7.3 Flow Rate and Viscosity

You probably noticed that not all fluids flow at the same rate. Water out of a tap, for example, flows much faster than honey flows over your spoon (Figure 1). Flow rate is the term used to describe how quickly fluids move. **Flow rate** measures the volume of fluid moving past a certain point in a given amount of time. We use flow rate to measure fluids moving through or out of a pipe. For example, if it takes 4 seconds to fill up a 1 L container of water from your kitchen tap, the flow rate from the tap is 1 L/4 s or 0.25 L/s. If you turn the tap only halfway, will the flow rate increase or decrease? Flow rate depends on several factors:

- the type of fluid that is flowing (thin fluids flow faster than thick ones)
- the force pushing on the fluid (stronger forces produce faster flow rates)
- the size of the pipe or opening the fluid is flowing through (larger openings allow for faster flow)
- the type of surface over which the fluid is flowing (smooth surfaces allow for faster flow)

flow rate: a measure of how quickly fluids move; measured in a volume per unit time (for example, L/s)

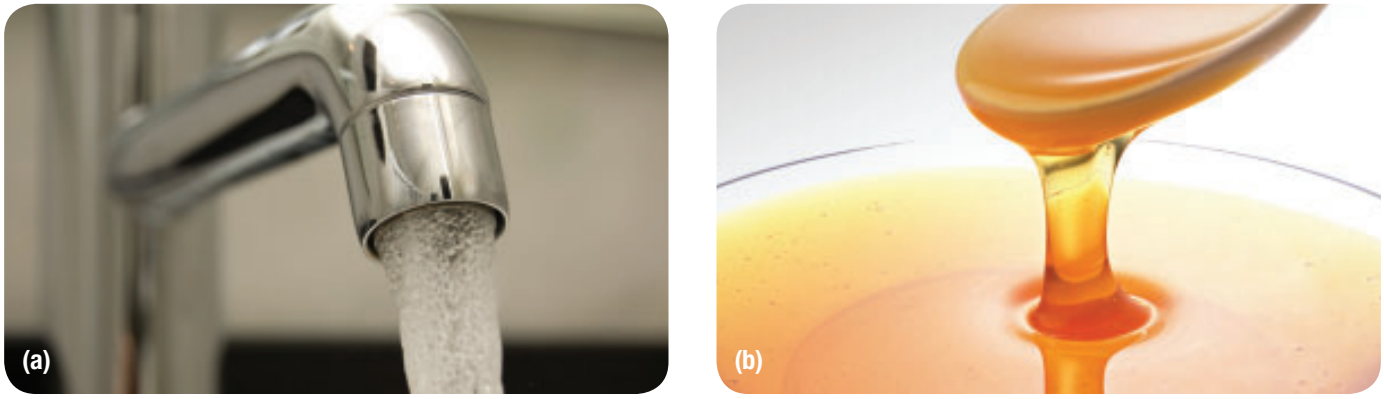

Figure 1 The flow rate of water out of a tap (a) is quite different from the flow rate of honey (b).

TRY THIS: Measuring Drips

SKILLS MENU: predicting, performing, observing, analyzing, evaluating, communicating

SKILLS HANDBOOK 2.B.3., 2.B.7.

A dripping tap wastes water… but how much? In this activity, you will determine the flow rate of a dripping tap.

Equipment and Materials: faucet; container (for example, large can, plastic jar, 600 mL beaker); graduated cylinder or measuring cup; timing device

1. Turn the faucet on so that the tap drips at a steady rate.
2. Estimate how much water the tap will waste in 1 h. Record your estimate.
3. Use your container to collect the water that drips from the tap over a 10 min period. Measure and record the volume of water collected.
4. If time allows, repeat using a faster drip rate.

A. Calculate the volume of water the tap would drip in 1 h.

B. Calculate the flow rate of the dripping tap in litres per hour (L/h) or millilitres per minute (mL/min).

C. How did your results compare with your estimates?

D. There are approximately 12 million people in Ontario. If we assume that there are three people per home, how much water would be wasted every hour if each home had one tap that dripped at the rate yours did?

LINKING TO LITERACY

Compare and Contrast: Photographs

Sometimes, illustrations or photographs are placed side by side to invite the reader to make a comparison. Look at the two photos on the right. Read the captions below the photos. What comparison are you asked to make? Can you explain why these fluids are different?

Viscosity

Some fluids pour more quickly than others. Which fluid pours more quickly, maple syrup or soy sauce (Figure 2)? Thick fluids, such as maple syrup, flow more slowly than thin, runny fluids, such as soy sauce.

Figure 2 What causes some fluids to flow more easily than others?

viscosity: a measure of how easily a fluid's particles are able to slide past one another

The **viscosity** of a fluid refers to its "thickness," or its resistance to flow. A number of factors affect a fluid's ability to flow. Two factors are cohesion and adhesion.

Cohesion

cohesion: a measure of how strongly the particles of a fluid attract each other

Cohesion is the force of attraction between the particles of a substance. Fluids with slow flow rates, such as maple syrup, have particles with greater cohesion. They stick together. We say such fluids are viscous. Some fluids, such as caramel, are so viscous that they fold over on themselves (Figure 3). Less viscous fluids, such as water and milk, show less cohesion. They flow more freely. Gases are the least viscous fluids, since their particles are farther apart.

Figure 3 Fluids with high viscosity, such as caramel, pour slowly.

Less viscous fluids are thin and runny and have faster flow rates. Thicker fluids are more viscous and have slower flow rates.

Surface Tension

surface tension: the strong attraction among the particles that form the surface of a liquid

The cohesion of particles on a liquid's surface is called **surface tension**. Insects such as water striders (Figure 4) use surface tension to their advantage. The force of attraction among the water particles is greater than the force of gravity pulling the strider down on the water's surface. This attraction forms a cohesive "skin" on the water's surface that the insect can walk or skate across.

Figure 4 Surface tension keeps this water strider from sinking into the water.

Sometimes the cohesion of water needs to be reduced. When fighting forest fires, a "wetting agent" can be added to water to reduce cohesion. The wetting agent allows the water to disperse more readily. Water with reduced cohesion spreads out when it hits the trees and ground (Figure 5).

To learn more about cohesion, Go to Nelson Science

Figure 5 Fire retardants often contain chemicals to reduce cohesion and increase water's ability to spread out and cover the burning material.

Adhesion

Another factor that affects flow rate is adhesion. **Adhesion** is the force of attraction between particles of a fluid and particles of other substances. When you have finished drinking a glass of milk, you may have noticed a thin film of milk on the sides and bottom of the glass (Figure 6). Fluid particles adhere to the sides of containers, pipes, and tubing. Adhesion between water particles and the container is responsible for the curved top surface you see when water touches the sides of a cup, graduated cylinder, or other container. This curved surface is called a meniscus.

adhesion: the attraction between the particles of one substance and the particles of another substance

Adhesion causes gases and liquids to travel faster near the centre of pipes and tubes than at the edges. The fluid's attraction to the material the pipes and tubes are made of slows down the flow of the fluid. In a similar way, water flows faster at the centre of a stream or river than along the edges.

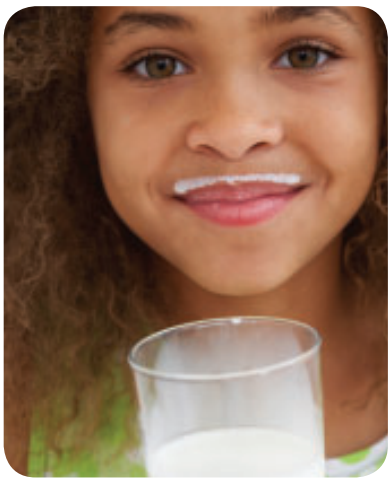

Figure 6 Adhesion causes the milk to stick to both glass and skin.

CHECK YOUR LEARNING

1. **(a)** In your own words, define "flow rate" and "viscosity."
   (b) Describe the relationship between flow rate and viscosity.
2. In your own words, define "cohesion" and "surface tension."
3. Use the term "viscosity" to explain how wetting agents are used to help fight fires.
4. **(a)** How does adhesion affect flow rate?
   (b) Give an example in real life that shows adhesion at work.
5. Explain why fluids travel faster near the centre of pipes and tubes than at the edges.