

Past-paper walk-through

1.1

# Physical quantities

---

A-Level Physics

# A number *and* a unit

A **physical quantity** has two parts:

- a **magnitude** – the number
- a **unit** – what the number means

The number alone tells you **nothing**.

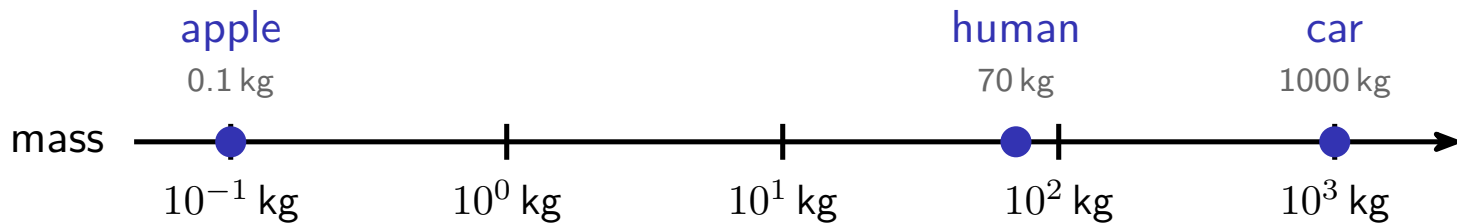
|                                                                                     |                                                                                     |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 1.5                                                                                 | m                                                                                   |
|  |  |
| magnitude                                                                           | unit                                                                                |

“1.5” ❌

“1.5 m” ✅

# Estimate the everyday

A good estimate has the right **order of magnitude** – the right power of ten.  
Paper 1 usually opens with one.



Each step along the line is a **factor of ten**. Pick the answer on the right step: a human is about  $10^2$  kg, not  $10^1$  or  $10^3$ .

# Estimates to know by heart

human **mass**

70 kg

human **weight**

700 N

human height

1.7 m

an apple

0.1 kg

speed of sound in air

$340 \text{ m s}^{-1}$

speed of light in  
a **vacuum**

$3.0 \times 10^8 \text{ m s}^{-1}$

**free fall**

$g \approx 9.81 \text{ m s}^{-2}$

An apple weighs about 1 N. That one number lets you check every other force estimate.

# More values to know

## Sizes

- a car:  $\sim 1000 \text{ kg}$
- height of a room:  $\sim 3 \text{ m}$
- visible light wavelength:  
 $\sim 5 \times 10^{-7} \text{ m}$
- **diameter** of an  
atom:  $\sim 10^{-10} \text{ m}$ ; a  
nucleus:  $\sim 10^{-15} \text{ m}$

## Speeds and power

- walking:  $\sim 1.5 \text{ m s}^{-1}$
- a car on a fast road:  
 $\sim 30 \text{ m s}^{-1}$
- a kettle:  $\sim 2 \text{ kW}$
- a person climbing  
stairs:  $\sim 300 \text{ W}$

## Materials and the air

- **density** : water  
 $1000 \text{ kg m}^{-3}$ , air  
 $\sim 1.2 \text{ kg m}^{-3}$ , steel  
 $\sim 8000 \text{ kg m}^{-3}$
- **atmospheric  
pressure** :  
 $\sim 1.0 \times 10^5 \text{ Pa}$
- room temperature:  
 $\sim 20^\circ\text{C} \approx 293 \text{ K}$

The right power of ten matters most: for a human, 70 kg is a good estimate; 7 kg is not.

# Building an estimate

Not on the list? **Build it** from values that are.

## Kinetic energy of a car

$m \approx 1000 \text{ kg}$ ,  $v \approx 30 \text{ m s}^{-1}$ :

$$\frac{1}{2}mv^2 \approx \frac{1}{2} \times 1000 \times 30^2 \approx 5 \times 10^5 \text{ J}$$

## Pressure under a standing person

weight  $\approx 700 \text{ N}$  on about  $0.02 \text{ m}^2$ :

$$p \approx \frac{700}{0.02} \approx 4 \times 10^4 \text{ Pa}$$

Always check that the **power of ten** looks sensible before you move on.

# Adding or subtracting – add the *absolute* uncertainties

$$\Delta y = \Delta a + \Delta b$$

Both  $y = a + b$  and  $y = a - b$  add them.

A *difference* keeps the whole  $\Delta$  but has a far smaller value, so its % is the worst of the three.

$$a = (50.0 \pm 0.5) \text{ mm} \quad \text{---} \cdot \text{---} \quad 1.0\%$$

$$b = (20.0 \pm 0.2) \text{ mm} \quad \text{---} \cdot \text{---} \quad 1.0\%$$

---


$$a - b = (30.0 \pm 0.7) \text{ mm} \quad \text{---} \cdot \text{---} \quad 2.3\%$$

one scale for all three – the *difference* is the widest

## Exercises 1-2

---

**1** A man of weight 600 N stands with both feet flat on the ground.

☐

What is a reasonable estimate of the pressure exerted on the ground by the weight of the man?

- A**  $1 \times 10^0 \text{ Pa}$       **B**  $1 \times 10^2 \text{ Pa}$       **C**  $1 \times 10^4 \text{ Pa}$       **D**  $1 \times 10^6 \text{ Pa}$

---

A-Level Physics: **w25 12**

---

**2** What is a reasonable estimate of the weight of an adult human?

☐

- A**  $7 \times 10^0 \text{ N}$       **B**  $7 \times 10^2 \text{ N}$       **C**  $7 \times 10^4 \text{ N}$       **D**  $7 \times 10^6 \text{ N}$

# Exercises 1-2

---

1 A man of weight 600 N stands with both feet flat on the ground.

☐

What is a reasonable estimate of the pressure exerted on the ground by the weight of the man?

- A**  $1 \times 10^0 \text{ Pa}$       **B**  $1 \times 10^2 \text{ Pa}$       **C**  $1 \times 10^4 \text{ Pa}$       **D**  $1 \times 10^6 \text{ Pa}$

1 C

Why

- Two adult feet cover roughly  $0.05 \text{ m}^2$  – about 25 cm by 10 cm each.
- $p = F/A = 600/0.05 \approx 1 \times 10^4 \text{ Pa}$ .
- B would need feet of about  $6 \text{ m}^2$ ; D would need them the size of a stamp.

---

A-Level Physics: w25 12

---

2 What is a reasonable estimate of the weight of an adult human?

☐

- A**  $7 \times 10^0 \text{ N}$       **B**  $7 \times 10^2 \text{ N}$       **C**  $7 \times 10^4 \text{ N}$       **D**  $7 \times 10^6 \text{ N}$

2 B

Why

- A typical adult has a mass of about 70 kg.
- $W = mg = 70 \times 9.81 \approx 700 \text{ N}$ , which is  $7 \times 10^2 \text{ N}$ .
- A is the weight of a 0.7 kg object; C is the weight of about 7000 kg.

## Exercise 3

---

---

A-Level Physics: w25 14

---

**3** What is essential to accurately represent all physical quantities?

☐

**A** a base unit and a number

**B** a unit and a number expressed in standard form (scientific notation)

**C** a unit and a numerical magnitude

**D** an SI unit and a numerical magnitude

## Exercise 3

---

---

A-Level Physics: w25 14

---

**3** What is essential to accurately represent all physical quantities?

☐

- A** a base unit and a number
- B** a unit and a number expressed in standard form (scientific notation)
- C** a unit and a numerical magnitude
- D** an SI unit and a numerical magnitude

**3 C**

### Why

- Every physical quantity is a numerical magnitude together with a unit.
- The unit need not be an SI one: 5 miles is still a length, so D is too strict.
- It need not be a base unit either (A), and standard form is only a way of writing it (B).

## Exercise 4

---

---

A-Level Physics: **s25 12**

---

**4** 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

# Exercise 4

---

---

A-Level Physics: **s25 12**

---

4 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

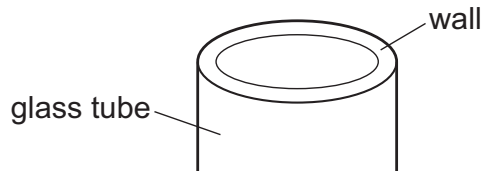
4 **D**

## Why

- A physical quantity is always a number together with a unit, such as  $m = 2.5 \text{ kg}$ .
- Only vectors carry a direction, so A and B would exclude scalars like mass.
- A prefix is optional – the k in kg – so C is not essential.

## Exercise 5

- 5 Calipers are used to determine the thickness of the wall of a glass tube.



The following measurements are made.

internal diameter of the tube =  $(10.0 \pm 0.1)$  mm

external diameter of the tube =  $(12.0 \pm 0.1)$  mm

What is the thickness of the wall of the tube?

**A**  $(1.0 \pm 0.1)$  mm

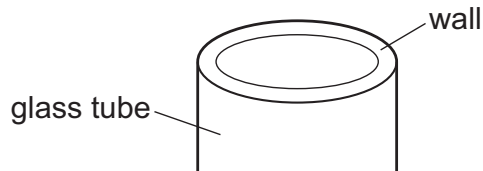
**B**  $(1.0 \pm 0.2)$  mm

**C**  $(2.0 \pm 0.1)$  mm

**D**  $(2.0 \pm 0.2)$  mm

## Exercise 5

- 5 Calipers are used to determine the thickness of the wall of a glass tube.



The following measurements are made.

internal diameter of the tube =  $(10.0 \pm 0.1)$  mm

external diameter of the tube =  $(12.0 \pm 0.1)$  mm

What is the thickness of the wall of the tube?

**A**  $(1.0 \pm 0.1)$  mm

**B**  $(1.0 \pm 0.2)$  mm

**C**  $(2.0 \pm 0.1)$  mm

**D**  $(2.0 \pm 0.2)$  mm

**5 A**

**Why**

- A diameter crosses the wall twice, so the thickness is  $(12.0 - 10.0)/2 = 1.0$  mm.
- For a subtraction the absolute uncertainties add:  $0.1 + 0.1 = 0.2$  mm.
- Halving the difference halves that too, giving  $\pm 0.1$  mm; B forgets to halve it.