

Fermi problems: estimate like a scientist

Ages 12–16 · Estimation: Fermi problems, unit conversion, volume, orders of magnitude

Name _____ Class _____ Date _____

The physicist Enrico Fermi was famous for quick, good estimates of things nobody had measured. The trick is to break a big question into small steps you can guess or measure.

- 1 Write down what you know.
- 2 Put the sizes in the same unit.
- 3 Round to easy numbers and multiply or divide.
- 4 Ask: is the answer sensible? Is it in the tens, the thousands or the millions?

1. Rice to the treetops

How many grains of rice, laid end to end, would reach the top of a coast redwood tree?

A grain of rice is about 7 mm long. A coast redwood tree is about 70 m tall.

Working

My estimate: _____

2. Blueberries in a watermelon

About how many blueberries would fit inside a watermelon?

A blueberry is about 1.5 cm across. A watermelon is about 30 cm across.

Working

My estimate: _____

3. Stairs up Mount Fuji

If there were a staircase from the sea to the top of Mount Fuji, about how many stairs would it have?

Mount Fuji is about 3,776 m high. Measure the height of one stair at your school.

Working

My estimate: _____

4. Cells along a ruler

About how many human liver cells would fit side by side along a 30 cm ruler?

A human liver cell (a hepatocyte) is about 25 μm across.

Working

My estimate: _____

5. A tower of students on Uluru

About how many students, each standing on the shoulders of the one below, would reach the top of Uluru?

Uluru rises about 348 m above the plain around it. Measure your own shoulder height.

Working

My estimate: _____

What students practise

Breaking a problem into steps; converting units; stating assumptions; scaling from length to volume; judging an answer by its order of magnitude. Any answer within a factor of two or three of these is a good Fermi estimate, and different assumptions (a taller stair, a shorter student) give different, equally valid answers.

Worked answers

1. $70 \text{ m} \div 7 \text{ mm} = 10,000$ grains of rice.
2. The watermelon is 20 blueberries across, so it has room for $20^3 = 8,000$ blueberry-sized spaces. Round berries leave gaps (about a third of the space): about 5,000 blueberries.
3. With a 17 cm stair: $3,776 \text{ m} \div 0.17 \text{ m} \approx 22,000$ stairs.
4. $30 \text{ cm} = 300,000 \text{ }\mu\text{m}$; $300,000 \text{ }\mu\text{m} \div 25 \text{ }\mu\text{m} = 12,000$ cells.
5. Each student adds their shoulder height. With 1.3 m: $348 \text{ m} \div 1.3 \text{ m} \approx 270$ students.

Good to know

Scientists use estimates like these to check whether a calculation is sensible before they trust it. Sizes are typical values from the Magnitude catalogue, rounded (how we measure: magnitude.fit/methodology).