SECTION 3

Fluids in Motion

SECTION OBJECTIVES

- **Examine the motion of a fluid using the continuity equation.**
- **Recognize the effects of Bernoulli's principle on fluid motion.**

FLUID FLOW

Have you ever gone canoeing or rafting down a river? If so, you may have noticed that part of the river flowed smoothly, allowing you to float calmly or to simply paddle along. At other places in the river, there may have been rocks or dramatic bends that created foamy whitewater rapids.

When a fluid, such as river water, is in motion, the flow can be characterized in one of two ways. The flow is said to be *laminar* if every particle that passes a particular point moves along the same smooth path traveled by the particles that passed that point earlier. The smooth stretches of a river are regions of laminar flow.

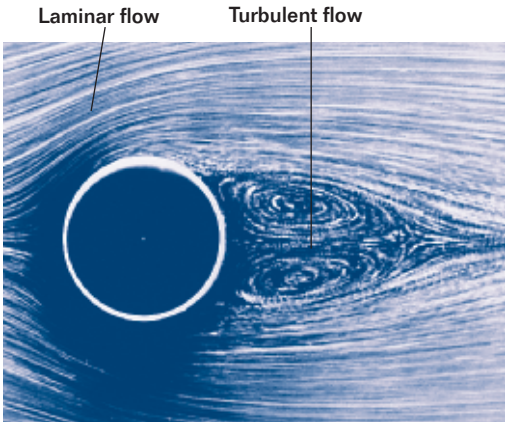

Figure 8
The water flowing around this cylinder exhibits laminar flow and turbulent flow.

In contrast, the flow of a fluid becomes irregular, or *turbulent,* above a certain velocity or under conditions that can cause abrupt changes in velocity, such as where there are obstacles or sharp turns in a river. Irregular motions of the fluid, called *eddy currents,* are characteristic of turbulent flow.

Figure 8 shows a photograph of water flowing past a cylinder. Hydrogen bubbles were added to the water to make the streamlines and the eddy currents visible. Notice the dramatic difference in flow patterns between the laminar flow and the turbulent flow. Laminar flow is much easier to model because it is predictable. Turbulent flow is extremely chaotic and unpredictable.

The ideal fluid model simplifies fluid-flow analysis

ideal fluid

a fluid that has no internal friction or viscosity and is incompressible

Many features of fluid motion can be understood by considering the behavior of an **ideal fluid.** Although no real fluid has all the properties of an ideal fluid, the ideal fluid model does help explain many properties of real fluids, so the model is a useful tool for analysis. While discussing density and buoyancy, we assumed all of the fluids used in problems were practically incompressible. A fluid is incompressible if the density of the fluid always remains constant.

The term *viscosity* refers to the amount of internal friction within a fluid. A fluid with a high viscosity flows more slowly than does a fluid with a low viscosity. As a viscous fluid flows, part of the kinetic energy of the fluid is transformed into internal energy due to the friction of the fluid particles sliding past each other. Ideal fluids are considered *nonviscous,* so they lose no kinetic energy due to friction as they flow. Ideal fluids are also characterized by a *steady flow.* In other words, the velocity, density, and pressure at each point in the fluid are constant. Ideal flow of an ideal fluid is also *nonturbulent,* which means that there are no eddy currents in the moving fluid.