A-LEVEL PHYSICS • EXERCISE SHEET

1.1 Physical quantities

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

KEY WORDS physical quantities 物理量 • magnitude 大小 • unit 单位 • order of magnitude 数量级 • derived quantity 导出量

Objective

Build the skills to answer exam questions on **physical quantities** 物理量 — magnitude and unit, and making sensible estimates.

You must be able to:

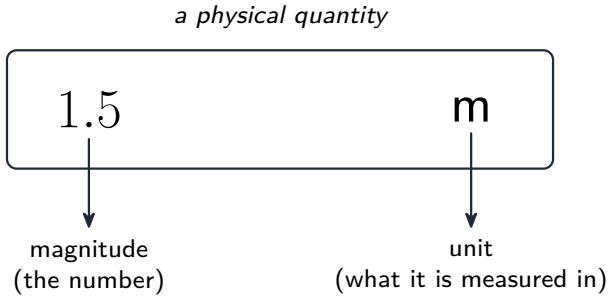
- state that every physical quantity has a **magnitude** 大小 and a **unit** 单位
- make reasonable **estimates** 估算 of common quantities
- give an answer to the right **order of magnitude** 数量级 (power of ten)

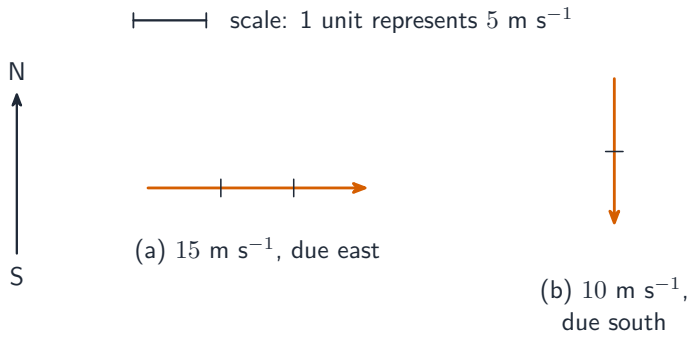
1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ 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:





Quantities are scalars or vectors

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}

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.

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

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

2 Practice

Now apply the methods above.

2.1 A student writes "the mass is 60". State what is **missing** to make it a physical quantity. [1]

2.2 Estimate the **mass of an apple**, giving a unit. [1]

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

2.4 Estimate the **height of a typical room** (floor to ceiling), giving a unit. [1]

3 Exam-style questions

3.1 What must all physical quantities have? [1]

- **A** a direction and a magnitude
- **B** a direction and a unit
- **C** a magnitude and a prefix
- **D** a magnitude and a unit

3.2 Which is the best estimate of the **mass of an adult human**? [1]

- **A** 7 kg
- **B** 70 kg
- **C** 700 kg
- **D** 7000 kg

3.3 Estimate the number of **seconds in one day**. Give your answer to an **order of magnitude**. [2]

3.4 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. [2]

3.5 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? [1]

- **A** 1.4×10^4 Pa
- **B** 3.5×10^4 Pa
- **C** 3.5×10^6 Pa
- **D** 1.4×10^7 Pa

Solutions

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

2.2 About 0.1 kg (100 g) — any value $\sim$ 0.05–0.2 kg.

2.3 10^{8} m s^{-1}.

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

3.1 D — a magnitude and a unit.

3.2 B — about 70 kg.

3.3 $24 \times 60 \times 60 = 86\,400$ s; $\approx 10^{5}$ s.

3.4 $t = 1000/30 \approx 33$ s; order of magnitude 10^{1} s.

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