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Exponentially Speaking
Powers and Exponents

Vocabulary

Write the term that best completes each statement.

1. The _____ of a power is the number of times that the factor is repeatedly multiplied.

2. An expression used to represent a factor as repeated multiplication is called a _____.

3. The _____ of a power is the repeated factor in a power.

Problem Set

State the base and the exponent of each power.

1. 9^4

The base is 9 and the exponent is 4.

2. 10^2

3. 18^6

4. 2^7

5. -11^9

6. -48^3

7. $(-15)^2$

8. $(-14)^6$

9. 7^3x^3

10. $(13x)^2$

11. $(-22y)^4$

12. $-(71y)^5$

16

Write each power in expanded notation and evaluate to calculate the product.

13. 4^3

The expanded notation is $(4)(4)(4) = 64$.

14. 2^4

15. 5^4

16. 7^5

17. 3^8

18. 6^3

Write each power in expanded notation and evaluate to calculate the product.

19. $(-8)^3$

The expanded notation is $(-8)(-8)(-8) = -512$.

20. $(-4)^5$

21. $(-3)^4$

22. $(-6)^6$

23. $-(2^5)$

24. $-(5^6)$

25. $-(7^2)$

26. $-(8^3)$

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16

Write each expression in expanded notation and evaluate to calculate the product.

27. $(4)^2(-5)^3$

The expanded notation is
$(4)(4)(-5)(-5)(-5) = -2000$.

28. $(-4)^4(7)^2$

29. $(2)^5(-6)^2$

30. $(-2)^5(8)^3$

31. $-(3)^6(2)^4$

32. $-(6)^3(4)^2$

33. $-(4)^3(8)^2$

34. $-(5)^3(9)^2$

Write each expression in expanded notation.

35. 3^2x^3

The expanded notation is
$(3)(3)(x)(x)(x)$.

36. 2^5y^2

37. 5^2y^4

38. x^5z^2

16

39. $(5x)^4$

40. $(7x)^2$

41. $(6z)^3$

42. $(2xy)^5$

43. $5x^3$

44. $4y^5$

Write each expression in expanded notation.

45. $-(7z)^5$

The expanded notation is
$-(7z)(7z)(7z)(7z)(7z)$.

46. $-(6y)^3$

47. $(-4a)^3$

48. $(-2b)^6$

49. $-8z^4$

50. $-6m^7$

51. $-(3x)^2 y^4$

52. $(-8y)^3 z^2$

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Write each expression using exponents.

53. (7)(7)(7)(7)

    The power is 7^4.

54. $2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$

55. $4 \cdot 4 \cdot 4 \cdot 4 \cdot 4 \cdot 4$

56. (5)(5)(5)(5)

57. $(-3)(-3)(-3)(-3)(-3)$

58. $-9 \cdot -9 \cdot -9 \cdot -9 \cdot -9 \cdot -9 \cdot -9$

59. $-4 \cdot -4 \cdot -4 \cdot -4 \cdot -4$

60. $-(6)(6)(6)(6)$

61. $-2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$

62. $-5 \cdot 5 \cdot 5$

Write each expression using exponents.

63. $y \cdot y \cdot y \cdot y \cdot y$

    The power is y^5.

64. $x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x$

65. $(a)(a)(a)(a)(a)(a)(a)$

66. $b \cdot b \cdot b \cdot b \cdot b \cdot b$

67. $-z \cdot -z \cdot -z \cdot -z$

68. $(-m)(-m)(-m)(-m)(-m)(-m)$

69. $-b \cdot -b \cdot -b \cdot -b \cdot -b$

70. $-n \cdot n \cdot n \cdot n \cdot n$

71. $-(x)(x)(x)(x)$

72. $-y \cdot y \cdot y \cdot y \cdot y \cdot y \cdot y \cdot y$

Write each expression using exponents.

73. $(-x)(-x)(-x)(-y)(-y)$

   The power is $(-x)^3(-y)^2$.

74. $(-a)(-a)(-a)(-a)(c)(c)(c)(c)(c)$

75. $(-y) \cdot (-y) \cdot z \cdot z \cdot z \cdot z \cdot z$

76. $(-m) \cdot (-m) \cdot (-m) \cdot (-m) \cdot (-m) \cdot n \cdot n \cdot n$

77. $(-a)(-a)(-a)(b)(b)(b)$

78. $-6 \cdot 6 \cdot 6 \cdot b \cdot b \cdot h \cdot h \cdot h$

79. $-4 \cdot 4 \cdot 4 \cdot 4 \cdot 4 \cdot m \cdot m \cdot m \cdot n \cdot n$

80. $-3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot y \cdot y \cdot y \cdot y \cdot z \cdot z \cdot z$

81. $-5 \cdot 5 \cdot a \cdot a \cdot a \cdot a \cdot a \cdot b \cdot b$

82. $-2 \cdot 2 \cdot 2 \cdot 2 \cdot x \cdot x \cdot x \cdot y \cdot y \cdot y \cdot y$

Write each expression using exponents.

83. $3x \cdot 3x \cdot 3x \cdot y \cdot y \cdot y \cdot z \cdot z \cdot z \cdot z \cdot z$

   The power is $(3x)^3 y^3 z^5$.

84. $4a \cdot 4a \cdot 2b \cdot 2b \cdot 2b \cdot c \cdot c \cdot c \cdot c$

85. $5mn \cdot 5mn \cdot 5mn \cdot 5mn \cdot l \cdot l \cdot l$

86. $(-2x)(-2x)(-2x)(y)(y)(z)(z)(z)$

87. $a \cdot a \cdot a \cdot (-4b) \cdot (-4b) \cdot c \cdot c$

88. $-6m \cdot 6m \cdot 6m \cdot 6m \cdot n \cdot n \cdot n$

89. $-3x \cdot 3x \cdot 3x \cdot (-2y) \cdot (-2y) \cdot z \cdot z \cdot z \cdot z$

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Digital Storage
Multiplying and Dividing Powers

Problem Set

Write each expression in expanded form.

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

$5 \cdot 5 \cdot 5 \cdot 5 \cdot 5 \cdot 5$

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

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

4. $2^2 \cdot 2^3$

Simplify each expression. Show your work.

5. $(9)^2(9)^4$

$(9)^2(9)^4 = 9^{2+4}$

$ = 9^6$

6. $(-4)^3(-4)^7$

7. $(-2)^2(-2)^5$

8. $(-8)^4(-8)^5$

Write each expression in expanded form.

9. $x^2 \cdot x^3$

$x \cdot x \cdot x \cdot x \cdot x$

10. $y \cdot y^2$

11. $m^5 \cdot m^2$

12. $n^4 \cdot n^5$

16

Simplify each expression. Show your work.

13. $(-a)^3(-a)^4$

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

$= (-a)^7$

14. $(-b)^2(-b)^4$

15. $(-c)(-c)^3$

16. $(-z)^6(-z)^2$

Simplify each expression. Show your work.

17. $x^2y^2x^3y^5$

$x^2y^2x^3y^5 = (x^2x^3)(y^2y^5)$

$= x^{2+3}y^{2+5}$

$= x^5y^7$

18. $a^3b^2ab^4$

19. $7y^3z^4 \cdot 2yz^3$

20. $3mn^3 \cdot 8m^6n^7$

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21. $5y^3 \cdot 3yz^3 \cdot z^2$

22. $9b^2 \cdot 2a^5 \cdot a^2b^6$

23. $(-y)^2 \cdot (-y)^4 \cdot z \cdot z$

24. $(-m)^2 \cdot n^3 \cdot (-m)^4 \cdot n^2$

25. $3x^3 \cdot 2x^2 \cdot y^3 \cdot y$

26. $(-b) \cdot 4a \cdot (-b)^5 \cdot 2a^3$

16

Simplify each expression. Show your work.

27. $(2^2)^3$

$(2^2)^3 = 2^{2\cdot3}$

$\qquad = 2^6$

28. $(4^3)^5$

29. $(7^2)^4$

30. $(3^3)^2$

31. $-(2^2)^4$

32. $-(6^5)^2$

Simplify each expression. Show your work.

33. $(x^5)^2$

$(x^5)^2 = x^{5\cdot2}$

$\qquad = x^{10}$

34. $(y^3)^2$

35. $(m^3)^5$

36. $(n^4)^3$

37. $(-b^2)^6$

38. $-(m^2)^4$

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Simplify each expression. Show your work.

39. $(3x^2y)^4$

$(3x^2y)^4 = 3^4(x^2)^4y^4$

$\qquad = 81(x)^{2\cdot4}y^4$

$\qquad = 81x^8y^4$

40. $(2a^2b^3)^5$

41. $(-4mn^3)^3$

42. $(-5y^3z^2)^5$

43. $(-2cd^2)^4$

44. $(-2x^3y^4)^2$

Write each numerator and denominator in expanded form.

45. $\dfrac{7^4}{7^2}$

$$\dfrac{7 \cdot 7 \cdot 7 \cdot 7}{7 \cdot 7}$$

46. $\dfrac{4^8}{4^5}$

16

47. $\dfrac{9^6}{9^2}$

48. $\dfrac{5^9}{5^3}$

Simplify each expression. Show your work.

49. $\dfrac{3^5}{3^2}$

$$\dfrac{3^5}{3^2} = 3^{5-2}$$

$$= 3^3$$

50. $\dfrac{6^8}{6^5}$

51. $\dfrac{-12^8}{12^4}$

52. $\dfrac{3^9}{-3^2}$

Write each numerator and denominator in expanded form.

53. $\dfrac{x^5}{x^3}$

$$\dfrac{x \cdot x \cdot x \cdot x \cdot x}{x \cdot x \cdot x}$$

54. $\dfrac{y^4}{y^3}$

55. $\dfrac{z^7}{z^2}$

56. $\dfrac{a^6}{a^3}$

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Simplify each expression. Show your work.

57. $\dfrac{n^5}{n^4}$

$\dfrac{n^5}{n^4} = n^{5-4}$

$\quad = n$

58. $\dfrac{m^9}{m^6}$

59. $\dfrac{b^6}{-b^4}$

60. $\dfrac{-h^{14}}{h^6}$

61. $\dfrac{-12x^7}{3x^2}$

62. $\dfrac{24y^8}{4y^4}$

63. $\dfrac{45a^7b^3}{-5a^4b}$

64. $\dfrac{10m^8n^3}{2m^7}$

Simplify each expression. Show your work.

65. $3a^2 \cdot 4a^3$

$3a^2 \cdot 4a^3 = (3 \cdot 4)(a^2 \cdot a^3)$

$\qquad = (12)(a^{2+3})$

$\qquad = 12a^5$

66. $-5m^8 \cdot 7m^2$

67. $(-2b)^3 \cdot 3b^4$

68. $(2n^2)^4$

69. $(-5mn^3)^2$

70. $(4y^3)^2 \cdot (-3y)^2$

71. $\dfrac{12g^5}{2g^3}$

72. $\dfrac{14h^5}{2h^4}$

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73. $\dfrac{-32x^8y^5}{4x^6y}$

74. $\dfrac{40a^5b^7}{-8a^2b^6}$

75. $\dfrac{-18m^5 \cdot m^2n^4}{-6m^3n}$

76. $\dfrac{56xy^3 \cdot (x^3y)^2 \cdot y}{8x^6y}$

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Extending the Rules
Zero and Negative Exponents

Problem Set

Simplify each expression using the properties of powers. Express your solution in expanded notation, and then calculate the value.

1. $\dfrac{5^3}{5^3}$

$\dfrac{5^3}{5^3} = 5^{3-3}$

$\quad = 5^0$

$\quad = 1$

2. $\dfrac{2^4}{2^4}$

3. $\dfrac{7^2}{7^2}$

4. $\dfrac{3^6}{3^6}$

5. $\dfrac{4^9}{4^9}$

6. $\dfrac{6^2}{6^2}$

Simplify each expression using the Quotient Rule of Powers.

7. $\dfrac{2^0}{2^4}$

$\dfrac{2^0}{2^4} = 2^{0-4}$

$\quad = 2^{-4}$

8. $\dfrac{9^0}{9^5}$

9. $\dfrac{8^0}{8^3}$

10. $\dfrac{4^0}{4^3}$

11. $\dfrac{5^0}{5^8}$

12. $\dfrac{3^0}{3^2}$

Rewrite each expression so that the exponent is positive.

13. 3^{-2}

$\dfrac{1}{3^2}$

14. 5^{-9}

15. 6^{-3}

16. 2^{-5}

17. 4^{-8}

18. 7^{-3}

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Rewrite each expression so that the exponent is positive.

19. x^{-3} **20.** y^{-8}

$\dfrac{1}{x^3}$

21. $a^{-8}b^{-2}$ **22.** $m^{-4}n^{-5}$

23. $y^{-4}z^{-3}$ **24.** $x^{-2}y^{-6}$

Rewrite each expression so that the exponent is positive.

25. $\dfrac{1}{2^{-5}}$ **26.** $\dfrac{1}{6^{-3}}$

2^5

27. $\dfrac{1}{9^{-4}}$ **28.** $\dfrac{1}{4^{-2}}$

29. $\dfrac{1}{7^{-3}}$ **30.** $\dfrac{1}{5^{-4}}$

Rewrite each expression so that the exponent is positive.

31. $\dfrac{1}{y^{-4}}$ **32.** $\dfrac{1}{x^{-7}}$

y^4

33. $\dfrac{1}{x^{-6}y^{-2}}$ **34.** $\dfrac{1}{a^{-3}b^{-8}}$

35. $\dfrac{1}{m^{-5}n^{-9}}$ **36.** $\dfrac{1}{g^{-7}h^{-4}}$

Simplify each expression. Show your work.

37. $\dfrac{x^4}{x^4}$

$\quad \dfrac{x^4}{x^4} = x^{4-4}$

$\quad\quad = x^0$

$\quad\quad = 1$

38. $\dfrac{y^{-2}}{y^{-2}}$

39. $(6^0)(6^3)$

40. $(2^0)(2^5)$

41. $\dfrac{12x^2y^3}{4x^2y}$

42. $\dfrac{15a^5b^4}{3a^2b^4}$

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Simplify each expression. Then, calculate the value. Do not leave your answer as a power.

43. $\dfrac{3^2}{3^4}$

$\dfrac{3^2}{3^4} = 3^{2-4}$

$= 3^{-2}$

$= \dfrac{1}{3^2}$

$= \dfrac{1}{9}$

44. $\dfrac{4^5}{4^8}$

45. $(6^5)(6^{-7})$

46. $(2^4)(2^{-8})$

47. $\dfrac{5^{-3}}{5^{-6}}$

48. $\dfrac{3^{-5}}{3^{-2}}$

Simplify each expression so that the exponent is positive. Show your work.

49. $\dfrac{y^3}{y^5}$

$$\dfrac{y^3}{y^5} = y^{3-5}$$

$$= y^{-2}$$

$$= \dfrac{1}{y^2}$$

50. $\dfrac{x^4}{x^9}$

51. $\dfrac{a^{-5}}{a^2}$

52. $\dfrac{c^8}{c^{-4}}$

53. $\dfrac{x^4 y^{-3}}{xy^2}$

54. $\dfrac{m^3 n^2}{m^5 n^6}$

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55. $\dfrac{(x^2y^{-5}) \cdot (xy)}{x^4y^3}$

56. $\dfrac{18a^2b^2}{6ab^3 \cdot ab^{-4}}$

57. $\dfrac{36m^4n^6}{4m^2n^3 \cdot mn^8}$

58. $\dfrac{5c^2d^3 \cdot c^5d}{40c^4 \cdot cd^7}$

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Let's Get Scientific!
Scientific Notation

Vocabulary

Match each definition to its corresponding term.

1. a way to express a very large or very small number as the product of a number between 1 and 10 and a power of 10

a. scientific notation

2. the decimal part of a number written in scientific notation; the number a in $a \times 10^n$

b. order of magnitude

3. an estimate of size expressed as a power of 10

c. mantissa

4. the exponent of 10 for a number written in scientific notation; the number n in $a \times 10^n$

d. characteristic

Problem Set

Write each number in scientific notation. Show your work.

1. 45,000,000

$45,000,000 = (4.5)(10,000,000)$

$= (4.5)(10^7)$

The number written in scientific notation is 4.5×10^7.

2. 3700

3. 562,000

4. 92,400,000,000

5. There are over 29,000 grains of long-grain rice in a one-pound bag.

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6. There are about 100,000,000,000 stars in our galaxy.

7. The distance from the Earth to the Moon is about 385,000,000 meters.

8. The average distance between the Earth and the Sun is about 93,000,000 miles.

Write each number in standard notation. Show your work.

9. 5.2×10^7

$5.2 \times 10^7 = (5.2)(10^7)$

$= (5.2)(10{,}000{,}000)$

The number written in standard notation is 52,000,000.

10. 3.7×10^8

11. 2.871×10^{11}

12. 4.26×10^9

13. There are about 1×10^5 strands of hair on the human head.

14. The population of Texas is about 2.4×10^7 people.

15. The population of California is about 3.7×10^7 people.

16. The circumference of the Earth at the equator is about 4.008×10^7 meters.

Write each number in scientific notation. Show your work.

17. 0.000067

$0.000067 = (6.7)(0.00001)$

$0.00001 = \dfrac{1}{100,000}$

$= \dfrac{1}{10^5}$

$= 10^{-5}$

The number written in scientific notation is
6.7×10^{-5}.

18. 0.000831

19. 0.00000000253

20. 0.00000092

21. A grain of rice weighs about 0.025 grams.

22. The diameter of a red blood cell is about 0.00004 inches.

16

16

23. A grain of salt weighs about 0.0000585 grams.

24. A credit card is about 0.0299 inches thick.

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Write each number in standard notation. Show your work.

25. 8.3×10^{-5}

$8.3 \times 10^{-5} = (8.3)(10^{-5})$

$\qquad = (8.3)\left(\dfrac{1}{10^5}\right)$

$\qquad = (8.3)\left(\dfrac{1}{100,000}\right)$

$\qquad = (8.3)(0.00001)$

The number written in standard notation is 0.000083.

26. 6.22×10^{-9}

27. 4.7×10^{-3}

28. 3.85×10^{-12}

16

29. An oxygen atom has a radius of about 4.8×10^{-11} meters.

30. The diameter of a white blood cell is about 1×10^{-5} meters.

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31. A nitrogen atom has a radius of about 5.6×10^{-11} meters.

32. The width of a human hair is about 1.8×10^{-3} centimeters.

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Are We There Yet? What Is the Distance?
Operations with Scientific Notation

Problem Set

Calculate each product. Express the product in scientific notation.

1. $(4 \times 10^3)(2 \times 10^6)$

$(4 \times 10^3)(2 \times 10^6) = (4)(2)(10^3)(10^6)$

$= (8)(10^{3+6})$

$= 8 \times 10^9$

2. $(3 \times 10^7)(2 \times 10^5)$

3. $(8 \times 10^6)(1 \times 10^{-3})$

4. $(2 \times 10^{-3})(3 \times 10^8)$

5. $(3.7 \times 10^4)(5.2 \times 10^9)$

6. $(7.9 \times 10^3)(2.6 \times 10^5)$

16

7. $(2.8 \times 10^{-8})(6.31 \times 10^{4})$

8. $(4.2 \times 10^{-4})(9.1 \times 10^{-6})$

9. Seismosaurus is the longest known dinosaur. It measured 1800 inches. How far would 3000 Seismosaurus dinosaurs span if they were placed head to tail? Use scientific notation to calculate the length.

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10. According to many scientists, Argentinosaurus is the heaviest known dinosaur. It weighed 220,000 pounds. How much would 1500 Argentinosaurus dinosaurs weigh? Use scientific notation to calculate the weight.

11. The bee hummingbird is the world's smallest bird. It is about 0.05842 meters long. How far would 2,000,000 bee hummingbirds span if they were placed head to tail? Use scientific notation to calculate the length.

12. The pygmy shrew is the world's smallest mammal by weight. It weighs just 0.0013 kilograms. How much would 3,000,000 pygmy shrews weigh? Use scientific notation to calculate the weight.

16

Simplify each expression. Express the quotient in scientific notation.

13. $\dfrac{(8 \times 10^5)}{(2 \times 10^2)}$

$$\frac{(8 \times 10^5)}{(2 \times 10^2)} = \left(\frac{8}{2}\right)\left(\frac{10^5}{10^2}\right)$$

$$= (4)(10^{5-2})$$

$$= (4)(10^3)$$

$$= 4 \times 10^3$$

14. $\dfrac{(12 \times 10^8)}{(6 \times 10^3)}$

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15. $\dfrac{(15 \times 10^{-7})}{(5 \times 10^{4})}$

16. $\dfrac{(18 \times 10^{-2})}{(3 \times 10^{-6})}$

17. $\dfrac{(1.508 \times 10^{7})}{(2.6 \times 10^{3})}$

18. $\dfrac{(5.92 \times 10^{6})}{(3.7 \times 10^{4})}$

19. $\dfrac{(3.68 \times 10^{-8})}{(3.2 \times 10^{-4})}$

20. $\dfrac{(8.82 \times 10^{-7})}{(2.52 \times 10^{-2})}$

Simplify each expression. Express your answer in scientific notation.

21. $(5.9 \times 10^5)(4.8 \times 10^3)$

$(5.9 \times 10^5)(4.8 \times 10^3) = (5.9)(4.8)(10^5)(10^3)$

$$= (28.32)(10^{5+3})$$

$$= 28.32 \times 10^8$$

$$= 2.8 \times 10^9$$

22. $(7.83 \times 10^3)(2.9 \times 10^8)$

23. $(2.90 \times 10^{-7})(4.860 \times 10^{-2})$

24. $(5.31 \times 10^5)(6 \times 10^{-8})$

25. $\dfrac{(4.5 \times 10^5)}{(3.8 \times 10^2)}$

26. $\dfrac{(5.12 \times 10^6)}{(8 \times 10^3)}$

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27. A football is about 280 millimeters long. A football field is about 100,000 millimeters long. How many footballs placed end to end would be needed to span the field? Use scientific notation to calculate the number of footballs.

16

28. A large Siberian tiger can weigh up to 305,000 grams. A small Sand cat can weigh as little as
    1500 grams. How many times greater is the weight of a Siberian tiger than the weight of a
    Sand cat? Use scientific notation to calculate the difference in weight.

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Watch Your Step!
Identifying the Properties of Powers

Problem Set

Justify each step to simplify the expression. Choose the properties from the box.

Product Rule of Powers	Power to a Power Rule	Negative Exponent Rule	Quotient Rule of Powers
Zero Power Rule	Simplify Powers	Identity Property of Multiplication	Commutative Property of Multiplication

1. $4x^5 \cdot 6x^2y^6 \cdot xy$

$4x^5 \cdot 6x^2y^6 \cdot xy = (4 \cdot 6)(x^5x^2x)(y^6y)$ Commutative Property of Multiplication

$\qquad\qquad = (24)(x^{5+2+1})(y^{6+1})$ Product Rule of Powers

$\qquad\qquad = 24x^8y^7$ Simplify Powers

2. $3a^2b^3 \cdot 7ab^5 \cdot b^2$

3. $(4m^2n^5)^3$

4. $(-3x^7y^3)^5$

5. $\dfrac{27y^8z^5}{-3y^4z^2}$

6. $\dfrac{-96m^9n^2}{8m^2n^6}$

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7. $-2x^5y^3 \cdot 8x^2y^{-5} \cdot x^{-9}y^2$

8. $\dfrac{42m^5n^3 \cdot m^4n^2}{6m^6n^5}$

Choose which solution is correct.

9. a.

$3x^2 \cdot 4x^3 = (3 \cdot 4)(x^2 x^3)$

$= (12)(x^{2+3})$

$= (12)(x^5)$

$= 12x^5$

b.

$3x^2 \cdot 4x^3 = (3 \cdot 4)(x^2 x^3)$

$= (12)(x^{2-3})$

$= (12)(x^{-1})$

$= \dfrac{12}{x}$

c.

$3x^2 \cdot 4x^3 = (3 \cdot 4)(x^2 x^3)$

$= (12)(x^{2 \cdot 3})$

$= (12)(x^6)$

$= 12x^6$

The correct solution is a.

10. a.

$-5a^6 \cdot 2a^3$

$= (-5 \cdot 2)(a^6 a^3)$

$= (-10)(a^{6-3})$

$= (-10)(a^3)$

$= -10a^3$

b.

$-5a^6 \cdot 2a^3$

$= (-5 \cdot 2)(a^6 a^3)$

$= (-10)(a^{6 \cdot 3})$

$= (-10)(a^{18})$

$= -10a^{18}$

c.

$-5a^6 \cdot 2a^3$

$= (-5 \cdot 2)(a^6 a^3)$

$= (-10)(a^{6+3})$

$= (-10)(a^9)$

$= -10a^9$

11. a.

$\dfrac{36m^{12}}{4m^4} = \left(\dfrac{36}{4}\right)\left(\dfrac{m^{12}}{m^4}\right)$

$= (9)(m^{12 \div 4})$

$= (9)(m^3)$

$= 9m^3$

b.

$\dfrac{36m^{12}}{4m^4} = \left(\dfrac{36}{4}\right)\left(\dfrac{m^{12}}{m^4}\right)$

$= (9)(m^{12-4})$

$= (9)(m^8)$

$= 9m^8$

c.

$\dfrac{36m^{12}}{4m^4} = \left(\dfrac{36}{4}\right)\left(\dfrac{m^{12}}{m^4}\right)$

$= (9)(m^{12+4})$

$= (9)(m^{16})$

$= 9m^{16}$

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12. a.

$$\frac{60x^2}{5x^8} = \left(\frac{60}{5}\right)\left(\frac{x^2}{x^8}\right)$$

$$= (12)(x^{8-2})$$

$$= (12)(x^6)$$

$$= 12x^6$$

b.

$$\frac{60x^2}{5x^8} = \left(\frac{60}{5}\right)\left(\frac{x^2}{x^8}\right)$$

$$= (12)(x^{2+8})$$

$$= (12)(x^{10})$$

$$= 12x^{10}$$

c.

$$\left(\frac{60x^2}{5x^8}\right) = \left(\frac{60}{5}\right)\left(\frac{x^2}{x^8}\right)$$

$$= (12)(x^{2-8})$$

$$= (12)(x^{-6})$$

$$= \frac{12}{x^6}$$

13. a.

$$(5x^2)^3 = (5)^3(x^2)^3$$

$$= (125)(x^{2\cdot3})$$

$$= (125)(x^6)$$

$$= 125x^6$$

b.

$$(5x^2)^3 = (5)^3(x^2)^3$$

$$= (125)(x^{2+3})$$

$$= (125)(x^5)$$

$$= 125x^5$$

c.

$$(5x^2)^3 = (5)^3(x^2)^3$$

$$= (125)(x^{2^3})$$

$$= (125)(x^8)$$

$$= 125x^8$$

14. a.

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

$$= (64)(y^{-3+3})$$

$$= (64)(y^0)$$

$$= (64)(1)$$

$$= 64$$

b.

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

$$= (64)(y^{-3\cdot3})$$

$$= (64)(y^{-9})$$

$$= \frac{64}{y^9}$$

c.

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

$$= (64)(y^{-3-3})$$

$$= (64)(y^{-6})$$

$$= \frac{64}{y^6}$$

16

Simplify each expression. Show your work.

15. $12x^4y^3 \cdot 3x^2y^{-5}$

$12x^4y^3 \cdot 3x^2y^{-5} = (12 \cdot 3)(x^4x^2)(y^3y^{-5})$

$= (36)(x^{4+2})(y^{3+(-5)})$

$= (36)(x^6)(y^{-2})$

$= \dfrac{36x^6}{y^2}$

16. $17a^{-5}b^{-3} \cdot 2a^7b^{-2}$

17. $(-3x^4y^{-3})^2$

18. $(2a^5b^2c^3)^5$

19. $\dfrac{28m^3n^5}{14m^7n^2}$

20. $\dfrac{35x^8y^6}{7x^5y^3}$

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21. $(2x^5y^3)^2 \cdot x^2y^4$

22. $\dfrac{3a^4b^5 \cdot 4a^3b^2}{6a^7b^9}$

23. $\dfrac{(4m^3n^2)^4}{8m^5}$

24. $\dfrac{5x^2y^4 \cdot 6x^4y}{10x^3y^3}$