Dimensional Analysis:
Converting Units with Confidence

Purpose: replace guesswork with a repeatable, unit-tracking conversion method

Conversions appear in cooking, travel, medication labels, labs, and trade reports

Core promise: units carry meaning; tracking them prevents silent errors

Roadmap: dimensions, SI units, factors, chain method, prefixes, traps, practice, verification

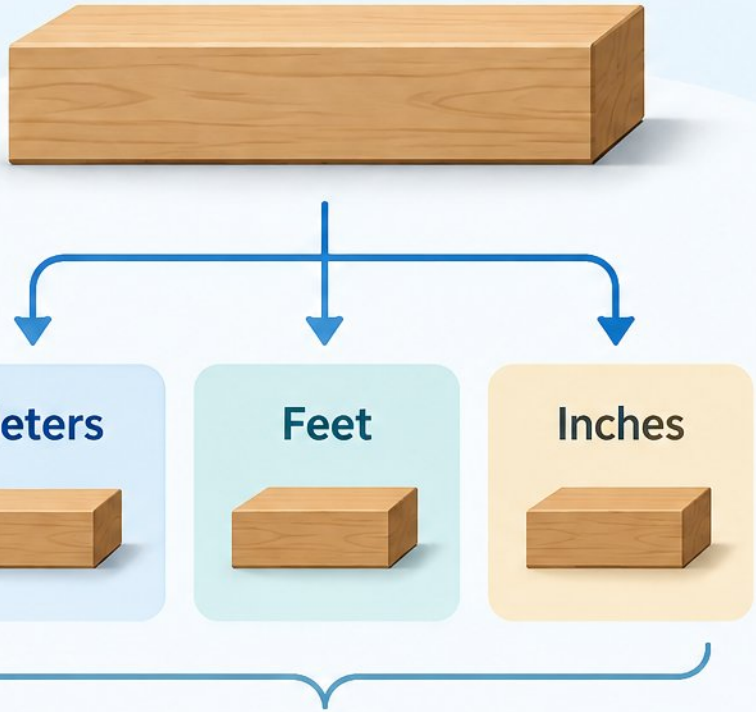
Learning goals tailored for students, adult learners, and educators



Same Quantity.
New Unit.
Greater Confidence.

Why Units Matter: Dimensions Versus Units

Same physical object, different units

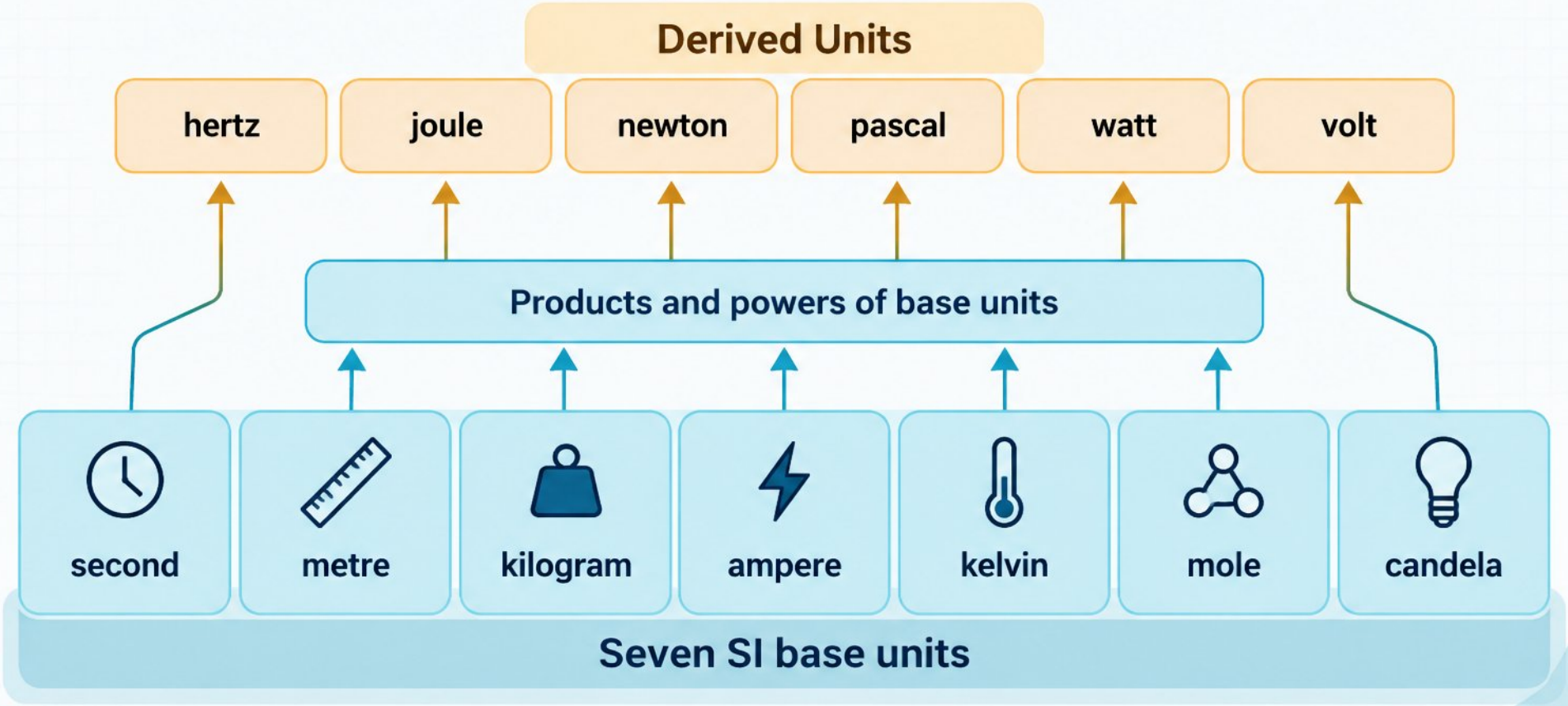


Length is a dimension; meters and feet are units of it

- A unit is a label that carries meaning, not decoration
- Length is a dimension; meters and feet are units of it
- Separate quantity, dimension, and unit when reading a problem
- Missing or mismatched units signal an early error
- Memorized factor lists fail on multi-step, unfamiliar problems

The Seven SI Base Quantities and Derived Units

- Seven SI base units: second, metre, kilogram, ampere, kelvin, mole, candela
- Since 2019, base units rest on fixed defining constants (BIPM SI Brochure, rev. June 2026)
- Derived units are products and powers of base units: hertz, joule, newton, pascal, watt, volt
- Dimension formulas: area L^2, speed L/T, density M/L^3, force ML/T^2, pressure $M/(LT^2)$, energy ML^2/T^2
- Check equation plausibility by matching dimensions before computing



Conversion Factors: Ratios Equal to One

1. A conversion factor is a ratio of equal quantities, so it equals 1
2. Build exact factors from definitions: 1 in = 2.54 cm; 1 ft = 0.3048 m
3. Orientation matters: place the unwanted unit opposite the wanted unit
4. NIST marks exact factors in boldface or underlined—approximate ones are not
5. Catch inverted factors by checking which unit cancels

A Conversion Factor Equals 1

$$\frac{1\ \text{in}}{2.54\ \text{cm}} = \frac{2.54\ \text{cm}}{1\ \text{in}}$$

Unwanted unit in the opposite position

Wanted unit in the opposite position

$$\frac{\cancel{\text{in}}}{\cancel{\text{in}}} = 1$$

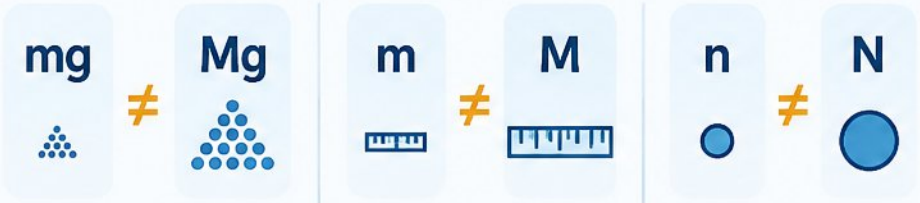
Prefixes and Unit Notation Read Correctly

1 SI prefixes run quecto (10^{-30}) to quetta (10^{30}), with 2022 additions

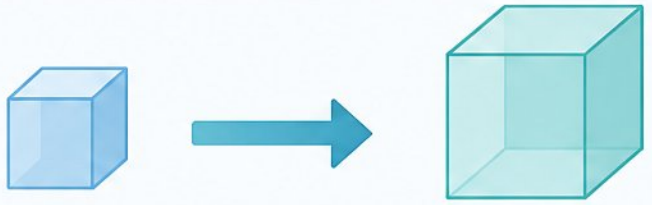


SI prefix scale (selected endpoints)

2 Casing changes size: mg ≠ Mg; m ≠ M; n ≠ N



3 Prefixes attach inseparably: 2.3 cm^3 = 2.3 × 10^{-6} m^3



4 Only one prefix per unit: no compound prefixes like mkg

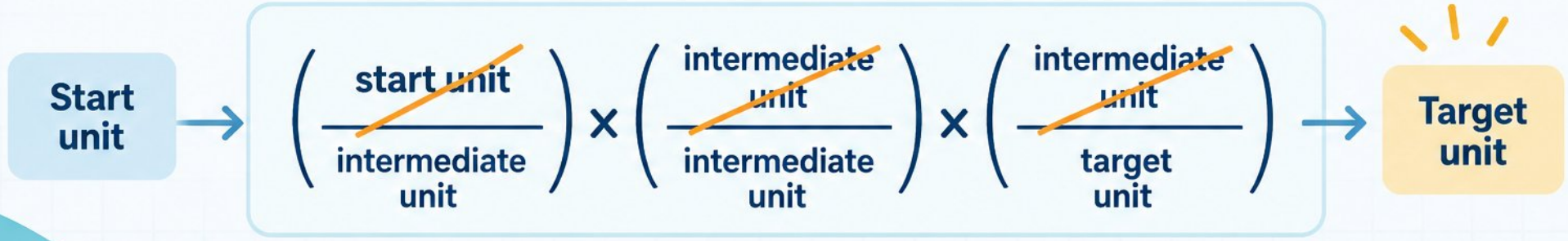


5 Watch solidus misuse and implied parentheses in compound units



The Chain Method: One Expression, Many Steps

- Five-step routine: start unit, target unit, pick factors, cancel, compute
- Write units as fractions; cancel diagonally across a single chain
- Carry three or more factors in one organized expression
- Confirm the final unit matches the target before multiplying
- Templates: mph → m/s, fl oz → mL, ft^2 → m^2



Temperature and Other Non-Ratio Conversions

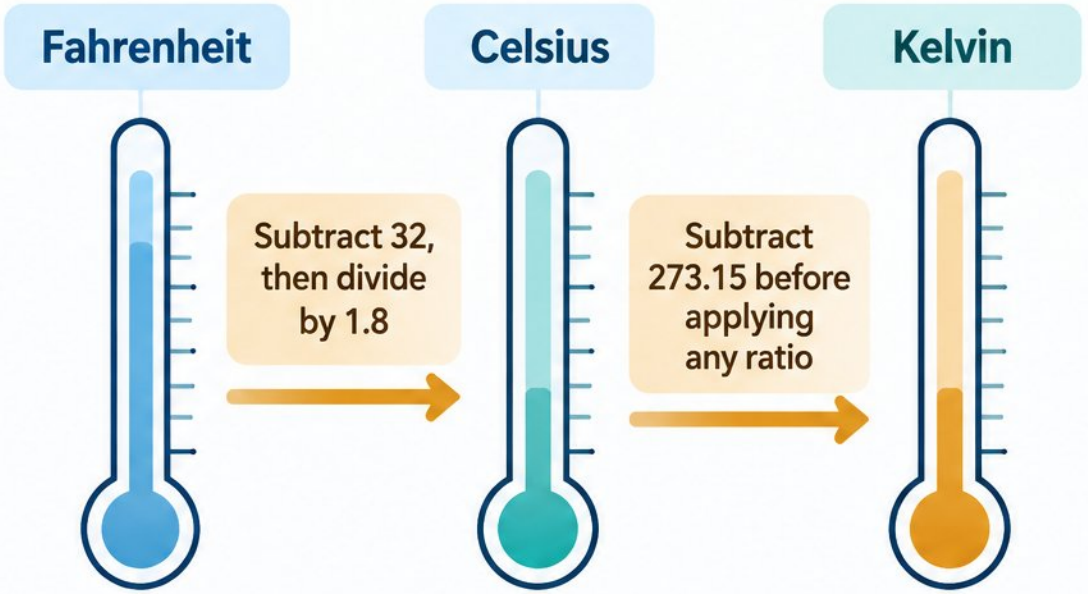
Offsets break ratio logic: temperature scales need addition and subtraction

Celsius: subtract 32, then divide by 1.8

Kelvin: subtract 273.15 before applying any ratio

Temperature values use **scale formulas;** temperature intervals use plain ratios

An offset cannot be hidden inside a unit-cancellation chain



Not a valid approach: $°F \times \frac{\text{ratio}}{\quad} = °C$

Moving Between Metric and US Customary Units

Metric	Conversion Factors	US Customary
centimeter (cm)	⟷	inch (in)
kilogram (kg)	⟷	pound (lb)
liter (L)	⟷	quart (qt)
kilometer (km)	⟷	mile (mi)

Quick estimates: 1 in ≈ 2.54 cm; 1 lb ≈ 0.45 kg; 1 qt ≈ 0.95 L; 1 mi ≈ 1.61 km

Use **exact factors** for trade, legal metrology, and technical documents — Exact

Fuel economy is not a simple ratio: L/100 km = 235.215 ÷ (miles per US gallon)

US survey foot retired in 2022; use the international foot (1 ft = 0.3048 m)

Label every quantity to reduce hybrid-system confusion in shared reports

Common Traps and How to Avoid Them

Small checks prevent big mistakes.

• Inverted or double-divided factors — always check which unit cancels	✗ $\frac{m}{s} \times \frac{s}{m}$	✓ 1
• Area and volume prefixes: square or cube the prefix too ($2.3\ cm^3 = 2.3 \times 10^{-6}\ m^3$)	✗ $2.3\ cm^3 = 2.3 \times 10^{-2}\ m^3$	✓ $2.3\ cm^3 = 2.3 \times 10^{-6}\ m^3$
• Mixing unit systems mid-calculation — convert consistently, one system at a time	✗ 5 km + 300 m	✓ 5,300 m
• Rounding too early — keep all digits internally, round once at the end	✗ Use a rounded value early	✓ Keep all digits internally
• Temperature offsets and symbol case: mg vs. Mg differ by 10^9	✗ 1000 mg = 1 Mg	✓ 1000 mg = 10^{-6} Mg

Check your units.
Build confidence.



Checking Your Work: Magnitude and Precision

- **Unit check:** confirm your final unit before trusting the number
- **Sanity check:** does the answer match everyday expectations?
- **Keep all digits** during work; round once at the end
- **Report only the precision** your measurement truly supports
- **Use a short personal checklist,** even under time pressure



Practice Workshop: Student and Lab Scenarios

Think-aloud walkthrough: multi-step solution with visible cancellation

Lab problems: convert mg/L to micrograms per liter

Check the dimensions of a formula before substituting numbers

Progression: one-step, then two-step, then three-or-more-step conversions

Peer check: verify the unit path before comparing answers

Lab Scenario: mg/L to Micrograms per Liter



Convert a concentration from mg/L to micrograms per liter.

Unit-Cancellation Chain

$$\frac{\text{mg}}{\text{L}} \times \frac{\mu\text{g}}{\cancel{\text{mg}}} \times \frac{\cancel{\text{L}}}{\text{L}} \rightarrow \frac{\mu\text{g}}{\text{L}}$$



Peer Check

Verify the unit path before comparing answers.

Practice Workshop: Everyday and Educator Scenarios

Travel distances



Recipe scaling



Grocery unit prices



Medication label checks



- Workplace: converting packaged goods or fuel figures with documented factors
- Educators: grade exercises, trace where unit tracking broke down
- Rationales reward unit reasoning, not just correct numbers
- Exit task: one unfamiliar conversion, chain method, defensible precision



Reference Sources and Tools



Trust software for routine work; trace units by hand when unsure

Build a short personal quick-reference and cite the source

Managing Conversions Confidently at Work: Review and Next Steps

Build on what you've learned and keep going with confidence.



Metric Conversion Act (1975) and 1988 Trade Act set SI as federal target



Self-check: 10-item mixed quiz, scored on unit tracking



Spaced review: one deliberate conversion per week at work



Extend to rates, flow, energy, radiation, and digital prefixes



Wrap-up: NIST and BIPM resources for ongoing reference



PersonWise.

PersonWise • AI digital-human course platform

Scan the code or click anywhere to watch this course live, with voice Q&A

personwise.ai/t/480aa755/public