<td>$4.59 \boxed{}$</td>
<td>$4.59 \boxed{}$</td>
</tr>
<tr>
<td>3.</td>
<td>0.0061</td>
<td></td>
<td>$\boxed{} \times 10$</td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td>$7.58 \times 0.001$</td>
<td>$6.2 \times \frac{1}{1000}$</td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td>$9.1 \times 10^{-4}$</td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
<td>$8.03 \times 10^{-5}$</td>
</tr>
</tbody>
</table>

8. Explain why $0.21 \times 10^{-5}$ is NOT in scientific notation. Then rewrite it in scientific notation.
### PRACTICE WITH SCIENTIFIC NOTATION

Determine whether each number is in scientific notation. If NOT, write it in scientific notation.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>89.2 \times 10^8</td>
</tr>
<tr>
<td>2.</td>
<td>145 \times 10^5</td>
</tr>
<tr>
<td>3.</td>
<td>0.23 \times 10^{-6}</td>
</tr>
<tr>
<td>4.</td>
<td>4.55 \times 10^{-10}</td>
</tr>
<tr>
<td>5.</td>
<td>0.043 \times 10^{-4}</td>
</tr>
<tr>
<td>6.</td>
<td>2.4 \times 10^6</td>
</tr>
</tbody>
</table>

7. Circle the greater number. The number you circled is how many times as large as the smaller number?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5 \times 10^3</td>
<td>7 \times 10^5</td>
</tr>
</tbody>
</table>

Use symbols <, =, or > to compare each pair of numbers.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>8.</td>
<td>1.65 \times 10^5</td>
</tr>
<tr>
<td>9.</td>
<td>3.2 \times 10^6</td>
</tr>
<tr>
<td>10.</td>
<td>8 \times 10^9</td>
</tr>
<tr>
<td>11.</td>
<td>5.2 \times 10^7</td>
</tr>
<tr>
<td>12.</td>
<td>6.41 \times 10^{-5}</td>
</tr>
<tr>
<td>13.</td>
<td>1.1119 \times 10^{-4}</td>
</tr>
</tbody>
</table>

14. Jorge multiplied 60 million by 4 billion on his calculator. The calculator display showed: 2.4 \times 10^{17} Explain to him what you think this means.
# WORLD POPULATION

1. Complete the table.

<table>
<thead>
<tr>
<th>Country</th>
<th>Population</th>
<th>US population is how many times larger? (estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>rounded to the nearest thousand</td>
<td>rounded to one significant digit</td>
</tr>
<tr>
<td>United States</td>
<td>315,250,000</td>
<td>300,000,000</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>63,182,000</td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>50,004,000</td>
<td></td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>29,559,000</td>
<td></td>
</tr>
<tr>
<td>Syria</td>
<td>21,949,000</td>
<td></td>
</tr>
<tr>
<td>Somalia</td>
<td>9,797,000</td>
<td></td>
</tr>
<tr>
<td>Paraguay</td>
<td>6,337,000</td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>4,588,000</td>
<td></td>
</tr>
<tr>
<td>Iceland</td>
<td>320,000</td>
<td></td>
</tr>
</tbody>
</table>

Source: Wikipedia, February, 2013. Figures are based on the most recent estimate or projections by the national census authority where available and rounded off.

2. The world population is the total number of living humans on Earth. A 2013 estimate by the United States Census Bureau (USCB) is 7.063 billion people. The two most populous countries in the world are India and China. Round the population numbers appropriately to help you estimate what fraction of the total world population lives in these countries.

| India (1,210,193,000) | China (1,354,040,000) |
### SKILL BUILDERS, VOCABULARY, AND REVIEW

#### SKILL BUILDER 1

<table>
<thead>
<tr>
<th>ten thousands</th>
<th>thousands</th>
<th>hundreds</th>
<th>tens</th>
<th>ones</th>
<th>tenths</th>
<th>hundredths</th>
<th>thousandths</th>
<th>ten thousandths</th>
</tr>
</thead>
</table>

1. What does the 7 represent in 84.273? ________________
2. What does the 3 represent in 84.273? ________________
3. Write 30.194 in words. ________________
4. Circle the digit in the tenths place. 3 0 . 1 9 4
5. Circle the digit in the tens place. 3 0 . 1 9 4
6. Round 457.568 to the nearest tenth. ________________
7. Round 79.302 to the nearest hundredth. ________________

**Solve mentally.**

8. $24 - b = 8; \quad b = _____$
9. $-3(p + 7) = -36; \quad p = _____$

**Solve.**

10. $3(x + 6) - 12 = 3x - 6$
11. $\frac{1}{6} = 2x - \frac{1}{5}$

**Solve as indicated.**

12. Circumference of a circle: $C = \pi d$; solve for $d$
13. Volume of a rectangular prism: $V = \ell wh$; solve for $h$
SKILL BUILDER 2

Compute.

1. \(-7 - (-9)\)  
2. \(9 - (-7)\)  
3. \(-3(-7 - 2)\)  
4. \(5 - (-6 + 12)\)  
5. \(-\frac{8 - 16}{-2}\)  
6. \(-\frac{4(-1 + 9)}{-8}\)  
7. \(\frac{5 - 35}{-6 - 14}\)  
8. \(\frac{4}{-7 + 15} + \frac{-3 - 3}{22 + (-14)}\)

Solve.

9. \(-8x + (5x - 7) = -(4x - 2) - 9\)  
10. \(-\frac{1}{2}(x + 10) = \frac{3}{4}(x - 8)\)

Solve each system using the substitution method or the elimination method.

11. \[
\begin{align*}
y + 3x &= 1 \\
2x - 4 &= y
\end{align*}
\]

12. \[
\begin{align*}
\frac{1}{3}x - 2y &= -3 \\
y &= 3
\end{align*}
\]
**SKILL BUILDER 3**

- Match each equation (1-6) to one set of ordered pairs (a-f) and also to one graph (U-Z).
- **Circle** the equation(s) of the line(s) with the greatest slope.
- **Box** the equation(s) of the line(s) with the least slope.

<table>
<thead>
<tr>
<th>Equation</th>
<th>Ordered pairs</th>
<th>Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ( y = 2x )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. ( y = 2x + 3 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. ( y = 3x + 2 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. ( y = 3x - 2 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. ( y = -x + 3 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. ( y = -x )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>a. (0, 0) (1, -1) (-1, 1)</th>
<th>b. (0, 0) (1, 2) (-1, -2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>c. (0, 3) (1, 5) (-1, 1)</td>
<td>d. (0, 3) (1, 2) (-1, 4)</td>
<td></td>
</tr>
<tr>
<td>e. (0, 2) (1, 5) (-1, -1)</td>
<td>f. (0, -2) (1, 1) (-1, -5)</td>
<td></td>
</tr>
</tbody>
</table>

**MathLinks:** Grade 8 (Student Packet 11)
SKILL BUILDER 4

A hundred 8th grade boys were asked the following questions and frequency tables were constructed based on the data.

- Is your shoe size bigger than a size 10?
- Are you taller than 5 feet?

<table>
<thead>
<tr>
<th></th>
<th>shoe size &lt; 10</th>
<th>shoe size &gt; 10</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>shorter than 5 feet tall</td>
<td>93%</td>
<td>7%</td>
<td>100%</td>
</tr>
<tr>
<td>taller than 5 feet tall</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>shoe size &lt; 10</th>
<th>shoe size &gt; 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>shorter than 5 feet tall</td>
<td>81%</td>
<td>25%</td>
</tr>
<tr>
<td>taller than 5 feet tall</td>
<td>19%</td>
<td>75%</td>
</tr>
</tbody>
</table>

Use the data above. Draw lines to match the percent with the correct statement.

1. 93% A. of students who wear a shoe size less than 10 are shorter than 5 feet tall.
2. 75% B. of students who are shorter than 5 feet tall wear a shoe size less than 10.
3. 81% C. of students who are shorter than 5 feet tall wear a shoe size greater than 10.
4. 7% D. of students who have a shoe size greater than 10 are taller than 5 feet tall.

5. Describe the association between height and shoe size. _______________________

6. If numerical data was collected about the height and shoe size of these same 8th graders and graphed as a scatter plot, which scatter plot might best represent the data? Explain.
SKILL BUILDER 5

- Use fractions and decimals to approximate each square root.
- Use your table of squares from page 2 to help if needed.
- Then label the tick marks on the number line below and graph the approximate locations of the numbers in problems 1 and 2. The distance from one tick mark to the next need not be 1 unit of length.

<table>
<thead>
<tr>
<th>Number Between square roots of perfect squares:</th>
<th>Between 2 consecutive integers:</th>
<th>About (fraction):</th>
<th>About (decimal):</th>
<th>Calculator check (to nearest tenth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. $\sqrt{17}$ ___ and ___ ___ and ___</td>
<td>___ and ___</td>
<td>[Blank]</td>
<td>[Blank]</td>
<td>[Blank]</td>
</tr>
<tr>
<td>2. $\sqrt{38}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. You have a square plot of land that is 800 sq. feet that you want to use as a vegetable garden. Your neighbor offers you a tool shed that is 6 ft. x 30 ft.
   a. What amount of land (area) would this shed need?
   b. Will this shed fit on your land? Explain.
   c. How much land is left for the vegetable garden?

4. Find the volume of the right rectangular prism with the following dimensions. The length of the prism is 20 cm. The width is half the length. The height is 5 less than the width.

   \[ l = \____ w = \____ h = \____ \]

   Volume of the prism = \__________
**SKILL BUILDER 6**

Write each expression in exponent form \((b^n)\).

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>(7^8 \cdot 7^9)</td>
<td>2.</td>
</tr>
<tr>
<td>4.</td>
<td>((x^5)^5)</td>
<td>5.</td>
</tr>
<tr>
<td>7.</td>
<td>(\frac{(6^4)^3}{6^6 \cdot 6^5})</td>
<td>8.</td>
</tr>
</tbody>
</table>

10. Compute: \(2^3 + 2^4\).  
   Can this value be written as 2 raised to a whole number power? Use some examples to justify your answer.

Compute. Fractions are okay.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td>(4^2)</td>
<td>12.</td>
<td>((-4)^2)</td>
</tr>
</tbody>
</table>

15. Write \(x^4\) in three different but equivalent ways that include exponents.

16. Write two expressions equal to 32 that are in the form \(2^m \cdot 2^n\), where \(m\) and \(n\) are integers.
**SKILL BUILDER 7**

**ERROR ALERT!** Be careful with exponential expressions that include a minus sign.

The minus sign is part of the base

\((-4)^2 = (-4)(-4) = 16.\)

The minus sign is not part of the base

\(4^2 = (4)(4) = 16.\)

1. Here are four expressions that contain exponents: \(3^2; \ (-3)^2; \ -3^2; \ 0 - 3^2\)

Circle the expressions that are equal to 9. Show work to justify:

Box the expressions that are equal to -9. Show work to justify:

**Compute.**

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

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

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

5. \(6 - 5^2\)

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

7. \(-7^2\)

8. \(\left(\frac{1}{4}\right)^2\)

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

10. \(\left(\frac{1}{4}\right)^{-3}\)

11. Write numerical examples for the following statements. Show work to justify the answers.

a. A negative number to a negative power that has a positive value.

b. A negative number to a negative power that has a negative value.
SKILL BUILDER 8

Determine whether each number is in scientific notation. If NOT, write it in scientific notation.

1. $346 \times 10^5$

2. $0.22 \times 10^{-8}$

Use symbols $<$, $=$, or $>$ to compare each pair of numbers. Show work.

3. $1.5 \times 10^8 \quad 451 \times 10^5$

4. $0.123 \times 10^{-4} \quad 3.2 \times 10^{-6}$

5. Abel multiplied two large numbers on his calculator and got: $8.71 \ E12$
   Explain to him what his calculator is doing, and the number this represents.

6. Consider the numbers $50 \times 10^{-8}$ and $0.5 \times 10^{-4}$.
   a. Write both numbers as a single digit times a power of 10, and circle the greater number.
   
   b. How many times as large is the number you circled compared to the smaller one?

7. Dr. Jerry Buss purchased the Los Angeles Lakers basketball team in 1979 for approximately $67.5$ million. At his death in 2013, the team was reportedly worth about $1$ billion.
   a. Write each dollar amount as a number rounded to two significant digits.
   
   b. Write each value using scientific notation.
   
   c. The value of the Lakers at Dr. Buss’ death is about how many times as large as the value when he purchased the team?
FOCUS ON VOCABULARY

Use vocabulary in the word bank and throughout this packet to complete the crossword.

Across

2. \( \frac{3^5}{3^2} = 3^{5-2} \) is an example of the exponent ____ rule.
4. \( 5^34^2 \) is in ____ notation.
6. 9 is the square ____ of 81.
7. \( 5.2 \times 10^{-2} \) is in ____ notation.
10. 25 is the ____ of (-5)
12. 6, 7, and 8 are ____ numbers.

Down

1. \( (2^3)^4 = 2^{3\times4} \) is an example of the exponent ____ rule.
3. the name of this symbol: \( \sqrt{\phantom{0}} \)
5. \( 5^45^2 = 5^{4+2} \) is an example of the exponent ____ rule.
8. 5.5 is a(n) _______ for \( \sqrt{30} \)
9. 4 is a _____ of 40
11. The name of 30 in 8 down is ____.
SELECTED RESPONSE

Show your work on a separate sheet of paper and choose the best answer(s).

1. Choose all expressions equivalent to $2^{12}$.
   
   A. $(2^3)^4$  
   B. $2^6 \cdot 2^2$  
   C. $2^{-1} \cdot 2^{13}$  
   D. $2^4 \cdot 2^8$

2. Choose all expressions equivalent to $(x^5)^2$.
   
   A. $x^7$  
   B. $x^{10}$  
   C. $2x^5$  
   D. $\frac{x^{20}}{x^{10}}$

3. Choose all expressions equivalent to $10 \cdot 10^6$.
   
   A. $10^7$  
   B. $10^6$  
   C. $(10^2)^3$  
   D. $10^{-5}$

4. Choose all expressions equivalent to $\frac{y^7}{y^2}$.
   
   A. $y^5$  
   B. $y^{-5}$  
   C. $y^9$  
   D. $\frac{y^{-2}}{y^{-7}}$

5. Choose all symbols that make $\frac{(7^4)^2}{7^8} \quad \Box \quad 7^0$ a true statement.
   
   A. $<$  
   B. $>$  
   C. $=$  
   D. $\geq$

6. Express $5.50 \times 10^{-6}$ in standard notation.
   
   A. 550,000  
   B. 5,500,000  
   C. 0.00000055  
   D. 0.000055

7. Express 17,000,000 in scientific notation.
   
   A. $1.7 \times 10^7$  
   B. $1.7 \times 10^6$  
   C. $1.7 \times 10^5$  
   D. $17 \times 10^6$

8. Which of these numbers has a value between 11 and 12?
   
   A. $\sqrt{107}$  
   B. $\sqrt{120}$  
   C. $\sqrt{136}$  
   D. $\sqrt{145}$

9. The square root of 91 is between
   
   A. 8 and 9  
   B. 9 and 10  
   C. 10 and 11  
   D. 11 and 12
**KNOWLEDGE CHECK**

Show your work on a separate sheet of paper and write your answers on this page.

### 11.1 Squares and Square Roots

Estimate each square root between two integers.

1. \( \sqrt{59} \)
2. \( \sqrt{136} \)

Use fractions and decimals to express each square root approximation.

3. \( \sqrt{39} \)
4. \( \sqrt{105} \)

### 11.2 Conjectures About Exponents

Compare. Use >, <, or = to complete each statement.

5. \((7^2)(7^3) \quad (7^3)^2\)
6. \(\frac{9^8}{9^5} \quad (9^8)^5\)

Write in exponent form.

7. \(x^5 \cdot x^7\)
8. \((x^5)^7\)

9. \(\frac{(5^4)^3}{5^7}\)
10. \(\frac{(5^4)^2}{5^3 \cdot 5^7}\)

11. Complete the equation \(\frac{1}{8^2} = 8\) \(\Box\).

12. Compute \(\left(\frac{1}{5}\right)^{-2}\)

### 11.3 Large and Small Numbers

13. Write the number 0.000638 in scientific notation.

14. Write the number \(5.79 \times 10^7\) in standard notation.
HOME-SCHOOL CONNECTION

Here are some questions from this week’s lessons to review with your young mathematician.

1. Approximate $\sqrt{70}$ in the following 3 ways:
   a. By listing the two consecutive whole numbers between which it lies.
   b. By writing it as a mixed number (whole number plus fraction).
   c. By writing it as a decimal number (whole number plus decimal fraction).

2. Consider the following expression, and write it in exponent form in the given ways:
   \[
   \frac{8^4 \cdot 8^6}{(8^3)^5}
   \]
   a. As a power of 8 (in the form $8^n$)  
   b. As a power of 2 (in the form $2^n$)

3. Give an example a numerical expression in exponent form, $b^n$, where $n$ is a negative number but the value of the expression is positive.

4. Give an example of a base number with a positive exponent where the result is negative.

5. Explain why $0.2 \times 10^4$ is not in scientific notation, and then write it in scientific notation.

Parent (or Guardian) Signature ________________________________

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COMMON CORE STATE STANDARDS – MATHEMATICS

STANDARDS FOR MATHEMATICAL CONTENT

| 8.NS.2 | Use rational approximations of irrational numbers to compare the size of irrational numbers, locate them approximately on a number line diagram, and estimate the value of expressions (e.g., \( \pi^2 \)). For example, by truncating the decimal expansion of \( \sqrt{2} \), show that \( \sqrt{2} \) is between 1 and 2, then between 1.4 and 1.5, and explain how to continue on to get better approximations. |
| 8.EE.1 | Know and apply the properties of integer exponents to generate equivalent numerical expressions. For example, \( 3^2 \times 3^{-5} = 3^{-3} = 1/3^3 = 1/27 \). |
| 8.EE.2 | Use square root and cube root symbols to represent solutions to equations of the form \( x^2 = p \) and \( x^3 = p \), where \( p \) is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that \( \sqrt{2} \) is irrational. |
| 8.EE.3 | Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. For example, estimate the population of the United States as \( 3 \times 10^8 \) and the population of the world as \( 7 \times 10^9 \), and determine that the world population is more than 20 times larger. |
| 8.EE.4 | Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology. |

STANDARDS FOR MATHEMATICAL PRACTICE

| MP1 | Make sense of problems and persevere in solving them. |
| MP2 | Reason abstractly and quantitatively. |
| MP3 | Construct viable arguments and critique the reasoning of others. |
| MP5 | Use appropriate tools strategically. |
| MP6 | Attend to precision. |
| MP7 | Look for and make use of structure. |
| MP8 | Look for and express regularity in repeated reasoning. |