

1.4 Scalars and vectors

Name: _____ Class: _____ Date: _____

Total: 34 marks

KEY WORDS vector 矢量 • scalar 标量 • component 分量 • perpendicular 垂直
• magnitude 大小

Objective

Build the skills to answer the real exam questions on **scalars and vectors**. In the exam, 1.4 is tested by **multiple-choice** questions and by short parts inside longer questions: classify a quantity, find a **resultant**, or **resolve** a vector into components.

You must be able to:

- tell a **scalar** 标量 from a **vector** 矢量 and complete a classification table
- find the **resultant** 合矢量 of two **perpendicular** 垂直 vectors (size and direction)
- give the direction of $\vec{X} + \vec{Y}$ and $\vec{X} - \vec{Y}$
- find the resultant of **two equal forces** at an angle
- **resolve** 分解 any vector (a force *or* a velocity) into two perpendicular **components** 分量
- add three or more **coplanar** 共面 vectors by components
- **sketch** each component of a projectile's velocity against time

1 Worked examples

Study these first. Each one shows the method for an exam question type used below — read them and you can do the Practice and Exam-style questions yourself.

■ A — Scalar or vector?

A scalar has size only; a vector has size **and** direction. **Quick test:** if “in which direction?” makes sense, it is a vector. In the exam you often tick a table:

Quantity	Scalar	Vector
speed	✓	
acceleration		✓
energy	✓	
momentum		✓

(Common scalars: mass, time, temperature, energy, distance, speed. Common vectors: displacement, velocity, acceleration, force, momentum.)

■ B — Add two perpendicular vectors

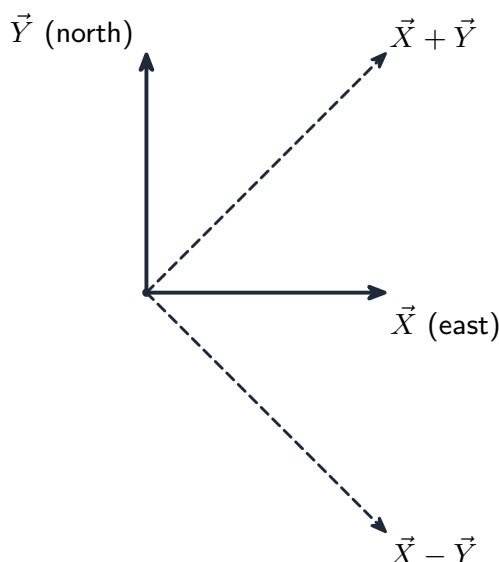
Draw them **tip to tail**; the resultant closes the triangle. For two vectors at 90° the size is $|\vec{R}| = \sqrt{X^2 + Y^2}$ and the direction is $\tan \theta = Y/X$.

Worked example. A swimmer heads north at 1.2 m s^{-1} ; the river flows east at 0.5 m s^{-1} :

$$|\vec{R}| = \sqrt{1.2^2 + 0.5^2} = 1.3 \text{ m s}^{-1}, \quad \tan \theta = \frac{0.5}{1.2} \Rightarrow \theta \approx 23^\circ \text{ east of north.}$$

■ C — Direction of $\vec{X} + \vec{Y}$ and $\vec{X} - \vec{Y}$

To **add**, place the arrows tip to tail. To **subtract**, reverse the second arrow first: $\vec{X} - \vec{Y} = \vec{X} + (-\vec{Y})$, where $-\vec{Y}$ is the same size as $\vec{Y}$ but points the opposite way.



With $\vec{X}$ east and $\vec{Y}$ north: $\vec{X} + \vec{Y}$ points **north-east**, and $\vec{X} - \vec{Y}$ points **south-east**.

■ C2 — Adding three or more coplanar vectors

Coplanar 共面 vectors all lie in the same flat plane — every vector in this course is coplanar. For three or more, drawing triangles gets messy, so **use components**: add all the x -parts, add all the y -parts, then recombine.

Worked example. Three coplanar forces act at a point: 2.0 N east, 3.0 N north, 4.0 N west.

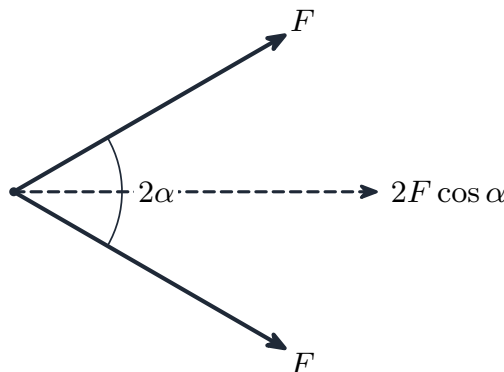
$$\sum x = 2.0 - 4.0 = -2.0 \text{ N}, \quad \sum y = +3.0 \text{ N}$$

$$R = \sqrt{2.0^2 + 3.0^2} = 3.6 \text{ N}, \quad \tan \theta = \frac{3.0}{2.0} \Rightarrow \theta = 56^\circ \text{ north of west}$$

Take one direction as positive and stay with it — a lost minus sign is the usual error.

■ D — Two equal forces at an angle

Two equal forces of size F with an angle 2α between them have a resultant of size $2F \cos \alpha$, along the line that **cuts the angle in half**.

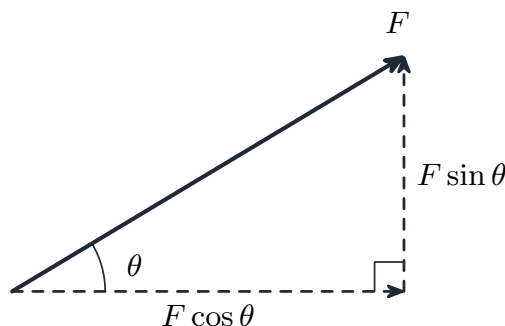


Worked example. Two 6.0 N forces act with 60° between them. Here $2\alpha = 60^\circ$, so $\alpha = 30^\circ$:

$$R = 2F \cos \alpha = 2(6.0) \cos 30^\circ = 10.4 \text{ N.}$$

■ E — Resolve a vector into components

Any vector $\vec{v}$ at angle θ to the horizontal splits into a horizontal part $v \cos \theta$ and a vertical part $v \sin \theta$ — this works for a force **or** a velocity 速度.



Force example. A 50 N force at 30° : horizontal = $50 \cos 30^\circ = 43 \text{ N}$, vertical = $50 \sin 30^\circ = 25 \text{ N}$.

Velocity example. A ball kicked at 28 m s^{-1} , 34° above the horizontal: $v_H = 28 \cos 34^\circ = 23 \text{ m s}^{-1}$, $v_V = 28 \sin 34^\circ = 16 \text{ m s}^{-1}$.

On a slope of angle θ , the weight splits into $W \sin \theta$ **along** the slope and $W \cos \theta$ **into** the slope.

■ F — The two components of a projectile, against time

Once the components are found, each one has its own simple graph — and the exam asks you to sketch both on one grid:

- **horizontal** v_H : a **horizontal straight line** (no horizontal force, so it never changes).
- **vertical** v_V : a **straight line sloping down**, starting at $+v \sin \theta$, crossing zero at the top of the flight, and reaching $-v \sin \theta$ on landing (taking up as positive).

The gradient of that second line is $-g$, and the time to the top is v_V/g . Label each line, and use the whole time axis you are given.

2 Practice

Now apply the methods above.

2.1 Complete the table by ticking **scalar** or **vector** for each quantity. [3]

Quantity	Scalar	Vector
distance		
force		
temperature		
velocity		
power		
acceleration		

2.2 Forces of 3.0 N east and 4.0 N north act at a point. Find the **magnitude** 大小 of the resultant. [2]

2.3 Resolve a 50 N force acting at 30° to the horizontal into its horizontal and vertical components. [2]

2.4 A ball leaves the ground at 20 m s^{-1} at 60° above the horizontal. Find the **horizontal** and **vertical** components of its velocity. [2]

2.5 Two forces, each 5.0 N , act at a point with 90° between them. Find the **magnitude** of the resultant. [2]

2.6 Three **coplanar** forces act at a point: 6.0 N east, 2.0 N west and 5.0 N north. Find the **magnitude** and the **direction** of the resultant. [3]

3 Exam-style questions

3.1 Which of these is a **vector** quantity? [1]

A	B
C	D

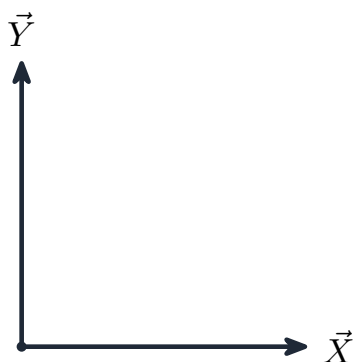
A energy

B power

C displacement

D temperature

3.2 Two vectors $\vec{X}$ and $\vec{Y}$ are shown: $\vec{X}$ points east and $\vec{Y}$ points north. What are the directions of $\vec{X} + \vec{Y}$ and $\vec{X} - \vec{Y}$? [1]



- | | |
|---|---|
| A | B |
| C | D |
- A** $\vec{X} + \vec{Y}$ north-east; $\vec{X} - \vec{Y}$ south-east
B $\vec{X} + \vec{Y}$ north-east; $\vec{X} - \vec{Y}$ north-west
C $\vec{X} + \vec{Y}$ south-west; $\vec{X} - \vec{Y}$ south-east
D $\vec{X} + \vec{Y}$ south-east; $\vec{X} - \vec{Y}$ north-east

3.3 Two forces of 6.0 N and 8.0 N act at a point at right angles to each other. What is the magnitude of the resultant force? [1]

- | | |
|---|---|
| A | B |
| C | D |
- A** 2.0 N
B 10 N
C 14 N
D 48 N

3.4 A stone is thrown with a velocity of 15 m s^{-1} at 40° above the horizontal.

(a) Find the **horizontal** and **vertical** components of this velocity. [2]

(b) Air resistance is negligible. State which component stays **constant** during the flight, and why. [2]

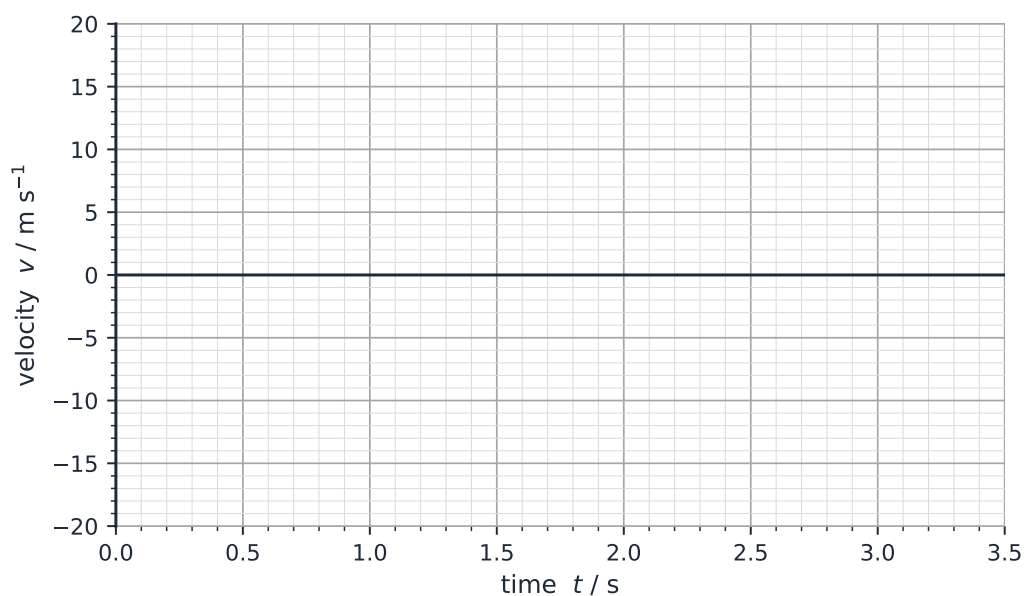
3.5 Two forces, each 7.0 N, act at a point with 80° between them. Find the **magnitude** of the resultant. [2]

3.6 A player kicks a ball from level ground with a velocity of 21 m s^{-1} at 55° to the horizontal. Air resistance is negligible.

(a) **Calculate** the horizontal component v_H and the vertical component v_V of the velocity of the ball as it leaves the ground. [2]

(b) **Show that** the ball reaches its maximum height at time $t = 1.75 \text{ s}$. [1]

- (c) The ball lands at time $t = 3.5$ s. On the grid below, **sketch** the variation with time t of v_H and of v_V , from $t = 0$ to $t = 3.5$ s. Take the upward direction as positive. **Label** your lines H and V. [4]



- (d) **Determine** the magnitude and the direction of the velocity of the ball just before it lands. [3]

- (e) State why the horizontal component of the velocity does not change during the flight. [1]