

# Properties of Exponents

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Score: \_\_\_\_\_ / 26

## Quick Review

The **exponent rules**: (1) **Product rule**:  $x^a \cdot x^b = x^{a+b}$  (same base → add exponents). (2) **Quotient rule**:  $\frac{x^a}{x^b} = x^{a-b}$  (same base → subtract). (3) **Power rule**:  $(x^a)^b = x^{ab}$  (multiply). (4) **Zero exponent**:  $x^0 = 1$  (for any  $x \neq 0$ ). (5) **Negative exponent**:  $x^{-a} = \frac{1}{x^a}$  (flip to denominator and negate). (6) **Power of product**:  $(xy)^a = x^a y^a$ . (7) **Power of quotient**:  $\left(\frac{x}{y}\right)^a = \frac{x^a}{y^a}$ .  
 Memorize these and most simplification problems become straightforward substitutions.

## PRACTICE

Simplify each expression.

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

## VISUAL PRACTICE

Use the graph, table, chart, or diagram to answer the question.

21. Find the area of the rectangle.



Answer: \_\_\_\_\_

22. Find the area of the rectangle.



Answer: \_\_\_\_\_

## Word Problems

23. A bacteria population doubles every hour. If it starts at  $x$ , write the population after 5 hours. \_\_\_\_\_
24. A design file is compressed to  $\left(\frac{1}{2}\right)^3$  of its original size, then compressed again to  $\left(\frac{1}{2}\right)^2$  of that result. What fraction of the original file remains? \_\_\_\_\_
25. A storage box has side lengths  $2x$  inches,  $3x$  inches, and  $x^2$  inches. Write a simplified expression for its volume. \_\_\_\_\_
26. A sensor records one reading every  $\frac{1}{1000}$  second. Write the time between readings as a power of 10 with a negative exponent. \_\_\_\_\_



## Answer Keys

- |  |  |
|--|--|
| <ol style="list-style-type: none"> <li>1. <math>x^7</math></li> <li>2. <math>y^7</math></li> <li>3. <math>x^5</math></li> <li>4. <math>x^8</math></li> <li>5. <math>8x^3</math></li> <li>6. <math>\frac{1}{x^2}</math></li> <li>7. 1</li> <li>8. <math>x^3</math></li> <li>9. <math>9x^4</math></li> <li>10. <math>\frac{x^3}{8}</math></li> <li>11. <math>x^3</math></li> <li>12. <math>x^{-4} = \frac{1}{x^4}</math></li> <li>13. <math>x^2y^6</math></li> </ol> | <ol style="list-style-type: none"> <li>14. <math>\frac{1}{x^3}</math></li> <li>15. <math>3x^3</math></li> <li>16. <math>16x^{12}</math></li> <li>17. <math>\frac{1}{x^2}</math></li> <li>18. <math>\frac{4x^4}{9}</math></li> <li>19. <math>x^2</math></li> <li>20. <math>-27x^6</math></li> <li>21. <math>6x^5</math></li> <li>22. <math>12a^7</math></li> <li>23. <math>32x</math></li> <li>24. <math>\frac{1}{32}</math></li> <li>25. <math>6x^4</math></li> <li>26. <math>10^{-3}</math> second</li> </ol> |
|--|--|

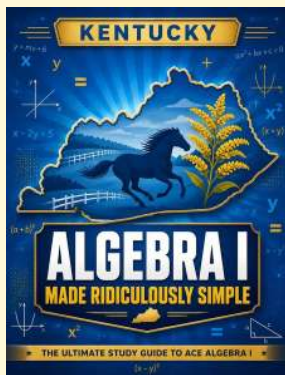
### Step-by-Step Tutor Notes

1. Work one inverse operation at a time and keep both sides balanced. Add exponents:  $3 + 4 = 7$ . After simplifying, the answer is  $x^7$ .
2. This is a good place to slow down, check the notation, and simplify cleanly.  $2 + 5 = 7$ . So the answer is  $y^7$ .
3. Keep the order of operations in view, then simplify without skipping the sign check. Subtract:  $8 - 3 = 5$ . After simplifying, the answer is  $x^5$ .
4. Move carefully through the arithmetic; one clean operation usually unlocks the next one. Multiply:  $2 \cdot 4 = 8$ . After simplifying, the answer is  $x^8$ .
5. Start with the definition the problem is testing, then apply it directly.  $(2)^3 \cdot x^3 = 8x^3$ . So the answer is  $8x^3$ .
6. Start with the definition the problem is testing, then apply it directly. Negative exponent flips to denominator. So the answer is  $\frac{1}{x^2}$ .
7. Use the structure of the expression to find the important point, then check that it fits the context. Anything (nonzero) to the 0 is 1. That leads to 1.
8. Work one inverse operation at a time and keep both sides balanced. Combine top:  $x^6$ . Divide:  $x^{6-3} = x^3$ . After simplifying, the answer is  $x^3$ .
9. Take it one clear step at a time and keep the original question in mind.  $9 \cdot x^4$ . So the answer is  $9x^4$ .
10. Start with the definition the problem is testing, then apply it directly.  $\frac{x^3}{2^3} = \frac{x^3}{8}$ . So the answer is  $\frac{x^3}{8}$ .
11. Take it one clear step at a time and keep the original question in mind.  $5 + (-2) = 3$ . So the answer is  $x^3$ .
12. This is a good place to slow down, check the notation, and simplify cleanly.  $2 - 6 = -4$ . Or write as  $\frac{1}{x^4}$ . So the answer is  $x^{-4} = \frac{1}{x^4}$ .
13. Use the structure of the expression to find the important point, then check that it fits the context. Each factor gets the exponent. That leads to  $x^2y^6$ .
14. Work one inverse operation at a time and keep both sides balanced. Multiply:  $3 \cdot (-1) = -3$ . After simplifying, the answer is  $\frac{1}{x^3}$ .
15. Use the clue in the question first, then let the arithmetic finish the job. Numbers:  $6/2 = 3$ . Variables:  $x^{5-2} = x^3$ . So the answer is  $3x^3$ .
16. Take it one clear step at a time and keep the original question in mind.  $2^4 = 16$  and  $x^{3 \cdot 4} = x^{12}$ . So the answer is  $16x^{12}$ .
17. Focus on the main idea of the problem, then simplify carefully.  $3 + (-5) = -2$ , so  $\frac{1}{x^2}$ . So the answer is  $\frac{1}{x^2}$ .
18. This is a good place to slow down, check the notation, and simplify cleanly. Square top and bottom. So the answer is  $\frac{4x^4}{9}$ .
19. This is a good place to slow down, check the notation, and simplify cleanly.  $(a + 1) - (a - 1) = 2$ . So the answer is  $x^2$ .
20. Start with the definition the problem is testing, then apply it directly.  $(-3)^3 = -27$ ,  $x^6$ . So the answer is  $-27x^6$ .
21. Move carefully through the arithmetic; one clean operation usually unlocks the next one. Multiply coefficients and add exponents:  $(3x^3)(2x^2) = 6x^5$ . After simplifying, the answer is  $6x^5$ .
22. Work one inverse operation at a time and keep both sides balanced. Multiply the coefficients and add exponents:  $4a^2 \cdot 3a^5 = 12a^7$ . After simplifying, the answer is  $12a^7$ .
23. Set up the model from the story, then calculate carefully. Doubling 5 times:  $x \cdot 2^5 = 32x$ .
24. Both factors have the same base, so add the exponents:  $(\frac{1}{2})^3 (\frac{1}{2})^2 = (\frac{1}{2})^5 = \frac{1}{32}$ .
25. Multiply:  $2 \cdot 3 \cdot 1 = 6$  for the coefficients. For variables:  $x \cdot x \cdot x^2 = x^4$ . Volume =  $6x^4$  cubic inches.
26.  $1000 = 10^3$ , so  $\frac{1}{1000} = 10^{-3}$ . The negative exponent is a compact way to show a small fraction of a second.



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