



**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  $\theta$  and compare with the vector  $\vec{D}$  shown in **Figure 3-14 (b)**.

#### SOLUTION

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