

Algebra Packet 12

Name _____

Assigned Teacher _____

Date _____

Exponents

Day	Homework (due next class unless otherwise stated)

- Use Properties of Exponents to Simplify Expressions (Standard 2.0)

Warm Ups

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Warm Ups

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Lesson 7-1

Zero and Negative Exponents

Lesson Objectives <ul style="list-style-type: none"> • Simplify expressions with zero and negative exponents • Evaluate exponential expressions 	California Content Standards 2.0
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Take Note

Zero as an Exponent

For every nonzero number a , $a^0 = 1$.

Examples $5^0 = 1$ $(-2)^0 = \square$ $(1.02)^0 = \square$ $(\frac{1}{3})^0 = \square$

Negative Exponent

For every nonzero number a and integer n , $a^{-n} = \frac{1}{a^n}$.

Examples $6^{-4} = \frac{1}{6^4}$ $(-8)^{-1} = \frac{1}{(-8)^1}$

Examples

① **Simplifying a Power** Simplify:

a. $3^{-2} = \square$ Use the definition of negative exponent.
 $= \square$ Simplify.

b. $(-22.4)^0 = \square$ Use the definition of zero as an exponent.

② **Simplifying an Exponential Expression** Simplify the expression.

$\frac{1}{x^{-3}} = 1 \div x^{-3}$ Rewrite using a division symbol.
 $= 1 \div \frac{1}{\square}$ Use the definition of negative exponent.
 $= 1 \cdot \square$ Multiply by the reciprocal of $\frac{1}{x^3}$, which is \square .
 $= \square$ Identity Property of Multiplication

CA Standards Check

1. Simplify each expression.

a. 3^{-4}

b. $(-7)^0$

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Example

3 Evaluating an Exponential Expression Evaluate $4x^2y^{-3}$ for $x = 3$ and $y = -2$.

$$4x^2y^{-3} = 4(\square)^2(\square)^{-3} \quad \text{Substitute } \square \text{ for } x \text{ and } \square \text{ for } y.$$

$$= \frac{4(\square)^2}{(\square)^3} \quad \text{Use the definition of negative exponent.}$$

$$= \frac{36}{-8} = \square \quad \text{Simplify.}$$

CA Standards Check

2. Simplify each expression.

a. $11m^{-5}$

b. $7s^{-4}t^2$

c. $\frac{2}{a^{-3}}$

d. $\frac{n^{-5}}{v^2}$

3. Evaluate each expression for $n = -2$ and $w = 5$.

a. $n^{-3}w^0$

b. $\frac{n^{-1}}{w^2}$

c. $\frac{w^0}{n^4}$

d. $\frac{1}{nw^{-2}}$

Practice 7-1

Zero and Negative Exponents

Simplify each expression.

1. 23^0

2. 2^{-2}

3. 3^{-3}

4. $12 \cdot 5^0$

5. 7^0

6. $\frac{3}{5^{-1}}$

7. $\frac{6^{-2}}{6^0}$

8. $(13.6)^0$

9. 9^{-1}

Evaluate each expression for $x = -2$ and $y = 6$.

10. y^{-2}

11. x^{-3}

12. $(-x)^{-4}$

13. $4x^{-3}$

14. $2y^{-2}$

15. $(3x)^{-2}$

Simplify each expression.

16. x^{-4}

17. xy^{-5}

18. $a^{-2}b$

19. $\frac{1}{x^{-3}}$

20. $\frac{3}{a^{-8}}$

21. $\frac{5}{d^{-7}}$

Write each number as a power of 10 using negative exponents.

22. $\frac{1}{10,000}$

23. $\frac{1}{1,000,000}$

24. $\frac{1}{10,000,000}$

Write each expression as a decimal.

25. 10^{-3}

26. 10^{-5}

27. $9 \cdot 10^{-1}$

Lesson 7-2

Scientific Notation

Lesson Objectives <ul style="list-style-type: none"> • Write numbers in scientific and standard notation • Use scientific notation 	California Content Standards 2.0
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Take Note

Scientific Notation

A number in scientific notation is written as the product of two factors in the form $a \times 10^n$, where n is an integer and $1 \leq a < 10$.

Examples 3.4×10^6 5.43×10^{13} 2.1×10^{-10}

Examples

1 Writing a Number in Scientific Notation Write each number in scientific notation.

a. 234,000,000

$$234,000,000 = \boxed{} \times 10^{\boxed{}}$$

Move the decimal point $\boxed{}$ places to the left and use $\boxed{}$ as an exponent. Drop the zeros after the 4.

b. 0.000063

$$0.000063 = \boxed{} \times 10^{\boxed{}}$$

Move the decimal point $\boxed{}$ places to the right and use $\boxed{}$ as an exponent. Drop the zeros before the 6.

2 Writing a Number in Standard Notation Write each number in standard notation.

a. elephant's mass: 8.8×10^4 kg

$$8.8 \times 10^4 = \boxed{}$$

$$= \boxed{} \text{ kg}$$

A positive exponent indicates a number greater than 10. Move the decimal point $\boxed{}$ places to the right.

b. ant's mass: 7.3×10^{-5} kg

$$7.3 \times 10^{-5} = \boxed{}$$

$$= \boxed{} \text{ kg}$$

A negative exponent indicates a number between 0 and 1. Move the decimal point $\boxed{}$ places to the left.

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Example

3 Multiplying a Number in Scientific Notation Simplify. Write each answer using scientific notation.

a. $6(8 \times 10^{-4}) = (\square \cdot \square) \times 10^{-4}$
 $= \square \times 10^{-4}$
 $= \square \times 10^{\square}$

Use the Associative Property of Multiplication.

Simplify inside the parentheses.

Write the product in scientific notation.

b. $0.3(1.3 \times 10^3) = (\square \cdot \square) \times 10^3$
 $= \square \times 10^3$
 $= \square \times 10^{\square}$

Use the Associative Property of Multiplication.

Simplify inside the parentheses.

Write the product in scientific notation.

CA Standards Check

1. Write each number in scientific notation.

a. 0.0000325

b. 46,205,000

2. Write each number in standard notation.

a. 5.07×10^4

b. 8.3×10^{-2}

3. Simplify. Write each answer using scientific notation.

a. $2.5(6 \times 10^3)$

b. $0.4(2 \times 10^{-9})$

Practice 7-2

Scientific Notation

Write each number in standard notation.

1. 3×10^4

2. 6×10^{-2}

3. 4.7×10^5

4. 2.34×10^{-5}

5. 8.155×10^7

6. 5.0307×10^2

7. 42.4×10^6

8. 7.502×10^8

9. 0.018×10^{-1}

Write each number in scientific notation.

10. 24,000,000

11. 525,000,000,000

12. 0.00000063

13. 385×10^3

14. 426×10^{-3}

15. 0.07×10^6

Simplify. Write each answer using scientific notation.

16. $4(4 \times 10^5)$

17. $5(6 \times 10^{-2})$

18. $7(9 \times 10^9)$

19. $8(9 \times 10^6)$

20. $3(1.2 \times 10^{-4})$

21. $2(6.1 \times 10^{-8})$

22. $3(1.2 \times 10^{-4})$

23. $3(4.3 \times 10^{-4})$

24. $3(3.2 \times 10^{-2})$

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Lesson 7-3

Multiplication Properties of Exponents

Lesson Objectives <ul style="list-style-type: none"> • Multiply powers • Work with scientific notation 	California Content Standards 2.0, 10.0
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Take Note

Multiplying Powers With the Same Base
 For every nonzero number a and integers m and n , $a^m \cdot a^n = a^{m+n}$.
Example $3^5 \cdot 3^4 = 3^{5+4} = 3^{\square}$

Examples

1 **Multiplying Powers** Rewrite the expression using each base only once.

$$7^3 \cdot 7^2 = 7^{\square} \square^2$$

$$= \square$$

\square exponents of powers with the same base.
 Simplify the sum of the exponents.

2 **Multiplying Powers in an Algebraic Expression** Simplify the expression.

$$4x^6 \cdot 5x^{-4} = (\square \cdot \square)(x^{\square} \cdot x^{-4})$$

$$= \square(x^{\square + (\square)})$$

$$= \square$$

\square Property of Multiplication
 Add exponents of powers with the same base.
 Simplify.

CA Standards Check

1. Rewrite each expression using each base only once.

a. $5^3 \cdot 5^6$

b. $2^4 \cdot 2^{-3}$

c. $7^{-3} \cdot 7^2 \cdot 7^6$

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Example

- 3** **Multiplying Numbers in Scientific Notation** Simplify $(3 \times 10^{-3})(7 \times 10^{-5})$.
Write the answer in scientific notation.

$$\begin{aligned} (3 \times 10^{-3})(7 \times 10^{-5}) &= (3 \cdot \square)(10^{\square} \cdot 10^{\square}) \\ &= \square \times 10^{\square} \\ &= 2.1 \times 10^{\square} \cdot 10^{\square} \\ &= 2.1 \times 10^{\square + \square} \\ &= 2.1 \times 10^{\square} \end{aligned}$$

Commutative and Associative Properties of Multiplication

Simplify.

Write 21 in scientific notation.

Add exponents of powers with the same base.

Simplify the sum of the exponents.

CA Standards Check

2. Simplify each expression.

a. $n^2 \cdot n^3 \cdot 7n$

b. $2y^3 \cdot 7x^2 \cdot 2y^4$

c. $m^2 \cdot n^{-2} \cdot 7m$

3. Simplify each expression. Write each answer in scientific notation.

a. $(2.5 \times 10^8)(6 \times 10^3)$

b. $(1.5 \times 10^{-2})(3 \times 10^4)$

c. $(9 \times 10^{-6})(7 \times 10^{-9})$

Practice 7-3

Multiplication Properties of Exponents

Simplify each expression.

1. $(5a^{-2})(5a^6)$

2. $(-6x^6)(4x^6)$

3. $t^{-5} \cdot t^{-10}$

4. $r^3 \cdot r$

5. $3^7 \cdot 3^6$

6. $(3p^{-15})(6p^{11})$

7. $\frac{1}{y^{-7} \cdot y^5}$

8. $b^6 \cdot q^2 \cdot b^3$

9. $\frac{1}{x^5 \cdot x^{-3}}$

10. $r^6 \cdot a^4 \cdot a \cdot r^4$

11. $\frac{1}{h^7 \cdot h^3}$

12. $2^3 \cdot 2^2$

13. $f^5 \cdot f^2 \cdot f^0$

14. $r^6 \cdot r^{-13}$

15. $5^{-6} \cdot 5^4$

Simplify each expression. Write each answer in scientific notation.

16. $(5 \times 10^6)(5 \times 10^{-4})$

17. $(3 \times 10^8)(2 \times 10^4)$

18. $(9.5 \times 10^{-4})(2 \times 10^{-5})$

19. $(4 \times 10^9)(4.1 \times 10^8)$

20. $(7.2 \times 10^{-7})(2 \times 10^{-5})$

21. $(5 \times 10^7)(6 \times 10^3)$

22. $(6 \times 10^{-6})(5.2 \times 10^4)$

23. $(6 \times 10^6)(6 \times 10^8)$

24. $(6.1 \times 10^9)(8 \times 10^{14})$

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Lesson 7-4

More Multiplication Properties of Exponents

Lesson Objectives <ul style="list-style-type: none"> • Raise a power to a power • Raise a product to a power 	California Content Standards 2.0, 10.0
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Take Note

Raising a Power to a Power

For every nonzero number a and integers m and n , $(a^m)^n = a^{mn}$.

Examples $(5^4)^2 = 5^4 \cdot 2 = 5^8$ $(n^2)^5 = n^2 \cdot 5 = n^{10}$

Raising a Product to a Power

For every nonzero number a and b and integer n , $(ab)^n = a^n b^n$.

Example $(3x)^4 = 3^4 x^4 = 81x^4$

Examples

❶ **Simplifying a Power Raised to a Power** Simplify $(a^3)^4$.

$$(a^3)^4 = a^3 \square^4$$

$$= a \square$$

exponents when raising a power to a power.
Simplify.

❷ **Simplifying an Expression With Powers** Simplify $b^2(b^3)^{-2}$.

$$b^2(b^3)^{-2} = b^2 \cdot b^3 \square (-2)$$

$$= b^2 \cdot b \square$$

$$= b^2 \square (-6)$$

$$= b \square$$

$$= \square$$

exponents in $(b^3)^{-2}$.
Simplify.
 exponents when multiplying powers of the same base.
Simplify.
Write using only positive exponents.

CA Standards Check

Simplify each expression.

1. $(a^4)^7$

2a. $(a^{-4})^7$

2b. $(n^4)^3 \cdot n^5$

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Examples

3 Simplifying a Product Raised to a Power Simplify $(4xy^3)^2(x^3)^{-3}$.

$$\begin{aligned} (4xy^3)^2(x^3)^{-3} &= 4 \square x \square (y^3) \square \cdot (x^3)^{-3} \\ &= 4^2 \cdot x^2 \cdot y \square \cdot x \square \\ &= 4^2 \cdot x^2 \cdot x \square \cdot y \square \\ &= 4^2 \cdot x \square \cdot y^6 \\ &= \square \end{aligned}$$

Raise the three factors to the second power.

exponents of a power raised to a power.

Use the Commutative Property of Multiplication.

Add exponents of powers with the same base.

Simplify.

4 Application An object has a mass of 10^2 kg. The expression $10^2 \cdot (3 \times 10^8)^2$ describes the amount of resting energy, in joules, the object contains. Simplify the expression.

$$\begin{aligned} 10^2 \cdot (3 \times 10^8)^2 &= 10 \square \cdot 3 \square \cdot (10^8) \square \\ &= 10 \square \cdot 3 \square \cdot 10 \square \\ &= 3 \square \cdot 10 \square \cdot 10 \square \\ &= 3 \square \cdot 10 \square + \square \\ &= \square \times 10 \square \end{aligned}$$

Raise each factor within parentheses to the second power.

Simplify $(10^8)^2$.

Use the Commutative Property of Multiplication.

Add exponents of powers with the same base.

Simplify. Write in scientific notation.

CA Standards Check

3. Simplify each expression.

a. $(2z)^4$

b. $(4g^5)^{-2}$

c. $(2a^3)^5(3ab^2)^3$

4. The mass of a feather is 10^{-5} . Simplify the expression $(10^{-5})(3 \times 10^8)^2$ to find the amount of resting energy in joules the feather contains.

Practice 7-4

More Multiplication Properties of Exponents

Simplify each expression.

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

2. $(2^{-2})^6$

3. $(5^2)^2$

4. $(x^5)^2$

5. $2^7 \cdot (2^3)^2$

6. $d^2 \cdot (d^4)^4$

7. $c^4 \cdot (c^6)^2$

8. $(z^{-4})^{-3}$

9. $(a^2b)^4$

10. $(d^2)^{-4}$

11. $(b^{-3})^6$

12. $(y^5)^3$

13. $(s^2)^8$

14. $(x^4y)^3$

15. $d^5 \cdot (d^2)^4$

Simplify. Write each answer in scientific notation.

16. $10^{-9} \cdot (2 \times 10^2)^2$

17. $(3 \times 10^{-6})^3$

18. $10^4 \cdot (4 \times 10^6)^3$

19. $(7 \times 10^7)^2$

20. $10^{-3} \cdot (2 \times 10^3)^5$

21. $(6 \times 10^5)^3$

22. $(5 \times 10^5)^4$

23. $(2 \times 10^{-3})^3$

24. $(5 \times 10^2)^{-3}$

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Lesson 7-5

Division Properties of Exponents

Lesson Objectives <ul style="list-style-type: none"> • Divide powers with the same base • Raise a quotient to a power 	California Content Standards 2.0, 10.0
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Take Note

Dividing Powers With the Same Base

For every nonzero number a and integers m and n , $\frac{a^m}{a^n} = a^{m-n}$.

Example $\frac{3^7}{3^3} = 3^{7-3} = 3^{\square}$

Raising a Quotient to a Power

For every nonzero number a and b and integer n , $\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$.

Example $\left(\frac{4}{5}\right)^3 = \frac{4^3}{5^3} = \frac{\square}{\square}$

Examples

1 **Simplifying an Algebraic Expression** Simplify.

$\frac{p^3j^{-4}}{p^{-3}j^6} = p^{3-(-\square)}j^{-4-\square} = \square^{\square} \square^{\square}$ exponents when dividing powers with the same base.

$= p^{\square}j^{\square}$ Simplify the exponents.

$= \square$ Rewrite using positive exponents.

2 **Raising a Quotient to a Power** Simplify $\left(\frac{3}{y^3}\right)^4$.

$\left(\frac{3}{y^3}\right)^4 = \frac{3^{\square}}{(y^3)^{\square}}$ Raise the numerator and the denominator to the \square power.

$= \frac{3^4}{y^{\square}}$ Multiply the exponents in the denominator.

$= \square$ Simplify.

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Example

3 Simplifying an Exponential Expression

Simplify $(\frac{2}{3})^{-3}$.

$$(\frac{2}{3})^{-3} = (\boxed{})^{\boxed{}}$$

Rewrite using the reciprocal of $\frac{2}{3}$.

$$= \frac{3^{\boxed{}}}{2^{\boxed{}}}$$

Raise the numerator and denominator to the $\boxed{}$ power.

$$= \boxed{} \text{ or } \boxed{}$$

Simplify.

CA Standards Check

1. Simplify each expression.

a. $\frac{b^4}{b^9}$

b. $\frac{a^2b}{a^4b^3}$

c. $\frac{m^{-1}n^2}{m^3n}$

2. Simplify each expression.

a. $(\frac{3}{x^2})^2$

b. $(\frac{x}{y^2})^3$

3. Simplify each expression.

a. $(\frac{3}{4})^{-3}$

b. $(\frac{-1}{2})^{-5}$

c. $(\frac{2r}{s})^{-1}$

Practice 7-5

Division Properties of Exponents

Simplify each expression.

1. $\frac{c^{13}}{c^7}$

2. $\left(\frac{a^3}{b^2}\right)^4$

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

4. $\frac{3^7}{3^4}$

5. $\frac{7^{-4}}{7^{-7}}$

6. $\frac{a^6b^3}{a^4b}$

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

8. $\frac{z^6}{z^{-4}}$

9. $\left(\frac{s^{-4}}{t^{-1}}\right)^{-2}$

10. $\frac{m^4}{m^8}$

11. $\left(\frac{2^2m^5n^{-3}}{p^4}\right)^0$

12. $\frac{4^6}{4^8}$

13. $\frac{x^5y^3}{x^2y^9}$

14. $\frac{h^{-12}}{h^{-7}}$

15. $\frac{4^{-1}}{4^2}$

16. $\frac{n^8}{n^{14}}$

17. $\left(\frac{r^3s^{-1}}{r^2s^6}\right)^{-1}$

18. $\frac{n^{-7}}{n^5}$

Simplify each quotient. Write each answer in scientific notation.

19. $\frac{2.16 \times 10^{-9}}{4.36 \times 10^{-5}}$

20. $\frac{8.43 \times 10^{-4}}{2.64 \times 10^{-6}}$

21. $\frac{6 \times 10^8}{3 \times 10^4}$

22. $\frac{7.5 \times 10^7}{3 \times 10^{10}}$

23. $\frac{8.19 \times 10^5}{4.76 \times 10^{-4}}$

24. $\frac{4 \times 10^{-6}}{2 \times 10^5}$

25. $\frac{3.6 \times 10^6}{9 \times 10^{-3}}$

26. $\frac{3.9 \times 10^4}{1.3 \times 10^9}$

27. $\frac{4.9 \times 10^{12}}{7 \times 10^3}$

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