Course compass

Question directrice : What do a fraction, a ratio and a proportion mean before any formula?

Markers: 📏 MEASURED · 📐 CONVENTION · 🧮 CALCULATED · 🎓 TEACHING ASSUMPTION · ⚠️ APPROXIMATION

- understand the concept
- do a simple calculation
- explain every symbol
- check a result

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1 — Before symbols: understand what is being shared

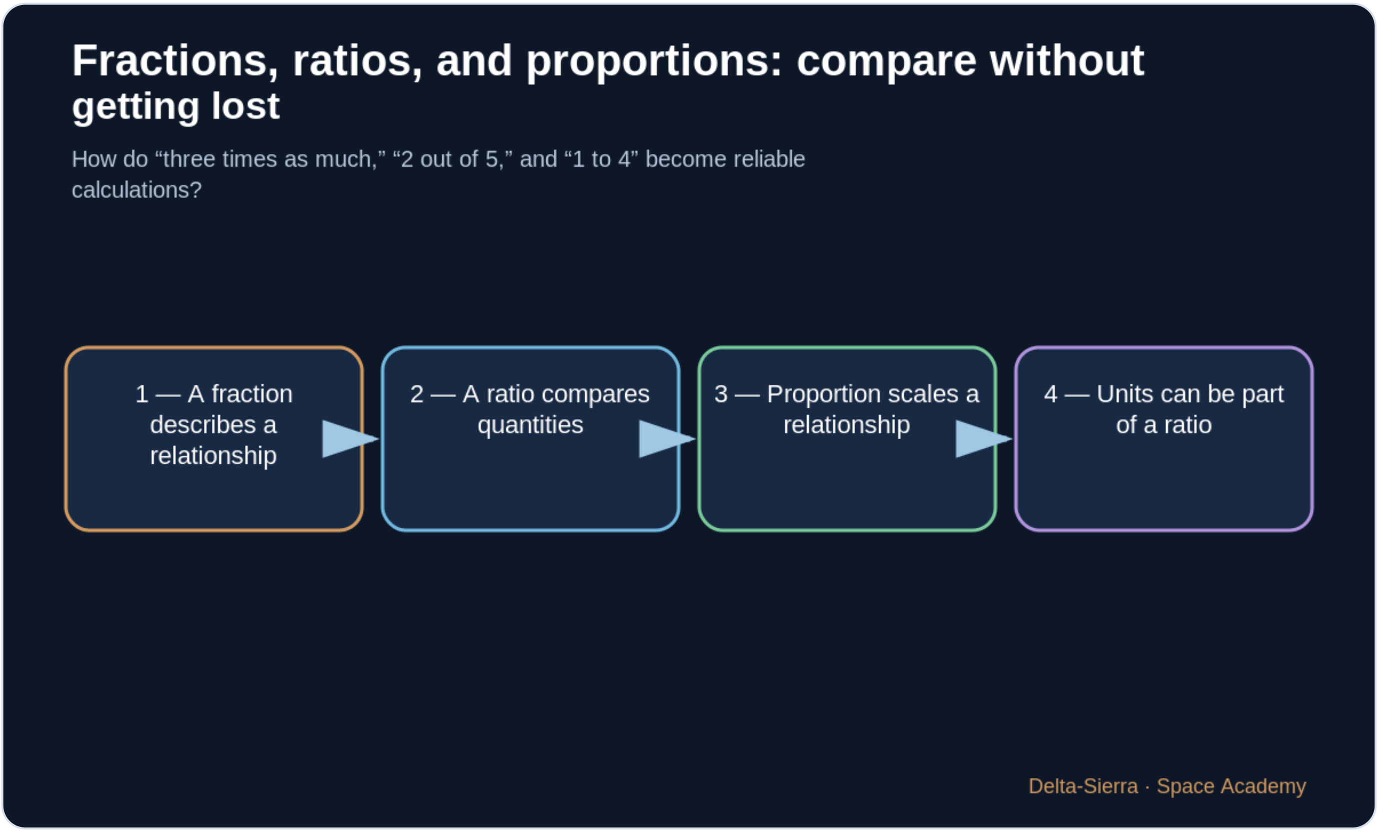
A fraction, ratio or proportion is not primarily a formula. It is a way to answer a concrete question: **how is a total quantity shared, compared or scaled?**

Before calculating, name the objects. “3 out of 4” is incomplete unless we know what the four things are: batteries, kilograms of water, hours of operation, or something else. Context gives the number meaning.

The word “part”

In this course, a **part** means one equal share of a total that we mentally divide for distribution. It is not necessarily a physical object.

Example: if 8 kg are divided into 4 equal parts, one part is 8 ÷ 4 = 2 kg.



Fractions, ratios and proportions are three ways to describe sharing or comparison.

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2 — A fraction describes part of a whole

$3/4$ is read **"three quarters"**. It means three equal parts taken out of four equal parts.

The fraction bar also means division: $3/4 = 3 \div 4 = 0.75$. Since 0.75 equals 75%, we may write $3/4 = 0.75 = 75\%$.

Concrete example — Three batteries available out of four

A Mars base has 4 identical batteries. Three are available and one is under maintenance. The available fraction is 3/4.

Decimal form: 3 ÷ 4 = 0.75. Percentage: 0.75 × 100 = 75%.

Plain English: 75% of the batteries are available.

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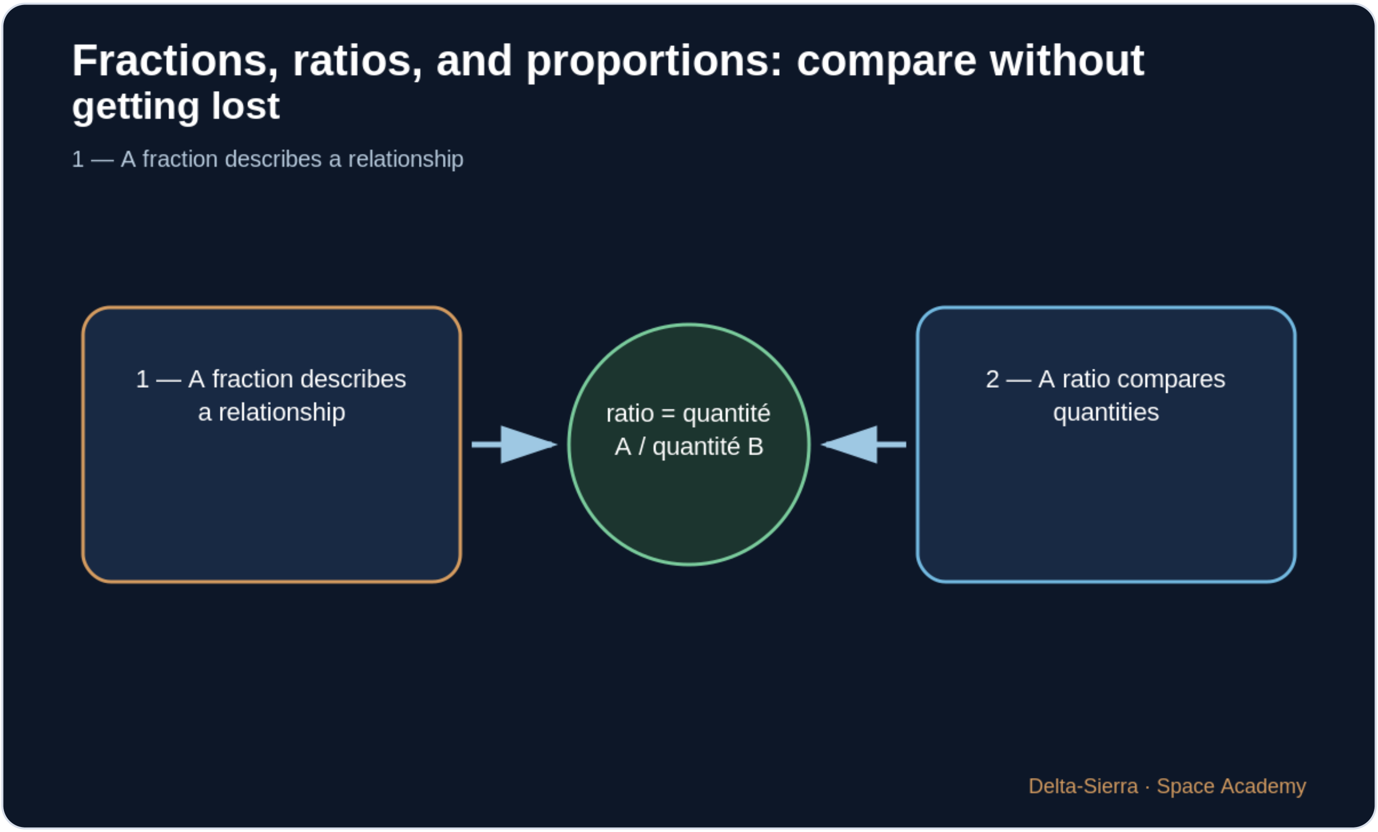
3 — A ratio compares two quantities

The ratio $3{:}1$ is read **"three to one"**. It means that when the first quantity receives three equal parts, the second receives one.

Important: 3:1 does not automatically mean 3 kg and 1 kg. The ratio gives a **relationship**; a total or one known quantity is still needed to find actual values.



A ratio compares quantities before their final values are known.

Master example — A Mars computer and its protective shell

We must send an 8 kg computer package to Mars. The 8 kg total includes the computer and its protective shell.

For this teaching example, use the ratio **computer : protection = 3:1**.

Step 1. Total parts = 3 + 1 = 4.

Why add? Because we need the total number of equal parts making up the 8 kg package.

Step 2. One part = 8 kg ÷ 4 = 2 kg.

Why divide by 4? Because the total is split into four equal shares.

Step 3. Computer = 3 × 2 kg = 6 kg.

Step 4. Protection = 1 × 2 kg = 2 kg.

Check. 6 + 2 = 8 kg.

Plain English: the computer is 6 kg and the protective shell is 2 kg in this example.

Calculator sequence

Type **8 ÷ 4 =** to obtain 2. Then **3 × 2 =** to obtain 6. Check with **6 + 2 =** to recover 8.

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4 — Proportionality lets us scale

A relationship is **proportional** when multiplying one quantity by a factor multiplies the other by the same factor. The essential condition is that the amount per unit remains constant.

Concrete example — Identical oxygen bottles

We have 4 identical bottles. Each contains **5 kg of oxygen**.

With 4 bottles: 4 × 5 kg = **20 kg of oxygen**.

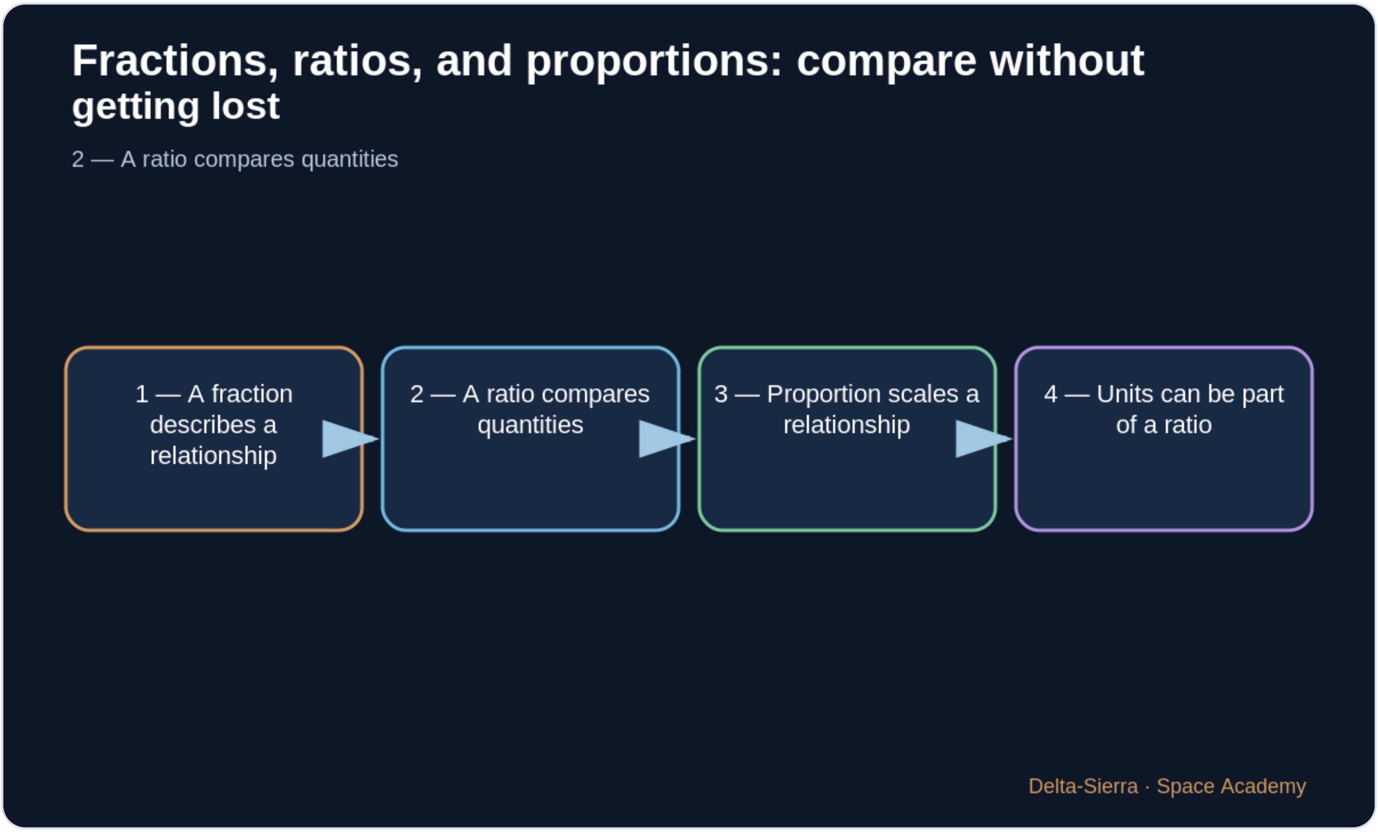
With 7 identical bottles: 7 × 5 kg = **35 kg of oxygen**.

Why multiply? Because every bottle contributes the same 5 kg.

The relationship is proportional only because the bottles are identical and equally filled.

Counterexample — One bottle is half full

If one bottle contains only 2.5 kg instead of 5 kg, “number of bottles × 5 kg” no longer works. The simple proportional rule is broken.



Before using a rule of three, check that the quantity per unit really stays constant.

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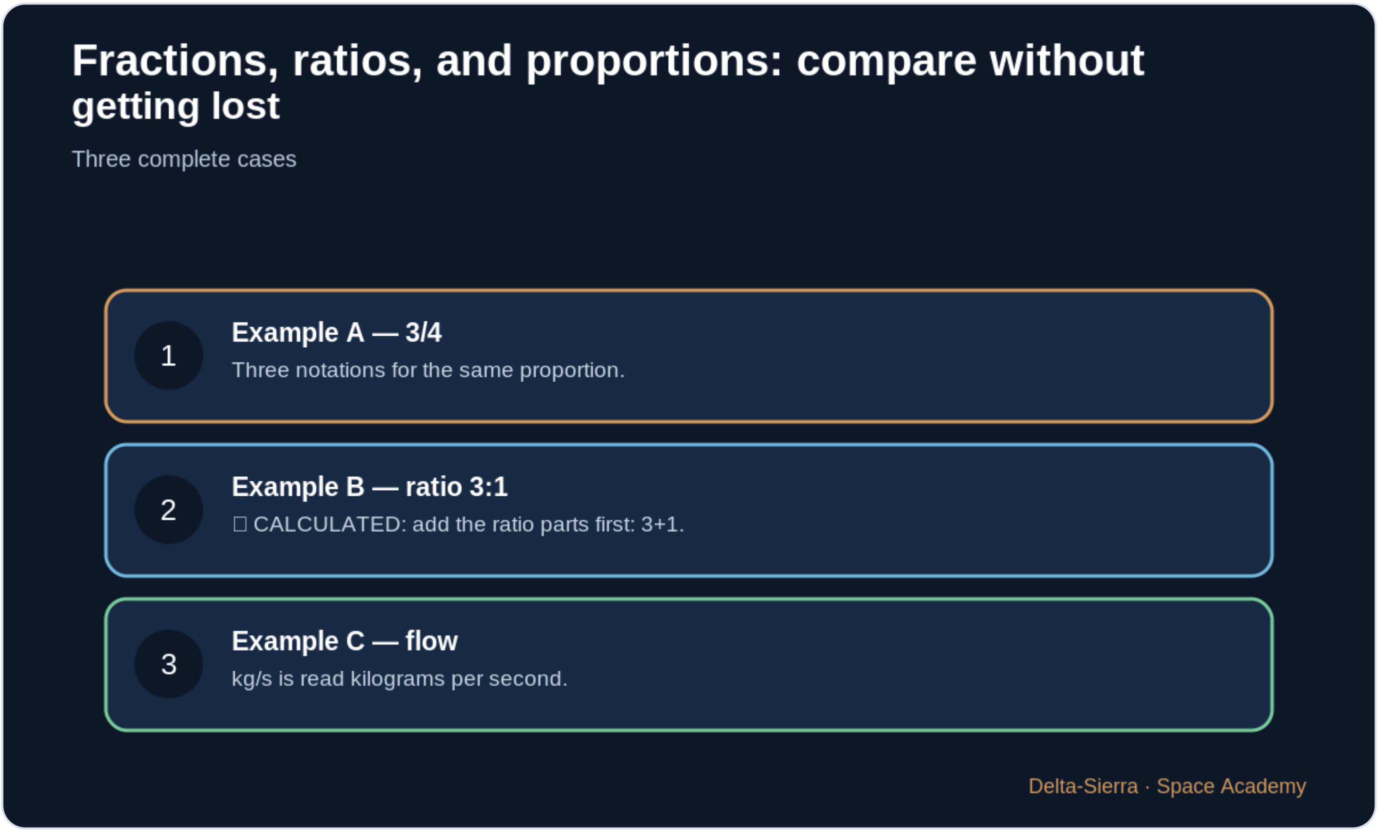
5 — Rates with units should be read aloud

Some comparisons use different physical quantities and create units such as **kg/s**, **N/kg** or **W/m²**.

- **kg/s** means “kilograms per second”;
- **N/kg** means “newtons per kilogram”;
- **W/m²** means “watts per square metre”.

The word **per** is the key: it tells us that one quantity is being related to another.

Three complete examples: understand before abbreviating



Concrete situations before abstract notation.

Example A — Share 12 litres of water at 2:1

Total parts: 2 + 1 = 3. One part: 12 ÷ 3 = 4 L. First tank: 8 L. Second tank: 4 L. Check: 8 + 4 = 12 L.

Example B — Share 20 kg of equipment at 3:2

Total parts: 5. One part: 20 ÷ 5 = 4 kg. First crate: 12 kg. Second crate: 8 kg.

Example C — Seven oxygen bottles

Each bottle contains 5 kg. Seven bottles provide 7 × 5 = 35 kg. If the number doubles to 14, the oxygen mass doubles to 70 kg.

6 — Only now move to abstraction

Once the idea is understood, we may call the two masses **A** and **B** and write $A:B = 3:1$.

If the total is **T**, there are four parts. One part is $T/4$, so $A = 3T/4$ and $B = T/4$.

This notation is shorter, but it is useful only after the reader knows what A, B, T and the four parts mean.

Common traps and checks

- Confusing a ratio with actual values.
- Using proportional reasoning when the relationship is not proportional.
- Leaving numbers without objects or units.
- Failing to recombine the parts to check the original total.

Final check: explain the answer in ordinary language. If the result cannot be stated without symbols, the calculation is not fully understood yet.

Exercises and solutions

Exercise 1 — Ratio 4:1

A 25 kg total is split at 4:1. Find both masses.

Solution: 5 parts; 25 ÷ 5 = 5 kg per part; first mass 20 kg, second mass 5 kg.

Exercise 2 — Proportion

One identical cartridge contains 3 kg of consumable. What mass do 8 cartridges provide?

Solution: 8 × 3 = 24 kg, provided all cartridges are filled the same way.

Exercise 3 — Check the ratio

For a 2:3 ratio and a 30 kg total, a student gives 18 kg and 12 kg. Is the ratio correct?

Solution: no. 18:12 = 3:2. For 2:3, one part is 6 kg, giving 12 kg and 18 kg in that order.

Primary and teaching sources

- NIST — SI Units
- NASA Glenn — Guide to Rockets