FIBO / MATH / ALGEBRA · UNIT 5 · POWERS & ROOTS

Exponent Rules — Lecture

Exponents are shorthand for repeated multiplication: 2 4 means 2·2·2·2 = 16. Five small rules run everything — multiplying powers, dividing powers, powers of powers, zero, and negative exponents.

BY THE END OF THIS LESSON, YOU WILL BE ABLE TO

- ✓ Read exponent notation: base × base × … (exponent = factor count)
- ✓ Apply the five exponent rules to simplify power expressions
- ✓ Explain why zero and negative exponents behave the way they do

⏱ About 25 min · Needs: multiplication facts · Unit 5 · Powers & Roots

Name: _____ **Date:** _____

Printable companion to the interactive lesson at fibotutors.com — full color. Worked examples and application solutions are shown in full; Try-It answers live in the separate Answer Key.

CONCEPTS

The Big Picture

The big number is the **base**; the small raised number is the **exponent** — it **counts how many times the base multiplies itself**.

$$2^4 = \underbrace{2}_{\text{factor 1}} \times \underbrace{2}_{\text{factor 2}} \times \underbrace{2}_{\text{factor 3}} \times \underbrace{2}_{\text{factor 4}}$$

$$= 2 \times 2 \times 2 \times 2 = 16$$

the exponent **4** counts the factors of **2**

The exponent **4** is a counter: four factors of **2**.

Exponents turn "multiply by 2, then by 2, then by 2..." into one short symbol — the language of growth.

Five rules run everything. **Name the rule first, then apply it**:

1. **Multiply powers → add exponents** $x^3 \cdot x^4 = x^7$
2. **Divide powers → subtract exponents** $2^5 \div 2^2 = 2^3$
3. **Power of a power → multiply exponents** $(3^2)^4 = 3^8$
4. **Zero exponent → 1 (base ≠ 0)** $5^0 = 1$
5. **Negative exponent → flip to denominator** $2^{-3} = 1 \div 2^3$

All five rules, color-coded: **base** in blue, **exponent** in red.

The negative-exponent rule makes sense as a **halving pattern**: $2^3 = 8$, $2^2 = 4$, $2^1 = 2$, $2^0 = 1$, $2^{-1} = \frac{1}{2}$ — each step down halves the value.

REAL LIFE FIRST

Math in the Wild

REAL LIFE FIRST

📷 Picture this: a petri dish of bacterial colonies under lab light

A dish starts with **5** bacteria; every hour the population **doubles**. Writing "×2 ×2 ×2..." gets old fast — the exponent counts the doublings: after n hours there are $5 \cdot 2^{n}$.



Doubling every hour is $5 \cdot 2^{n}$ — the exponent counts the doublings.

Where you already meet exponents: compound interest, computer memory (2^{10} = 1,024 bytes), scientific measurements, area and volume formulas (x^2, x^3).

WORKED EXAMPLES

See Every Step

Example 1 — Multiply: $x^3 \cdot x^4$

Step 1 **Name the rule:** same base, multiplying → **add the exponents**.

Step 2 3 + 4 = 7.

Step 3 Answer: x^7.

$$x^3 \cdot x^4 = x^7$$

→ Check: 3 factors times 4 factors = 7 factors of x — exponents just count factors.

✏️ Workspace — rework this example

✏️ Try It 1 — your turn

Simplify: $y^2 \cdot y^5$.

(Answer in the separate Answer Key — try it on your own first!)

✏️ Workspace — solve the Try-It here

Example 2 — Divide: $2^5 \div 2^2$

Step 1 **Name the rule:** same base, dividing → **subtract the exponents**.

Step 2 $5 - 2 = 3 \rightarrow 2^3$.

Step 3 Evaluate: $2^3 = 8$.

$$2^5 \div 2^2 = 2^3 = 8$$

→ Check: $32 \div 4 = 8$ ✓ — canceling two factors of 2 from five leaves three.

✏️ Workspace — rework this example

✏️ Try It 2 — your turn

Simplify, then evaluate: $10^6 \div 10^4$.

(Answer in the separate Answer Key — try it on your own first!)

✏️ Workspace — solve the Try-It here

Example 3 — Power of a power: $(3^2)^4$

Step 1 **Name the rule:** a power raised to a power → **multiply the exponents**.

Step 2 $2 \times 4 = 8$ → 3^8.

Step 3 Evaluate: $3^8 = 6{,}561$.

$(3^2)^4 = 3^8 = 6{,}561$

→ Check: $3^4 = 81$ and $81^2 = 6{,}561$ ✓ — the outer 4 hits *every* inner factor.

✏️ Workspace — rework this example

✏️ Try It 3 — your turn

Simplify, then evaluate: $(2^3)^2$.

(Answer in the separate Answer Key — try it on your own first!)

✏️ Workspace — solve the Try-It here

Example 4 — Zero and negative: 5^0 and 2^{-3}

Step 1 **Name the rules:** anything nonzero to the 0 power is 1; a negative exponent flips into the denominator.

Step 2 $5^0 = 1$.

Step 3 $2^{-3} = \frac{1}{2^3} = \frac{1}{8}$.

$$5^0 = 1 \cdot 2^{-3} = \frac{1}{8}$$

→ Check the pattern: $2^3 = 8$, $2^2 = 4$, $2^1 = 2$, $2^0 = 1$, $2^{-1} = \frac{1}{2}$ — keeps halving, consistent.

✏️ Workspace — rework this example

✏️ Try It 4 — your turn

Evaluate: 7^0 and 3^{-2}.

(Answer in the separate Answer Key — try it on your own first!)

✏️ Workspace — solve the Try-It here

USE IT FOR REAL

Application Problems

USE IT FOR REAL

App 1 — Bacteria colony

A dish starts with **5** bacteria, doubling every hour. How many after **6** hours?



$5 \cdot 2^6 = 5 \cdot 64 = 320$ **bacteria**

Six doublings: $5 \cdot 2^6 = 320$.

Solution. After n hours: $5 \cdot 2^n$.

After 6 hours: $5 \cdot 2^6 = 5 \cdot 64 =$ **320 bacteria**.

✏️ **Workspace — solve it your way first, then compare**

App 2 — Phone storage

One kilobyte is 2^{10} = 1,024 bytes. How many bytes in **3** KB?

$$3 \times \boxed{1{,}024} \text{ bytes}$$

$$3 \times 2^{10} = 3 \times 1{,}024$$

$$= 3{,}072 \text{ bytes}$$

Computer memory is built on powers of 2.

Solution. 3 KB = $3 \times 2^{10} = 3 \times 1{,}024 =$ **3,072 bytes**.

✏️ **Workspace — solve it your way first, then compare**

App 3 — Paper folding

Each fold doubles the layers of a paper. Starting from 1 layer, how many layers after **10** folds?



...

$2^{10} = 1{,}024$ **layers**

10 doublings from a single sheet

Ten doublings turn one sheet into a 1,024-layer stack.

Solution. Each fold multiplies layers by 2: after 10 folds, 2^{10} = **1,024 layers**.

✏️ **Workspace — solve it your way first, then compare**

KEEP FOREVER

Key Points — Cheat Sheet

- $x^m \cdot x^n = x^{m+n}$ — multiply powers: **add** exponents
- $x^m \div x^n = x^{m-n}$ — divide powers: **subtract** exponents
- $(x^m)^n = x^{mn}$ — power of a power: **multiply** exponents
- $x^0 = 1\ (x \neq 0) \cdot x^{-n} = \frac{1}{x^n}$ — zero is 1, negative flips
- Rules work across × and ÷ only — a **+** or **−** between powers stops them