This sheet is meant to supplement your learning. Please also refer to in-class demonstrations and explanations as well as your textbook.

Bernoulli's Principle

"When the speed of a fluid increases, internal pressure in the fluid decreases."

<u>Internal pressure</u>- refers to the pressure acting on the walls of a pipe, for example, or on an object that is being carried along in the fluid.

To understand internal pressure, let's discuss three examples.

Example 1:

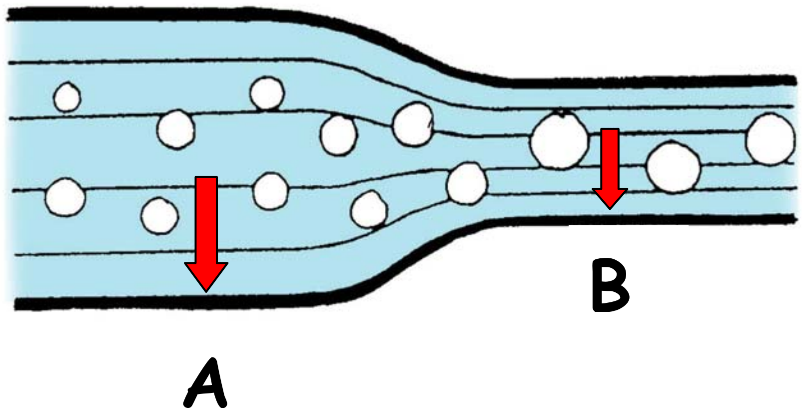

Figure 1: Pressure against the walls of the pipe

The internal pressure can be visualized in Figure 1 as the pressure of the water pushing on the side of the pipe at point A and point B. In accordance with Bernoulli's law, the pressure at point B is less than the pressure at point A ($v_B > v_A$, therefore $P_B < P_A$)..

Example 2:

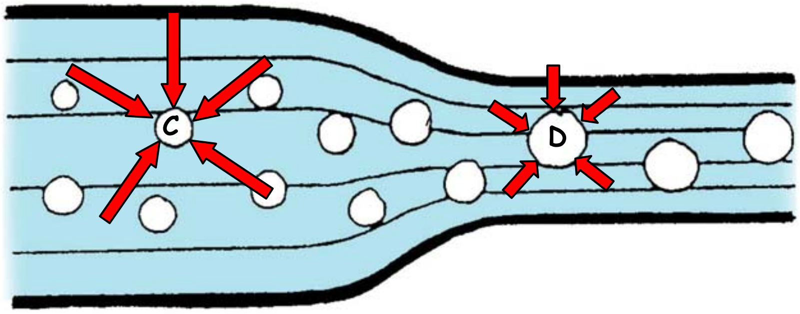

Figure 2: Pressure against a bubble in the fluid

The internal pressure can also be visualized in Figure 2 as the pressure of the fluid on the bubbles that are moving along with the fluid. In accordance with Bernoulli's law, the pressure at point D is less than the pressure at point C ($v_D > v_C$, therefore $P_D < P_C$).

Example 3:

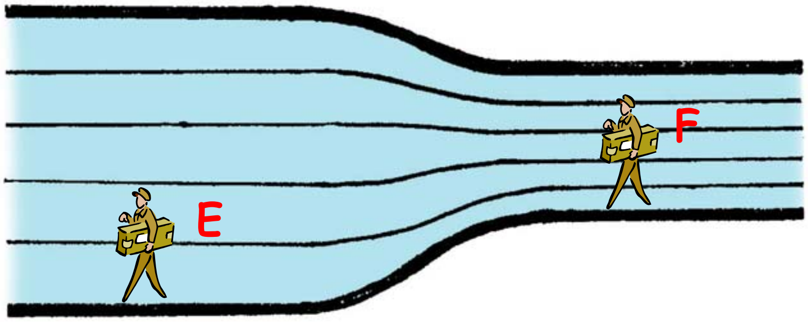

Figure 3: This is NOT how to visualize internal pressure

A man standing at point E will feel the water acting on him differently at point E than he will when standing at point F. However, this does NOT have to do with the internal pressure of the fluid.

As mentioned in class, Bernoulli's law is counterintuitive. The first step is to determine whether we have evidence to believe it is true. The answer, I think, is yes. The demonstration with the soda cans/straws and blowing over the paper both demonstrated that increasing the velocity of the air lowered the pressure. I can think of no other way to explain the results of those demonstrations.

The direction of the air was important in these demonstrations. In the soda can demonstration, the air was directed between the cans and not at the cans. The flow or air was therefore parallel to the sides of the cans at the place where the gap between the cans was smallest. When blowing over the paper, I blew parallel to the paper. The direction is important because Bernoulli's law discusses the internal pressure (see examples 1 and 2). If we place an object directly in the path of the fluid's motion, then it is not a case where we are only considering the internal pressure (see example 3) and Bernoulli's Law cannot be easily applied.

Why is Bernoulli's Law true?

This is more difficult to understand and is not necessary for this class. However, you should be able to remember Bernoulli's law and apply it (to the demonstrations we did in class or new examples). To do this, you need not understand why it is true.

However, for those of you still interested enough to still be reading, let me try to explain it, as best I can. The internal pressure in a fluid arises from the collisions of the molecules with the sides of the pipe (to continue with the 3 examples above). First, we must differentiate between bulk velocity and the velocity of individual molecules.

The water in a drinking glass sitting on the table has no bulk velocity (the water remains in the glass). However, the individual molecules do have velocity and are colliding with the sides of the container and thus exerting pressure on the sides of the container. Water flowing through a pipe, on the other hand, does have a bulk velocity (in the 3 examples above, water would be flowing out of the end of the pipe on the right).

In a stationary fluid, the molecules are unorganized and equal numbers of the molecules are going in each direction (right, left, down, up, etc.). In a moving fluid, the molecules are more organized. In the fat (left) part of the pipe, more of the molecules are moving to the right than are moving to the left, up, or down. In the skinny (right) part of the pipe, an <u>even greater</u> percentage of the molecules are moving to the right. This means even less molecules are moving left, up, or down. Less molecules moving up or down means less collisions with the sides of the pipe which means less pressure exerted on the pipe than when the water was moving more slowly (i.e. in the fat part of the pipe).

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