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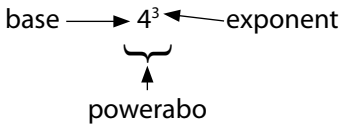
Lesson 1 Reteach

Powers and Exponents

A number that is expressed using an exponent is called a **power.** The **base** is the number that is multiplied. The **exponent** tells how many times the base is used as a factor. So, 4^3 has a base of 4 and an exponent of 3, and $4^3 = 4 \cdot 4 \cdot 4 = 64$.



Example 1 Write each expression using exponents.

a. 10 • 10 • 10 • 10 • 10

The base is 10. It is a factor 5 times, so the exponent is 5.

$10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 = 10^5$

b. $(p + 2)(p + 2)(p + 2)$

The base is $p + 2$. It is a factor 3 times, so the exponent is 3.

$(p + 2)(p + 2)(p + 2) = (p + 2)^3$

When evaluating expressions with exponents, follow the order of operations.

Example 2 Evaluate $x^2 - 4$ if $x = -6$.

$x^2 - 4 = (-6)^2 - 4$	Replace x with -6.
$= (-6)(-6) - 4$	-6 is a factor 2 times.
$= 36 - 4$	Multiply.
$= 32$	Subtract.

Exercises

Write each expression using exponents.

1. $5 \cdot 5 \cdot 5 \cdot 5 \cdot 5 \cdot 5 \cdot 5$ **5^7**
2. $(-7)(-7)(-7)$ **$(-7)^3$**
3. $\left(\frac{1}{3}\right) \cdot \left(\frac{1}{3}\right) \cdot \left(\frac{1}{3}\right) \cdot \left(\frac{1}{3}\right)$ **$\left(\frac{1}{3}\right)^4$**
4. $x \cdot x \cdot y \cdot y$ **x^2y^2**
5. $(z - 4)(z - 4)$ **$(z - 4)^2$**
6. $3(-t)(-t)(-t)$ **$3(-t)^3$**

Evaluate each expression if $g = 3$, $h = -1$, and $m = 9$.

7. g^5 **243**
8. $5g^2$ **45**
9. $g^2 - m$ **0**
10. $4(2m - 3)^2$ **900**
11. $-2(g^3 + 1)$ **−56**
12. $5(h^4 - m^2)$ **−400**

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Lesson 2 Reteach

Negative Exponents

A **negative exponent** is the result of repeated division. Extending the pattern below shows that $4^{-1} = \frac{1}{4}$ or $\frac{1}{4^1}$.

$4^2 = 16$

$\div 4$

$4^1 = 4$

$\div 4$

$4^0 = 1$

$\div 4$

$4^{-1} = \frac{1}{4}$

This suggests the following definition.

$a^{-n} = \frac{1}{a^n}$ for $a \neq 0$ and any whole number n. Example: $6^{-4} = \frac{1}{6^4}$

For $a \neq 0$, $a^0 = 1$. Example: $9^0 = 1$

Example 1 Write each expression using a positive exponent.

a. 3^{-4}

$3^{-4} = \frac{1}{3^4}$ Definition of negative exponent

b. y^{-2}

$y^{-2} = \frac{1}{y^2}$ Definition of negative exponent

Example 2 Write each fraction as an expression using a negative exponent other than -1.

a. $\frac{1}{6^3}$

$\frac{1}{6^3} = 6^{-3}$ Definition of negative exponent

b. $\frac{1}{81}$

$\frac{1}{81} = \frac{1}{9^2}$ Definition of exponent

$= 9^{-2}$ Definition of negative exponent

Exercises

Write each expression using a positive exponent.

1. 6^{-4} $\mathbf{\frac{1}{6^4}}$
2. $(-7)^{-8}$ $\mathbf{\frac{1}{(-7)^8}}$
3. b^{-6} $\mathbf{\frac{1}{b^6}}$
4. n^{-1} $\mathbf{\frac{1}{n^1}}$ **or** $\mathbf{\frac{1}{n}}$
5. $(-2)^{-5}$ $\mathbf{\frac{1}{(-2)^5}}$
6. 10^{-3} $\mathbf{\frac{1}{10^3}}$
7. j^{-9} $\mathbf{\frac{1}{j^9}}$
8. a^{-2} $\mathbf{\frac{1}{a^2}}$

Write each fraction as an expression using a negative exponent other than -1.

9. $\frac{1}{2^2}$ $\mathbf{2^{-2}}$
10. $\frac{1}{13^4}$ $\mathbf{13^{-4}}$
11. $\frac{1}{25}$ $\mathbf{5^{-2}}$
12. $\frac{1}{49}$ $\mathbf{7^{-2}}$
13. $\frac{1}{3^3}$ $\mathbf{3^{-3}}$
14. $\frac{1}{9^2}$ $\mathbf{9^{-2}}$
15. $\frac{1}{121}$ $\mathbf{11^{-2}}$
16. $\frac{1}{27}$ $\mathbf{3^{-3}}$

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Lesson 3 Reteach

Multiplying and Dividing Monomials

When multiplying powers with the same base, add the exponents.

Symbols	$a^m \cdot a^n = a^{m+n}$
Example	$4^2 \cdot 4^5 = 4^{2+5}$ or 4^7

Example 1 Find the product $5^7 \cdot 5$.

$5^7 \cdot 5 = 5^7 \cdot 5^1$ $5 = 5^1$

$= 5^{7+1}$ Product of Powers Property; the common base is 5.

$= 5^8$ Add the exponents.

Example 2 Find the product $2a^2 \cdot 3a$.

$2a^{-2} \cdot 3a = 2 \cdot 3 \cdot a^{-2} \cdot a$ Commutative Property of Multiplication

$= 2 \cdot 3 \cdot a^{-2+1}$ Product of Powers Property; the common base is a.

$= 2 \cdot 3 \cdot a^{-1}$ Add the exponents.

$= 6a^{-1}$ Multiply.

When dividing powers with the same base, subtract the exponents.

Symbols	$\frac{a^m}{a^n} = a^{m-n}$, where $a \neq 0$
Example	$\frac{5^6}{5^2} = 5^{6-2}$ or 5^4

Example 3 Find the quotient $\frac{(-8)^4}{(-8)^2}$.

$\frac{(-8)^4}{(-8)^2} = (-8)^{4-2}$ Quotient of Powers Property; the common base is (−8).

$= (-8)^2$ Subtract the exponents.

Exercises

Find each product. Express using positive exponents.

1. $4^7 \cdot 4^6$ **4^{13}**
2. $v^5 \cdot v^4$ **v^9**
3. $(f^3)(f^9)$ **f^{12}**
4. $(-31^4)(-31^{-2})$ **31^2**
5. $(-cr^{-5})(-r^2)$ **cr^{-3}**
6. $9z^3 \cdot 2z$ **$-18z^4$**
7. $3^8 \cdot 3^3$ **3^{11}**
8. $-7u^6(-6u^5)$ **$42u^{11}$**
9. $-5m^3(4m^6)$ **$-20m^9$**

Find each quotient. Express using positive exponents.

10. $\frac{7^5}{7^2}$ **7^3**
11. $\frac{1^8}{1^6}$ **1^2**
12. $\frac{(-12)^3}{(-12)^3}$ **$(-12)^0$ or 1**
13. $\frac{(-p^{18})}{(-p^{12})}$ **p^6**
14. $\frac{2w^{-3}}{2w}$ **w^{-4}**
15. $\frac{e^{10}}{e^{-3}}$ **e^{13}**

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Lesson 4 Reteach

Scientific Notation

Numbers like 5,000,000 and 0.0005 are in **standard form** because they do not contain exponents. A number is expressed in **scientific notation** when it is written as a product of a factor and a power of 10. The factor must be greater than or equal to 1 and less than 10.

By definition, a number in scientific notation is written as $a \times 10^n$, where $1 \leq a < 10$ and n is an integer.

Example 1 Express the number 7.8×10^{-6} in standard form.

$7.8 \times 10^{-6} = 7.8 \times 0.000001$ $10^{-6} = 0.000001$

$= 0.0000078$ Move the decimal point 6 places to the left.

Example 2 Express the number 62,000,000 in scientific notation.

$62{,}000{,}000 = 6.2 \times 10{,}000{,}000$ The decimal point moves 7 places.

$= 6.2 \times 10^7$ The exponent is positive.

To compare numbers in scientific notation, compare the exponents.

- If the exponents are positive, the number with the greatest exponent is the greatest.
- If the exponents are negative, the number with the least exponent is the least.
- If the exponents are the same, compare the factors.

Example 3 Compare each set of numbers using <, > or =.

a. 2.097×10^5 ● 3.12×10^3 Compare the exponents: $5 > 3$.

So, $2.097 \times 10^5 > 3.12 \times 10^3$.

b. 8.706×10^{-5} ● 8.809×10^{-5} The exponents are the same, so compare the factors: $8.706 < 8.809$.

So, $8.706 \times 10^{-5} < 8.809 \times 10^{-5}$.

Exercises

Express each number in standard form.

1. 4.12×10^6 **4,120,000** **2.** 5.8×10^2 **580** **3.** 9.01×10^{-3} **0.00901**

4. 1.034×10^9 **1,034,000,000** **5.** 3.48×10^{-4} **0.000348** **6.** 6.02×10^{-6} **0.00000602**

Express each number in scientific notation.

7. 12,000,000,000 **1.2×10^{10}** **8.** 5000 **5.0×10^3** **9.** 0.00475 **4.75×10^{-3}**

10. 7,989,000,000 **7.989×10^9** **11.** 0.0000403 **4.03×10^{-5}** **12.** 13,000,000 **1.3×10^7**

Order each set of numbers from least to greatest.

13. 6.9×10^3, 7.6×10^{-6}, 7.1×10^3, 6.8×10^4
7.6×10^{-6}, 6.9×10^3, 7.1×10^3, 6.8×10^4

14. 4.02×10^{-8}, 4.15×10^{-3}, 4.2×10^2, $\times 4.0 \times 10^{-8}$
4.0×10^{-8}, 4.02×10^{-8}, 4.15×10^{-3}, 4.2×10^2

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Lesson 5 Reteach

Compute with Scientific Notation

When you multiply and divide with numbers in scientific notation, multiply or divide the leading numbers first, then use the Product of Powers or Quotient of Powers properties to multiply or divide the powers of 10.

Example 1 **Evaluate $(4.9 \times 10^3) \times (2 \times 10^5)$. Express the result in scientific notation.**

$= (4.9 \times 2) \times (10^3 \times 10^5)$ Commutative and Associative Properties.

$= (9.8) \times (10^3 \times 10^5)$ Multiply 4.9 by 2.

$= 9.8 \times 10^{3+5}$ Product of Powers

$= 9.8 \times 10^8$ Add the exponents.

When you add and subtract with numbers in scientific notation, the exponents must be the same. Sometimes you need to rewrite one of the numbers so it has the same exponent as the other.

Example 2 **Evaluate $(4.68 \times 10^5) + (7.2 \times 10^6)$. Express the result in scientific notation.**

$= (4.68 \times 10^5) + (72 \times 10^5)$ Write 7.2×10^6 as 72×10^5.

$= (4.68 + 72) \times 10^5$ Distributive Property

$= 76.68 \times 10^5$ Add 4.68 and 72.

$= 7.668 \times 10^6$ Write 76.68×10^5 in scientific notation.

Exercises

Evaluate each expression. Express the result in scientific notation.

1. $(4.3 \times 10^5)(7.5 \times 10^3)$ **3.225×10^9**

2. $(1.07 \times 10^2)(9.2 \times 10^{-3})$ **9.844×10^{-1}**

3. $(1.41 \times 10^{-4})(27{,}000)$ **3.807**

4. $(7.53 \times 10^7)(8 \times 10^{-7})$ **6.024×10^1**

5. $\frac{3.96 \times 10^3}{1.8 \times 10^2}$ **2.2×10^1**

6. $\frac{1.68 \times 10^4}{2.8 \times 10^{-2}}$ **6×10^5**

7. $(2.4 \times 10^2) + (1.77 \times 10^3)$ **2.01×10^3**

8. $(5.18 \times 10^{-2}) + (4.9 \times 10^{-1})$ **5.418×10^{-1}**

9. $(6.21 \times 10^7) + (1.1 \times 10^8)$ **1.721×10^8**

10. $(8.88 \times 10^4) - (8.8 \times 10^2)$ **8.792×10^4**

11. $(2.7 \times 10^{-6}) - (1.7 \times 10^{-8})$ **2.683×10^{-6}**

12. $(7.328 \times 10^6) - (2.37 \times 10^5)$ **7.091×10^6**

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Lesson 6 Reteach

Square Roots and Cube Roots

- A **square root** of a number is one of two equal factors of the number.
- A **radical sign**, $\sqrt{\ }$, is used to indicate a positive square root.
- Every positive number has a positive square root and a negative square root.
- The square root of a negative number, such as -64, is not real because the square of a number cannot be negative.

Example 1 Find each square root.

a. $-\sqrt{121}$

$-\sqrt{121} = -11$ Find the negative square root of 121; $11^2 = 121$.

b. $\pm\sqrt{49}$

$\pm\sqrt{49} = \pm 7$ Find both square roots of 49; $7^2 = 49$.

- A **cube root** of a number is one of three equal factors of the number.
- The symbol $\sqrt[3]{\ }$ is used to indicate the cube root of a number.
- The cube root of a positive number is positive.
- The cube root of a negative number is negative.

Example 2 Find each cube root.

a. $\sqrt[3]{729}$

$\sqrt[3]{729} = 9$ $93 = 9 \cdot 9 \cdot 9$ or 729

b. $\sqrt[3]{-125}$

$\sqrt[3]{-125} = -5$ $(-5)^3 = (-5) \cdot (-5) \cdot (-5)$ or -125

Exercises

Find each square root.

1. $\sqrt{25}$ **5**
2. $\sqrt{-25}$ **not possible**
3. $\sqrt{169}$ **13**
4. $\sqrt{-9}$ **not possible**
5. $-\sqrt{484}$ **−22**
6. $\sqrt{1521}$ **39**

Find each cube root.

7. $\sqrt[3]{-1000}$ **−10**
8. $\sqrt[3]{1728}$ **12**
9. $\sqrt[3]{8}$ **2**
10. $\sqrt[3]{0}$ **0**
11. $\sqrt[3]{-2197}$ **−13**
12. $\sqrt[3]{-8000}$ **−20**

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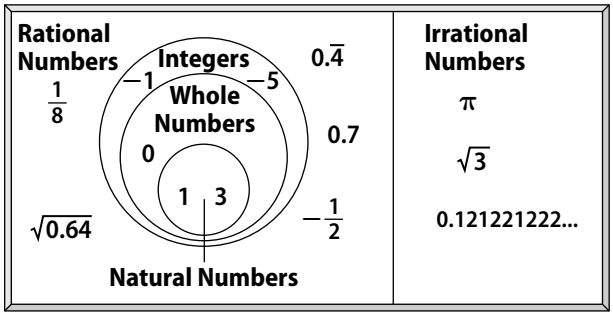
Lesson 7 Reteach

The Real Number System

The set of **real numbers** consists of all natural numbers, whole numbers, integers, rational numbers, and irrational numbers.

- **Rational numbers** can be written as fractions.
- **Irrational numbers** are numbers that



Example 1 **Name all sets of numbers to which each real number belongs. Write *natural*, *whole*, *integer*, *rational*, or *irrational*.**

a. 7

This number is a natural number, a whole number, an integer, and a rational number.

b. $0.\overline{6}$

This repeating decimal is a rational number because it is equivalent to $\frac{2}{3}$.

c. $\sqrt{71}$

It is not the square root of a perfect square so it is an irrational number.

If $x^2 = y$, then $x = \pm\sqrt{y}$.
If $x^3 = y$, then $x = \sqrt[3]{y}$.

Example 2 **Solve the equation $b^2 = 121$.**

$b^2 = 121$	Write the equation.
$b = \pm\sqrt{121}$	Definition of square root
$b = 11$ and -11	Check $11 \cdot 11 = 121$ and $(-11) \cdot (-11) = 121$

The solutions are 11 and -11.

Exercises

Name all sets of numbers to which each real number belongs. Write *natural*, *whole*, *integer*, *rational*, or *irrational*.

1. 21 **natural, whole, integer, rational**
2. $\frac{3}{7}$ **rational**
3. $\frac{8}{12}$ **rational**
4. -5 **integer, rational**
5. 17 **natural, whole, integer, rational**
6. 0 **whole, integer, rational**
7. 0.257 **rational**
8. 0.9 **rational**
9. $\sqrt{5}$ **irrational**

Solve each equation. Round to the nearest tenth, if necessary.

10. $x^2 = 9$ **3, −3**
11. $4h^3 = 864$ **6**
12. $16t^2 = 784$ **7, −7**
13. $4s^2 = 576$ **12, −12**
14. $3a^2 = 243$ **9, −9**
15. $5m^3 = -6655$ **−11**

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