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 ⇒ 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. $\dfrac{a^{-3}}{a^{-7}}$ _____

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. $\dfrac{x^6}{x^{-2}}$ _____

7. $\dfrac{x^4 \cdot x^{-2}}{x^3}$ _____

8. $\left(\dfrac{2x}{y^3}\right)^{-2}$ _____

9. $\dfrac{8x^8}{2x^2}$ _____

10. $\dfrac{(3a^2b^{-1})^2 \cdot a^{-3}}{6ab^{-4}}$ _____

11. $x^5 \cdot x^0$ _____

12. $(3x^2y)^3$ _____

13. $\dfrac{12x^5y^3}{4x^2y}$ _____

14. $(x^{-3})^{-2}$ _____

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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 ($m \to 3m$) and its speed doubles ($v \to 2v$), 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 $\left(\frac{x^3}{y^{-1}}\right)^2$. _____

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Answer Keys

1. $\boxed{x^{10}}$
2. $\boxed{a^{12}}$
3. $\boxed{16x^{12}}$
4. $\boxed{a^4}$
5. $\boxed{2x^2}$
6. $\boxed{x^8}$
7. $\boxed{\frac{1}{x}}$
8. $\boxed{\frac{y^6}{4x^2}}$
9. $\boxed{4x^6}$
10. $\boxed{\frac{3b^2}{2}}$
11. $\boxed{x^5}$
12. $\boxed{27x^6y^3}$

Additional Practice Answers

25. $\boxed{x^{13}}$
26. $\boxed{a^{15}}$
27. $\boxed{m^7}$
28. $\boxed{8y^6}$
29. $\boxed{\frac{1}{p^6}}$
30. $\boxed{\frac{1}{2x^6}}$
31. $\boxed{\frac{16a^2}{b^4}}$
32. $\boxed{x^6y^2}$
13. $\boxed{3x^3y^2}$
14. $\boxed{x^6}$
15. $\boxed{\frac{1}{16}}$
16. $\boxed{10x^2}$
17. $\boxed{\frac{a^{12}}{b^8}}$
18. $\boxed{2x^2}$
19. $\boxed{x}$
20. $\boxed{4x^2}$
21. $\boxed{4x^6}$
22. $\boxed{2^8 = 256}$
23. $\boxed{27x^6 \text{ cubic inches}}$
24. $\boxed{12}$

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

Step-by-Step Explanations

1. 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 $x^3 \cdot x^7 = x^{3+7} = x^{10}$.

2. Power raised to a power: *multiply* the exponents. $4 \cdot 3 = 12$. (Adding them gives 7, which is the common trap.)

3. 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.)

4. Quotient rule: top minus bottom. $-3-(-7) = -3+7 = 4$. The double negative is where most mistakes happen — write it out.

5. 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: $2x^2$.

6. Subtract exponents: $6-(-2) = 6+2 = 8$. Dividing by a negative power is the same as multiplying by a positive one.

7. 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 $x \neq 0$.)

8. Negative exponent on a fraction flips the fraction first: $\left(\frac{y^3}{2x}\right)^2$. Now square top and bottom: $\frac{y^6}{4x^2}$.

9. 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.

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

11. 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.

12. 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.

13. 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.

14. Keep the rule visible: Multiply exponents: $(-3)(-2) = 6$. Two negatives multiply to a positive. That gives a quick check on the answer.

15. 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: $4^{-2} = \frac{1}{4^2} = \frac{1}{16}$.

16. Multiply coefficients: $2 \cdot 5 = 10$. Add exponents on x: $3+(-1) = 2$. Final: $10x^2$.

17. 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.

18. 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.

19. Add the fractional exponents: $\frac{1}{2} + \frac{1}{2} = 1$. So the product is $x^1 = x$. (This is why $\sqrt{x} \cdot \sqrt{x} = x$.)

20. 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.

21. 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 $4x^6$.

22. 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.)

23. Volume of a cube is side^3. $(3x^2)^3$: cube each factor. $3^3 = 27$ and $(x^2)^3 = x^6$. Volume is $27x^6$ cubic inches.

24. 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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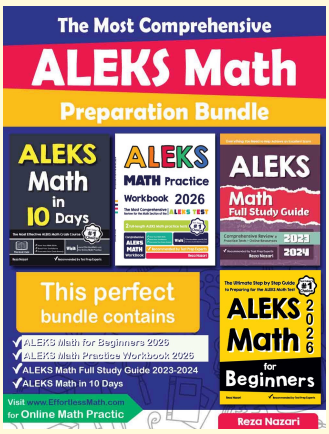

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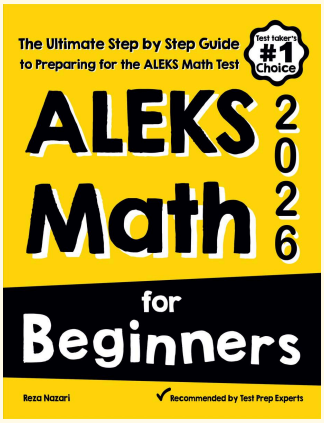

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