SECTION 2

Vector Operations

SECTION OBJECTIVES

- **Identify appropriate coordinate systems for solving problems with vectors.**
- **Apply the Pythagorean theorem and tangent function to calculate the magnitude and direction of a resultant vector.**
- **Resolve vectors into components using the sine and cosine functions.**
- **Add vectors that are not perpendicular.**

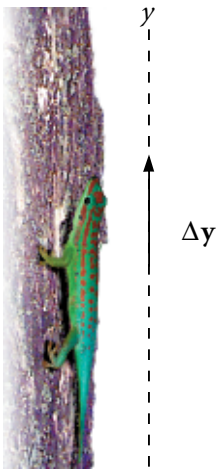

Figure 5
A gecko's displacement while climbing a tree can be represented by an arrow pointing along the *y*-axis.

COORDINATE SYSTEMS IN TWO DIMENSIONS

In the chapter "Motion in One Dimension," the motion of a gecko climbing a tree was described as motion along the *y*-axis. The direction of the displacement of the gecko was denoted by a positive or negative sign. The displacement of the gecko can now be described by an arrow pointing along the *y*-axis, as shown in **Figure 5.** A more versatile system for diagraming the motion of an object, however, employs vectors and the use of both the *x*- and *y*-axes simultaneously.

The addition of another axis not only helps describe motion in two dimensions but also simplifies analysis of motion in one dimension. For example, two methods can be used to describe the motion of a jet moving at 300 m/s to the northeast. In one approach, the coordinate system can be turned so that the plane is depicted as moving along the *y*-axis, as in **Figure 6(a).** The jet's motion also can be depicted on a two-dimensional coordinate system whose axes point north and east, as shown in **Figure 6(b).**

One problem with the first method is that the axis must be turned again if the direction of the plane changes. Another problem is that the first method provides no way to deal with a second airplane that is not traveling in the same direction as the first airplane. Thus, axes are often designated using fixed directions. For example, in **Figure 6(b),** the positive *y*-axis points north and the positive *x*-axis points east.

Similarly, when you analyze the motion of objects thrown into the air, orienting the *y*-axis parallel to the vertical direction simplifies problem solving.

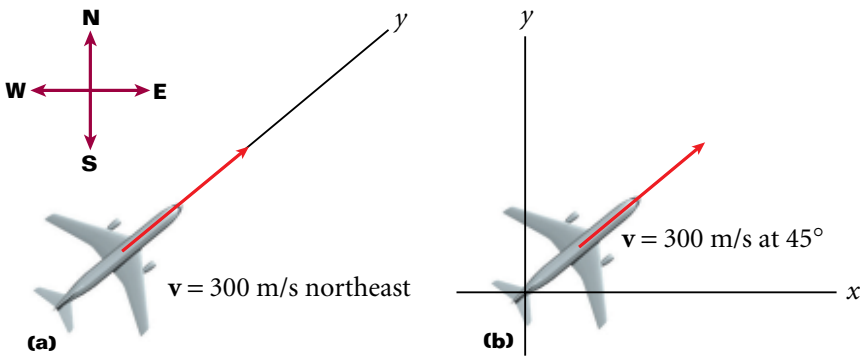

Figure 6
A plane traveling northeast at a velocity of 300 m/s can be represented as either **(a)** moving along a *y*-axis chosen to point to the northeast or **(b)** moving at an angle of 45° to both the *x*- and *y*-axes, which line up with west-east and south-north, respectively.