AP PHYSICS C: MECHANICS • EXERCISE SHEET

1.1 Scalars and Vectors

Name: _____ Class: _____ Date: _____ **Total: 16 marks**

KEY WORDS vector 矢量 • magnitude 大小 • components 分量 • scalar 标量 • direction 方向

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	displacement, velocity, force
time, energy, temperature	acceleration, momentum

■ **Resolving into components**

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

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

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

■ **Magnitude and direction from components**

Reverse the process with Pythagoras and the tangent:

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

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

■ **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:

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

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

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 $\vec{v}_1 = (4, 0)$ m s^{-1} and $\vec{v}_2 = (0, -3)$ m s^{-1}.

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

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

Solutions

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

2.2 $A_x = 20\cos 60^\circ = 10$ m; $A_y = 20\sin 60^\circ = 17$ 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) $(4, -3)$ m s^{-1}. (b) magnitude $\sqrt{4^2 + 3^2} = 5$ m s^{-1}; direction $\tan^{-1}(3/4) = 37^\circ$ below the x-axis.