Workshop Tutorials for Introductory Physics

PI3: **Fluid Flow**

A. Review of Basic Ideas:

Use the following words to fill in the blanks:
Flow, increases**,** heart, lower, incompressible, water, capillaries, high, air**,** volume, decreases, tangent friction, viscosity, swim, birds

Fluid flow

By definition, a fluid is a substance which can _____. As over 70% of the earth's surface is covered with _____, and the _____ above is also a fluid, it is important to understand how fluids flow. Fluids will flow from a region of _____ pressure to one of _____ pressure. This is how we breathe.

When we inhale, we increase the volume of our chest. This _____ the pressure in our lungs, and air flows in. To exhale we allow the chest to collapse back to its smaller volume, which _____ the pressure inside the lungs. This causes the air to flow out again.

When a fluid flows steadily along a pipe, the _____ rate of flow must be constant along the pipe. This means that if you measure the volume passing through one section of a pipe, as long as there are no holes in the pipe and the fluid is _____, the same volume will flow through any other section of the pipe in a given time. This is true even if the pipe gets wider or narrower. In a narrow section the fluid will flow faster, and it will flow more slowly in a wide section.

This is very important in the lungs. The total blood flow going up the pulmonary arteries from the _____ to the lungs must be the same as the flow through the capillaries, around the lungs, and back down the pulmonary veins to the heart to be pumped out to the body. In between, millions of tiny _____ each take a tiny flow of blood, and all together give a large flow.

A useful way of visualizing the flow of fluids is with streamlines. A streamline is the path of a particle of the fluid. The velocity of the particle is always _____ to the streamlines. We can trace streamlines in air by adding a little smoke to the air, or in fluids by adding a few drops of dye.

Flow rate also depends on _____. Viscosity is a measure of the _____ between molecules in the fluid, the more friction, the slower it will flow. If there were no frictional forces between the molecules, fish couldn't _____, and _____ couldn't fly.

Discussion question:
How would rowing be different if water had zero viscosity? Could birds fly if air had zero viscosity?

B. Activity Questions:

1. Hot honey

Honey is a good example of a viscous fluid.
Explain what happens to the density and viscosity when the honey is heated.
Does one change more than the other?

2. Chimney effect

Use the air jet to make the polystyrene balls rise up the tube.
Why do they rise? Can you think of an example where this effect would be useful?

3. Blowing and lifting

How is it possible to lift the foam block off the table by blowing down a hollow tube onto it?

4. Two sheets of paper

What happens if you blow between two sheets of paper held approximately parallel and about 2 cm apart? Can a similar phenomenon occur as two large trucks pass each other on a highway?

C. Qualitative Questions:

1. Density and viscosity.

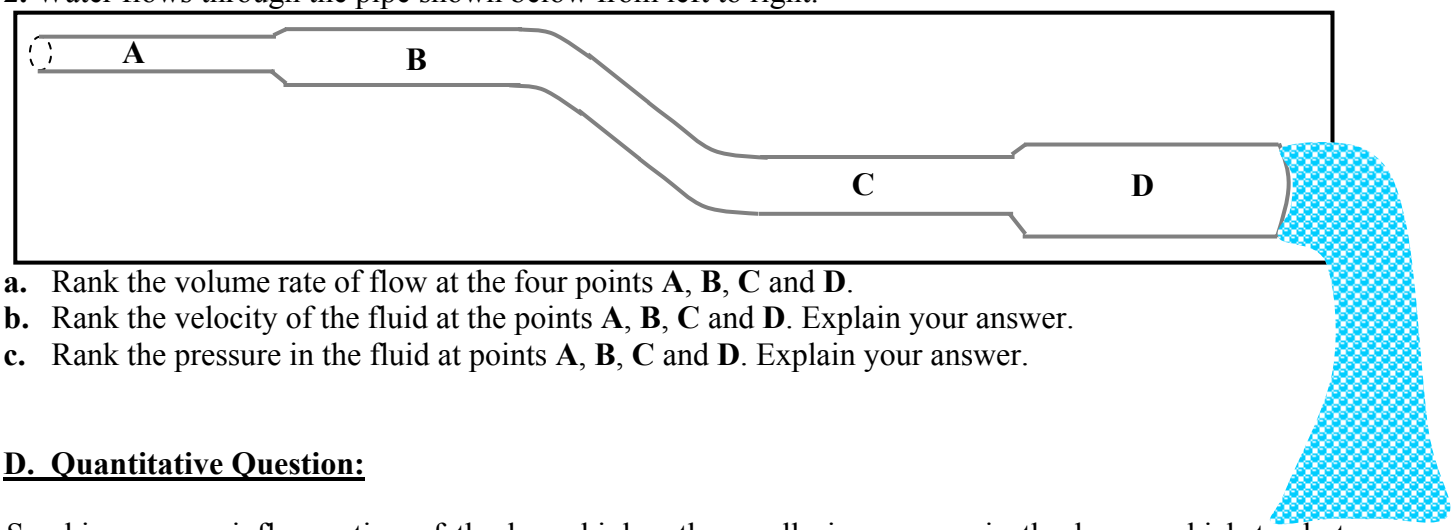
a. What is the difference between viscosity and density?

b. Give an example of a fluid which has high density and low viscosity.

c. Give an example of a fluid which has low density and high viscosity.

d. Spiders move by pumping fluid into and out of their legs. Why are spiders slower in winter?

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



a. Rank the volume rate of flow at the four points **A**, **B**, **C** and **D**.

b. Rank the velocity of the fluid at the points **A**, **B**, **C** and **D**. Explain your answer.

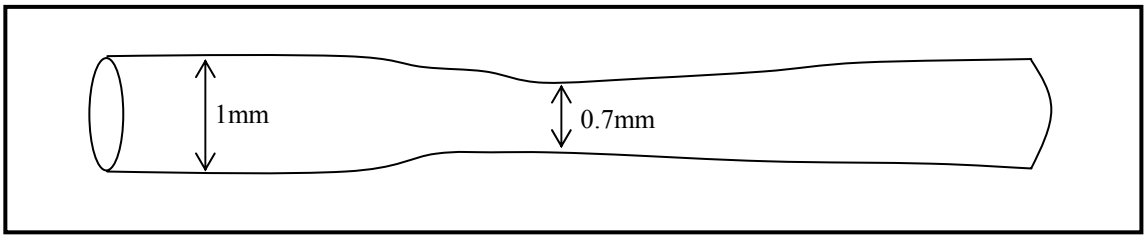
c. Rank the pressure in the fluid at points **A**, **B**, **C** and **D**. Explain your answer.

D. Quantitative Question:

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 mm at a velocity of 0.5 $m.s^{-1}$.

Part of the bronchiole is narrowed due to inflammation, and has a diameter of only 0.7 mm.



a. 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?