Exercise walk-through

Physical quantities and measurement techniques ▪ 1.1

eXercise

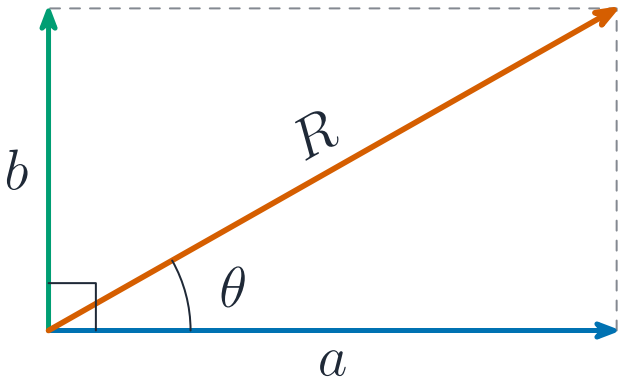
You must be able to

- measure length, volume and time correctly (read the meniscus; avoid parallax)
- find a small length or short time by measuring many and dividing
- tell scalars from vectors and add two perpendicular vectors

Method — Vectors at right angles

- **scalar** = size only (distance, speed, mass, energy); **vector** = size **and** direction (force, velocity, momentum).
- two perpendicular vectors: $R = \sqrt{a^2 + b^2}$.
- **small quantity:** time 20 swings and divide by 20; measure 100 sheets and divide.

Method — Vectors at right angles



$$R = \sqrt{a^2 + b^2}$$

Two perpendicular vectors as the sides of a rectangle, the resultant as the diagonal

Method — Measuring time, and the vector list

Use a **stopwatch** 秒表 or a **digital timer** 数字计时器 for a short interval and a clock for a long one. A hand-started stopwatch carries a **reaction time** 反应时间 error of about 0.2 s, so time a **long** interval, or time many repeats and divide.

Worked example. A pendulum takes 28.4 s for 20 complete swings. One period is $\dfrac{28.4}{20} = 1.42$ s. The reaction-time error of about 0.2 s is shared over 20 swings, so its effect on one period is only about 0.01 s.

The full syllabus lists: **scalars** are distance, speed, time, mass, energy and temperature; **vectors** are force, weight, velocity, acceleration, momentum, electric field strength and gravitational field strength.

Practice 2.1 ▪ 1 mark

State the difference between a scalar and a vector.

Solution 2.1

Method: Vectors at right angles

Worked steps

a scalar has size only; a vector has size **and** direction B1.

Practice 2.2 ▪ 2 marks

A student measures the time for 20 swings of a pendulum as 30 s. Find the period (time for one swing).

Solution 2.2

Method: Measuring time, and the vector list

Worked steps

$$\text{period} = \frac{30}{20} = 1.5 \text{ s} \quad \text{M1} \; \text{A1}.$$

Practice 2.3 ▪ 3 marks

A student times 20 swings of a pendulum as 31.0 s. Calculate the period, and explain why timing 20 swings is better than timing one.

Solution 2.3

Method: Measuring time, and the vector list

Worked steps

Period $= \dfrac{31.0}{20} = 1.55$ s (M1) (A1); the timing error is shared between 20 swings, so its effect on one period is 20 times smaller (B1).

Practice 2.4 ▪ 2 marks

From this list, write down the vectors: mass, weight, energy, velocity, temperature, momentum, gravitational field strength.

Solution 2.4

Method: Measuring time, and the vector list

Worked steps

Weight, velocity, momentum, gravitational field strength B2 *one mark for any two correct with no wrong ones added.*

Exam-style 3.1 ▪ 1 mark

Which is a vector quantity?

A mass

B energy

C velocity

D temperature

Solution 3.1

Method: Vectors at right angles

A mass

B energy

C velocity ✓

D temperature

Worked steps

C. Velocity has both size and direction.

Exam-style 3.2 ▪ 2 marks

Two forces of 3.0 N and 4.0 N act at right angles on a point.
(a) Find the magnitude of the resultant force.
(b) State why a force is a vector.

Solution 3.2

Method: Vectors at right angles

Worked steps

(a) $R = \sqrt{3.0^2 + 4.0^2} = \sqrt{25} = 5.0$ N **M1** **A1**.

(b) it has both a size and a direction **B1**.

Exam-style 3.3 ▪ 2 marks

Describe how to measure the thickness of one sheet of paper accurately, using a ruler and a book.

Solution 3.3

Worked steps

(a) Use a stopwatch or digital timer **B1**; start it as the pendulum passes the centre of its swing and count from zero **B1**; time 20 complete swings and repeat, then take an average **B1**.

(b) Period $= \dfrac{25.6}{20}$ **M1** $= 1.28$ s **A1**.

(c) Her reaction time affects the total once, at the start and the stop **B1**; dividing by 20 divides that error by 20 as well, so each period is far more accurate **B1**.

(d) $\dfrac{9.0}{100} = 0.090$ mm **M1** **A1**; one sheet is far thinner than the smallest division on the ruler, so measuring it directly would give a very large percentage error **B1**.

Exam-style 3.3 ▪ 3 marks

A student measures the period of a pendulum and the thickness of a sheet of paper.
(a) Describe how she should measure the period accurately, naming the instrument she uses.
(b) She times 20 swings as 25.6 s. Calculate the period.
(c) Explain why her method reduces the effect of her reaction time.
(d) She measures a stack of 100 sheets of paper as 9.0 mm thick. Calculate the thickness of one sheet in mm, and state why she did not measure one sheet directly.

Solution 3.3

Method: Measuring time, and the vector list

Worked steps

(a) Use a stopwatch or digital timer **B1**; start it as the pendulum passes the centre of its swing and count from zero **B1**; time 20 complete swings and repeat, then take an average **B1**.

(b) Period $= \dfrac{25.6}{20}$ **M1** $= 1.28$ s **A1**.

(c) Her reaction time affects the total once, at the start and the stop **B1**; dividing by 20 divides that error by 20 as well, so each period is far more accurate **B1**.

Solution 3.3

(d) $\dfrac{9.0}{100} = 0.090$ mm M1 A1; one sheet is far thinner than the smallest division on the ruler, so measuring it directly would give a very large percentage error B1.