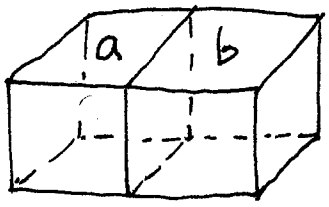
Fluids 2009

Problem Set #1, assigned 10/5/2009, due 10/12/2009 at the start of class

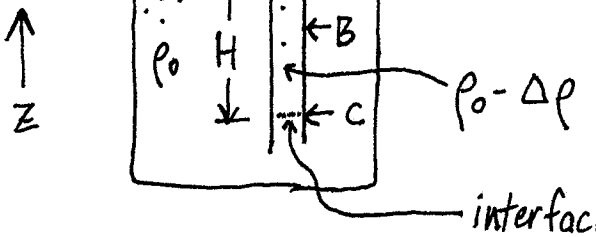
1. Consider two cubical fluids parcels that are next to each other (touching on one face). The pressure in the fluid is constant, there is no motion, no gravity, and the density is constant (boring!).



[1] Draw the force due to pressure on the faces of each parcel separately.

[2] Explain why the forces on the shared face are different for the two parcels, even though the pressure is the same there.

2. Consider a vat of water with a tube in it. The ~~tub~~ tube, like a straw, is open at both ends and is filled with water of a density different from that in the vat, as drawn.

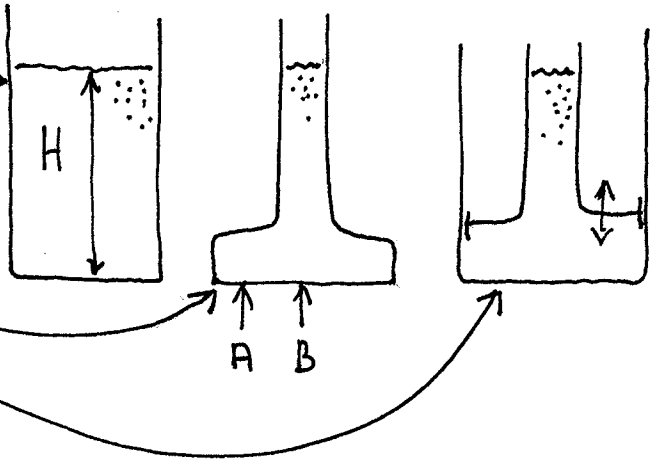


interface between the two fluids

[3] What is the height η of the free surface in the tube?

[5] If a hole is opened in the tube at any of locations A, B, or C which way will water flow (into or out of the tube)?

3. For the simple vat of water we considered in class we found that the bottom pressure in hydrostatic balance was given by $p(z=-H)=p_{ATM}+\rho_0 gH$.



[3] What is the bottom pressure at A and B if the vat is shaped like:

[3] If the upper part of the vat could slide relative to the lower part like a piston, which way would it move? Assume the vat material is weightless.

4. Consider a long tank of water in which the density increases from ρ_0 to $\rho_0 + \Delta\rho$ in the x-direction. The free surface is flat initially. Assume no variation in the y-direction.

[4] Draw the initial pressure field (sketch contours of constant p in the x-z plane) assuming the fluid is in hydrostatic balance.

[3] Sketch the field of initial x-force per unit volume (a field of vectors).

[3] Describe what you think will happen as the flow starts moving.

[3] What is the eventual steady state (assume no mixing)? Is this consistent with your answer to the question immediately above?