

1.4 Vector addition and multiplication by a scalar

If you've read the previous section on vector components, you've already seen two vector operations in action. Those two operations are the addition of vectors and multiplication of a vector by a scalar. Both of these operations are used in the expansion of a vector in terms of vector components as in Eq. 1.1 from Section 1.3:

$$\vec{A} = A_x \hat{i} + A_y \hat{j} + A_z \hat{k}.$$

In each of these terms, the unit vector ($\hat{i}$, $\hat{j}$, or $\hat{k}$) is being multiplied by a scalar (A_x , A_y , or A_z), and you already know the effect of that: it produces a new vector, in the same direction as the unit vector, but longer than unity by the value of the component (or shorter if the magnitude of the component is between zero and one). So multiplying a vector by any positive scalar does not change the direction of the vector, but only scales the length of the vector. Hence, $5\vec{A}$ is a vector in exactly the same direction as $\vec{A}$, but with length five times that of $\vec{A}$, as shown in Figure 1.7(a). Likewise, multiplying $\vec{A}$ by $(1/2)$ produces a vector that points in the same direction as $\vec{A}$ but is only half as long. So the vector component $A_x \hat{i}$ is a vector in the $\hat{i}$ direction, but with length A_x units (since $\hat{i}$ has a length of one unit).

There is a caveat that goes with the “changes length, not direction” rule when multiplying a vector by a scalar: if the scalar is *negative*, then the vector is reversed in direction in addition to being scaled in length. Thus multiplying vector $\vec{B}$ by -2 produces the new vector $-2\vec{B}$, and that vector is twice as long as $\vec{B}$ and points in the opposite direction to $\vec{B}$, as shown in Figure 1.7(b).

The other operation going on in Eq. 1.1 is vector addition, and you already have an idea of what that means if you recall Figure 1.5 and the process of getting from the beginning of vector $\vec{A}$ to the end. In that process, the quantity



Figure 1.7 Multiplication of a vector by a scalar.

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