

## 12.1 Exercises

### Concept Check

**Fill-in-the-Blank.** Complete each sentence using information found in this section.

- The quotient rule for exponents says that when dividing two powers with the same base, keep the base and \_\_\_\_\_ the exponents.
- The product rule for exponents says that when multiplying two powers with the same base, keep the base and \_\_\_\_\_ the exponents.
- An expression is considered simplified if each base appears only once and each base has only \_\_\_\_\_ exponents.
- The expression  $0^0$  is \_\_\_\_\_.
- For all real values of  $a$ ,  $a^1 = \underline{\hspace{1cm}}$ .
- For all real values of  $a$ ,  $a^0 = \underline{\hspace{1cm}}$ .

**True/False.** Determine whether each statement is true or false. If a statement is false, explain how it can be changed so the statement will be true. (**Note:** There may be more than one acceptable change.)

- If a constant does not have an exponent written, it is assumed that the exponent is 0.
- If  $a$  is a nonzero real number and  $n$  is an integer, then  $a^{-n} = -a^n$ .
- Since the product rule is stated for integer exponents, the rule is also valid for 0 and negative exponents.
- When using the quotient rule, you should subtract the smaller exponent from the larger exponent.

### Practice

Simplify each expression. The final form of the expressions with variables should contain only positive exponents. Assume that all variables represent nonzero numbers. See Examples 1 through 7.

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

25.  $2x^{-1}$

26.  $5y^{-4}$

27.  $-8y^{-2}$

28.  $-10x^{-3}$

29.  $5x^6y^{-4}$

30.  $x^0y^{-2}$

31.  $3x^0 + y^0$

32.  $5y^0 - 3x^0$

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

34.  $\frac{9^5}{9^2}$

35.  $\frac{10^3}{10^4}$

36.  $\frac{10}{10^5}$

37.  $\frac{2^3}{2^6}$

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

39.  $\frac{x^4}{x^2}$

40.  $\frac{x^6}{x^3}$

41.  $\frac{x^3}{x}$

42.  $\frac{y^7}{y^2}$

43.  $\frac{x^7}{x^3}$

44.  $\frac{x^8}{x^3}$

45.  $\frac{x^{-2}}{x^2}$

46.  $\frac{x^{-3}}{x}$

47.  $\frac{x^4}{x^{-2}}$

48.  $\frac{x^5}{x^{-1}}$

49.  $\frac{x^{-3}}{x^{-5}}$

50.  $\frac{x^{-4}}{x^{-1}}$

51.  $\frac{y^{-2}}{y^{-4}}$

52.  $\frac{y^3}{y^{-3}}$

53.  $3x^3 \cdot x^0$

54.  $3y \cdot y^4$

55.  $x^3 \cdot x^2 \cdot x^{-1}$

56.  $x^{-3} \cdot x^0 \cdot x^2$

57.  $(4x^3)(9x^0)$

58.  $(5x^2)(3x^4)$

59.  $(-2x^2)(7x^3)$

60.  $(3y^3)(-6y^2)$

61.  $(-4x^5)(3x)$

62.  $(6y^4)(5y^5)$

63.  $\frac{8y^3}{2y^2}$

64.  $\frac{12x^4}{3x}$

65.  $\frac{9y^5}{3y^3}$

66.  $\frac{-10x^5}{2x}$

67.  $\frac{-8y^4}{4y^2}$

68.  $\frac{12x^6}{-3x^3}$

69.  $\frac{x^{-1} \cdot x^2}{x^3}$

70.  $\frac{x \cdot x^3}{x^{-3}}$

71.  $\frac{10^4 \cdot 10^{-3}}{10^{-2}}$

72.  $\frac{10 \cdot 10^{-1}}{10^2}$

73.  $(9x^2)^0$

74.  $(-2x^{-3}y^5)^0$

75.  $(9x^2y^3)(-2x^3y^4)$

76.  $(-3xy)(-5x^2y^{-3})$

77.  $\frac{-8x^2y^4}{4x^3y^2}$

78.  $\frac{-8x^{-2}y^4}{4x^2y^{-2}}$

79.  $(3a^2b^4)(4ab^5c)$


80.  $(-6a^3b^4)(4a^{-2}b^8)$

81.  $\frac{36a^5b^0c}{-9a^{-5}b^{-3}}$

82.  $\frac{7x^2y^{-2}}{28x^0yz^{-2}}$

83.  $\frac{25y^6 \cdot 3y^{-2}}{15xy^4}$

84.  $\frac{12a^{-2} \cdot 18a^4}{36a^2b^{-5}}$

 Use a graphing calculator to evaluate each expression. Round quotients to the nearest ten-thousandth, if necessary. See Example 8.

85.  $(2.16)^0$

87.  $(1.6)^{-2}$

89.  $(6.4)^4(2.3)^2$

86.  $(-5.06)^2$

88.  $(2.5)^{-4}$

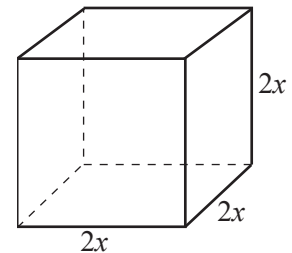
90.  $(-14.8)^2(21.3)^2$

## Applications

Solve.

91. Rylee wants to move all her files to a new hard drive that has  $2^{12}$  GB of storage on it. She wants to designate the same amount of storage for each of  $2^4$  projects. How much storage should be assigned to each project? Write your answer as a power of two.
92. Trey is studying patterns in bacteria. For a positive test result in his experiment, bacteria must grow in population at a minimum rate of  $3^2$  in 24 hours. If the initial population of the bacteria is  $3^5$  and his final measurement after 24 hours is  $3^8$ , should he mark the test as positive or negative?
93. A molecule being studied under a powerful microscope is cubic in shape. What is the volume of the molecule if the length of one side is  $10^{-8}$  cm?
94. A hurricane caused flooding in a home at the rate of  $2^3$  ft<sup>3</sup> per hour. If that home has a storage closet that is  $2^1$  feet wide,  $2^3$  feet long, and  $2^4$  feet high, how long will it take the storage closet to fill with water? Write your answer as a power of 2.
95. A conference center needs an array of gift bags set up for a meeting. There will be  $2^5$  gift bags per row and  $2^4$  rows of gift bags. The delivery truck can hold  $2^9$  gift bags per load. How many deliveries will the truck need to make in order to supply the gift bags needed?
96. A local children's convention receives donations of  $2^8$  bags of candy for use as gifts for attendees. The convention has  $2^7$  children attending. How many bags of candy will each child receive?
97. Molly buys land that is  $3^4$  yards wide and  $3^5$  yards long. What is the area of the land? Write your answer as a power of 3.
98. Samuel wants to buy grass seed to plant in his yard. His lawn is  $2^6$  feet wide and 27 feet long. Each bag of grass seed will cover  $2^{10}$  square feet. How many bags of seed should he purchase? Write your answer as a power of 2.

99. Barbara's Bombtastic Bakery makes *petit four glaces*, which are small bite-sized cakes. Each cake is in the shape of a cube that has a side length of  $2x$ , where  $x$  is a positive length which varies depending on the cake flavor.



- a. Write an expression using exponents to find the volume of the *petit four glaces*. Do not simplify.
- b. Which exponential rule will you need to use to simplify the expression from part a.?
- c. Simplify the expression from part a.
- d. If  $x = 2$  cm, determine the volume of the *petit four glaces* using the expression from part c.

- 100.** A strain of the influenza virus is spreading throughout a community and the number of confirmed cases of the flu doubles every day. On day 0 (the initial day) of the outbreak, 1 person has the virus. On day 1 of the outbreak,  $1 \cdot 2 = 2$  people will have the virus. On day 2 of the outbreak,  $1 \cdot 2 \cdot 2 = 1 \cdot 2^2 = 4$  people will have the virus.
- Write an exponential expression to describe how many people will have influenza virus on day 5. Write as a power of 2 and simplify.
  - Write an exponential expression to describe how many people would have the virus on day  $n$  if 3 people had the virus on day 0 of the outbreak. Write the expression in exponential form and simplify.
  - Use the expression from part b. to determine the number of people that will have the virus on day 5 of the outbreak if 3 people had the virus on day 0?
- 101.** A standard hard drive has  $2^{38}$  bytes of data. 1 gigabyte is equivalent to 230 bytes.
- Write an exponential expression to determine how many gigabytes are equivalent to  $2^{38}$  bytes?
  - Simplify the expression from part a. to determine how many gigabytes are in  $2^{38}$  bytes.
  - What rule of exponents did you use to simplify part b.?