are identical. In both examples, the only difference is the relationship of the airfoil with the oncoming airstream (angle). A paper airplane, which is simply a flat plate, has a bottom and top exactly the same shape and length. Yet, these airfoils do produce lift, and "flow turning" is partly (or fully) responsible for creating lift.

As an airfoil moves through air, the airfoil is inclined against the airflow, producing a different flow caused by the airfoil's relationship to the oncoming air. Think of a hand being placed outside the car window at a high speed. If the hand is inclined in one direction or another, the hand will move upward or downward. This is caused by deflection, which in turn causes the air to turn about the object within the air stream. As a result of this change, the velocity about the object changes in both magnitude and direction, in turn resulting in a measurable velocity force and direction.

A Third Dimension

To this point, the discussion has centered on the flow across the upper and lower surfaces of an airfoil. While most of the lift is produced by these two dimensions, a third dimension, the tip of the airfoil also has an aerodynamic effect. The high-pressure area on the bottom of an airfoil pushes around the tip to the low-pressure area on the top. *[Figure 4-8]* This action creates a rotating flow called a tip vortex. The vortex flows behind the airfoil creating a downwash that extends back to the trailing edge of the airfoil. This downwash results in an overall reduction in lift for the affected portion of the airfoil. Manufacturers have developed different methods to counteract this action. Winglets can be added to the tip of an airfoil to reduce this flow. The winglets act as a dam preventing the vortex from forming. Winglets can be on the top or bottom of the airfoil. Another method of countering the flow is to taper the airfoil tip, reducing the pressure differential and smoothing the airflow around the tip.

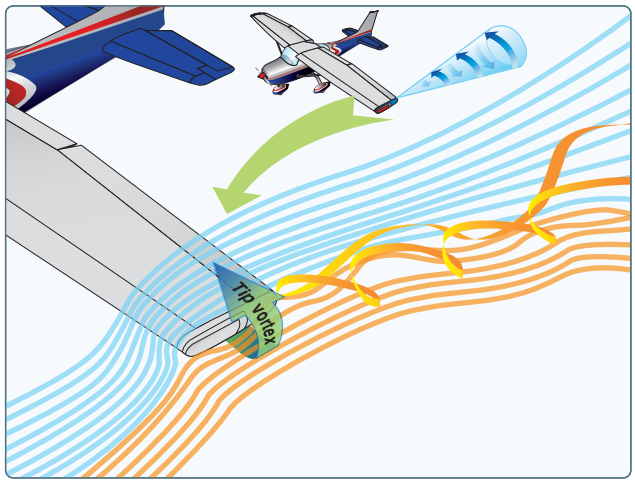

Figure 4-8. *Tip vortex.*

Chapter Summary

Modern general aviation aircraft have what may be considered high performance characteristics. Therefore, it is increasingly necessary that pilots appreciate and understand the principles upon which the art of flying is based. For additional information on the principles discussed in this chapter, visit the National Aeronautics and Space Administration (NASA) Beginner's Guide to Aerodynamics at www.grc.nasa.gov/www/k-12/airplane/bga.html.