

# Rules of Exponents

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Score: \_\_\_\_\_ / 32

## Quick Review

Five rules cover almost everything. **Product rule:**  $x^a \cdot x^b = x^{a+b}$  (same base  $\Rightarrow$  add the powers). **Quotient rule:**  $\frac{x^a}{x^b} = x^{a-b}$  (top minus bottom). **Power of a power:**  $(x^a)^b = x^{ab}$  (multiply the powers). **Power of a product:**  $(xy)^n = x^n y^n$  (the outside power lands on every factor inside — including the coefficient). **Negative exponent:**  $x^{-n} = \frac{1}{x^n}$  (a negative exponent flips the base to the other side of the fraction bar). And  $x^0 = 1$  for any  $x \neq 0$ . The classic trap is the difference between  $2x^3$  and  $(2x)^3$ : the first squares only  $x$  and leaves the 2 alone, the second cubes everything (and gives  $8x^3$ ).

## PRACTICE

Simplify completely, with positive exponents in the final answer.

1. The table shows two products and the single power each collapses to. Fill in the missing exponent for  $x^3 \cdot x^7$ . \_\_\_\_\_

product	single power
$x^2 \cdot x^4$	$x^6$
$x^5 \cdot x^1$	$x^6$
$x^3 \cdot x^7$	$x^?$

2.  $(a^4)^3$  \_\_\_\_\_
3.  $(2x^3)^4$  \_\_\_\_\_
4.  $\frac{a^{-3}}{a^{-7}}$  \_\_\_\_\_
5. The table breaks  $(8x^6)^{1/3}$  into its two factors. Use the table to write the simplified result. \_\_\_\_\_

factor	raised to $\frac{1}{3}$
8	2
$x^6$	$x^2$

6.  $\frac{x^6}{x^{-2}}$  \_\_\_\_\_
7.  $\frac{x^4 \cdot x^{-2}}{x^3}$  \_\_\_\_\_
8.  $\left(\frac{2x}{y^3}\right)^{-2}$  \_\_\_\_\_
9.  $\frac{8x^8}{2x^2}$  \_\_\_\_\_
10.  $\frac{(3a^2b^{-1})^2 \cdot a^{-3}}{6ab^{-4}}$  \_\_\_\_\_
11.  $x^5 \cdot x^0$  \_\_\_\_\_
12.  $(3x^2y)^3$  \_\_\_\_\_
13.  $\frac{12x^5y^3}{4x^2y}$  \_\_\_\_\_
14.  $(x^{-3})^{-2}$  \_\_\_\_\_



15. The table lists powers of 4. Continue the pattern down the table to find  $4^{-2}$ .

power	$4^2$	$4^1$	$4^0$	$4^{-1}$	$4^{-2}$
value	16	4	1	$\frac{1}{4}$	?

16.  $(2x^3)(5x^{-1})$

17.  $\left(\frac{a^3}{b^2}\right)^4$

18.  $\frac{(2x)^3}{4x}$

19.  $x^{1/2} \cdot x^{1/2}$

20.  $(16x^4)^{1/2}$

◆ Word Problems

21. A rectangular display has area  $8x^8$  square units. Its width is  $2x^2$  units, where  $x > 0$ . What expression represents the length of the display?

22. A computer's hard drive can store  $2^{40}$  bytes. A file takes up  $2^{32}$  bytes. How many such files fit on the drive?

23. A cube has side length  $3x^2$  inches. Write a simplified expression for its volume.

24. In physics, kinetic energy is  $\frac{1}{2}mv^2$ . If a car's mass triples ( $m \rightarrow 3m$ ) and its speed doubles ( $v \rightarrow 2v$ ), by what factor does the kinetic energy change?

Additional Practice

25. Simplify  $x^4 \cdot x^9$ .

26. Simplify  $(a^3)^5$ .

27. Simplify  $\frac{m^{11}}{m^4}$ .

28. Simplify  $(2y^2)^3$ .

29. Rewrite  $p^{-6}$  with a positive exponent.

30. Simplify  $\frac{3x^{-2}}{6x^4}$  with positive exponents.

31. Simplify  $(4ab^{-2})^2$  with positive exponents.

32. Simplify  $\left(\frac{x^3}{y^{-1}}\right)^2$ .



## Answer Keys

1.  $x^{10}$

2.  $a^{12}$

3.  $16x^{12}$

4.  $a^4$

5.  $2x^2$

6.  $x^8$

7.  $\frac{1}{x}$

8.  $\frac{y^6}{4x^2}$

9.  $4x^6$

10.  $\frac{3b^2}{2}$

11.  $x^5$

12.  $27x^6y^3$

## Additional Practice Answers

25.  $x^{13}$

26.  $a^{15}$

27.  $m^7$

28.  $8y^6$

13.  $3x^3y^2$

14.  $x^6$

15.  $\frac{1}{16}$

16.  $10x^2$

17.  $\frac{a^{12}}{b^8}$

18.  $2x^2$

19.  $x$

20.  $4x^2$

21.  $4x^6$

22.  $2^8 = 256$

23.  $27x^6$  cubic inches

24.  $12$

29.  $\frac{1}{p^6}$

30.  $\frac{1}{2x^6}$

31.  $\frac{16a^2}{b^4}$

32.  $x^6y^2$

**Additional Practice:** Answers for all numbered items, including the added practice, are shown in the grid above.

## Step-by-Step Explanations

- Look at the first two rows: in each, the exponents on the same base just add ( $2 + 4 = 6$ ,  $5 + 1 = 6$ ). That's the product rule. So  $x^3 \cdot x^7 = x^{3+7} = x^{10}$ .
- Power raised to a power: *multiply* the exponents.  $4 \cdot 3 = 12$ . (Adding them gives 7, which is the common trap.)
- The outside 4 lands on *everything* inside.  $2^4 = 16$  and  $(x^3)^4 = x^{12}$ . Final:  $16x^{12}$ . (Forgetting to raise the 2 gives  $2x^{12}$  — watch for that.)
- Quotient rule: top minus bottom.  $-3 - (-7) = -3 + 7 = 4$ . The double negative is where most mistakes happen — write it out.
- A  $\frac{1}{3}$  power is a cube root, applied to each factor. The table gives  $8^{1/3} = 2$  and  $(x^6)^{1/3} = x^2$ . Multiply the two columns of results:  $2x^2$ .
- Subtract exponents:  $6 - (-2) = 6 + 2 = 8$ . Dividing by a negative power is the same as multiplying by a positive one.
- Combine the top first:  $x^4 \cdot x^{-2} = x^2$ . Then divide:  $\frac{x^2}{x^3} = x^{-1} = \frac{1}{x}$ . (The problem requires  $x \neq 0$ .)
- Negative exponent on a fraction flips the fraction first:  $\left(\frac{y^3}{2x}\right)^2$ . Now square top and bottom:  $\frac{y^6}{4x^2}$ .
- A careful way to see it: Coefficients divide:  $8 \div 2 = 4$ . Exponents on  $x$  subtract:  $8 - 2 = 6$ . Answer:  $4x^6$ . That gives a quick check on the answer.
- Square the group on top:  $9a^4b^{-2}$ . Multiply by  $a^{-3}$ :  $9ab^{-2}$ . Now divide by  $6ab^{-4}$ . Coefficients:  $\frac{9}{6} = \frac{3}{2}$ . The  $a$ 's:  $a^{1-1} = a^0 = 1$ . The  $b$ 's:  $b^{-2-(-4)} = b^2$ . Combine:  $\frac{3b^2}{2}$ .
- One steady path is: Anything (nonzero) to the zero power is 1, so  $x^5 \cdot 1 = x^5$ . That gives a quick check on the answer.
- Start with the key idea: Cube each factor:  $3^3 = 27$ ,  $(x^2)^3 = x^6$ ,  $y^3 = y^3$ . Product:  $27x^6y^3$ . That gives a quick check on the answer.

- A careful way to see it: Coefficients:  $12 \div 4 = 3$ . The  $x$ 's:  $5 - 2 = 3$ . The  $y$ 's:  $3 - 1 = 2$ . Answer:  $3x^3y^2$ . That gives a quick check on the answer.
- Keep the rule visible: Multiply exponents:  $(-3)(-2) = 6$ . Two negatives multiply to a positive. That gives a quick check on the answer.
- Each step down the table divides by 4:  $16$ ,  $4$ ,  $1$ ,  $\frac{1}{4}$ , and then  $\frac{1}{4} \div 4 = \frac{1}{16}$ . That matches the negative-exponent rule:  $4^{-2} = \frac{1}{4^2} = \frac{1}{16}$ .
- Multiply coefficients:  $2 \cdot 5 = 10$ . Add exponents on  $x$ :  $3 + (-1) = 2$ . Final:  $10x^2$ .
- A careful way to see it: Raise the top and the bottom to the 4:  $(a^3)^4 = a^{12}$  and  $(b^2)^4 = b^8$ . That gives a quick check on the answer.
- Keep the rule visible: Top first:  $(2x)^3 = 8x^3$ . Then divide:  $\frac{8x^3}{4x} = 2x^2$ . This is the part to check before moving on, because it keeps the answer tied to the original question.
- Add the fractional exponents:  $\frac{1}{2} + \frac{1}{2} = 1$ . So the product is  $x^1 = x$ . (This is why  $\sqrt{x} \cdot \sqrt{x} = x$ .)
- Start with the key idea: Half-power on each factor:  $16^{1/2} = 4$  and  $(x^4)^{1/2} = x^2$ . That gives a quick check on the answer.
- Length equals area divided by width:  $\frac{8x^8}{2x^2}$ . Coefficients:  $8 \div 2 = 4$ . Exponents on  $x$  subtract:  $8 - 2 = 6$ . So the length is  $4x^6$ .
- Total bytes divided by bytes per file:  $\frac{2^{40}}{2^{32}} = 2^{40-32} = 2^8 = 256$  files. (When the bases match, the quotient rule saves you from computing the giant numbers.)
- Volume of a cube is side<sup>3</sup>.  $(3x^2)^3$ : cube each factor.  $3^3 = 27$  and  $(x^2)^3 = x^6$ . Volume is  $27x^6$  cubic inches.
- New energy:  $\frac{1}{2}(3m)(2v)^2 = \frac{1}{2}(3m)(4v^2) = 12 \cdot \frac{1}{2}mv^2$ . So the new energy is 12 times the old. (The doubled speed contributes a factor of 4 because the speed is squared — a common surprise in physics.)



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