

Using Units to Solve Multi-Step Problems

Grade 9 – Algebra 1 math · Lesson · Standards: N-Q.A.1, N-Q.A.2, N-Q.A.3

Quick answer: Unit analysis means carrying units through every step of a calculation and multiplying by conversion factors equal to 1 so that unwanted units cancel. The units show whether a setup is sensible, they define useful quantities such as unit rates, and they guide choices about graph scales and rounding.

Standards: N-Q.A.1, N-Q.A.2, N-Q.A.3 · **Level:** Grade 9 Algebra 1

How does unit analysis keep a problem on track?

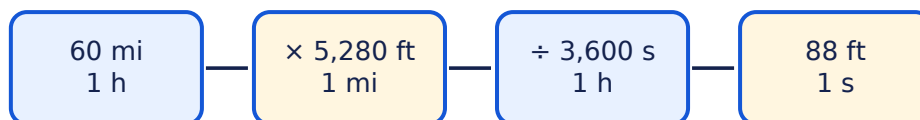
A **quantity** is a number with a unit, such as 45 miles or \$3.20 per gallon. When you multiply or divide quantities, the units multiply or divide too. Writing them in every step shows whether the final unit makes sense.

Unit analysis (dimensional analysis)

Multiplying by **conversion factors** (fractions equal to 1, like $\frac{(1 \text{ h})}{(60 \text{ min})}$) so that unwanted units cancel and the wanted unit remains.

How do you convert a rate?

A rate has two units, so convert each one in turn. Set the factors up so the old units sit diagonally and cancel.



Each arrow multiplies by a conversion factor equal to 1.

Method: convert 60 mi/h to feet per second

1. Write the rate as a fraction: $\frac{(60 \text{ mi})}{(1 \text{ h})}$.
2. Multiply by $\frac{(5,280 \text{ ft})}{(1 \text{ mi})}$ so miles cancel.
3. Multiply by $\frac{(1 \text{ h})}{(3,600 \text{ s})}$ so hours cancel.
4. Multiply the numbers: $60 \times 5,280 \div 3,600 = 88$, so the rate is **88 ft/s**.

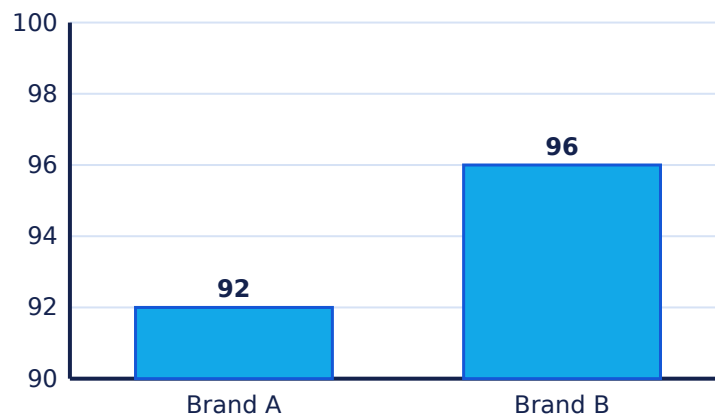
Which quantity should you define for a comparison?

Totals can mislead. A town with 9,000 residents is not necessarily more crowded than one with 6,000. Divide by the area to define **people per square mile**, a quantity that treats both fairly.

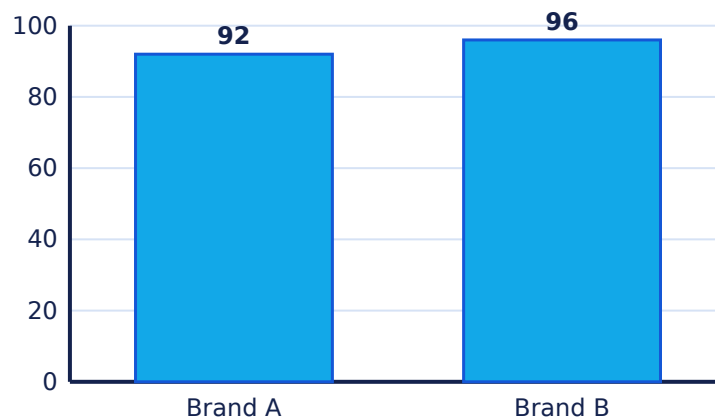
Question	Quantity to define	Unit
Which car is thriftier?	distance ÷ fuel	miles per gallon
Which store is cheaper?	price ÷ amount	dollars per ounce
Which team scores faster?	points ÷ time	points per minute

How do scale and origin change a graph?

The **scale** is the size of each step on an axis and the **origin** is where the axis starts. Choose both so that all data fits and the picture is honest.



A vertical axis that starts at 90 makes a 4-point gap look huge.



Starting at 0 shows the true size of the gap.

Common mistake

Starting an axis at 90 instead of 0 stretches small differences. Say where the axis begins whenever you compare bar heights.

How accurate should an answer be?

Report results with the accuracy of the least precise measurement. Round only at the end, never in the middle of a calculation.

Measured: 12.4 ft by 7.8 ft (3 and 2 significant figures)

Calculator: $12.4 \times 7.8 = 96.72 \text{ ft}^2$

Report with the weaker accuracy: 97 ft^2

The answer cannot be more precise than the measurements.

Mathbot's tip

Write the unit next to every number. If the units do not combine into the unit you expect, check the setup before you press any calculator keys.

Key points to remember

- A conversion factor is a fraction equal to 1, such as 5,280 ft over 1 mile.
- Convert a rate by converting the top unit and the bottom unit separately.
- Dividing by area or time defines fair quantities like people per acre.
- An axis that does not start at 0 exaggerates differences between bars.
- Round once at the end, matching the least precise measurement.

Using Units to Solve Multi-Step Problems: frequently asked questions

What is a conversion factor?

A conversion factor is a fraction whose top and bottom describe the same amount in different units, such as 12 inches over 1 foot. Because the value is 1, multiplying by it changes the unit but not the amount.

How do you convert square units?

Square the length factor. Since $1 \text{ yd} = 3 \text{ ft}$, $1 \text{ yd}^2 = 9 \text{ ft}^2$, so 2 yd^2 is 18 ft^2 . Converting an area with the length factor alone is a very common error.

Why can a graph with a cut-off axis be misleading?

Bar height is read as size. If the axis starts at 90, a bar for 96 is drawn three times as tall as a bar for 92 even though the values differ by only about 4 percent.

How many digits should an answer have?

Keep as many significant digits as the least precise measurement. If a length is 7.8 ft and another

is 12.4 ft, a product reported as 97 ft² has two significant figures, matching the weaker value.

When do you round up instead of to the nearest value?

Round up when the answer counts whole items that must cover a need, such as bags of soil or buses. If 17.2 bags are required, 18 bags must be bought.