Exercise walk-through

Physical quantities ▪ 1.1

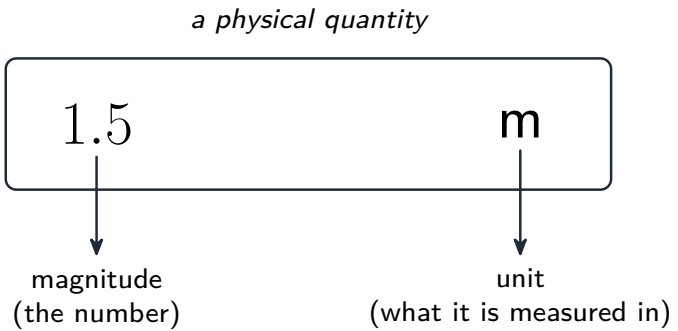
eXercise

You must be able to

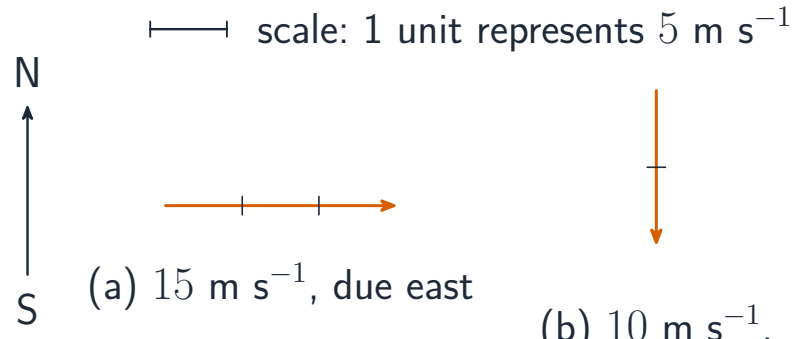
- state that every physical quantity has a **magnitude** 大小 and a **unit** 单位
- make reasonable **estimates** 估算 of common quantities
- give an answer to the right **order of magnitude** 数量级 (power of ten)

Method — Magnitude and unit

A physical quantity needs **both** a number and a unit. “The length is 1.5” means nothing; “the length is 1.5 m” is complete:



Method — Magnitude and unit



Quantities are scalars or vectors

Method — Making estimates

Learn these rough values so you can check whether an answer is sensible:

quantity	**estimate**
mass of an adult	~ 70 kg
height of an adult	~ 1.7 m
mass of an apple	~ 0.1 kg (weight ≈ 1 N)
speed of sound in air	~ 340 m s^{-1}
speed of light (vacuum)	3.0×10^8 m s^{-1}
free-fall acceleration	$g \approx 9.81$ m s^{-2}

Method — Order of magnitude

The **order of magnitude** is the nearest power of ten. A good estimate has the right power of ten: an adult's mass is $\sim 10^2$ kg (70 kg), **not** 10^1 (7 kg). To estimate the seconds in a day: $24 \times 60 \times 60 = 86\,400 \approx 9 \times 10^4$, so the order of magnitude is 10^5 s.

Method — Estimating a derived quantity

Combine sensible estimates. The **pressure** a standing person exerts on the floor: weight ≈ 700 N, area of two feet ≈ 0.02 m^2, so

$$p = \frac{F}{A} \approx \frac{700}{0.02} = 3.5 \times 10^4 \text{ Pa}.$$

Practice 2.1 ▪ 1 mark

A student writes “the mass is 60”. State what is **missing** to make it a physical quantity.

Solution 2.1

Worked steps

A **unit** (it has a magnitude but no unit) B1.

Practice 2.2 ▪ 1 mark

Estimate the **mass of an apple**, giving a unit.

Solution 2.2

Method: Making estimates

Worked steps

About 0.1 kg (100 g) — any value ~ 0.05–0.2 kg B1.

Practice 2.3 ▪ 1 mark

State the **order of magnitude** of the speed of light in a vacuum, in m s^{-1}.

Solution 2.3

Method: Making estimates

Worked steps

10^8 m s^{-1} **B1**.

Practice 2.4 ▪ 1 mark

Estimate the **height of a typical room** (floor to ceiling), giving a unit.

Solution 2.4

Method: Making estimates

Worked steps

About 2.5 m — any value $\sim$ 2–3 m with a unit B1.

Exam-style 3.1 ▪ 1 mark

What must all physical quantities have?

A a direction and a magnitude

B a direction and a unit

C a magnitude and a prefix

D a magnitude and a unit

Solution 3.1

Method: Magnitude and unit

A a direction and a magnitude

B a direction and a unit

C a magnitude and a prefix

D a magnitude and a unit ✓

Worked steps

D — a magnitude and a unit.

Exam-style 3.2 ▪ 1 mark

Which is the best estimate of the **mass of an adult human**?

A 7 kg

B 70 kg

C 700 kg

D 7000 kg

Solution 3.2

A 7 kg

B 70 kg ✓

C 700 kg

D 7000 kg

Worked steps

B — about 70 kg.

Exam-style 3.3 ▪ 2 marks

Estimate the number of **seconds in one day**. Give your answer to an **order of magnitude**.

Solution 3.3

Method: Order of magnitude

Worked steps

$24 \times 60 \times 60 = 86\,400$ s M1; $\approx 10^5$ s A1.

Exam-style 3.4 ▪ 2 marks

A car travels at about 30 m s^{-1}. Estimate the time it takes to travel 1 km, and state the **order of magnitude** of that time in seconds.

Solution 3.4

Method: Order of magnitude

Worked steps

$t = 1000/30 \approx 33$ s **M1**; order of magnitude 10^1 s **A1**.

Exam-style 3.5 ▪ 1 mark

A person of weight 700 N stands on both feet, total contact area about 0.02 m^2. Which is the best estimate of the pressure on the floor?

A 1.4×10^4 Pa

B 3.5×10^4 Pa

C 3.5×10^6 Pa

D 1.4×10^7 Pa

Solution 3.5

Method: Estimating a derived quantity

A 1.4×10^4 Pa

B 3.5×10^4 Pa ✓

C 3.5×10^6 Pa

D 1.4×10^7 Pa

Worked steps

B — $p = 700/0.02 = 3.5 \times 10^4$ Pa.