Pressure in fluids

- **Hydrostatic Pressure** (static fluid in the presence of gravity):

$$\Delta P = \rho g h$$

Here ρ is fluid density, g is gravitational acceleration, h is the depth difference between two points, and ΔP is the pressure difference between them.

- **Bernoulli Principle** (fluid in motion, no gravity):

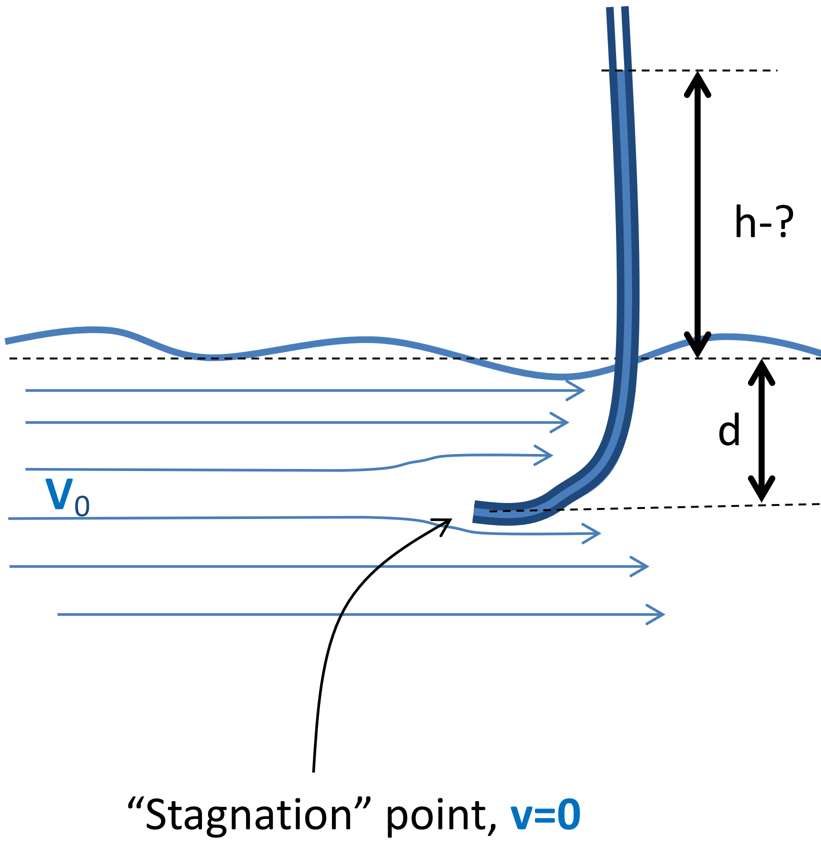
$$P + \frac{\rho v^2}{2} = const$$

is the speed of the fluid. The equation works only *along the flow*.

Problem 1

The picture shows a simple device that can be used to measure a speed of a fluid (or a speed of a boat with respect to water). A j-shaped pipe is immersed into the fluid with its inlet directed against the flow. The fluid runs into the pipe, and the level rises. Eventually, as the pressure in the pipe builds up, no fluid enters the pipe anymore. This means that the speed just near the entrance to the pipe is v=0 (this region is called stagnation point).

Find the level h to which the fluid will rise in the pipe, if the speed of the stream is v_0. You may assume this speed to be the same everywhere, except in the near vicinity of the pipe.



Problem 2

A ball of radius r is moving in air with speed v.

a) Find the extra pressure ΔP in a stagnation point in front of it, where air moves together with the ball. It is best to work in the reference frame where the ball is stationary, and air flow moves with speed v towards it. Use Bernoulli's principle. Air density is ρ.

b) Assuming that this extra pressure is roughly constant everywhere in front of the ball (not true, really), estimate the total air resistance force that acts on the ball.

c) Use your result from part (b) to estimate the speed with which a ping pong ball of radius $r=1cm$, and mass $m=4g$ would fall in Earth gravity, in the presence of air ($\rho=1.2kg/m^3$).