Dimensional Analysis

Grade 9 – 11 · the factor-label method

Name: Date: Score: / 26

Why this method is worth the setup

Dimensional analysis — also called the factor-label method — converts units by multiplying by fractions that are equal to one. Since 1000 m and 1 km are the same length, the fraction **1000 m / 1 km** equals one, and multiplying by it changes the units without changing the quantity.

The payoff is that the method **checks itself**. You arrange each fraction so the unit you want rid of sits on the opposite line from where it already is, then cross out the pairs. If the units left over are the ones you wanted, the arithmetic is the only thing that can still be wrong.

That matters more as problems get longer. Converting km/h to m/s by instinct means guessing whether to multiply or divide by 3600. Set up as fractions, the hours have to cancel, and there is only one way to write it that lets them.

$$\frac{2.5\ \text{km}}{} \times \frac{1000\ \text{m}}{1\ \text{km}} \times \frac{100\ \text{cm}}{1\ \text{m}}$$

= 250 000 cm

The km cancel against the first factor and the m against the second, leaving cm.

The method

- Write the quantity you have, then **multiply** by conversion factors written as fractions.
- Each factor is a **true statement** over itself, so it equals 1 and changes nothing but the units.
- Put the unit you want to **cancel** on the opposite line from where it already is.
- Cross out the cancelling pairs. The units left over must be the units you **wanted**.
- If the leftover units are wrong, the **set-up** is wrong — do not fix it by flipping the answer.
- Multiply the top, multiply the bottom, divide **once** at the end.

Part A — Set it up write the factors, then cancel (4 marks)

1. Convert 2.5 km to cm

2. Convert 45 min to seconds

Part B — Convert show the full set-up (18 marks)

1. Convert 72 km/h into m/s.

2. Convert 2.50 L to cm^3.

3. A car uses 8.0 L per 100 km. How many litres for a 350 km trip?

4. Convert 5.0 g/cm^3 to kg/m^3.

5. How many seconds are in 1.0 day?

6. A tap runs at 12 L/min. How many litres in 1.5 hours?

Part C — Find the error (4 marks)

1. To convert 5 km to m, a student writes 5 km × (1 km / 1000 m).

2. To convert 90 km/h to m/s, a student multiplies by 1000 and by 3600.

Dimensional Analysis — Answer Key

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Part A — Set it up

1. **250 000 cm**
   2.5 km to cm: start value (1000 m / 1 km) × (100 cm / 1 m)
2. **2700 s**
   45 min to seconds: start value (60 s / 1 min)

Part B — Convert

1. **20 m/s**
   72 × 1000 ÷ 3600 = 20. Two factors: 1000 m per km and 1 h per 3600 s.
2. **2500 cm^3**
   1 L = 1000 mL and 1 mL = 1 cm^3.
3. **28 L**
   350 km × (8.0 L / 100 km) = 28. The km cancel, leaving litres.
4. **5.0×10^3 kg/m^3**
   Divide by 1000 for g to kg, multiply by 10^6 for cm^3 to m^3. Net factor 1000.
5. **8.6×10^4 s**
   24 h × 60 min × 60 s = 86 400, which is 2 s.f. from the 1.0.
6. **1100 L**
   12 × 60 × 1.5 = 1080, rounded to 2 s.f. because 12 has 2.

Part C — Find the error

1. **The factor is upside down.**
   The km would have to cancel, so km must be on the bottom: 5 km × (1000 m / 1 km) = 5000 m. Written as the student has it, the leftover units are km^2/m, which is the warning sign.
2. **The time factor is the wrong way up.**
   Hours are on the bottom, so to cancel them the hours must go on top: divide by 3600, not multiply. 90 × 1000 ÷ 3600 = 25 m/s.