Properties of Integer Exponents

Exponents as Repeated Factors

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QUICK REVIEW

For a nonzero base a, $a^m a^n = a^{m+n}$, $\frac{a^m}{a^n} = a^{m-n}$, and $(a^m)^n = a^{mn}$. Also $a^0 = 1$ and $a^{-n} = \frac{1}{a^n}$. A product power acts on every factor: $(ab)^n = a^n b^n$. Parentheses matter: $(-2)^2 = 4$, while $-2^2 = -4$. State nonzero restrictions whenever reciprocals or quotient cancellation require them. Verify numeric results by expanding a short repeated product.

Worked example

Simplify $\frac{3^2 \cdot 3^4}{3^7}$ with positive exponents.

1. Combine numerator factors with common base: $3^2 \cdot 3^4 = 3^{2+4} = 3^6$. This product contains six factors of 3.

2. Divide by 3^7: $3^{6-7} = 3^{-1} = \frac{1}{3}$. One uncanceled denominator factor remains, so the final value is a reciprocal.

Answer: $\frac{1}{3}$.

Practice Problems

Show your thinking.

1. Write $2^4 \cdot 2^3$ as one power and evaluate.

2. Simplify $5^6 \div 5^4$ as one power and evaluate.

3. Write $(3^2)^3$ as one power and evaluate.

4. Evaluate $(2 \cdot 5)^3$ in two equivalent ways.

5. Write 4^{-2} as a fraction with positive exponents, then evaluate.

6. Evaluate $9^0 + 2^{-3}$.

7. Compare $(-3)^2$ and -3^2 by evaluating each.

8. Simplify $\left(\frac{2}{3}\right)^{-2}$ to a reduced fraction.

9. Assume $x \neq 0$. Simplify $x^5 x^{-2}$ using positive exponents.

10. Simplify $\frac{2^3 \cdot 2^{-1}}{2^4}$ and evaluate.

Answer Key

1. $2^7 = 128$.
2. $5^2 = 25$.
3. $3^6 = 729$.
4. 1000.
5. $\frac{1}{16}$.
6. $\frac{9}{8}$.
7. $(-3)^2 = 9$ and $-3^2 = -9$.
8. $\frac{9}{4}$.
9. x^3.
10. $2^{-2} = \frac{1}{4}$.

Step-by-Step Solutions

Follow each calculation, then check your own work.

Problem 1

1. The factors have the same base 2. Their repeated multiplication contains $4 + 3 = 7$ factors of 2, so $2^4 \cdot 2^3 = 2^7$.

2. Evaluate $2^7 = 128$. As a check, $2^4 = 16$ and $2^3 = 8$, and their product $16(8) = 128$ agrees.

Problem 2

1. Cancel four factors of 5 from numerator and denominator: $\frac{5^6}{5^4} = 5^{6-4} = 5^2$. The nonzero base permits this cancellation.

2. The two uncanceled factors give $5 \cdot 5 = 25$. Thus the original quotient equals 25, not $5^{6 \div 4}$.

Problem 3

1. Three copies of 3^2 multiply: $(3^2)^3 = 3^2 \cdot 3^2 \cdot 3^2 = 3^{2+2+2} = 3^6$. The exponents multiply because each copy contributes two factors.

2. Evaluate $3^6 = 729$. Equivalently, $3^2 = 9$ and $9^3 = 729$, confirming the value of the power of a power.

Problem 4

1. Evaluate inside the parentheses first: $(2 \cdot 5)^3 = 10^3 = 1000$. There are three copies of the entire product.

2. Alternatively distribute the exponent to the factors: $2^3 \cdot 5^3 = 8 \cdot 125 = 1000$. Both computations show the same exact result.

Problem 5

1. A negative exponent indicates a reciprocal, not a negative value: $4^{-2} = \frac{1}{4^2}$. The base 4 is nonzero.

2. Compute the denominator $4^2 = 16$. Thus $4^{-2} = \frac{1}{16}$, a positive fraction smaller than 1.

Problem 6

1. The nonzero base gives $9^0 = 1$. The negative power is a reciprocal: $2^{-3} = \frac{1}{2^3} = \frac{1}{8}$.

2. Add the exact values: $1 + \frac{1}{8} = \frac{8}{8} + \frac{1}{8} = \frac{9}{8}$. The zero exponent contributes one, not zero.

Problem 7

1. Parentheses include the sign in the base: $(-3)^2 = (-3)(-3) = 9$. Two negative factors produce a positive result.

2. Without parentheses, the exponent acts before the leading negative: $-3^2 = -(3 \cdot 3) = -9$. Thus the first expression is greater by 18.

Problem 8

1. The negative exponent takes the reciprocal of the nonzero base: $(\frac{2}{3})^{-2} = (\frac{3}{2})^2$. Both numerator and denominator are inverted.

2. Square each part: $\frac{3^2}{2^2} = \frac{9}{4}$. This is already reduced and positive, matching a reciprocal square.

Problem 9

1. Rewrite $x^{-2} = \frac{1}{x^2}$, which is defined because $x \neq 0$. Then $x^5 x^{-2} = \frac{x^5}{x^2}$.

2. Cancel two common factors to get $x^{5-2} = x^3$. The result has a positive exponent and is equivalent on the original domain $x \neq 0$.

Problem 10

1. Combine the numerator powers first: $2^3 \cdot 2^{-1} = 2^{3+(-1)} = 2^2$. Then divide by the denominator power.

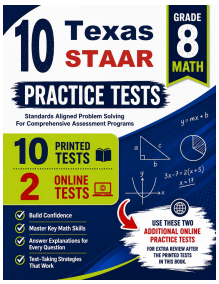
2. Subtract exponents: $2^{2-4} = 2^{-2} = \frac{1}{2^2} = \frac{1}{4}$. The reciprocal is required because the final exponent is negative.

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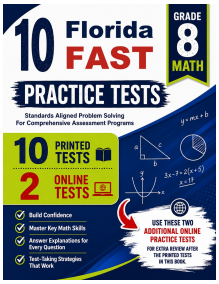
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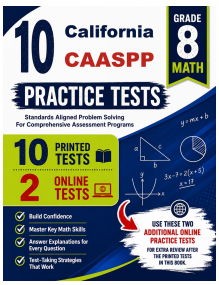
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