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LESSON 1-3

Homework and Practice

Exponents

Write each expression in exponential form.

1. $2 \times 2 \times 2 \times 2$ _____

2. $3 \times 3 \times 3 \times 3 \times 3$ _____

3. $9 \times 9 \times 9$ _____

4. 6×6 _____

5. $5 \times 5 \times 5 \times 5 \times 5 \times 5 \times 5$ _____

6. $7 \times 7 \times 7 \times 7 \times 7 \times 7$ _____

Find each value.

7. 5^2 _____

8. 9^3 _____

9. 3^4 _____

10. 2^6 _____

11. 121^1 _____

12. 4^5 _____

13. 12^2 _____

14. 29^0 _____

Compare using <, >, or =.

15. $3^4 \square 9^2$

16. $2^4 \square 3^3$

17. $5^3 \square 10^2$

18. $2^2 \square 16^1$

19. $6^2 \square 2^5$

20. $8^2 \square 2^6$

21. What whole number equals 49 when it is squared and 343 when it is cubed?

_____

22. Use exponents to write the number 16 three different ways.

_____

2^x
$2^4 =$
$2^3 =$
$2^2 =$
$2^1 =$
$2^0 =$

5^x
$5^4 =$
$5^3 =$
$5^2 =$
$5^1 =$
$5^0 =$

10^x
$10^4 =$
$10^3 =$
$10^2 =$
$10^1 =$
$10^0 =$

Elementary Algebra Skill

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

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Practice 8-1

Zero and Negative Exponents

Simplify each expression.

1. 16^0
2. 4^{-2}
3. 3^{-3}
4. 8^{-4}
5. $\frac{1}{2^{-5}}$
6. $\frac{4}{4^{-3}}$
7. $\frac{3}{6^{-1}}$
8. $\frac{2^{-1}}{2^{-5}}$
9. $3 \cdot 8^0$
10. $16 \cdot 2^{-2}$
11. 12^{-1}
12. -7^{-2}
13. $16 \cdot 4^0$
14. 9^0
15. $\frac{32^{-1}}{8^{-1}}$
16. $\frac{9}{2^{-1}}$
17. $\frac{8^{-2}}{4^0}$
18. $\frac{9^{-1}}{3^{-2}}$
19. $5(-6)^0$
20. $(3.7)^0$
21. $(-9)^{-2}$
22. $(-4.9)^0$
23. $-6 \cdot 3^{-4}$
24. $\frac{7^{-2}}{4^{-1}}$

Evaluate each expression for $a = -2$ and $b = 6$.

25. b^{-2}
26. a^{-3}
27. $(-a)^{-4}$
28. $-b^{-3}$
29. $4a^{-3}$
30. $2b^{-2}$
31. $(3a)^{-2}$
32. $(-b)^{-2}$
33. $2a^{-1}b^{-2}$
34. $-4a^{-2}b^{-3}$
35. $3^{-2}a^{-2}b^{-1}$
36. $(3ab)^{-2}$

Simplify each expression.

37. x^{-8}
38. xy^{-3}
39. $a^{-5}b$
40. m^2n^{-9}
41. $\frac{1}{x^{-7}}$
42. $\frac{3}{a^{-4}}$
43. $\frac{5}{d^{-3}}$
44. $\frac{6}{r^{-5}s^{-1}}$
45. $3x^{-6}y^{-5}$
46. $8a^{-3}b^2c^{-2}$
47. $15s^{-9}t^{-1}$
48. $-7p^{-5}q^{-3}r^2$
49. $\frac{d^{-4}}{e^{-7}}$
50. $\frac{3m^{-4}}{n^{-8}}$
51. $\frac{6m^{-8}n}{p^{-1}}$
52. $\frac{a^{-2}b^{-1}}{cd^{-3}}$

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

53. $\frac{1}{10{,}000}$
54. $\frac{1}{1{,}000{,}000}$
55. $\frac{1}{10{,}000{,}000}$
56. $\frac{1}{1{,}000{,}000{,}000}$

Write each expression as a decimal.

57. 10^{-5}
58. 10^{-8}
59. $4 \cdot 10^{-1}$
60. $6 \cdot 10^{-4}$

Evaluate each expression for $m = 4$, $n = 5$, and $p = -2$.

61. m^p
62. n^m
63. p^p
64. n^p
65. $m^p n$
66. m^{-n}
67. p^{-n}
68. mn^p
69. p^{-m}
70. $\frac{m}{n^p}$
71. $\frac{1}{n^{-m}}$
72. $-n^{-m}$

Multiplication Property of Exponents

Property:

Example: Multiplying Powers

Re-write each expression using each base only once:

1) $11^4 \cdot 11^5$ 2) $2^3 \cdot 2^2 \cdot 2^{-1}$ 3) $5^{-4} \cdot 5^4$

Example: Multiplying Powers in an Algebraic Expression

Simplify each expression:

4) $x \cdot x^2 \cdot x^3$ 5) $2n^5 \cdot 7n^{-2}$

6) $a \cdot a^5$ 7) $n^2 \cdot n^3 \cdot 7n$ 8) $6y^2 \cdot 3y^3 \cdot 2y^{-4}$

Simplify each expression:

9) $c^4 \cdot d^{-3} \cdot c^7$ 10) $5m \cdot 2p^4 \cdot 3m^8$

11) $b \cdot a \cdot b^5$ 12) $2y^3 \cdot 7x^2 \cdot 2y^4$ 13) $m^5 \cdot n^{-6} \cdot 7m$

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Reteaching 8-3

Multiplication Properties of Exponents

OBJECTIVE: Multiplying powers with the same base

MATERIALS: None

- A power is an expression in the form a^n.
- To multiply powers with the same base, add the exponents
  $a^m \cdot a^n = a^{m+n}$

Example

Simplify $4^6 \cdot 4^3$.

$4^6 \cdot 4^3$

$= 4^{6+3}$ ← **Rewrite as one base with the exponents added.**

$= 4^9$ ← **Add the exponents.**

So $4^6 \cdot 4^3 = 4^9$.

Exercises

Complete each equation.

1. $8^2 \cdot 8^3 = 8^{\blacksquare}$
2. $2^{\blacksquare} \cdot 2^6 = 2^9$
3. $a^{12} \cdot a^{\blacksquare} = a^{15}$
4. $x^{\blacksquare} \cdot x^5 = x^6$
5. $b^{-4} \cdot b^3 = b^{\blacksquare}$
6. $6^4 \cdot 6^{\blacksquare} = 6^2$
7. $3^4 \cdot 3^8 = 3^{\blacksquare}$
8. $c^{\blacksquare} \cdot c^{-7} = c^{11}$
9. $10^{-6} \cdot 10^{-3} = 10^{\blacksquare}$

Simplify each expression.

10. $3x^2 \cdot 4x \cdot 2x^3$
11. $m^2 \cdot 3m^4 \cdot 6a \cdot a^{-3}$
12. $p^3q^{-1} \cdot p^2q^{-8}$
13. $5x^2 \cdot 3x \cdot 8x^4$
14. $x^2 \cdot y^5 \cdot 8x^5 \cdot y^{-2}$
15. $7y^2 \cdot 3x^2 \cdot 9$
16. $2y^2 \cdot 3y^2 \cdot 4y^5$
17. $x^4 \cdot x^{-5} \cdot x^4$
18. $x^{12} \cdot x^{-8} \cdot y^{-2} \cdot y^3$
19. $6a^2 \cdot b \cdot 2a^{-1}$
20. $r^6 \cdot s^{-3} \cdot r^{-2} \cdot s$
21. $3p^{-2} \cdot q^3 \cdot p^3 \cdot q^{-2}$

Investigation: Powers of Powers

You can use what you learned in the previous lesson to find a shortcut for simplifying expressions with powers. Complete each statement by showing equivalent expressions. Let your final answer be written as a base raised to a single power.

1. $(3^6)^2 = 3^6 \cdot 3^6 =$

2. $(5^4)^3 = 5^4 \cdot 5^4 \cdot 5^4 =$

3. $(2^7)^4 =$ _____ $\cdot$ _____ $\cdot$ _____ $\cdot$ _____ $=$

4. $(4^5)^5 =$ _____ $\cdot$ _____ $\cdot$ _____ $\cdot$ _____ $\cdot$ _____ $=$

5. $(1^4)^6 =$

6. $(6^2)^4 =$

Look at your answers.

- What do you notice about the two exponents in the original expression as compared to the value of the exponent in the final expression?

- What operation would allow you to go straight from the original two exponents to the final one?

- Write a math rule to show how this would work in general or write it out in words.

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Reteaching 8-4

More Multiplication Properties of Exponents

OBJECTIVE: Using two more multiplication properties of exponents

MATERIALS: None

- To raise a power to a power, multiply the exponents.
- Every number and variable inside parentheses is being raised to the power to the right of the parentheses.

Example

Simplify $(4x^3)^2$.

$(4x^3)^2$

$(4^1x^3)^2$ ← Rewrite each number and variable with an exponent.

$(4^1x^3)^2$ ← Draw arrows from the exponent outside the parentheses to each exponent inside the parentheses.

$4^{2\cdot 1}x^{2\cdot 3}$ ← Rewrite, showing the exponents to be multiplied.

4^2x^6 ← Multiply the exponents.

$16x^6$ ← Simplify.

Exercises

Draw arrows from the exponent outside the parentheses to each exponent inside the parentheses. Then simplify each expression.

1. $(5^2)^4$
2. $(a^5)^4$
3. $(2^3)^2$
4. $(4x)^3$
5. $(7a^4)^2$
6. $(3g^2)^3$
7. $(g^2h^3)^5$
8. $(s^6)^2$

Simplify each expression.

9. $(x^2y^4)^3$
10. $(3r^5)^0$
11. $g^9 \cdot g^{-7}$
12. $(c^4)^7$
13. $(3.2)^5 \cdot (3.2)^{-5}$
14. $(8ab^6)^3$
15. $(x^2y^3)^2$
16. $(x^7)^2$
17. $(3x^2y)^2$
18. $(-2x^2)^3$
19. $(x^3y^4)^3$
20. $(3x^2y)^3$
21. $(-4x^2y^3)^3$
22. $(xyz)^0$
23. $x^5 \cdot x^{-7}$

Exponent Bingo

Cut, mix up and paste all 35 answers in the squares. When the problems are presented, find the answer below and cover it with a marker. Only the top section is used in the game, but mark all your answers so you know if you are getting the problems correct or not.

x^8	$8x^{15}$	$6x^3$	$4x^5$	$2x^7$
$64x^4$	$-27x^6$	$49x^{10}$	$-8x^6$	$2x^5$
$5x^{15}$	$30x^{11}$	$2x^{12}$	$20x^2$	$18x^7$
$7x^{12}$	$6x^2$	$8x^{14}$	$20x^{10}$	$45x^9$
$25x^3$	$15x^{12}$	$-32x^{12}$	$49x^6$	$49x^{14}$
$-9x^2$	$-9x^6$	$12x^6$	x^{10}	$20x^4$
$24x^8$	$9x^8$	$81x^8$	x^{30}	$18x^{10}$

Division Exploration:

Using Tables to Discover the Rule for Dividing Powers with the Same Base

Here is an example of how a table can help you evaluate $\frac{2^{11}}{2^6}$ and translate the result back to an exponent.

$$\frac{2^{11}}{2^6} = \frac{2048}{64} = 32 = 2^5$$

- Find the values of 2^{11} and 2^6 on the table
- Divide the numbers
- Find the new number on the table
- Record the power that corresponds to the new number.

2^5	32
2^6	64
2^7	128
2^8	256
2^9	512
2^{10}	1024
2^{11}	2048

Use this method and the tables below to find the quotient. Leave your answer in terms of a base with an exponent.

2. $\frac{4^5}{4^3} =$

2. $\frac{3^9}{3^5} =$

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

4. $\frac{3^{12}}{3^6} =$

5. $\frac{2^{10}}{2^2} =$

6. $\frac{4^8}{4^1} =$

2^1	2
2^2	4
2^3	8
2^4	16
2^5	32
2^6	64
2^7	128
2^8	256
2^9	512
2^{10}	1024
2^{11}	2048
2^{12}	4096

3^1	3
3^2	9
3^3	27
3^4	81
3^5	243
3^6	729
3^7	2187
3^8	6561
3^9	19683
3^{10}	59049
3^{11}	177147
3^{12}	531441

4^1	4
4^2	16
4^3	64
4^4	256
4^5	1024
4^6	4096
4^7	16384
4^8	65536
4^9	262144

5^1	5
5^2	25
5^3	125
5^4	625
5^5	3125
5^6	15625
5^7	78125
5^8	390625

If you did not have the tables to use, how else could you have simplified the expressions?

What pattern did you see between the original exponents and the resulting exponent? How could you write this as a general rule? *Hint: Make sure to add the appropriate restrictions to your variable(s).*

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Reteaching 8-5

Division Properties of Exponents

OBJECTIVE: Applying division properties of exponents

MATERIALS: None

To divide powers with the same base, subtract exponents.

Example

Simplify $\frac{4^3}{4^5}$.

Method 1

$\frac{4 \cdot 4 \cdot 4}{4 \cdot 4 \cdot 4 \cdot 4 \cdot 4}$ ← Expand the numerator and the denominator.

$\frac{\cancel{4} \cdot \cancel{4} \cdot \cancel{4}}{\cancel{4} \cdot \cancel{4} \cdot \cancel{4} \cdot 4 \cdot 4}$ ← Draw lines through terms that are in both the numerator and the denominator.

$\frac{1}{4 \cdot 4}$ ← Cancel.

$\frac{1}{4^2}$ or 4^{-2} ← Rewrite with exponents.

Method 2

$3 - 5 = -2$ ← Subtract the exponents from the original equation. Compare this to the exponent in the first answer.

So $\frac{4^3}{4^5} = 4^{3-5} = 4^{-2}$. ← Subtract the exponents from the original equation. Compare this to the exponent in the first answer.

$\frac{1}{4^2}$ ← Write with positive exponents.

To raise a quotient to a power use repeated multiplication.

Exercises

Use both methods shown in the example to simplify each expression. Use only positive exponents.

1. $\frac{z^6}{z^3}$
2. $\left(\frac{3^2}{4}\right)^3$
3. $\frac{m^{-3}}{m^{-4}}$
4. $\frac{5^3}{5^4}$
5. $\left(\frac{b^7}{b^5}\right)^3$
6. $\frac{5a^5}{15a^2}$
7. $\frac{2^2}{2^5}$
8. $\frac{d^8}{d^3}$
9. $\frac{x^7}{x^5}$
10. $\left(\frac{10^8}{10^2}\right)^3$
11. $\frac{14x^{11}}{7x^{10}}$
12. $\frac{8x^9}{12x^6}$
13. $\frac{x^{12}}{x^5}$
14. $\frac{6x^4}{4x^2}$
15. $\frac{x^3}{x^8}$
16. $\left(\frac{x^5}{x^3}\right)^4$

Unit 3 Review:

1. Write in exponential form: $r \cdot r \cdot r \cdot r \cdot r \cdot r$

2. Simplify $7z^{-3}$.

3. Simplify $\dfrac{7a^2b^{-2}}{c^5d^{-4}}$

4. Simplify $\dfrac{10\,x^5\,y^3}{15\,x^2\,y^5}$

5. Simplify $5x^2 \cdot 3x \cdot 2x^4$

6. Simplify $(x^{10}y^5z^{-1})^0$

7. Write in exponential form:

$(-3z)(-3z)(-3z)$

8. Simplify: $\frac{12x^6}{18x^{-5}}$

9. Simplify $(3a)^2 \cdot (4a^3)^2 \cdot a^3$

10. simplify $(3m^5n^2)(2m^{-2}n^3)(5m^4n^3)$

11. Simplify $(2ab)^3$

12. Simplify $(x^4)^5$

13. Rewrite without using exponents.

x^4y^5

14. Simplify $\frac{y^9}{y^{12}}$