



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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