Conceptual Questions

12.1 Flow Rate and Its Relation to Velocity

1.

What is the difference between flow rate and fluid velocity? How are they related?

2.

Many figures in the text show streamlines. Explain why fluid velocity is greatest where streamlines are closest together. (Hint: Consider the relationship between fluid velocity and the cross-sectional area through which it flows.)

3.

Identify some substances that are incompressible and some that are not.

12.2 Bernoulli's Equation

4.

You can squirt water a considerably greater distance by placing your thumb over the end of a garden hose and then releasing, than by leaving it completely uncovered. Explain how this works.

5.

Water is shot nearly vertically upward in a decorative fountain and the stream is observed to broaden as it rises. Conversely, a stream of water falling straight down from a faucet narrows. Explain why, and discuss whether surface tension enhances or reduces the effect in each case.

6.

Look back to Figure 12.4. Answer the following two questions. Why is P_{o} less than atmospheric? Why is P_{o} greater than P_{i}?

7.

Give an example of entrainment not mentioned in the text.

8.

Many entrainment devices have a constriction, called a Venturi, such as shown in Figure 12.24. How does this bolster entrainment?

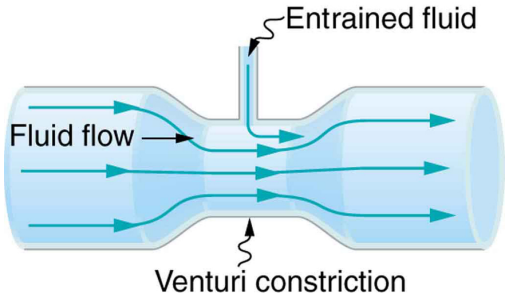

Figure 12.24 A tube with a narrow segment designed to enhance entrainment is called a Venturi. These are very commonly used in carburetors and aspirators.

9.

Some chimney pipes have a T-shape, with a crosspiece on top that helps draw up gases whenever there is even a slight breeze. Explain how this works in terms of Bernoulli's principle.

10.

Is there a limit to the height to which an entrainment device can raise a fluid? Explain your answer.

11.

Why is it preferable for airplanes to take off into the wind rather than with the wind?

12.

Roofs are sometimes pushed off vertically during a tropical cyclone, and buildings sometimes explode outward when hit by a tornado. Use Bernoulli's principle to explain these phenomena.

13.

Why does a sailboat need a keel?

14.

It is dangerous to stand close to railroad tracks when a rapidly moving commuter train passes. Explain why atmospheric pressure would push you toward the moving train.

15.

Water pressure inside a hose nozzle can be less than atmospheric pressure due to the Bernoulli effect. Explain in terms of energy how the water can emerge from the nozzle against the opposing atmospheric pressure.

16.

A perfume bottle or atomizer sprays a fluid that is in the bottle. (Figure 12.25.) How does the fluid rise up in the vertical tube in the bottle?

Figure 12.25 Atomizer: perfume bottle with tube to carry perfume up through the bottle. (credit: Antonia Foy, Flickr)

17.

If you lower the window on a car while moving, an empty plastic bag can sometimes fly out the window. Why does this happen?

12.3 The Most General Applications of Bernoulli's Equation

18.

Based on Bernoulli's equation, what are three forms of energy in a fluid? (Note that these forms are conservative, unlike heat transfer and other dissipative forms not included in Bernoulli's equation.)

19.

Water that has emerged from a hose into the atmosphere has a gauge pressure of zero. Why? When you put your hand in front of the emerging stream you feel a force, yet the water's gauge pressure is zero. Explain where the force comes from in terms of energy.

20.

The old rubber boot shown in Figure 12.26 has two leaks. To what maximum height can the water squirt from Leak 1? How does the velocity of water emerging from Leak 2 differ from that of leak 1? Explain your responses in terms of energy.

Figure 12.26 Water emerges from two leaks in an old boot.

21.

Water pressure inside a hose nozzle can be less than atmospheric pressure due to the Bernoulli effect. Explain in terms of energy how the water can emerge from the nozzle against the opposing atmospheric pressure.

12.4 Viscosity and Laminar Flow; Poiseuille's Law

22.

Explain why the viscosity of a liquid decreases with temperature—that is, how might increased temperature reduce the effects of cohesive forces in a liquid? Also explain why the viscosity of a gas increases with temperature—that is, how does increased gas temperature create more collisions between atoms and molecules?

23.

When paddling a canoe upstream, it is wisest to travel as near to the shore as possible. When canoeing downstream, it may be best to stay near the middle. Explain why.

24.

Why does flow decrease in your shower when someone flushes the toilet?

25.

Plumbing usually includes air-filled tubes near water faucets, as shown in Figure 12.27. Explain why they are needed and how they work.

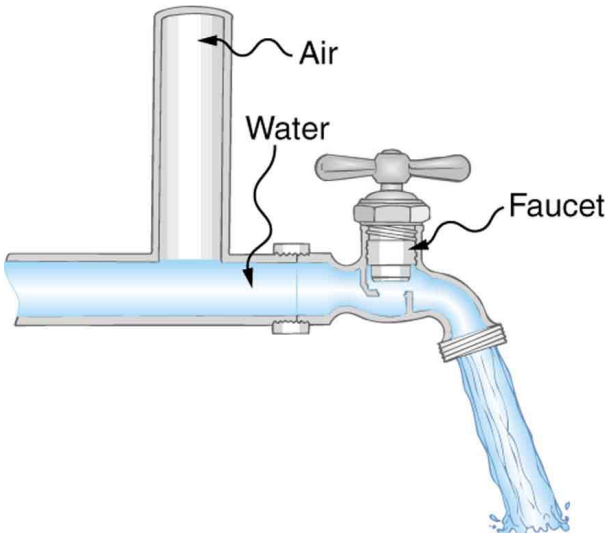

Figure 12.27 The vertical tube near the water tap remains full of air and serves a useful purpose.

12.5 The Onset of Turbulence

26.

Doppler ultrasound can be used to measure the speed of blood in the body. If there is a partial constriction of an artery, where would you expect blood speed to be greatest, at or nearby the constriction? What are the two distinct causes of higher resistance in the constriction?

27.

Sink drains often have a device such as that shown in Figure 12.28 to help speed the flow of water. How does this work?

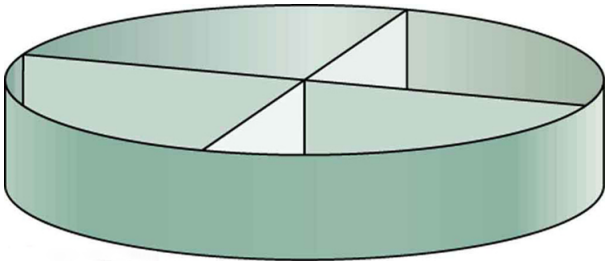

Figure 12.28 You will find devices such as this in many drains. They significantly increase flow rate.

28.

Some ceiling fans have decorative wicker reeds on their blades. Discuss whether these fans are as quiet and efficient as those with smooth blades.

12.6 Motion of an Object in a Viscous Fluid

29.

What direction will a helium balloon move inside a car that is slowing down—toward the front or back? Explain your answer.

30.

Will identical raindrops fall more rapidly in 5 C air or 25° C air, neglecting any differences in air density? Explain your answer.

31.

If you took two marbles of different sizes, what would you expect to observe about the relative magnitudes of their terminal velocities?

12.7 Molecular Transport Phenomena: Diffusion, Osmosis, and Related Processes

32.

Why would you expect the rate of diffusion to increase with temperature? Can you give an example, such as the fact that you can dissolve sugar more rapidly in hot water?

33.

How are osmosis and dialysis similar? How do they differ?