



Exponents, Roots, and Scientific Notation

Four focused lessons, worked examples, a mistake clinic, and 60 practice problems with full explanations.

In this booster

04.1 Exponent Basics and the Laws of Exponents

04.2 Square Roots, Cube Roots, and Irrational Numbers

04.3 Scientific Notation

04.4 Powers in Context

Every section teaches the idea, walks through the most common problem types, flags the traps students fall into, and ends with fifteen practice problems. Full answers and explanations are at the back.

04.1 Exponent Basics and the Laws of Exponents

Learn what an exponent means and use the product, quotient, and power rules, along with zero and negative exponents, to simplify expressions with confidence.

Why This Matters

An exponent is shorthand for repeated multiplication. It lets scientists write the number of stars in a galaxy, lets banks describe how money grows, and lets computers describe memory sizes. Once the numbers get big, writing $2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$ is slow and easy to miscount. Writing 2^{10} is clear.

Students get stuck on the **laws of exponents** because there are several rules that look alike. They add exponents when they should multiply, or they think a negative exponent makes the number negative, or they believe $5^0 = 0$. If you understand what an exponent really means, you can rebuild every rule on the spot instead of memorizing it.

Core Ideas

What an Exponent Means

a^n means a multiplied by itself n times. The number a is the **base** and n is the **exponent** (or power).

$2^4 = 2 \cdot 2 \cdot 2 \cdot 2 = 16$. Notice 2^4 is not $2 \cdot 4$.

Power	Expanded	Value
2^1	2	2
2^2	$2 \cdot 2$	4
2^3	$2 \cdot 2 \cdot 2$	8
2^4	$2 \cdot 2 \cdot 2 \cdot 2$	16
2^5	five 2s	32

Why do exponents add when you multiply? Write it out: $2^3 \cdot 2^4 = (2 \cdot 2 \cdot 2)(2 \cdot 2 \cdot 2 \cdot 2)$. That is seven 2s in a row, so it equals 2^7 . The same idea explains all three main laws.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

The Three Main Laws (same base)

Product rule: $a^m \cdot a^n = a^{m+n}$.

Quotient rule: $\frac{a^m}{a^n} = a^{m-n}$ (for $a \neq 0$).

Power rule: $(a^m)^n = a^{mn}$. Also $(ab)^n = a^n b^n$ and $\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$.

For the quotient rule, cancel matching factors: $\frac{3^8}{3^5}$ has five 3s on the bottom cancelling five of the eight on top, leaving $3^3 = 27$. If the bottom has more factors than the top you get a negative exponent, and that leads to the next rule. Look at the pattern in the table of powers of 2 and keep going **downward**: each step divides by 2.

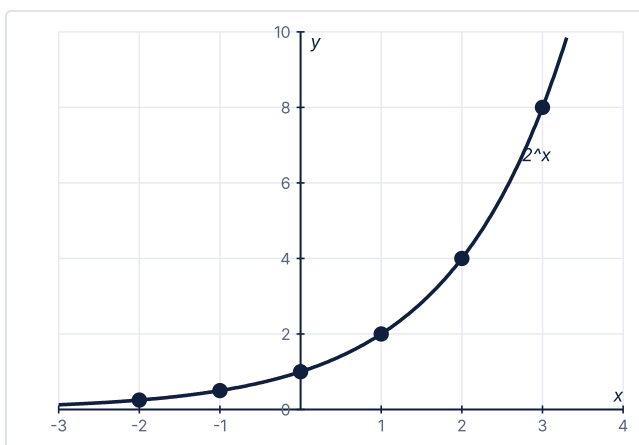
Power	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}
Value	8	4	2	1	$\frac{1}{2}$	$\frac{1}{4}$

Zero and Negative Exponents

$a^0 = 1$ for any $a \neq 0$.

$a^{-n} = \frac{1}{a^n}$. A negative exponent means 'flip to the other side of the fraction bar', not 'make the number negative'.

$$\left(\frac{a}{b}\right)^{-n} = \left(\frac{b}{a}\right)^n.$$



The graph of $y = 2^x$. Each step right doubles the value; each step left halves it. It passes through $(0, 1)$ and never reaches 0.

Worked Examples

EXAMPLE 1: PRODUCT RULE

Simplify (a) $2^3 \cdot 2^4$ and (b) $x^5 \cdot x^2$.

SOLUTION

Same base, so add exponents.

(a) $2^{3+4} = 2^7 = 128$.

(b) $x^{5+2} = x^7$.

EXAMPLE 2: QUOTIENT RULE

Simplify (a) $\frac{3^8}{3^5}$ and (b) $\frac{x^7}{x^3}$.

SOLUTION

Same base, so subtract exponents.

(a) $3^{8-5} = 3^3 = 27$.

(b) $x^{7-3} = x^4$.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

EXAMPLE 3: POWER RULESimplify (a) $(2^3)^2$ and (b) $(3x^2)^3$.**SOLUTION**(a) Multiply exponents: $2^6 = 64$.(b) The exponent 3 applies to both the 3 and the x^2 : $3^3 \cdot (x^2)^3 = 27x^6$.**EXAMPLE 4: ZERO AND NEGATIVE EXPONENTS**Evaluate (a) 5^0 , (b) 2^{-3} , (c) $(\frac{3}{4})^{-2}$.**SOLUTION**(a) Any nonzero base to the 0 is 1, so $5^0 = 1$.(b) $2^{-3} = \frac{1}{2^3} = \frac{1}{8}$.(c) Flip the fraction and make the exponent positive: $(\frac{4}{3})^2 = \frac{16}{9}$.**EXAMPLE 5: COMBINING THE LAWS**Simplify $\frac{(2x^3y)^2 \cdot x^{-4}y^3}{4y^2}$, writing the answer with positive exponents.**SOLUTION**Power rule on the top: $(2x^3y)^2 = 4x^6y^2$.Top becomes $4x^6y^2 \cdot x^{-4}y^3 = 4x^2y^5$ (add exponents of each base).Divide by $4y^2$: the 4s cancel and $y^{5-2} = y^3$.Answer: x^2y^3 .**EXAMPLE 6: POWERS OF A FRACTION**Simplify $(\frac{2x^2}{y^3})^3 \cdot \frac{y^7}{x^4}$ and write the answer with positive exponents.**SOLUTION**Apply the power to the top and bottom: $\frac{2^3x^6}{y^9} = \frac{8x^6}{y^9}$.Multiply: $\frac{8x^6}{y^9} \cdot \frac{y^7}{x^4} = \frac{8x^6y^7}{x^4y^9}$.Subtract exponents of each base: $x^{6-4} = x^2$ and $y^{7-9} = y^{-2}$.Move y^{-2} to the bottom: $\frac{8x^2}{y^2}$.**Coach's Playbook**

- 1 Check the bases.** Product and quotient rules only work when the bases match. $2^3 \cdot 3^2$ cannot be combined by adding exponents.
 - 2 Handle each base separately.** Group numbers, then each letter, and apply the laws to one base at a time.
 - 3 Remove parentheses first.** Apply the power rule to everything inside a parenthesis, including the coefficient.
 - 4 Finish with positive exponents.** Move any negative-exponent factor across the fraction bar, then recheck.
- ◆ If you forget a rule, expand a small case such as $x^2 \cdot x^3$ and count the factors.
 - ◆ Memorize powers: squares to 15, cubes to 10, and powers of 2 to $2^{10} = 1024$.
 - ◆ Sanity check: multiplying by a^m should make things bigger if $a > 1$ and $m > 0$.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

Common traps

1. $2^3 \cdot 2^4 = 2^{12}$. You add exponents in a product, so it is 2^7 . 2. $(x^4)^3 = x^7$. The power rule multiplies, so it is x^{12} . 3. $2^{-3} = -8$. A negative exponent means reciprocal: $\frac{1}{8}$. 4. $(2x)^3 = 2x^3$. The 2 is cubed too: $8x^3$.

Mistake Clinic**Spot the error**

A student writes: $(2x^3)^2 = 2x^6$. **What went wrong:** the power 2 applies to every factor inside the parentheses, including the 2. **Right solution:** $(2x^3)^2 = 2^2 \cdot (x^3)^2 = 4x^6$.

Spot the error

A student writes: $x^5 + x^5 = x^{10}$. **What went wrong:** the product rule adds exponents when you multiply. Here you are adding, so you combine like terms: two copies of x^5 . **Right solution:** $x^5 + x^5 = 2x^5$.

Spot the error

A student writes: $3^{-2} = -9$. **What went wrong:** a negative exponent means reciprocal, not a negative number. **Right solution:** $3^{-2} = \frac{1}{3^2} = \frac{1}{9}$.

Real-World Connection

A computer file of $2^{10} = 1024$ units is called a kilo-unit. Doubling memory ten times multiplies it by 1024. Powers of 2 are everywhere in technology.

Challenge Corner

Solve $4^x \cdot 8^{x-1} = 2^{12}$ for x . **Solution:** Write every base as a power of 2: $4 = 2^2$ and $8 = 2^3$. Then $4^x = 2^{2x}$ and $8^{x-1} = 2^{3(x-1)} = 2^{3x-3}$. The product rule gives $2^{2x+3x-3} = 2^{5x-3}$. When the bases match, the exponents must match: $5x - 3 = 12$, so $5x = 15$ and $x = 3$. Check: $4^3 \cdot 8^2 = 64 \cdot 64 = 4,096 = 2^{12}$. The answer is $x = 3$.

Practice**PRACTICE Exponent Basics and the Laws of Exponents**

Show your work on paper. Use a calculator only when a problem says so, or if it is allowed at your level.

- Simplify $3^2 \cdot 3^5$.
(A) 3^{10} (B) 9^7 (C) 3^7 (D) 3^3
- Simplify $(x^4)^3$.
(A) x^7 (B) x^{12} (C) $3x^4$ (D) x^{64}
- What is the value of 10^{-2} ?
(A) -20 (B) -100 (C) $\frac{1}{100}$ (D) 0.2
- What is the value of $\frac{6^9}{6^6}$?
(A) 216 (B) 6^{15} (C) $6^3 \cdot 3$ (D) 18
- Simplify $(2a^3)^4$.
(A) $8a^7$ (B) $16a^7$ (C) $2a^{12}$ (D) $16a^{12}$
- What is the value of $7^0 + 2^{-1}$?
(A) $\frac{3}{2}$ (B) $\frac{1}{2}$ (C) 1 (D) 0

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

7. Which expression is equivalent to x^{-3} ?
 (A) $-3x$ (B) $-x^3$ (C) $\frac{x}{3}$ (D) $\frac{1}{x^3}$
8. Simplify $\frac{x^9}{x^3 \cdot x^2}$.
 (A) x^8 (B) x^4 (C) x^6 (D) x^{14}
9. What is $(-2)^3 \cdot 2^{-1}$?
 (A) 4 (B) -16 (C) -4 (D) 16
10. Evaluate $\frac{2^5 \cdot 2^{-2}}{2^1}$.
11. Simplify $(3x^2y^{-1})^2$ and write it with positive exponents.
12. Evaluate $\left(\frac{4}{5}\right)^{-2}$.
13. Find n if $2^n = \frac{1}{32}$.
14. Simplify $\frac{(4a^2b)^3}{8a^4b^5}$ and write it with positive exponents.
15. Evaluate $\frac{2^{-3} + 2^{-2}}{2^{-4}}$.

04.2 Square Roots, Cube Roots, and Irrational Numbers

Find exact roots of perfect squares and cubes, estimate other roots, simplify radicals, and decide whether a number is rational or irrational.

Why This Matters

A square root answers a simple question: what number multiplied by itself gives this? If a square floor has an area of 169 square feet, its side is $\sqrt{169} = 13$ feet. Cube roots do the same job for volume. Roots appear in distance formulas, in the Pythagorean theorem, in science formulas, and in the next several years of math.

Students struggle because the symbol $\sqrt{\quad}$ looks mysterious, because most roots are not whole numbers, and because words like 'irrational' sound frightening. The good news: a few perfect squares memorized, one estimating trick, and one simplifying trick cover almost everything in this section.

Core Ideas

Square Roots and Cube Roots

$\sqrt{n}$ (the **principal square root**) is the nonnegative number whose square is n . So $\sqrt{144} = 12$ because $12^2 = 144$.

$\sqrt[3]{n}$ is the number whose cube is n . So $\sqrt[3]{125} = 5$ because $5^3 = 125$. A cube root can be negative: $\sqrt[3]{-27} = -3$.

You cannot take the square root of a negative number in the real numbers.

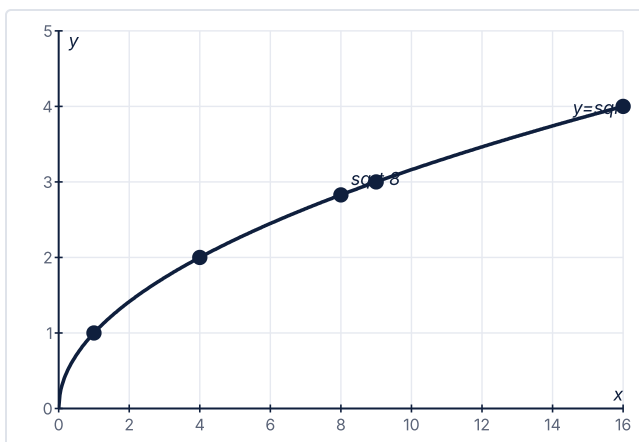
n	1	2	3	4	5	6	7	8	9	10	11	12
n^2	1	4	9	16	25	36	49	64	81	100	121	144
n^3	1	8	27	64	125	216	343	512	729	1000		

A **perfect square** is the square of a whole number, and a **perfect cube** is the cube of a whole number. Learning the squares through 15 and the cubes through 10 makes everything faster. Fractions and decimals work the same way: $\sqrt{\frac{9}{16}} = \frac{3}{4}$ and $\sqrt{0.49} = 0.7$.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →



The graph of $y = \sqrt{x}$. Perfect squares land on whole numbers. In between, the roots fall between whole numbers: $\sqrt{8}$ is about 2.83.

Estimating a Square Root

Find the two perfect squares around the number. The root lies between their roots.

$\sqrt{50}$: $49 < 50 < 64$, so $7 < \sqrt{50} < 8$. Since 50 is very close to 49, $\sqrt{50} \approx 7.1$.

The closer the number is to a perfect square, the closer the root is to that whole number.

Simplifying a Square Root

Pull out the largest perfect-square factor: $\sqrt{ab} = \sqrt{a} \cdot \sqrt{b}$ for $a, b \geq 0$.

$\sqrt{72} = \sqrt{36 \cdot 2} = 6\sqrt{2}$. The root is **simplified** when no perfect-square factor larger than 1 remains inside.



Irrational numbers sit on the number line too, between the whole numbers. They go on forever without repeating.

A number is **rational** if it can be written as a fraction of two integers. That includes integers, terminating decimals like 0.25, and repeating decimals like $0.\overline{3} = \frac{1}{3}$. A number is **irrational** if its decimal goes on forever without a repeating pattern. $\sqrt{2}$, $\sqrt{20}$, and π are irrational. A quick test: the square root of a whole number is rational only if that number is a perfect square.

Worked Examples

EXAMPLE 1: EXACT ROOTS

Evaluate (a) $\sqrt{144}$, (b) $\sqrt[3]{125}$, (c) $\sqrt{0.49}$, (d) $\sqrt{\frac{9}{16}}$.

SOLUTION

(a) $12 \cdot 12 = 144$, so 12.

(b) $5 \cdot 5 \cdot 5 = 125$, so 5.

(c) $0.7 \cdot 0.7 = 0.49$, so 0.7.

(d) $\frac{3}{4} \cdot \frac{3}{4} = \frac{9}{16}$, so $\frac{3}{4}$.

EXAMPLE 2: ESTIMATING

Between which two whole numbers is $\sqrt{75}$? Estimate it to the nearest tenth.

SOLUTION

$64 < 75 < 81$, so $8 < \sqrt{75} < 9$.

75 is $75 - 64 = 11$ above 64 and $81 - 75 = 6$ below 81, so the root is closer to 9.

Test $8.7^2 = 75.69$ and $8.6^2 = 73.96$. Since 75 is closer to 75.69, $\sqrt{75} \approx 8.7$.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

EXAMPLE 3: SIMPLIFYINGSimplify (a) $\sqrt{72}$ and (b) $\sqrt{48}$.**SOLUTION**(a) $72 = 36 \cdot 2$, so $\sqrt{72} = 6\sqrt{2}$.(b) $48 = 16 \cdot 3$, so $\sqrt{48} = 4\sqrt{3}$.Check (b): $4\sqrt{3} \approx 4(1.732) = 6.93$ and $\sqrt{48} \approx 6.93$.**EXAMPLE 4: RATIONAL OR IRRATIONAL?**Classify each as rational or irrational: 0.25, $\sqrt{16}$, $\sqrt{20}$, π , $0.\bar{3}$.**SOLUTION**0.25 = $\frac{1}{4}$: rational. $\sqrt{16} = 4$: rational. $\sqrt{20}$: 20 is not a perfect square, so irrational. π : irrational. $0.\bar{3} = \frac{1}{3}$: rational.**EXAMPLE 5: A GARDEN**

A square garden has an area of 50 square meters. Find the side length exactly and the length of fence needed to the nearest tenth of a meter.

SOLUTIONSide = $\sqrt{50} = \sqrt{25 \cdot 2} = 5\sqrt{2}$ meters.Perimeter = $4 \cdot 5\sqrt{2} = 20\sqrt{2}$ meters. $20 \times 1.414 = 28.28$, so about 28.3 meters.**EXAMPLE 6: ORDERING ROOTS**Put 5, $\sqrt{20}$, $\sqrt[3]{100}$, 4.5 in order from least to greatest.**SOLUTION**Estimate $\sqrt{20}$: $16 < 20 < 25$, and $4.5^2 = 20.25$, so $\sqrt{20}$ is just under 4.5 (about 4.47).Estimate $\sqrt[3]{100}$: $4^3 = 64$ and $5^3 = 125$, so it is between 4 and 5. Since $4.6^3 \approx 97.3$ and $4.7^3 \approx 103.8$, it is about 4.64.Compare: $4.47 < 4.5 < 4.64 < 5$.Order: $\sqrt{20}$, 4.5, $\sqrt[3]{100}$, 5.**Coach's Playbook**

- 1 **Know your perfect squares.** Recognizing 144, 169, and 225 instantly saves time everywhere.
 - 2 **Sandwich it.** For an estimate, find the perfect squares on each side and decide which is closer.
 - 3 **Factor out the biggest perfect square.** If you miss the largest, simplify again. $\sqrt{72} = \sqrt{4 \cdot 18} = 2\sqrt{18} = 2 \cdot 3\sqrt{2}$.
 - 4 **Square your answer.** To check a root, square it and see if you get the original number.
- ◆ Use the divisibility rules from earlier to find square factors: if a number ends in 00, it has a factor of 100.
 - ◆ A decimal that ends or repeats is rational.
 - ◆ Order roots by squaring: $\sqrt{30} < 6$ because $30 < 36$.

Common traps

1. $\sqrt{16} = 8$ (halving instead of finding the root).
2. $\sqrt{9 + 16} = \sqrt{9} + \sqrt{16} = 7$. Roots do not split over addition: the right answer is $\sqrt{25} = 5$.
3. Leaving $\sqrt{72}$ unsimplified when asked to simplify.
4. Believing every decimal that looks messy is irrational. $0.\bar{3}$ is rational.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

Mistake Clinic

Spot the error

A student writes: $\sqrt{9+16} = \sqrt{9} + \sqrt{16} = 3 + 4 = 7$. **What went wrong:** a square root does not split across addition. You must add first, then take the root. **Right solution:** $\sqrt{9+16} = \sqrt{25} = 5$.

Spot the error

A student simplifies $\sqrt{48}$ and writes $2\sqrt{12}$. **What went wrong:** 4 is a perfect square factor, but 48 has a larger one, 16. Because $\sqrt{12}$ can still be simplified, the work is not finished. **Right solution:** $\sqrt{48} = \sqrt{16 \cdot 3} = 4\sqrt{3}$.

Spot the error

A student says $\sqrt{25}$ is irrational because it has a root sign. **What went wrong:** the root sign does not decide it. 25 is a perfect square. **Right solution:** $\sqrt{25} = 5 = \frac{5}{1}$, which is a rational number.

Real-World Connection

If you know the area of a square screen or a square rug, the square root gives the side length. A rug of area 50 square feet needs a space about 7.1 feet on each side.

Challenge Corner

Find the smallest whole number n such that $\sqrt{180n}$ is a whole number, and give that whole number. **Solution:** Factor: $180 = 2^2 \cdot 3^2 \cdot 5$. A number is a perfect square when every prime has an even power. Only the 5 has an odd power, so multiply by one more 5: $n = 5$. Then $180 \cdot 5 = 900$ and $\sqrt{900} = 30$. Smaller values of n leave a prime with an odd power, so $n = 5$ is the smallest.

Practice

PRACTICE Square Roots, Cube Roots, and Irrational Numbers

Show your work on paper. Use a calculator only when a problem says so, or if it is allowed at your level.

- What is $\sqrt{81}$?
(A) 8 (B) 9 (C) 40.5 (D) 81^2
- What is $\sqrt[3]{64}$?
(A) 8 (B) 16 (C) 21.3 (D) 4
- Between which two whole numbers is $\sqrt{50}$?
(A) 6 and 7 (B) 7 and 8 (C) 8 and 9 (D) 24 and 26
- Which is the simplified form of $\sqrt{45}$?
(A) $9\sqrt{5}$ (B) $5\sqrt{3}$ (C) $3\sqrt{5}$ (D) $15\sqrt{3}$
- Which number is irrational?
(A) $\sqrt{49}$ (B) 0.125 (C) $\frac{22}{7}$ (D) $\sqrt{12}$
- Which is closest to $\sqrt{30}$?
(A) 5.0 (B) 5.5 (C) 6.0 (D) 15
- What is $\sqrt{121} - \sqrt[3]{8}$?
(A) 9 (B) 3 (C) 7 (D) 13
- Which is the simplified form of $\sqrt{98}$?
(A) $49\sqrt{2}$ (B) $2\sqrt{7}$ (C) $7\sqrt{2}$ (D) $14\sqrt{7}$

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

9. A square has an area of 20 square centimeters. Its side length is closest to
(A) 10 cm (B) 5 cm (C) 4 cm (D) 4.5 cm
10. Simplify $\sqrt{200}$.
11. A square patio has an area of 289 square feet. What is its perimeter in feet?
12. Evaluate $\sqrt[3]{-27} + \sqrt{36}$.
13. Between which two consecutive whole numbers does $\sqrt{110}$ lie?
14. Simplify $\sqrt{18} + \sqrt{50}$.
15. A cube has a volume of 343 cubic inches. Find its total surface area in square inches.

04.3

Scientific Notation

Write very large and very small numbers in scientific notation, convert back to standard form, compare sizes, and multiply, divide, and add numbers written this way.

Why This Matters

Scientists deal with numbers far too big or too small to write comfortably. The distance to the Sun is about 150,000,000 kilometers. A red blood cell is about 0.000007 meters across. Counting zeros is slow and error-prone. **Scientific notation** packs each number into a short, standard form so you can read, compare, and calculate quickly.

Students get stuck by moving the decimal the wrong way, by mixing up the sign of the exponent, and by forgetting to readjust after multiplying (for instance, getting 20×10^4 and stopping). We will use one simple idea throughout: the exponent counts how many places the decimal point jumps.

Core Ideas

Scientific Notation

A number is in scientific notation if it is written as $a \times 10^n$ where $1 \leq a < 10$ and n is an integer.
Large numbers (10 or more) have a **positive** exponent. Numbers between 0 and 1 have a **negative** exponent.
 $45,000,000 = 4.5 \times 10^7$ and $0.00032 = 3.2 \times 10^{-4}$.

Standard form	Scientific notation	Decimal moves
45,000,000	4.5×10^7	7 places left
620,000	6.2×10^5	5 places left
0.00032	3.2×10^{-4}	4 places right
0.5	5×10^{-1}	1 place right

To convert **into** scientific notation, move the decimal point until exactly one nonzero digit is to its left. Count the jumps. Jump left: positive exponent. Jump right: negative exponent. To convert **out of** it, do the opposite: a positive exponent moves the decimal right, a negative exponent moves it left (filling in zeros).

Thing	Size	Scientific notation
Distance to the Sun (km)	150,000,000	1.5×10^8
People in a large city	8,000,000	8×10^6
Width of a hair (m)	0.00008	8×10^{-5}
Red blood cell (m)	0.000007	7×10^{-6}

Power of ten	Name	Power of ten	Name
10^3	thousand	10^{-3}	thousandth
10^6	million	10^{-6}	millionth
10^9	billion	10^{-9}	billionth
10^{12}	trillion	10^{-12}	trillionth

Want a plan built around **your** student?
Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

Calculating with Scientific Notation

Multiply: multiply the front numbers, add the exponents. $(a \times 10^m)(b \times 10^n) = ab \times 10^{m+n}$.

Divide: divide the front numbers, subtract the exponents. $\frac{a \times 10^m}{b \times 10^n} = \frac{a}{b} \times 10^{m-n}$.

Add or subtract: first rewrite so both have the **same power of 10**, then add the front numbers. Afterward, if the front number is not between 1 and 10, adjust the exponent.

To **compare** two numbers in scientific notation, look at the exponents first. The bigger exponent means the bigger number (for positive front numbers). If the exponents tie, compare the front numbers. So 2.1×10^{-3} is greater than 8.5×10^{-4} , because $-3 > -4$.

Worked Examples

EXAMPLE 1: CONVERTING

Write 45,000,000 and 0.00032 in scientific notation, and write 6.2×10^5 in standard form.

SOLUTION

45,000,000: move the decimal 7 places left to get 4.5, so 4.5×10^7 .

0.00032: move 4 places right to get 3.2, so 3.2×10^{-4} .

6.2×10^5 : move 5 places right: 620,000.

EXAMPLE 2: MULTIPLYING

Find (a) $(3 \times 10^4)(2.5 \times 10^3)$ and (b) $(4 \times 10^5)(5 \times 10^3)$.

SOLUTION

(a) $3 \cdot 2.5 = 7.5$ and $10^{4+3} = 10^7$. Answer: 7.5×10^7 .

(b) $4 \cdot 5 = 20$ and $10^{5+3} = 10^8$, giving 20×10^8 . The front number must be below 10, so rewrite as 2×10^9 .

EXAMPLE 3: DIVIDING

Find (a) $\frac{9 \times 10^8}{3 \times 10^3}$ and (b) $\frac{1.2 \times 10^3}{4 \times 10^{-2}}$.

SOLUTION

(a) $9 \div 3 = 3$ and $10^{8-3} = 10^5$. Answer 3×10^5 .

(b) $1.2 \div 4 = 0.3$ and $10^{3-(-2)} = 10^5$, so 0.3×10^5 . Adjust: 3×10^4 .

EXAMPLE 4: ADDING

Find $3.2 \times 10^5 + 4.5 \times 10^4$.

SOLUTION

Match powers: $4.5 \times 10^4 = 0.45 \times 10^5$.

Add front numbers: $3.2 + 0.45 = 3.65$.

Answer: 3.65×10^5 (check: $320,000 + 45,000 = 365,000$).

EXAMPLE 5: SUNLIGHT

Sunlight travels at about 3×10^8 meters per second. The Sun is about 1.5×10^{11} meters away. How many seconds does the light take?

SOLUTION

Time = distance $\div$ speed = $\frac{1.5 \times 10^{11}}{3 \times 10^8}$.

$1.5 \div 3 = 0.5$ and $10^{11-8} = 10^3$, so 0.5×10^3 .

Adjust: $5 \times 10^2 = 500$ seconds, about 8 minutes 20 seconds.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

EXAMPLE 6: COMPARING AND ORDERING

Order from least to greatest: 4.1×10^{-3} , 0.0052, 3.9×10^{-2} , 6×10^{-4} .

SOLUTION

Put every number in the same form. Scientific notation for 0.0052 is 5.2×10^{-3} .

Sort by exponent first (a more negative exponent means smaller): 6×10^{-4} has -4 , the two with -3 come next, and 3.9×10^{-2} has the largest exponent.

For the tie at 10^{-3} , compare the front numbers: $4.1 < 5.2$.

Order: 6×10^{-4} , 4.1×10^{-3} , 0.0052, 3.9×10^{-2} .

Coach's Playbook

- 1 Check the front number.** After any calculation, make sure it is at least 1 and less than 10. If not, shift the decimal and adjust the exponent by the same amount in the opposite direction.
 - 2 Track the direction.** Big number means positive exponent, tiny number means negative exponent. Say it out loud as a check.
 - 3 Treat the two parts separately.** Multiplying: handle the digits, then the powers of ten. Do not mix them.
 - 4 Estimate.** Round the front numbers and think about size. $(2 \times 10^3)(3 \times 10^5)$ is about 6 followed by 8 zeros.
- ◆ For adding, convert to the larger exponent so you do not create negative-exponent decimals unnecessarily.
 - ◆ On a calculator, 'EE' or 'E' stands for 'times ten to the'. $3.2E5$ means 3.2×10^5 .
 - ◆ Check by writing the answer in standard form when the numbers are small enough.

Common traps

1. Moving the decimal the wrong direction, or using a positive exponent for a small number. 2. Adding exponents when adding numbers: $10^4 + 10^4$ is not 10^8 . 3. Leaving the answer as 20×10^8 . 4. Subtracting the exponents when multiplying, or adding them when dividing.

Mistake Clinic**Spot the error**

A student writes: $(3 \times 10^4)(5 \times 10^6) = 15 \times 10^{24}$. **What went wrong:** the student multiplied the exponents. When multiplying powers of 10 you add the exponents. Also, 15 is not between 1 and 10. **Right solution:** $15 \times 10^{10} = 1.5 \times 10^{11}$.

Spot the error

A student writes: $2.5 \times 10^5 + 3 \times 10^4 = 5.5 \times 10^5$. **What went wrong:** the two numbers have different powers of 10, so you cannot add the front numbers directly. **Right solution:** $3 \times 10^4 = 0.3 \times 10^5$, so the sum is $2.5 \times 10^5 + 0.3 \times 10^5 = 2.8 \times 10^5$.

Spot the error

A student writes $0.0007 = 7 \times 10^4$. **What went wrong:** a number smaller than 1 needs a negative exponent. The decimal moved 4 places to the right. **Right solution:** $0.0007 = 7 \times 10^{-4}$.

Real-World Connection

A human hair is about 8×10^{-5} meters wide, and a red blood cell is about 7×10^{-6} meters. Dividing shows the hair is a little more than 10 times wider.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

Challenge Corner

The Sun has a mass of about 2×10^{30} kilograms and Earth has a mass of about 6×10^{24} kilograms. About how many Earths would it take to match the Sun's mass? Answer in scientific notation. **Solution:** Divide: $\frac{2 \times 10^{30}}{6 \times 10^{24}} = \frac{2}{6} \times 10^{30-24} = 0.333 \dots \times 10^6$. The front number must be at least 1, so move the decimal one place: $3.33 \dots \times 10^5$. About 3.3×10^5 , or roughly 333,000 Earths.

Practice**PRACTICE Scientific Notation**

Show your work on paper. Use a calculator only when a problem says so, or if it is allowed at your level.

- Which is 5,300,000 in scientific notation?
(A) 53×10^5 (B) 5.3×10^7 (C) 5.3×10^{-6} (D) 5.3×10^6
- Which is 0.00072 in scientific notation?
(A) 7.2×10^{-4} (B) 7.2×10^4 (C) 7.2×10^{-3} (D) 72×10^{-5}
- Which number is the greatest?
(A) 9.8×10^4 (B) 2.5×10^5 (C) 3.1×10^5 (D) 4.0×10^3
- What is $(2 \times 10^3)(3 \times 10^5)$?
(A) 6×10^{15} (B) 6×10^8 (C) 5×10^8 (D) 6×10^2
- What is $\frac{8 \times 10^7}{4 \times 10^2}$?
(A) 2×10^9 (B) $2 \times 10^{3.5}$ (C) 2×10^5 (D) 12×10^5
- What is $6 \times 10^4 + 3 \times 10^3$?
(A) 9×10^4 (B) 6.3×10^4 (C) 9×10^7 (D) 6.3×10^3
- Which is 0.00000093 in scientific notation?
(A) 9.3×10^{-7} (B) 9.3×10^{-6} (C) 9.3×10^7 (D) 93×10^{-8}
- What is $(4 \times 10^3)(5 \times 10^4)$ in scientific notation?
(A) 20×10^7 (B) 9×10^7 (C) 2×10^{12} (D) 2×10^8
- Which number is the smallest?
(A) 1.1×10^{-4} (B) 4.2×10^{-6} (C) 3.9×10^{-5} (D) 5×10^{-5}
- Find $(5 \times 10^6)(4 \times 10^{-2})$ in scientific notation.
- Write 3.04×10^{-3} in standard form.
- Find $\frac{7.5 \times 10^9}{2.5 \times 10^{-3}}$ in scientific notation.
- Light travels about 3×10^5 kilometers per second. How many seconds does it take light to travel 1.5×10^8 kilometers?
- Find $3.6 \times 10^5 - 4 \times 10^4$ in scientific notation.
- A transistor on a chip is about 5×10^{-9} meters wide. How many fit side by side across 2×10^{-3} meters? Answer in scientific notation.

04.4 Powers in Context

Use powers to model growth, to relate length to area and volume, to count possibilities, and to avoid common mistakes with negatives and bases.

Why This Matters

Powers are the language of growth and size. A rumor spreads, bacteria multiply, a savings account earns interest, and a game board holds thousands of positions. In geometry, powers connect length, area, and volume: double the side of a square and the area grows four times, not two. Students who see powers only as symbols miss that story.

The most common struggles are treating exponential growth as if it were adding the same amount each time, forgetting that area uses a square and volume uses a cube, and slipping on negative signs and bases such as -2^4 versus $(-2)^4$. This section connects each of these to real pictures.

Want a plan built around **your** student?

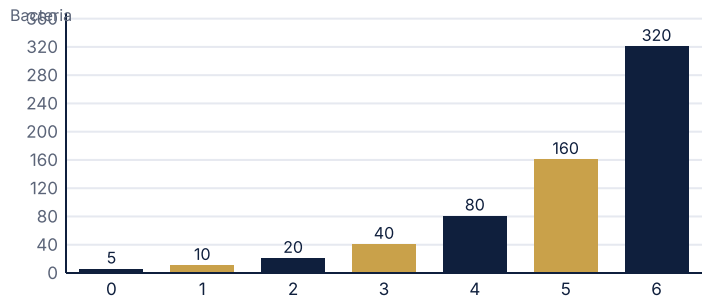
Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

Core Ideas

Repeated Multiplication Growth

If a quantity starts at A and is multiplied by r each step, then after n steps it is $A \cdot r^n$. Doubling means $r = 2$. Tripling means $r = 3$. Growing 10% means $r = 1.10$. Compare with **linear** growth, where you add the same amount each step. Exponential growth starts slowly and then explodes.



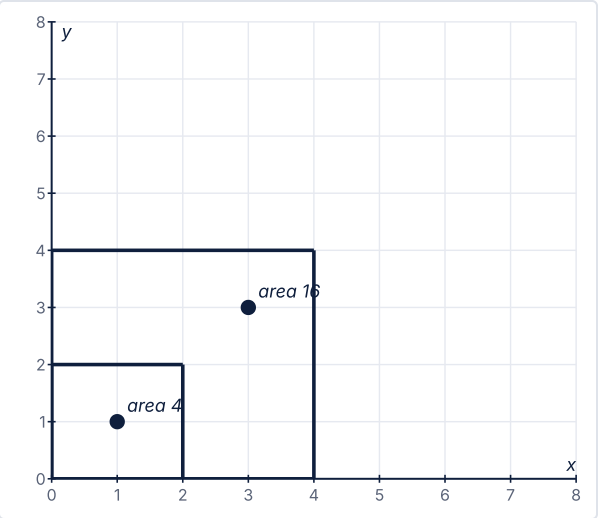
A culture of 5 bacteria that doubles every hour. Each bar is twice the one before: after 6 hours there are $5 \times 2^6 = 320$.

Hour	0	1	2	3	4
Doubling: $5 \cdot 2^n$	5	10	20	40	80
Adding 5 each time	5	10	15	20	25

Powers also count **possibilities**. If there are a choices for the first slot, b for the second, and so on, the total number of outcomes is the product $a \cdot b \cdots$. When every slot has the same number of choices, this becomes a power. A 4-digit code using digits 0 to 9 has $10^4 = 10,000$ possibilities, and five coin flips have $2^5 = 32$ outcomes.

Area and Volume Use Powers

A square with side s has area s^2 . A cube with edge s has volume s^3 . Scaling a figure by a factor k multiplies lengths by k , areas by k^2 , and volumes by k^3 . Double the side: area $\times 4$, volume $\times 8$.



Doubling the side from 2 to 4 makes the area go from 4 to 16, which is 4 times as large ($2^2 = 4$). A cube would grow 8 times.

Want a plan built around **your** student?
Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

Negatives and Bases

An exponent applies to what is directly to its left. $(-2)^4 = (-2)(-2)(-2)(-2) = 16$, but $-2^4 = -(2^4) = -16$.

A negative base to an **even** power is positive. To an **odd** power it is negative. $(-2)^3 = -8$ and $(-1)^{99} = -1$.

Order of operations still applies: exponents come before multiplying and before subtracting.

Worked Examples

EXAMPLE 1: DOUBLING GROWTH

A culture starts with 5 bacteria and doubles every hour. How many are there after 6 hours?

SOLUTION

Use $A \cdot r^n$ with $A = 5$, $r = 2$, $n = 6$.

$2^6 = 64$, so $5 \cdot 64 = 320$.

There are 320 bacteria.

EXAMPLE 2: SCALING AREA AND VOLUME

A cube has edge 3 cm. (a) What are its volume and one face area? (b) What happens to the volume if the edge doubles?

SOLUTION

(a) Volume $= 3^3 = 27$ cubic cm. Face area $= 3^2 = 9$ square cm.

(b) New edge $= 6$, new volume $= 6^3 = 216$.

$216 \div 27 = 8$, so doubling the edge multiplies the volume by 8 (not 2).

EXAMPLE 3: COUNTING WITH POWERS

How many 4-digit PINs are there (digits 0 to 9, repeats allowed)? How many license plates have 2 letters followed by 3 digits?

SOLUTION

PINs: four slots with 10 choices each, $10^4 = 10,000$.

Plates: $26 \cdot 26 \cdot 10 \cdot 10 \cdot 10 = 26^2 \cdot 10^3 = 676 \cdot 1000 = 676,000$.

EXAMPLE 4: NEGATIVES AND BASES

Evaluate (a) $(-2)^4$, (b) -2^4 , (c) $(-2)^3$, (d) $(-1)^{99}$.

SOLUTION

(a) Four negatives: even, so positive: 16.

(b) Exponent first, then the negative: $-(16) = -16$.

(c) Three negatives: -8 .

(d) 99 is odd, so -1 .

EXAMPLE 5: GROWING MONEY

You invest 200 dollars at 10% growth per year. How much do you have after 3 years?

SOLUTION

Each year multiplies by 1.10. So the amount is $200 \cdot 1.10^3$.

$1.10^3 = 1.331$.

$200 \cdot 1.331 = 266.20$ dollars.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

EXAMPLE 6: ADDING VERSUS DOUBLING

Plan A starts at 100 dollars and adds 20 dollars each week. Plan B starts at 5 dollars and doubles each week. After how many weeks does Plan B first have more money than Plan A?

SOLUTION

Plan A after n weeks: $100 + 20n$. Plan B: $5 \cdot 2^n$.

Build a table: week 3: A is 160, B is 40. Week 5: A is 200, B is 160. Week 6: A is 220, B is 320.

At week 5, B is still behind (160 versus 200). At week 6, B is ahead (320 versus 220).

Plan B first has more at **week 6**. Repeated multiplication always beats repeated adding eventually.

Coach's Playbook

- 1 Identify the pattern.** Is the same number added each time (linear) or multiplied each time (exponential)? Write the first few terms to see it.
 - 2 Name A , r , and n .** Start amount, multiplier, and number of steps. Count steps carefully: the starting time is step 0.
 - 3 Compute in the right order.** Find the power first, then multiply by the starting amount. Never multiply $A \cdot r$ first and then raise to n .
 - 4 Check with small cases.** Test $n = 1$ or $n = 2$ by hand before trusting the formula.
- ◆ Know the first ten powers of 2 and of 3. They appear constantly.
 - ◆ For scaling, ask: is this a length (power 1), area (power 2), or volume (power 3)?
 - ◆ Use parentheses around negative bases when you type them into a calculator.

Common traps

1. Computing $5 \cdot 2^6$ as $(5 \cdot 2)^6$. The power applies to the 2 only. 2. Thinking doubling the side doubles the area. It quadruples it, and volume goes up eight times. 3. Writing $-2^4 = 16$. The correct value is -16 . 4. Off-by-one counting: after 6 hours means 6 doublings starting from hour 0, not 7.

Mistake Clinic**Spot the error**

A student writes: $5 \cdot 2^3 = 10^3 = 1,000$. **What went wrong:** the student multiplied 5 and 2 first. The exponent belongs to the 2 only, and powers come before multiplication. **Right solution:** $2^3 = 8$, then $5 \cdot 8 = 40$.

Spot the error

A student says that doubling the side of a square with area 9 square cm gives a new area of 18 square cm. **What went wrong:** area depends on the side squared, so doubling the side multiplies the area by $2^2 = 4$, not 2. **Right solution:** the side is 3, the new side is 6, and the new area is $6^2 = 36$ square cm.

Spot the error

A student says that 10% growth per year for 2 years on 200 dollars means 20% growth, so the total is $200 \cdot 1.2 = 240$ dollars. **What went wrong:** the second year's growth is 10% of the larger amount, so the growth factors multiply. **Right solution:** $200 \cdot 1.1^2 = 200 \cdot 1.21 = 242$ dollars.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

Real-World Connection

Fold a sheet of paper in half again and again. After 7 folds you have $2^7 = 128$ layers. The thickness grows by powers, which is why folding more than about 7 times is nearly impossible.

Challenge Corner

A patch of algae doubles its area every day and covers a whole pond of 512 square meters on day 10. (a) How much area does it cover on day 6? (b) On which day was the pond one eighth covered? **Solution:** Going back one day halves the area. (a) From day 10 to day 6 is 4 days back, so the area is $512 \div 2^4 = 512 \div 16 = 32$ square meters. (b) One eighth of 512 is 64. Since $\frac{1}{8} = \frac{1}{2^3}$, that was 3 days before day 10, which is day 7. Check: day 7 is 64, day 8 is 128, day 9 is 256, day 10 is 512.

Practice**PRACTICE Powers in Context**

Show your work on paper. Use a calculator only when a problem says so, or if it is allowed at your level.

- A plant starts at 4 cm and doubles in height every week. How tall is it after 5 weeks?
(A) 40 cm (B) 128 cm (C) 20 cm (D) 1,024 cm
- What is the volume of a cube with edge 5 inches?
(A) 25 cubic inches (B) 15 cubic inches (C) 125 cubic inches
(D) 625 cubic inches
- If every edge of a cube is doubled, the volume is multiplied by
(A) 2 (B) 4 (C) 6 (D) 8
- What is the value of $(-3)^4$?
(A) 81 (B) -81 (C) -12 (D) 12
- A lock code has 3 letters (A to Z), and letters can repeat. How many codes are possible?
(A) 78 (B) 676 (C) 17,576 (D) 15,600
- You deposit 100 dollars and it grows 5% each year. How much is there after 2 years?
(A) 110.00 (B) 110.25 (C) 105.00 (D) 120.00
- A video has 3 views on day 0, and the number of views triples each day. How many views does it have on day 4?
(A) 12 (B) 81 (C) 6,561 (D) 243
- A square has side length 6 cm. If the side length is tripled, the new area is how many times the old area?
(A) 9 (B) 3 (C) 6 (D) 27
- What is the value of $-4^2 + (-4)^2$?
(A) 32 (B) 0 (C) -32 (D) 16
- Evaluate $-2^6 + (-2)^3$.
- A rumor starts with 1 student. Each student who hears it tells 3 new students the next day. How many students hear it for the first time on day 4?
- A square has area 144 square cm. Its side is doubled. What is the new area in square cm?
- A town of 500 people triples in number every year for 4 years in a model. What is the population at the end?
- A password has 2 letters (26 choices each, repeats allowed) followed by 3 digits (0 to 9, repeats allowed). How many passwords are possible?
- An account holds 500 dollars and grows 4% each year. How much is in it after 3 years, to the nearest cent, in dollars?

Answers **Answers and Explanations**

Complete solutions for every practice problem, numbered to match. Read the explanation even when your answer is right.

04.1 Exponent Basics and the Laws of Exponents

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

PRACTICE · EXPONENT BASICS AND THE LAWS OF EXPONENTS

1. C. Same base, so add exponents: $2 + 5 = 7$. Choice A multiplies the exponents, and choice B multiplies the bases.
2. B. Power rule: multiply exponents, $4 \cdot 3 = 12$. Choice A adds them, which is the product rule.
3. C. A negative exponent means reciprocal: $\frac{1}{10^2} = \frac{1}{100}$. Choice B treats the negative as making the answer negative.
4. A. Subtract exponents: $6^3 = 216$. Choice D computes $6 \cdot 3$, mistaking the exponent for a multiplier.
5. D. Both factors get the power: $2^4 = 16$ and $(a^3)^4 = a^{12}$. Choice C forgets to raise the 2 to the fourth.
6. A. $7^0 = 1$ and $2^{-1} = \frac{1}{2}$, so the sum is $\frac{3}{2}$. Choice D wrongly uses $7^0 = 0$.
7. D. A negative exponent means the reciprocal of the positive power: $x^{-3} = \frac{1}{x^3}$. Choice B confuses a negative exponent with a negative number.
8. B. The bottom is $x^{3+2} = x^5$. Then $x^{9-5} = x^4$. Choice C only divides by x^3 .
9. C. $(-2)^3 = -8$ and $2^{-1} = \frac{1}{2}$, so the product is -4 . Choice B treats 2^{-1} as 2 and multiplies.
10. 4. Top: $2^{5-2} = 2^3$. Then $2^{3-1} = 2^2 = 4$.
11. $\frac{9x^4}{y^2}$. Square each part: $9x^4y^{-2}$, then move y^{-2} to the bottom.
12. $\frac{25}{16}$. Flip the fraction: $(\frac{5}{4})^2 = \frac{25}{16}$.
13. $n = -5$. Since $2^5 = 32$, the reciprocal is 2^{-5} .
14. $\frac{8a^2}{b^2}$. Top: $4^3a^6b^3 = 64a^6b^3$. Divide: $\frac{64}{8} = 8$, $a^{6-4} = a^2$, $b^{3-5} = b^{-2}$. Move b^{-2} to the bottom.
15. 6. Top: $\frac{1}{8} + \frac{1}{4} = \frac{3}{8}$. Bottom: $\frac{1}{16}$. Then $\frac{3}{8} \div \frac{1}{16} = \frac{3}{8} \cdot 16 = 6$.

04.2 Square Roots, Cube Roots, and Irrational Numbers**PRACTICE · SQUARE ROOTS, CUBE ROOTS, AND IRRATIONAL NUMBERS**

1. B. $9 \cdot 9 = 81$. Choice C halves 81, mistaking root for division by 2.
2. D. $4 \cdot 4 \cdot 4 = 64$. Choice A is the square root of 64.
3. B. $49 < 50 < 64$, so $7 < \sqrt{50} < 8$. Choice D halves 50.
4. C. $45 = 9 \cdot 5$, so $\sqrt{45} = 3\sqrt{5}$. Choice A forgets to take the root of 9.
5. D. $\sqrt{12}$ is not a root of a perfect square, so it is irrational. $\sqrt{49} = 7$, $0.125 = \frac{1}{8}$, and $\frac{22}{7}$ is a fraction, so those are rational.
6. B. $25 < 30 < 36$ and $5.5^2 = 30.25$, very close to 30. Choice C is the root of 36, and D halves 30.
7. A. $\sqrt{121} = 11$ and $\sqrt[3]{8} = 2$, so $11 - 2 = 9$. Choice B subtracts 8 instead of its cube root.
8. C. $98 = 49 \cdot 2$, so $\sqrt{98} = 7\sqrt{2}$. Choice A forgets to take the root of 49.
9. D. The side is $\sqrt{20}$. Since $4.5^2 = 20.25$, the side is just under 4.5. Choice A halves 20.
10. $10\sqrt{2}$. $200 = 100 \cdot 2$, so $\sqrt{200} = 10\sqrt{2}$.
11. 68 feet. Side = $\sqrt{289} = 17$, perimeter = $4 \cdot 17 = 68$.
12. 3. $\sqrt[3]{-27} = -3$ and $\sqrt{36} = 6$, so $-3 + 6 = 3$.
13. 10 and 11. $100 < 110 < 121$, so $10 < \sqrt{110} < 11$ (about 10.5).
14. $8\sqrt{2}$. $\sqrt{18} = 3\sqrt{2}$ and $\sqrt{50} = 5\sqrt{2}$. These are like terms, so $3\sqrt{2} + 5\sqrt{2} = 8\sqrt{2}$.
15. 294 square inches. Edge = $\sqrt[3]{343} = 7$. Each face has area $7^2 = 49$, and a cube has 6 faces, so $6 \cdot 49 = 294$.

04.3 Scientific Notation**PRACTICE · SCIENTIFIC NOTATION**

1. D. Move the decimal 6 places left to get 5.3, so the exponent is 6. Choice A has a front number of 53, which is not between 1 and 10.
2. A. Move the decimal 4 places right, so the exponent is -4 . Choice C counts one place too few.
3. C. The two numbers with exponent 5 are bigger than the rest, and $3.1 > 2.5$. Choice A has the biggest front number but a smaller exponent.
4. B. Multiply $2 \cdot 3 = 6$ and add exponents $3 + 5 = 8$. Choice A multiplies the exponents.
5. C. Divide $8 \div 4 = 2$ and subtract exponents $7 - 2 = 5$. Choice A adds the exponents.
6. B. Rewrite $3 \times 10^3 = 0.3 \times 10^4$, then $6 + 0.3 = 6.3$. Choice A adds the front numbers without matching the powers.
7. A. Move the decimal 7 places right to get 9.3, so the exponent is -7 . Choice D is not in proper form because 93 is more than 10.
8. D. $4 \cdot 5 = 20$ and $10^{3+4} = 10^7$, giving 20×10^7 . That front number is too big, so it becomes 2×10^8 . Choice A is correct in value but not in scientific notation.
9. B. The most negative exponent is -6 , which is the smallest. Choice A has the largest front number but the largest exponent, so it is the biggest.
10. 2×10^5 . $5 \cdot 4 = 20$ and $10^{6-2} = 10^4$, so $20 \times 10^4 = 2 \times 10^5$.
11. 0.00304. Move the decimal 3 places left.
12. 3×10^{12} . $7.5 \div 2.5 = 3$ and $10^{9-(-3)} = 10^{12}$.
13. 500 seconds. $\frac{1.5 \times 10^8}{3 \times 10^5} = 0.5 \times 10^3 = 500$.
14. 3.2×10^5 . Write $4 \times 10^4 = 0.4 \times 10^5$. Then $3.6 - 0.4 = 3.2$.
15. 4×10^5 . Divide: $\frac{2 \times 10^{-3}}{5 \times 10^{-9}} = 0.4 \times 10^6 = 4 \times 10^5$.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →

04.4 Powers in Context**PRACTICE · POWERS IN CONTEXT**

1. B. $4 \cdot 2^5 = 4 \cdot 32 = 128$. Choice D is 4^5 , which uses 4 as the multiplier, and choice C adds 4 each week.
2. C. Volume $= 5^3 = 125$. Choice A is the area of one face.
3. D. Volume uses a cube: $2^3 = 8$. Choice B is the factor for area.
4. A. Four factors of -3 multiply to a positive: 81. Choice B is -3^4 , where the negative is outside.
5. C. $26^3 = 17,576$. Choice A adds $(26 \cdot 3)$ and choice B is 26^2 .
6. B. $100 \cdot 1.05^2 = 110.25$. Choice A adds 5% of the original each year, which ignores growth on the interest.
7. D. $3 \cdot 3^4 = 3 \cdot 81 = 243$. Choice A adds 3 each day instead of multiplying. Choice B forgets the starting 3.
8. A. Area uses a square: $3^2 = 9$. Choice D would be the factor for volume.
9. B. $-4^2 = -16$ and $(-4)^2 = 16$, so the sum is 0. Choice A treats both as positive 16.
10. -72 . $-2^6 = -64$ and $(-2)^3 = -8$. Sum: -72 .
11. 81. Day n has 3^n new listeners, so day 4 has $3^4 = 81$.
12. 576. The side is 12, the new side is 24, and $24^2 = 576$. (Check: $144 \cdot 4 = 576$.)
13. 40,500. $500 \cdot 3^4 = 500 \cdot 81 = 40,500$.
14. 676,000. Count the choices: $26^2 \cdot 10^3 = 676 \cdot 1000 = 676,000$.
15. 562.43 dollars. $500 \cdot 1.04^3 = 500 \cdot 1.124864 = 562.432$, which rounds to 562.43.

Want a plan built around **your** student?

Book a free consultation. The short intake takes about a minute and opens right away.

BOOK NOW →