AS | Physics - 9702 - 1.4 Scalars and Vectors

INTRODUCTION

As we have been learning, physical quantities are a characteristic or properties of an object that can be measured or calculated from other measurements. Scientists often make measurements. These need to be stated with the units of the quantity being measured, and the accuracy of the measurements. In this unit we will learn about scalars and vectors.

LEARNING OBJECTIVES

By the end of this unit you should be able to:

1. Understand the difference between scalar and vector quantities and give examples of scalar and vector quantities included in the syllabus.
2. Add and subtract coplanar vectors.
3. Represent a vector as two perpendicular components.

Scalars and Vectors

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Scalars and Vectors

Scalars and Vectors

Introduction

We continue our exploration of measurements. In this section we look at scalars and vectors and the difference between them.

LEARNING OBJECTIVES

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TABLE OF CONTENTS

TERMS AND DEFINITIONS

Scalars - A scalar quantity can be described fully by stating its magnitude (size) only eg mass of a rock.

Vector - A vector quantity can be described fully by stating its magnitude (size) and direction eg force of gravity.

1. Difference Between Scalar and Vector Quantities

A ***scalar*** is a quantity that **only has a magnitude or size**. For examples: distance, speed, mass, time, energy, volume, density, pressure, electric charge and temperature.

A ***vector*** is a quantity that **has both a magnitude and a direction**. For examples: displacement, velocity, acceleration, force and momentum.

If we look at the example of a person walking in the woods, the distance travelled will be a scalar quantity because it describes how far an object has travelled, but it does not indicate the direction the person travelled in. For example: the person has walked 10 km.

However, the displacement is described as 10 km north. Therefore, displacement is a vector quantity because it describes how far the person has walked and in which direction.

2. Combining Vectors

We represent vectors by an **arrow**. The **arrowhead** shows the **direction of the vector**, while the **length** of the arrow represents its **magnitude**.

We can combine vectors by adding or subtracting them, and two methods can be used to combine vectors. When two or more vectors are combined into a single vector, the single vector is known as the resultant vector.

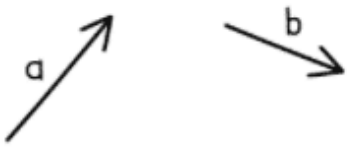
2.1 The triangle method

To combine vectors using the **triangle method**, you follow these 2 steps:

1. Link the vectors head-to-tail.
2. The resultant force is formed by connecting the first vector's tail to the second vector's head.

Click the arrows below to navigate through the steps of the example.

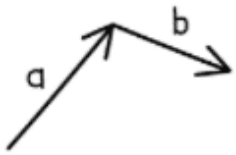
EXAMPLE



Draw the vector c = a + b

Step 2

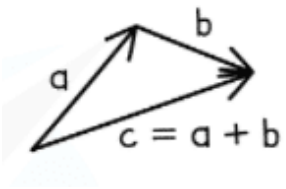
Link the vectors head-to-tail.



Translate vector b such that its tail is in contact with the head of vector a. Do not change the direction of b, simply shift (translate) it.

Step 3

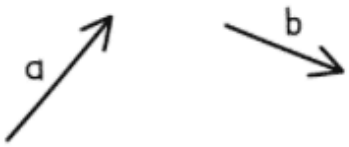
Form the resultant vector by linking the tail of a to the head of b.



Create the Resultant vector, which is the 3rd side of the triangle by putting its tail at the starting point of the sequence of a and b, and its head at the end point.

Click the arrows below to navigate through the steps of the example.

EXAMPLE

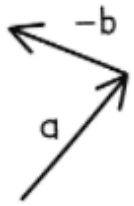


Draw the vector c = a - b

Note: Subtracting vectors requires you to first reverse the direction of vector b to make -b.

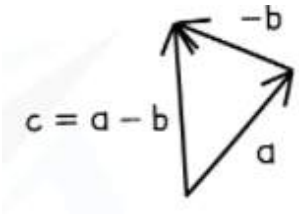
Step 2

Link the vectors head-to-tail.



Step 3

Form the resultant vector by linking the tail of a to the head of -b.



The Resultant is usually signified by double arrows.

To calculate the Resultant force using the triangle method, you can either use **Pythagoras theorem,** for a right-angled triangle or trigonometric ratios. Vectors at this stage are seldom drawn to scale.

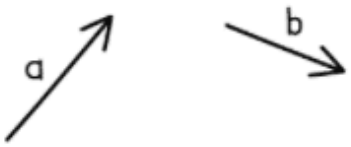
2.2 The parallelogram method

To combine vectors using the **parallelogram method**, you follow these 3 steps:

1. Link the vectors tail-to-tail.
2. Complete the resulting parallelogram.
3. The diagonal of the parallelogram will be the resultant vector.

Click the arrows below to navigate through the steps of the example.

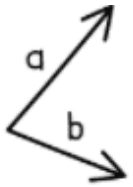
EXAMPLE



Draw the vector c = a + b.

Step 2

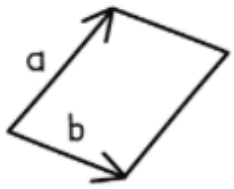
Link the vectors tail-to-tail.



Translate vector b such that its tail is in contact with the tail of vector a.

Step 3

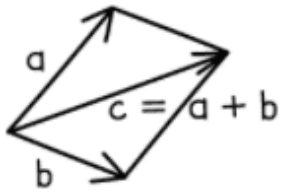
Complete the resulting parallelogram.



Complete the parallelogram by drawing dashed lines that are parallel to vectors a and b.

Step 4

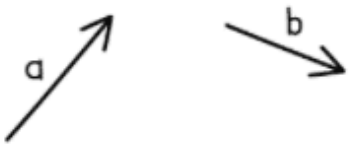
The resultant vector is the diagonal of the parallelogram.



Draw a diagonal as shown

Click the arrows below to navigate through the steps of the example.

EXAMPLE

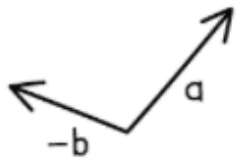


Draw the vector c = a - b

Note: Subtracting vectors, require you to first reverse the direct of vector b to make - b.

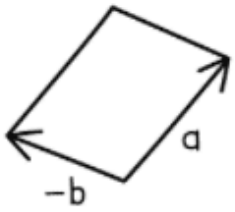
Step 2

Link the vectors tail-to-tail.



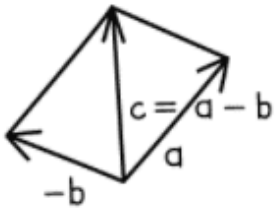
Step 3

Complete the resulting parallelogram.



Step 4

The resultant vector is the diagonal of the parallelogram.



To further visualise the formation of Resultant vectors, watch the short video ▶ here ◀.

EXAM - STYLE QUESTIONS

The following question is an exam style question on the Paper 1, multiple choice exam. Before reading the feedback and the explanation, try the question yourself and make sure you also understand the reason for not selecting the incorrect options.

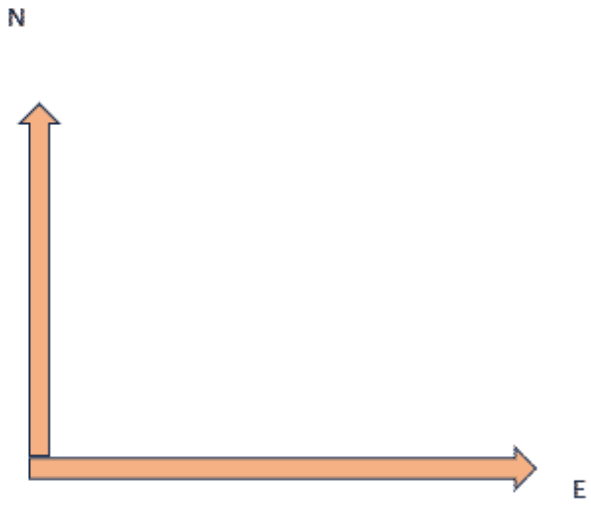
QUESTION	FEEDBACK	EXPLANATION

1. Two forces of equal magnitude are represented by two coplanar vectors. One is directed towards the east and the other is directed towards the north. In which direction will the resultant force be in?

A	towards the north-east
B	towards the north-west
C	towards the south-east
D	towards the south-west

QUESTION	FEEDBACK	EXPLANATION
1. A		

QUESTION	FEEDBACK	EXPLANATION
1. The two vectors can be illustrated as shown below. Either a triangle of vectors can be drawn or a parallelogram can be drawn and the diagonal will be the resultant. The resultant force is in the North East.		



EXAM - STYLE QUESTIONS

Consider the EXAM-STYLE QUESTION below. After reflecting on this question, click the FEEDBACK and EXPLANATION tabs to reveal the suggested answer.

QUESTION | FEEDBACK | EXPLANATION

1. Complete the table below by putting a tick (✓) in the appropriate column to indicate whether the listed quantities are scalars or vectors.

quantity	scalar	vector
acceleration		
density		
temperature		
momentum		

[2]

QUESTION	FEEDBACK	EXPLANATION

1. Scalars: density, temperature
   Vectors: acceleration, momentum

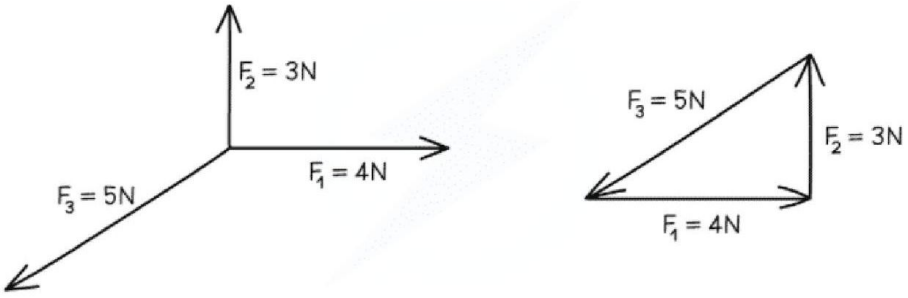
QUESTION	FEEDBACK	EXPLANATION

1. Acceleration and momentum have both magnitude and direction.
   Density and temperature have magnitude only.

3. Resolving Vectors

Coplanar forces are forces that **act in the same plane** eg a vertical plane. Coplanar forces may act from a single point. When 3 co-planar forces acting from the same point can form a closed triangle, then they are in equilibrium.

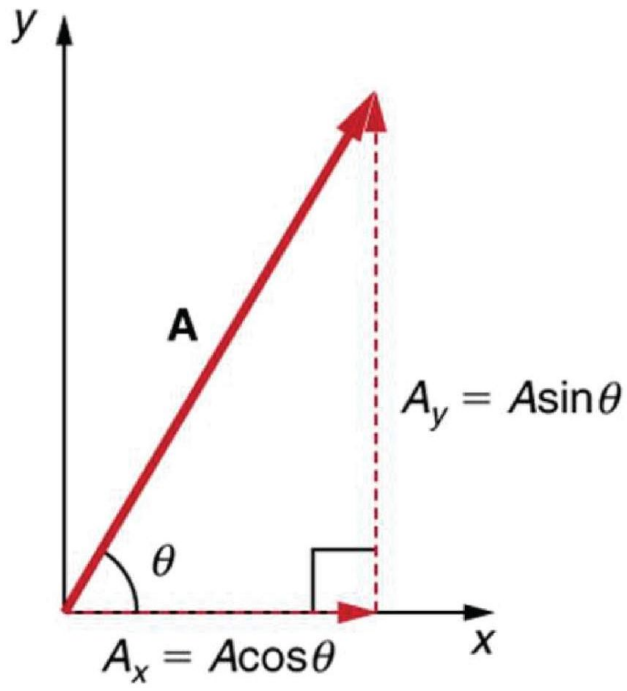
For example:



A **resultant vector** can be resolved and represented by two vectors which in combination have the same effect as the original one. The parts which a single resultant vector can be broken into are called its **components**.

For example, the vector below (red) has a magnitude of A and is at an angle of θ to the horizontal. You can resolve this vector into its **horizontal and vertical components** using trigonometry.

For the horizontal component, A_x = Acosθ and for the vertical component, A_y = Asinθ.



Watch the video below for another example of resolving vectors:

Resolving vectors

Cowen Physics

VIDEO

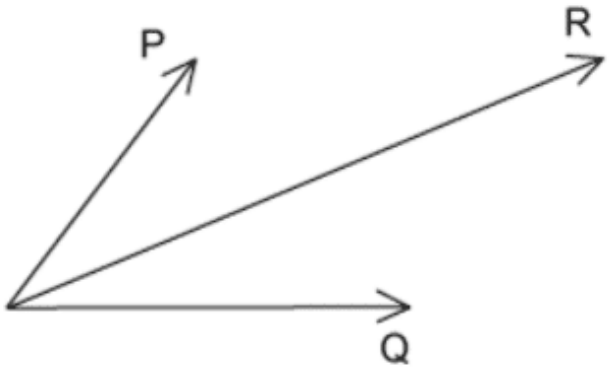
KEY TAKEAWAYS

- Vectors possess a both magnitude and direction.
- A scalar quantity can be described fully by stating its magnitude only.
- The result of adding vectors together is called the resultant.
- Co-planar vectors come from a single point and if they are 3 of them and in equilibrium, they form a triangle of vectors.
- Vectors can be resolved using a parallelogram of vectors or a vector triangle.

- The direction of a vector may be stated in terms of its angle to the horizontal or vertical.

TEST YOUR KNOWLEDGE

1. Two physical quantities P and Q are added together. The sum of P and Q is R, as shown in the diagram. Which quantity could be represented by P and by Q?



- Kinetic energy
- Power
- Speed
- Velocity

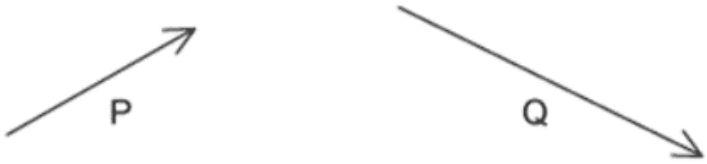
SUBMIT

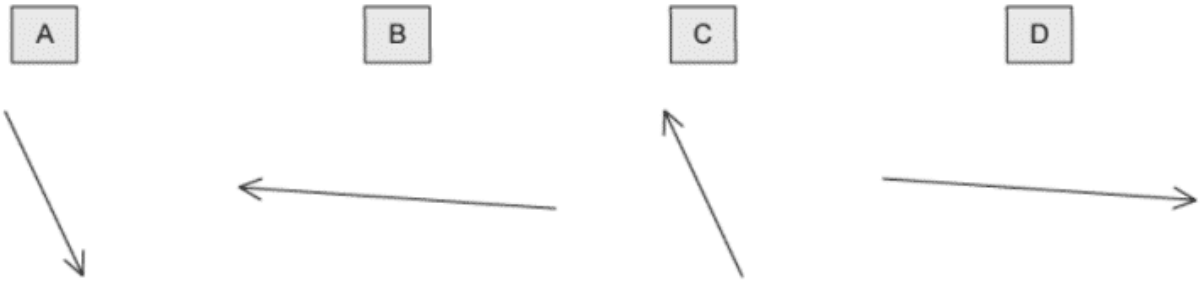
2. The speed of an aeroplane in still air is 200 kmh^{-1}. The wind blows from the west at a speed of 85.0 kmh^{-1}. In which direction must the pilot steer the aeroplane in order to fly due north?

- ○ 23.0 ° east of north
- ○ 23.0 ° west of north
- ○ 25.2 ° east of north
- ○ 25.2 ° west of north

SUBMIT

3. Vectors P and Q are drawn to scale. Which diagram (A to D) represents the vector (P - Q)?

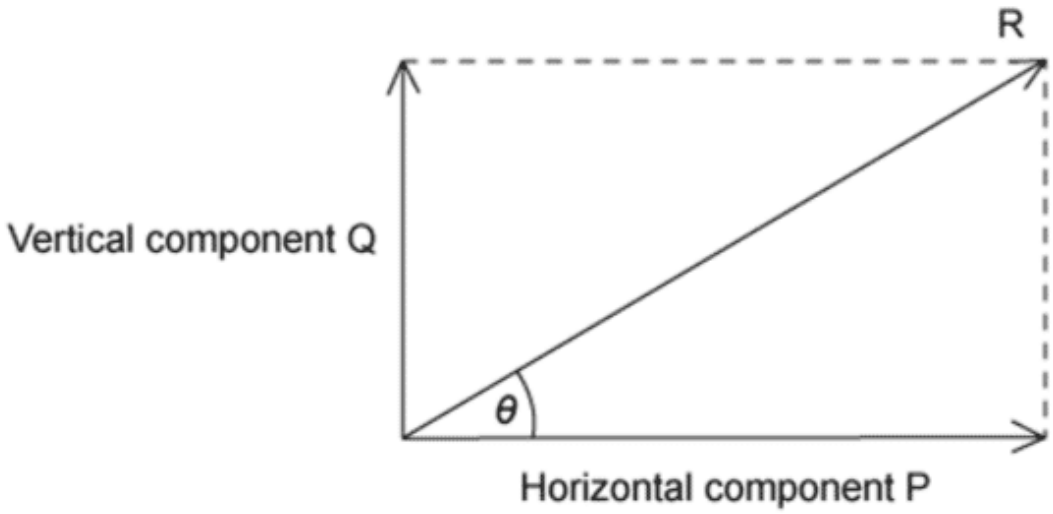




- ○ A
- ○ B
- ○ C
- ○ D

SUBMIT

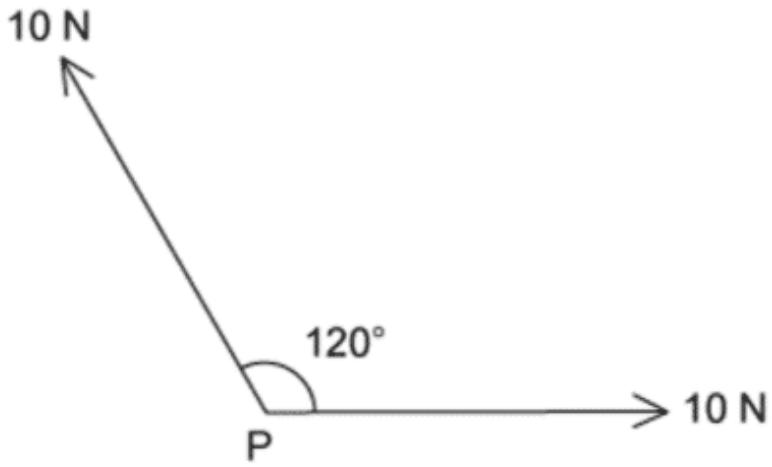
4. A vector has magnitude R and perpendicular components P and Q, as shown in the diagram. Which of the options below describes the perpendicular components?



- Vertical Component = Q & Horizontal Component = sinθ
- Vertical Component = Rcosθ & Horizontal Component = P
- Vertical Component = Rcosθ & Horizontal Component = Rsinθ
- Vertical Component = Rsinθ & Horizontal Component = Rcosθ

SUBMIT

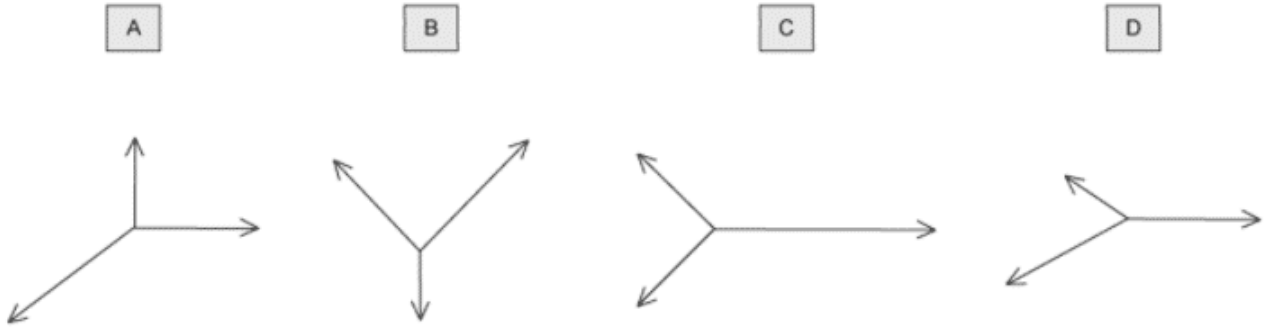
5. Two forces, each of 10 N, act at a point P as shown in the diagram. The angle between the force vectors is 120°. What is the magnitude of the resultant force?



- 5 N
- 10 N
- 17 N
- 20 N

SUBMIT

6. The diagrams represent systems of coplanar forces acting at a point. The lengths of the force vectors represent the magnitude of forces. Which system of forces is in equilibrium?



- A
- B
- C
- D

SUBMIT

REFERENCES

- Crundell M, Goodwin G (2020), Cambridge International AS & A Level Physics Student's Book, https://www.hoddereducation.co.uk/
- Sang D, Jones G, Woodside R and Chadha G (2020), Cambridge International AS & A Level Physics: Coursebook, Third Edition, http://www.cambridge.org/education

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