Common Core 7+

Exponents and Applications

8.EE.A1

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.A2

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 √2 is irrational.

8.EE.A3

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.A4

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

This packet belongs to _____

Exponents

SWBAT: _____

8.EE.A1

Know and apply the properties of integer exponents to generate equivalent numerical expressions. For example, $3^2 \times 3^{-5} = 3^{-3} = 1/3^3 = 1/27$.

Find the value of each expression

1) $5^5 =$ 2) $2^{11} =$ 3) $6^3 =$ 4) $9^3 =$

5) $100^2 =$ 6) $6^5 =$ 7) $10^7 =$ 8) $3^5 =$

9) $4^8 =$ 10) $12^4 =$ 11) $16^2 =$ 12) $27^1 =$

Simplify each expression

13) $(36 \div 9)^3 - 87$ 14) $(7^2 + 41) \div 3 - 94$ 15) $3^2 + (26 - 9) \times 2$

16) $14 + 75 - (31 \times 3^2)$ 17) $3^3 + 77 \div (27 - 16) + 7 + 66 \div (2^4 - 5)$

Homework

Find the value of each expression.

1) $35^1 =$

2) $5^3 =$

3) $9^4 =$

4) $6^5 =$

5) $120^3 =$

6) $7^3 =$

7) $10^8 =$

8) $3^4 =$

9) $4^4 =$

10) $12^3 =$

11) $15^4 =$

12) $17^2 =$

Simplify each expression

13) $32 \div 2^3 \times (5 + 3) - (21 + 6)$

14) $26 + 3^2 \times (8 \div 4) + 16 \times 2$

15) $84 \div (36 - 32) \times 3 + 7^2$

16) $125 \div 5^2 + (8 \times 5) + 28 - 37$

17) $3 \times 36 \div (2 + 4)^2 - 42 + 81 \div (3 \times 3) + 12 - (5 + 7)^2 + 5 \times (2 + 3)^3 - 22 - 17$

Exponent Rules

SWBAT: _____

8.EE.A1

Know and apply the properties of integer exponents to generate equivalent numerical expressions. For example, $3^2 \times 3^{-5} = 3^{-3} = 1/3^3 = 1/27$.

1. **PRODUCT RULE:** To multiply when two bases are the same, write the base and ADD the exponents.

$$x^m \cdot x^n =$$

Examples:

A. $x^3 \cdot x^8 =$ B. $2^4 \cdot 2^2 =$ C. $(x^2y)(x^3y^4) =$

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2. **QUOTIENT RULE:** To divide when two bases are the same, write the base and SUBTRACT the exponents.

$$\frac{x^m}{x^n} =$$

Examples:

A. $\frac{x^5}{x^2} =$ B. $\frac{3^5}{3^3} =$ C. $\frac{x^2y^5}{xy^3} =$

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3. **ZERO EXPONENT RULE:** Any base (except 0) raised to the zero power is equal to one.

$$x^0 =$$

Examples:

A. $y^0 =$ B. $6^0 =$ C. $(7a^3b^{-1})^0 =$

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4. **POWER RULE:** To raise a power to another power, write the base and MULTIPLY the exponents.

$$(x^m)^n =$$

Examples:

A. $(x^3)^2 =$ B. $(3^2)^4 =$ C. $(z^5)^2 =$

Examples

Multiply. Write the product as one power.

1. $2^2 \cdot 2^3$ **2.** $3^5 \cdot 3^2$ **3.** $1^3 \cdot 1^5$ **4.** $5^4 \cdot 5^3$

5. $8^1 \cdot 8^1$ **6.** $7^4 \cdot 7^5$ **7.** $12^1 \cdot 12^2$ **8.** $4^3 \cdot 4^1$

Divide. Write the quotient as one power.

9. $\frac{2^5}{2^2}$ **10.** $\frac{10^4}{10^3}$ **11.** $\frac{4^6}{4^3}$ **12.** $\frac{(-3)^6}{(-3)^4}$

13. $\frac{5^8}{5^6}$ **14.** $\frac{24^9}{24^3}$ **15.** $\frac{(-4)^8}{(-4)^1}$ **16.** $\frac{1^7}{1^5}$

Write the product or quotient as one power.

17. $\frac{5^7}{5^2}$ **18.** $4^5 \cdot 4^1$ **19.** $7^6 \cdot 7^2$ **20.** $\frac{6^8}{6^4}$

21. $15^7 \cdot 15^7$ **22.** $3^7 \cdot 3^3$ **23.** $\frac{20^9}{20^8}$ **24.** $\frac{2^{10}}{2^8}$

Homework

Multiply. Write the product as one power.

1. $10^5 \cdot 10^7$ _____

2. $x^9 \cdot x^8$ _____

3. $14^7 \cdot 14^9$ _____

4. $12^6 \cdot 12^8$ _____

5. $y^{12} \cdot y^{10}$ _____

6. $15^9 \cdot 15^{14}$ _____

7. $(-11)^{20} \cdot (-11)^{10}$ _____

8. $(-a)^6 \cdot (-a)^7$ _____

Divide. Write the quotient as one power.

9. $\frac{12^9}{12^2}$ _____

10. $\frac{(-11)^{12}}{(-11)^8}$ _____

11. $\frac{x^{10}}{x^5}$ _____

12. $\frac{16^{10}}{16^2}$ _____

13. $\frac{17^{19}}{17^2}$ _____

14. $\frac{14^{15}}{14^{13}}$ _____

15. $\frac{23^{17}}{23^9}$ _____

16. $\frac{(-a)^{12}}{(-a)^7}$ _____

Write the product or quotient as one power.

17. $\frac{22^8}{22^2}$ _____

18. $d^8 \cdot d^5$ _____

19. $(-15)^5 \cdot (-15)^{10}$ _____

20. $\frac{w^{12}}{w^3}$ _____

21. $31^{16} \cdot 31^8$ _____

22. $\frac{25^{20}}{25^{10}}$ _____

23. $(-x)^{18} \cdot (-x)^9$ _____

24. $\frac{r^{18}}{r^7}$ _____

Examples

1) $10^{12} \bullet 10^{35} =$

2) $a^{7} \bullet a^{12} =$

3) $c^{3} \bullet c^{8} =$

4) $\dfrac{10^{6}}{10^{2}} =$

5) $\dfrac{4^{17}}{4^{14}} =$

6) $\dfrac{9^{210}}{9^{207}} =$

7) $3^{0} =$

8) $6701^{0} =$

9) $0^{0} =$

10) $\left(x^{2}\right)^{3} =$

11) $\left(a^{7}\right)^{5} =$

12) $\left(w^{-21}\right)^{-15} =$

13) $\left(8c^{5}\right)^{2} =$

14) $\left(-3h^{9}\right)^{3}$

15) $\left(y^{4}d^{6}\right)^{8} =$

16) $\left(\dfrac{x}{y}\right)^{6} =$

17) $\left(\dfrac{5c}{d^{2}}\right)^{2} =$

18) $\left(\dfrac{4d^{3}}{c^{5}}\right)^{3} =$

Homework

1) $d^7 \bullet d^9 =$

2 $x^{2e} \bullet x^{8e} =$

3) $w^{103} \bullet w^{1030} =$

4) $a^6 \bullet b^5 =$

5) $10^a \bullet 10^b =$

6) $g^{12} \bullet g^{19} \bullet g^{11} =$

7) $\frac{7^{12}}{7^6} =$

8) $\frac{23^{87}}{23^{56}} =$

9) $\frac{3^{12}3^5 3^4}{3^2 3^6} =$

10) $\frac{x^3}{x} =$

11) $\frac{y^4}{y} =$

12) $\frac{x^3 y}{xy^3} =$

13) $0^0 =$

14) $12^0 =$

15) $78^0 =$

16) $\left(y^{13}\right)^4 =$

17) $\left(5^2\right)^3 =$

18) $\left(23^7\right)^8 =$

19) $\left(-y^5\right)^4 =$

20) $\left(4y^3\right)^2 =$

21) $\left(k^9\right)^5 \left(k^3\right)^2 =$

22) $\frac{6r^3}{2r} =$

23) $\left(\frac{3w}{g^6}\right)^4 =$

24) $\left(\frac{2d^4}{4e}\right)^3 =$

25) $\frac{-16w^7 r^2}{-4wr} =$

26) $\frac{a^5 b^5 c^5}{-a^2 b^3 c^4} =$

27) $\frac{21d^{18}e^5}{7d^{11}e^3} =$

Negative Exponents

SWBAT: _____

8.EE.A1

Know and apply the properties of integer exponents to generate equivalent numerical expressions. For example, $3^2 \times 3^{-5} = 3^{-3} = 1/3^3 = 1/27$.

The pattern in this table will help you evaluate powers with exponents.

Column 1	Column 2	Column 3
$2^3 =$	$3^3 =$	$4^3 =$
$2^2 =$	$3^2 =$	$4^2 =$
$2^1 =$	$3^1 =$	$4^1 =$
$2^0 =$	$3^0 =$	$4^0 =$
$2^{-1} =$	$3^{-1} =$	$4^{-1} =$
$2^{-2} =$	$3^{-2} =$	$4^{-2} =$

NEGATIVE EXPONENTS: If a factor in the numerator or denominator is moved across the fraction bar, the sign of the exponent is changed.

$$x^{-m} = \qquad \frac{1}{x^{-m}} = \qquad \left(\frac{x}{y}\right)^{-n} =$$

Examples:

A. $x^{-3} =$

B. $4^{-2} =$

C. $-4x^5y^{-2} =$

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

Examples

1) $3^{-2} =$

2) $-3^{-2} =$

3) $(-3)^{-2} =$

Examples continued…

4) $(-2)^{-3} =$

5) $(-4)^{-2} =$

6) $2^{-4} =$

7) $5^{-2} =$

8) $-6^{-2} =$

9) $(-6)^{-2} =$

10) $\left(\frac{1}{2}\right)^{-2} =$

11) $\left(\frac{2}{3}\right)^{-1} =$

12) $\left(\frac{-4}{3}\right)^{-2} =$

13) $\left(-\frac{5}{6}\right)^{-2} =$

14) $\left(\frac{1}{8}\right)^{-2} =$

15) $\left(\frac{6}{7}\right)^{-2} =$

16) $3^{-2} \cdot 3^{n} = \frac{1}{81}$

17) $4^{-2} \cdot 4^{n} = \frac{1}{256}$

18) $5^{-n} \cdot 5^{-7} = \frac{1}{625}$

Homework

1) $2^{-2} =$

2) $-2^{-2} =$

3) $(-5)^{-2} =$

4) $(-3)^{-3} =$

5) $(-5)^{-2} =$

6) $3^{-4} =$

7) $7^{-2} =$

8) $-8^{-2} =$

9) $(-3)^{-2} =$

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

11) $\left(\frac{1}{3}\right)^{-1} =$

12) $\left(\frac{1}{4}\right)^{-2} =$

13) $\left(\frac{5}{6}\right)^{-3} =$

14) $\left(\frac{-1}{8}\right)^{-3} =$

15) $\left(\frac{6}{5}\right)^{-3} =$

16) $2^{-2} \cdot 2^{n} = \frac{1}{32}$

17) $6^{-7} \cdot 6^{n} = \frac{1}{216}$

18) $8^{-n} \cdot 8^{-7} = \frac{1}{4096}$

Applying the Exponent Rule for Negative Exponents

Simplify.

1) 8^{-1}

2) 3^{-2}

3) y^{-7}

4) w^{-12}

5) $(3x)^{-1}$

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

7) $4c^{-3}$

8) $2pr^{-5}$

9) $-6q^{-2}$

10) $-18a^2b^{-3}$

11) $\dfrac{1}{x^{-2}}$

12) $\dfrac{5}{z^{-3}}$

13) $-\dfrac{2x}{a^{-4}}$

14) $\dfrac{3b}{-5c^{-1}}$

15) $\dfrac{a^{-1}}{b^{-1}}$

16) $\dfrac{2n^{-2}}{3p^{-3}}$

17) $-\dfrac{xy^{-1}}{9z^{-2}}$

18) $\dfrac{4ab^{-2}}{-3c^{-2}}$

19) $\dfrac{(ab)^{-1}}{cd^{-2}}$

20) $\dfrac{w(xy)^{-2}}{(3tv)^{-2}}$

21) $\left(\dfrac{3}{4}\right)^{-1}$

22) $\left(\dfrac{2}{5}\right)^{-2}$

23) $\left(\dfrac{2a}{9c}\right)^{-2}$

24) $\left(\dfrac{5x}{3yz}\right)^{-3}$

Practice Worksheet for Law of Exponents

Use the laws of exponents you discovered in your investigation to simplify each of t following expressions with positive exponents.

1. $3^3 \bullet 3^4$
2. $x^8 \bullet x^5$
3. $3x^3 \bullet 4x^2$
4. $x^2y^4 \bullet x^5y^{12}$
5. $\left(5^2\right)^3$
6. $\left(x^4\right)^5$
7. $(2x)^3$
8. $\left(x^4y^5\right)^3$
9. $\left(3x^4y^3z^5\right)^3$
10. $\left(2x^3\right)^4\left(-3x^2y^3\right)^2$
11. 3^{-4}
12. $\frac{8^5}{8^2}$
13. 27^0
14. $\frac{12x^5}{4x^2}$
15. $\frac{2x^6y^5}{16x^4y}$
16. $\frac{3^5}{3^7}$
17. $\frac{4x^5y^2}{20x^3y^4}$
18. $\frac{12xy^2}{3x^4y^2}$
19. $\left(\frac{2x^4}{3x}\right)^3$
20. $\frac{18x^{-5}y^4}{12x^{-3}y^{-3}}$

Simplify. Your answer should contain only positive exponents.

1) $2m^2 \cdot 2m^3$

2) $m^4 \cdot 2m^{-3}$

3) $4r^{-3} \cdot 2r^2$

4) $4n^4 \cdot 2n^{-3}$

5) $2k^4 \cdot 4k$

6) $2x^3y^{-3} \cdot 2x^{-1}y^3$

7) $2y^2 \cdot 3x$

8) $4v^3 \cdot vu^2$

9) $4a^3b^2 \cdot 3a^{-4}b^{-3}$

10) $x^2y^{-4} \cdot x^3y^2$

11) $(x^2)^0$

12) $(2x^2)^{-4}$

13) $(4r^0)^4$

14) $(4a^3)^2$

15) $(3k^4)^4$

16) $(4xy)^{-1}$

17) $\left(2b^4\right)^{-1}$

18) $\left(x^2y^{-1}\right)^2$

19) $\left(2x^4y^{-3}\right)^{-1}$

20) $(3m)^{-2}$

21) $\dfrac{r^2}{2r^3}$

22) $\dfrac{x^{-1}}{4x^4}$

23) $\dfrac{3n^4}{3n^3}$

24) $\dfrac{m^4}{2m^4}$

25) $\dfrac{3m^{-4}}{m^3}$

26) $\dfrac{2x^4y^{-4}z^{-3}}{3x^2y^{-3}z^4}$

27) $\dfrac{4x^0y^{-2}z^3}{4x}$

28) $\dfrac{2h^3j^{-3}k^4}{3jk}$

29) $\dfrac{4m^4n^3p^3}{3m^2n^2p^4}$

30) $\dfrac{3x^3y^{-1}z^{-1}}{x^{-4}y^0z^0}$

EXPONENTS PRACTICE

Simplify:

1. $3 \cdot 4^3$
2. $4x^3 \cdot 2x^3$
3. $x^5 \cdot x^3$
4. $2x^3 \cdot 2x^2$
5. $\frac{6^5}{6^3}$
6. $\frac{x^4}{x^7}$
7. 8^0
8. $-(9x)^0$
9. $(y^4)^3$
10. $(x^2y)^4$
11. $\frac{6x^7}{2x^4}$
12. $\frac{8x^5}{4x^2}$
13. $(2cd^4)^2(cd)^5$
14. $(2fg^4)^4(fg)^6$
15. $\frac{x^5y^6}{xy^2}$
16. $\frac{x^2y^5}{xy^4}$
17. $\left(\frac{4x^5y}{16xy^4}\right)^3$
18. $\left(\frac{5x^3y}{20xy^5}\right)^4$
19. y^{-7}
20. 7^{-2}
21. $\frac{1}{x^{-5}}$
22. $\frac{1}{2^{-4}}$
23. $x^5 \cdot x^{-1}$
24. x^{-6}
25. $x^9 \cdot x^{-7}$
26. $(j^{-13})(j^4)(j^6)$
27. $\frac{x^{-1}}{x^{-8}}$
28. $\frac{52x^6}{13x^{-7}}$
29. $f^{-3}(f^2)(f^{-3})$
30. $\frac{x^{-4}}{x^{-9}}$
31. $\frac{24x^6}{12x^{-8}}$
32. $\frac{3x^2y^{-3}}{12x^6y^3}$
33. $(2x^3y^{-3})^{-2}$
34. $\frac{2x^4y^{-4}}{8x^7y^3}$
35. $(4x^4y^{-4})^3$
36. $5x^2y(2x^4y^{-3})$
37. $\left(\frac{-7a^2b^3c^0}{3a^3b^4c^3}\right)^{-4}$
38. $\left(\frac{-2a^3b^2c^0}{3a^2b^3c^7}\right)^{-2}$

EXPONENTS PRACTICE ANSWERS

1. 192
2. $8x^6$
3. x^8
4. $4x^5$
5. 36
6. $\frac{1}{x^3}$
7. 1
8. -1
9. y^{12}
10. x^8y^4
11. $3x^3$
12. $2x^3$
13. $4c^7d^{13}$
14. $16f^{10}g^{22}$
15. x^4y^4
16. xy
17. $\frac{x^{12}}{64y^9}$
18. $\frac{x^8}{256y^{16}}$
19. $\frac{1}{y^7}$
20. $\frac{1}{49}$
21. x^5
22. 16
23. x^4
24. $\frac{1}{x^6}$
25. x^2
26. $\frac{1}{j^3}$
27. x^7
28. $4x^{13}$
29. $\frac{1}{f^4}$
30. x^5
31. $2x^{14}$
32. $\frac{1}{4x^4y^6}$
33. $\frac{y^6}{4x^6}$
34. $\frac{1}{4x^3y^7}$
35. $\frac{64x^{12}}{y^{12}}$
36. $\frac{10x^6}{y^2}$
37. $\frac{81a^4b^4c^{12}}{2401}$
38. $\frac{9b^2c^{14}}{4a^2}$

Square roots and cube roots

SWBAT: _____

8.EE.A2

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 √2 is irrational.

The **square root of a number** is one of its two equal factors. **EX. 5 is a square root of 25 because 5*5 = 25**

Examples

1. $\sqrt{9}$
2. $\sqrt{144}$
3. $\sqrt{625}$
4. $\sqrt{900}$

Sometimes the larger number cannot be broken down into two equal integers, in this case we estimate the amount using a calculator. These numbers are _____.

Find each square root, rounded to the nearest tenth. Use a calculator.

5. $\sqrt{7}$
6. $\sqrt{19}$
7. $\sqrt{62}$
8. $\sqrt{175}$

A **cube root of a number** is one of its three equal factors.
EX. 3 is a cube root of 27 because 3*3*3 = 27

Examples

1. $\sqrt[3]{-8}$ 2. $\sqrt[3]{512}$ 3. $\sqrt[3]{1000}$ 4. $\sqrt[3]{216}$

Sometimes the larger number cannot be broken down into three equal integers, in this case we estimate the amount using a calculator. These numbers are also _____.

Find each cube root, rounded to the nearest tenth. Use a calculator.

5. $\sqrt[3]{24}$ 6. $\sqrt[3]{-125}$ 7. $\sqrt[3]{72}$ 8. $\sqrt[3]{64}$

Turn your calculators over now.

Using Prime factorization without a calculator to determine the square root of a number

Which of the following numbers are perfect squares?

484 11250 841 729

Which of the following numbers are perfect cubes?

128 343 729 1331

Homework

Find the square root, round to the nearest tenth if necessary. You may use a calculator for these.

1) $\sqrt{100} =$ 2) $\sqrt{135} =$ 3) $\sqrt{27} =$

4) $\sqrt{10} =$ 5) $\sqrt{196} =$ 6) $\sqrt{25} =$

7) $\sqrt{80} =$ 8) $\sqrt{17} =$ 9) $\sqrt{324} =$

Find the cube root, round to the nearest tenth if necessary. You may use a calculator for these.

10) $\sqrt[3]{-37} =$ 11) $\sqrt[3]{96} =$ 12) $\sqrt[3]{1331} =$

13) $\sqrt[3]{1728} =$ 14) $\sqrt[3]{358} =$ 15) $\sqrt[3]{-2197} =$

Without using a calculator, use prime factorization to determine which of the following numbers are perfect cubes or perfect squares.

16) 576 17) 3375 18) 7242

Scientific Notation

SWBAT: _____

8.EE.A3

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.

Scientific Notation

***Part A*: Express each of the following in standard form.**

1. 9.65×10^{-4}

2. 6.452×10^{2}

3. 2.71×10^{4}

4. 6.4×10^{-3}

***Part B*: Express each of the following in scientific notation.**

5. 78,000

6. 16

7. 250

8. 0.875×10^{-3}

***Part C*: Use the associative property to simplify. Express your final answer in scientific notation rounded to the nearest tenth.**

9. $(6.02 \times 10^{23})(8.65 \times 10^{4})$

10. $\dfrac{(5.4 \times 10^{4})(2.2 \times 10^{7})}{4.5 \times 10^{5}}$

11. $\dfrac{5.6 \times 10^{-18}}{8.9 \times 10^{8}}$

12. $\dfrac{(6.02 \times 10^{23})(-5.11 \times 10^{-27})}{-8.23 \times 10^{5}}$

13. A cubic millimeter of blood contains about 5×10^{6} red blood cells. An adult human body contains approximately 5×10^{6} cubic millimeters of blood. About how many red blood cells does a human body contain?

Scientific Notation Homework

***Part A*: Express each of the following in standard form.**

1. 8.5×10^{-2}

2. 8.77×10^{-1}

***Part B*: Express each of the following in scientific notation.**

3. 0.00053×10^{6}

4. 0.0043

***Part C*: Use the associative property to simplify. Express your final answer in scientific notation rounded to the nearest tenth.**

5. $(6.02 \times 10^{23})(9.63 \times 10^{-2})$

6. $\dfrac{(6.02 \times 10^{23})(-1.42 \times 10^{-15})}{6.54 \times 10^{-6}}$

7. $(-4.12 \times 10^{-4})(7.33 \times 10^{12})$

8. $\dfrac{(3.1 \times 10^{14})(4.4 \times 10^{-12})}{-6.6 \times 10^{-14}}$

9. The head of a pin has a diameter of 1×10^{-4} meter. A bacterium has a diameter of 5×10^{-7} meter. How many bacteria that size would fit across the diameter of the pinhead?