



FIGURE 3-14 Vector subtraction. (a) The vector \vec{B} and its negative $-\vec{B}$. (b) A vector construction for $\vec{D} = \vec{A} - \vec{B}$.

For example, the vectors \vec{B} and $-\vec{B}$ are indicated in **Figure 3-14 (a)**. Thus, to subtract \vec{B} from \vec{A} , simply reverse the direction of \vec{B} and add it to \vec{A} , as indicated in **Figure 3-14 (b)**.

In terms of components, you subtract vectors by simply subtracting the components. For example, if

$$\vec{D} = \vec{A} - \vec{B}$$

then

$$D_x = A_x - B_x$$

and

$$D_y = A_y - B_y$$

Once the components of \vec{D} are found, its magnitude and direction angle can be calculated as usual.

EXERCISE 3-5

- For the vectors given in **Figure 3-12**, find the components of $\vec{D} = \vec{A} - \vec{B}$.
- Find D and θ and compare with the vector \vec{D} shown in **Figure 3-14 (b)**.

SOLUTION

- $D_x = -1.26 \text{ m}$, $D_y = 2.96 \text{ m}$.
- $D = 3.22 \text{ m}$, $\theta = -66.9^\circ \pm 180^\circ = 113^\circ$. In **Figure 3-14 (b)** we see that \vec{D} is shorter than \vec{B} , which has a magnitude of 4.00 m , and its direction angle is somewhat greater than 90° , in agreement with our numerical results.

3-4 Unit Vectors

Unit vectors provide a convenient way of expressing an arbitrary vector in terms of its components, as we shall see. But first, let's define what we mean by a unit vector. In particular, the unit vectors \hat{x} and \hat{y} are defined to be dimensionless vectors of unit magnitude pointing in the positive x and y directions, respectively:

- The x unit vector, \hat{x} , is a dimensionless vector of unit length pointing in the positive x direction.
- The y unit vector, \hat{y} , is a dimensionless vector of unit length pointing in the positive y direction.

Figure 3-15 shows \hat{x} and \hat{y} on a two-dimensional coordinate system. Since unit vectors have no physical dimensions—like mass, length, or time—they are used to specify direction only.

Multiplying Unit Vectors by Scalars

To see the utility of unit vectors, consider the effect of multiplying a vector by a scalar. For example, multiplying a vector by 3 increases its magnitude by a factor of 3, but does not change its direction, as shown in **Figure 3-16**. Multiplying by -3 increases the magnitude by a factor of 3 and reverses the direction of the vector. This is also shown in **Figure 3-16**. In the case of unit vectors—which have a magnitude of 1 and are dimensionless—multiplication by a scalar results in a vector with the same magnitude and dimensions as the scalar.

For example, if a vector \vec{A} has the scalar components $A_x = 5 \text{ m}$ and $A_y = 3 \text{ m}$, we can write it as

$$\vec{A} = (5 \text{ m})\hat{x} + (3 \text{ m})\hat{y}$$



FIGURE 3-15 Unit vectors. The unit vectors \hat{x} and \hat{y} point in the positive x and y directions, respectively.

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Table of Contents Physics Walker 4th Edition Solutions Chapter 19

1. Understanding the eBook Physics Walker 4th Edition Solutions Chapter 19
 - The Rise of Digital Reading Physics Walker 4th Edition Solutions Chapter 19
 - Advantages of eBooks Over Traditional Books
2. Identifying Physics Walker 4th Edition Solutions Chapter 19
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Physics Walker 4th Edition Solutions Chapter 19
 - User-Friendly Interface
4. Exploring eBook Recommendations from Physics Walker 4th Edition Solutions Chapter 19
 - Personalized Recommendations

- Physics Walker 4th Edition Solutions Chapter 19 User Reviews and Ratings
- Physics Walker 4th Edition Solutions Chapter 19 and Bestseller Lists
- 5. Accessing Physics Walker 4th Edition Solutions Chapter 19 Free and Paid eBooks
 - Physics Walker 4th Edition Solutions Chapter 19 Public Domain eBooks
 - Physics Walker 4th Edition Solutions Chapter 19 eBook Subscription Services
 - Physics Walker 4th Edition Solutions Chapter 19 Budget-Friendly Options
- 6. Navigating Physics Walker 4th Edition Solutions Chapter 19 eBook Formats
 - ePub, PDF, MOBI, and More
 - Physics Walker 4th Edition Solutions Chapter 19 Compatibility with Devices
 - Physics Walker 4th Edition Solutions Chapter 19 Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Physics Walker 4th Edition Solutions Chapter 19
 - Highlighting and Note-Taking Physics Walker 4th Edition Solutions Chapter 19
 - Interactive Elements Physics Walker 4th Edition Solutions Chapter 19
- 8. Staying Engaged with Physics Walker 4th Edition Solutions Chapter 19
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Physics Walker 4th Edition Solutions Chapter 19
- 9. Balancing eBooks and Physical Books Physics Walker 4th Edition Solutions Chapter 19
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Physics Walker 4th Edition Solutions Chapter 19
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Physics Walker 4th Edition Solutions Chapter 19
 - Setting Reading Goals Physics Walker 4th Edition Solutions Chapter 19
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Physics Walker 4th Edition Solutions Chapter 19
 - Fact-Checking eBook Content of Physics Walker 4th Edition Solutions Chapter 19

- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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