Topic 1.1

Scalars and Vectors in One Dimension

Learning Objectives

- Understand that certain physical quantities can be represented by scalars or vectors.
- Describe a scalar or vector quantity using magnitude and direction, as appropriate.
- Understand how arrows can be used to represent vector values.
- Learn that the addition of two physical quantities can represent other important quantities and can be determined by vector addition.

Topic Questions

- What is a scalar quantity? What is a vector quantity?
- How does a vector represent a physically significant quantity with magnitude and direction?
- How can the magnitude of a resultant vector be found when vectors are added together in one dimension?
- How should vectors be drawn when added together in one dimension, and what is the direction of the resultant vector?

1.1.01 Scalar and Vector Quantities

[1.1.A.1 1.1.A.2]

When a physical quantity is measured experimentally, it is expressed by using SI units (or combinations of SI units). These quantities can be organized into two main categories: **scalars**, which are described by only a numerical value (eg, distance, speed), or **vectors**, which also include a direction (eg, displacement, velocity, acceleration).

Scalar values are said to contain only a magnitude (ie, the numerical value), whereas vectors contain both magnitude and direction. To distinguish variables representing vector quantities, an arrow is placed above the variable:

$$\vec{v} = \text{vector quantity}$$

Visually, vectors can be represented by an arrow. The length of the arrow represents the vector's relative magnitude, and the direction of the arrow indicates the direction of the vector (see Figure 1.1).

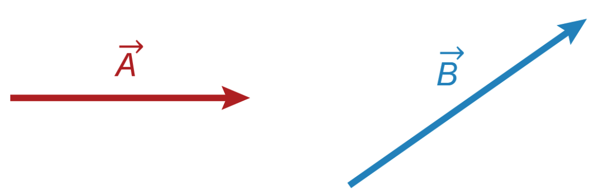


Figure 1.1 Vectors with different magnitudes and directions.

The basic kinematic variables are displacement, velocity, and acceleration (see Topic 1.2). These variables are vector quantities because an object can move in any arbitrary direction in space. Vectors can also be assigned at specific points in space (in what are called vector fields) to represent the magnitude and direction of a physical quantity (eg, force) at each point in space.

1.1.02 Adding Vectors in One Dimension

[1.1.A.3 1.1.B.1]

In some cases, it may be necessary to consider the addition of two vectors, such as when two forces act on an object. The sum of two vectors in one dimension depends on whether the vectors are in the same direction or in opposite directions. As shown in Figure 1.2, when two vectors with magnitudes of v_A and v_B are in the same direction, the magnitude of their sum equals the sum of the magnitudes:

$$\vec{v}_{\mathrm{A}} + \vec{v}_{\mathrm{B}} = v_{\mathrm{A}} + v_{\mathrm{B}}$$

Also, the direction of their sum is the same as the direction of the original vectors.

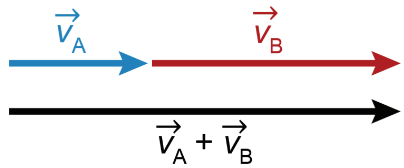


Figure 1.2 Adding two vectors with the same direction in one dimension.

However, Figure 1.3 shows that when two vectors of magnitude v_A and v_C are in opposite directions, the magnitude of their sum equals the difference of the magnitudes:

$$\vec{v}_{\mathrm{A}} + \vec{v}_{\mathrm{C}} = v_{\mathrm{A}} - v_{\mathrm{C}}$$

In addition, the direction of their sum is the same as the direction of the original vector with the largest magnitude.

Furthermore, the sum of vectors $\vec{v}_{\mathrm{A}}$, $\vec{v}_{\mathrm{B}}$, and $\vec{v}_{\mathrm{C}}$ is equal to:

$$\vec{v}_{\mathrm{A}} + \vec{v}_{\mathrm{B}} + \vec{v}_{\mathrm{C}} = v_{\mathrm{A}} + v_{\mathrm{B}} - v_{\mathrm{C}}$$

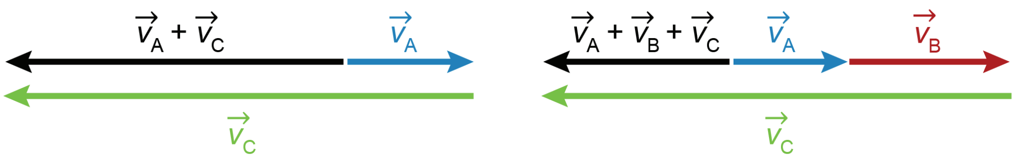
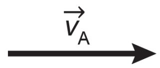


Figure 1.3 Adding vectors with opposite directions in one dimension.

Topic 1.1 Scalars and Vectors in One Dimension

Check for Understanding Quiz

1. Vector A $\vec{\boldsymbol{v}}_{\mathbf{A}}$ is shown below. Which of the following arrows best represents vector B if $\vec{\boldsymbol{v}}_{\mathbf{B}} = \mathbf{2}\vec{\boldsymbol{v}}_{\mathbf{A}}$?



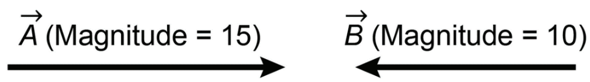
A. 

B. 

C. 

D. 

2. Vector $\vec{\boldsymbol{A}}$ and $\vec{\boldsymbol{B}}$ are shown below. If vectors $\vec{\boldsymbol{A}} + \vec{\boldsymbol{B}} + \vec{\boldsymbol{C}} = \mathbf{0}$, which arrow best represents vector $\vec{\boldsymbol{C}}$?



A. 

B. 

C. 

D. 

Note: Answers to this quiz are in the back of the book (appendix).