

1.1 Physical quantities and measurement

Name: _____ Class: _____ Date: _____

Total: 24 marks

KEY WORDS vector quantity 矢量 • resultant 合矢量 • physical quantities and measurement 物理量与测量
 • scalars and vectors 标量与矢量 • resultant force 合力

Objective

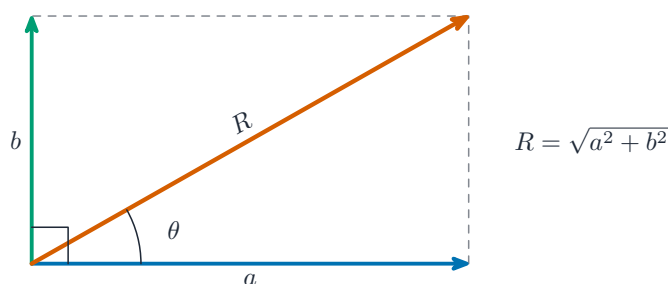
Build the skills to answer exam questions on **physical quantities and measurement** 物理量与测量 — using instruments, measuring small quantities, and **scalars and vectors** 标量与矢量.

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

1 Worked examples

■ Vectors at right angles



Two vectors at right angles add to a resultant R , the diagonal of the rectangle

- **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.

■ 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 $\frac{28.4}{20} = 1.42$ 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.

2 Practice

2.1 State the difference between a scalar and a vector. [1]

2.2 A student measures the time for 20 swings of a pendulum as 30 s. Find the period (time for one swing). [2]

2.3 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. [3]

2.4 From this list, write down the vectors: mass, weight, energy, velocity, temperature, momentum, gravitational field strength. [2]

3 Exam-style questions

3.1 Which is a vector quantity? [1]

- A mass
- B energy

- **C** velocity
 - **D** temperature
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3.2 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. [2]

(b) State why a force is a vector. [1]

3.3 Describe how to measure the thickness of one sheet of paper accurately, using a ruler and a book. [2]

3.3 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. [3]

(b) She times 20 swings as 25.6 s. Calculate the period. [2]

(c) Explain why her method reduces the effect of her reaction time. [2]

(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. [3]

Solutions

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

2.2 period = $\frac{30}{20} = 1.5$ s.

3.1 C. Velocity has both size and direction.

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

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

3.3 measure the total thickness of a known large number of sheets (e.g. 100) with the ruler; divide the total thickness by the number of sheets.

2.3 Period = $\frac{31.0}{20} = 1.55$ s; the timing error is shared between 20 swings, so its effect on one period is 20 times smaller.

2.4 Weight, velocity, momentum, gravitational field strength.

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

(b) Period = $\frac{25.6}{20} = 1.28$ s.

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

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