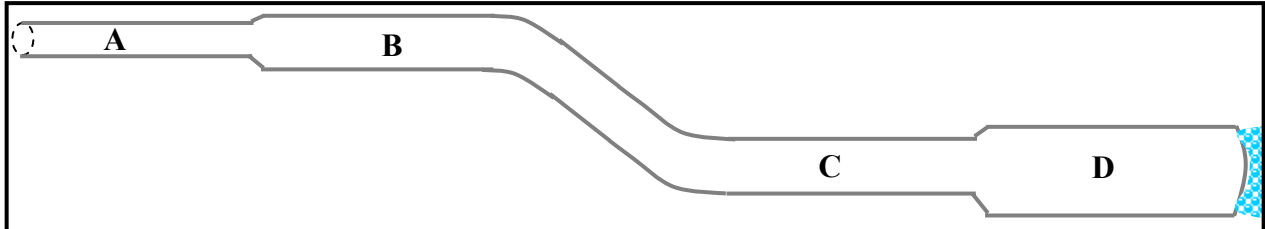


Workshop Tutorials for Biological and Environmental Physics

PR3B: Fluid Flow I

A. Qualitative Questions:

1. Water flows through the pipe shown below from left to right.



- Rank the volume rate of flow at the four points **A**, **B**, **C** and **D**.
- Rank the velocity of the fluid at the points **A**, **B**, **C** and **D**. Explain your answer.
- Rank the pressure in the fluid at points **A**, **B**, **C** and **D**. Explain your answer.

2. Bernoulli's equation follows from Newton's laws and is essentially a statement of conservation of energy for fluid flow.

- Write down Bernoulli's equation and, referring to each term, explain how it is a statement of conservation of energy.
- Using Bernoulli's equation, explain how raising a mound around a burrow entrance can help to ventilate an animal's burrow. Draw a diagram showing the air flow.

B. Activity Questions:

1. Ball in an air jet

How is the Ping-Pong ball kept in midair by a jet of air?
Draw a diagram showing the streamlines around the ball.

2. Chimney effect

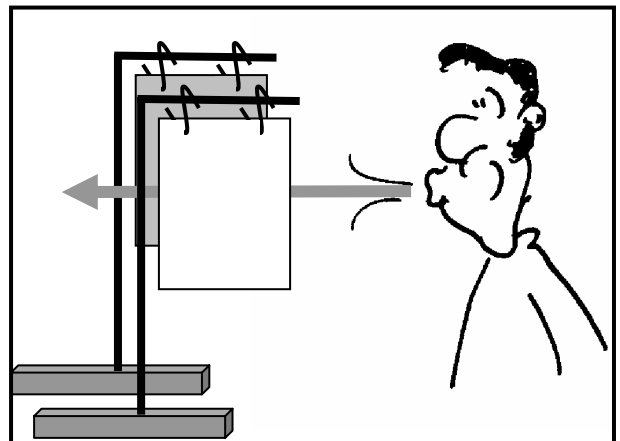
Use the air jet to make the polystyrene balls rise up the tube.
Why do they rise?
Can you think of a use for this effect?

3. Blowing and lifting

How is it possible to lift the foam block off the table by blowing down a hollow tube onto it?
Draw a diagram showing how this works.

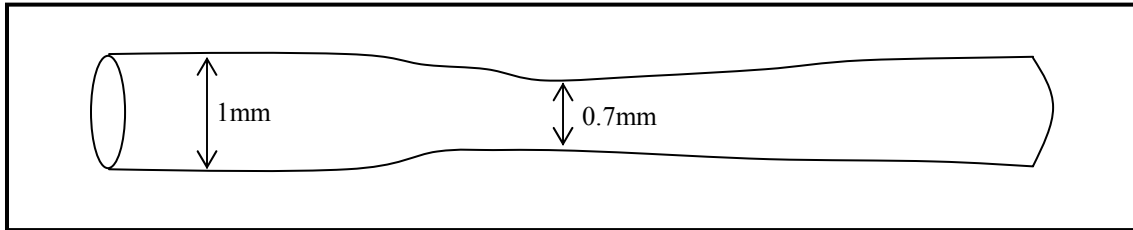
4. Two sheets of paper

What happens if you blow between two sheets of paper held approximately parallel and about 2 cm apart?
Hold a flat sheet of paper horizontally in front of you and blow along it. What happens? Why?



C. Quantitative Questions:

1. Smoking causes inflammation of the bronchioles, the small air passages in the lungs, which tends to decrease the flow of air into the lungs and hence the oxygen supply to the blood. Air is flowing down a normal section of a bronchiole with a diameter of 1.0 mm at a velocity of $0.5 \text{ m}\cdot\text{s}^{-1}$.



- a. Part of the bronchiole is narrowed due to inflammation, and has a diameter of only 0.77 mm. What is the velocity of the air in this section of the bronchiole?
- b. What are the consequences of this for gas exchange in the lung?

2. Rebecca and Brent are brewing their own ginger beer and have set up a large vat with a narrow pipe near the bottom to take samples so they can tell when its ready for bottling. The vat has a diameter of 60 cm, is open at the top, and has a pressure gauge mounted on the pipe 1.0 m below the top of the vat. The vat is full, and as Rebecca takes a sample the fluid level falls at a rate of $1.0 \text{ cm}\cdot\text{s}^{-1}$ and flows out the bottom of the pipe at $50 \text{ cm}\cdot\text{s}^{-1}$. The density of the ginger beer is $1.0 \times 10^3 \text{ kg}\cdot\text{m}^{-3}$. What pressure reading (absolute) does the gauge show? (Hint: use Bernoulli's equation.)

