

1.1 Scalars and Vectors

Name: _____ Class: _____ Date: _____

Total: 16 marks

Objective

Build the skills to answer exam questions on **scalars and vectors**—resolving a vector into components, finding its magnitude and direction, and adding vectors.

You must be able to:

- distinguish a **scalar** 标量 (magnitude only) from a **vector** 矢量 (magnitude **and** direction 方向)
- resolve a vector into **components** 分量: $A_x = A \cos \theta$, $A_y = A \sin \theta$
- find a vector's **magnitude** 大小 $A = \sqrt{A_x^2 + A_y^2}$ and its direction $\theta = \tan^{-1}(A_y/A_x)$
- add vectors by adding their components separately

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.

■ Scalar or vector?

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

scalar	vector
distance, speed, mass time, energy, temperature	displacement, velocity, force acceleration, momentum

■ Resolving into components

A vector of magnitude A at angle θ above the x -axis splits into

$$A_x = A \cos \theta, \quad A_y = A \sin \theta.$$

For $A = 10$ at $\theta = 30^\circ$: $A_x = 10 \cos 30^\circ = 8.7$, $A_y = 10 \sin 30^\circ = 5.0$.

■ Magnitude and direction from components

Reverse the process with Pythagoras and the tangent:

$$A = \sqrt{A_x^2 + A_y^2}, \quad \theta = \tan^{-1} \frac{A_y}{A_x}.$$

For $A_x = 3$, $A_y = 4$: $A = \sqrt{3^2 + 4^2} = 5$, and $\theta = \tan^{-1}(4/3) = 53^\circ$.

■ Adding vectors by components

Add the x -components and the y -components **separately**, then recombine. Two forces $\vec{F}_1 = (3, 0)$ N and $\vec{F}_2 = (0, 4)$ N:

$$\vec{F}_{\text{net}} = (3 + 0, 0 + 4) = (3, 4) \text{ N}, \quad |\vec{F}_{\text{net}}| = 5 \text{ N}.$$

2 Practice

Now apply the methods above.

2.1 State whether each is a scalar or a vector: (a) speed, (b) velocity, (c) mass, (d) acceleration. [2]

2.2 A displacement has magnitude 20 m at 60° above the x -axis. Find its x - and y -components. [2]

2.3 A vector has components $A_x = 6$ and $A_y = 8$. Find its magnitude. [2]

2.4 Add $\vec{A} = (5, 2)$ and $\vec{B} = (-1, 3)$ by components, and give the magnitude of the resultant. [2]

3 Exam-style questions

3.1 Which quantity is a vector? [1]

- A speed
- B distance
- C acceleration
- D mass

3.2 A vector of magnitude 12 makes an angle of 30° with the x -axis. Its x -component is closest to [1]

- **A** 6.0
 - **B** 10.4
 - **C** 12
 - **D** 0
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3.3 A vector has components $A_x = 9$ and $A_y = 12$.

(a) Find the magnitude of the vector. [2]

(b) Find the angle it makes with the x -axis. [1]

3.4 Two velocity vectors are $\vec{v}_1 = (4, 0) \text{ m s}^{-1}$ and $\vec{v}_2 = (0, -3) \text{ m s}^{-1}$.

(a) Find the components of the resultant. [1]

(b) Find the magnitude and direction of the resultant. [2]

4 Go further

You are ready for more on this subtopic:

- work through the interactive **1.1 Scalars and Vectors** lesson on the **Learn** page;
- read the **Kinematics** section of the AP Physics C: Mechanics handout on the **Know** page for the full explanation and worked diagrams.

Solutions

2.1 (a) scalar; (b) vector; (c) scalar; (d) vector.

2.2 $A_x = 20 \cos 60^\circ = 10 \text{ m}$; $A_y = 20 \sin 60^\circ = 17 \text{ m}$.

2.3 $A = \sqrt{6^2 + 8^2} = \sqrt{100} = 10$.

2.4 $(5 - 1, 2 + 3) = (4, 5)$; magnitude $= \sqrt{4^2 + 5^2} = \sqrt{41} \approx 6.4$.

3.1 C —acceleration is a vector; the others are scalars.

3.2 B — $12 \cos 30^\circ = 10.4$.

3.3 (a) $A = \sqrt{9^2 + 12^2} = \sqrt{225} = 15$. (b) $\theta = \tan^{-1}(12/9) = 53^\circ$.

3.4 (a) $(4, -3) \text{ m s}^{-1}$. (b) magnitude $\sqrt{4^2 + 3^2} = 5 \text{ m s}^{-1}$; direction $\tan^{-1}(3/4) = 37^\circ$ below the x -axis.