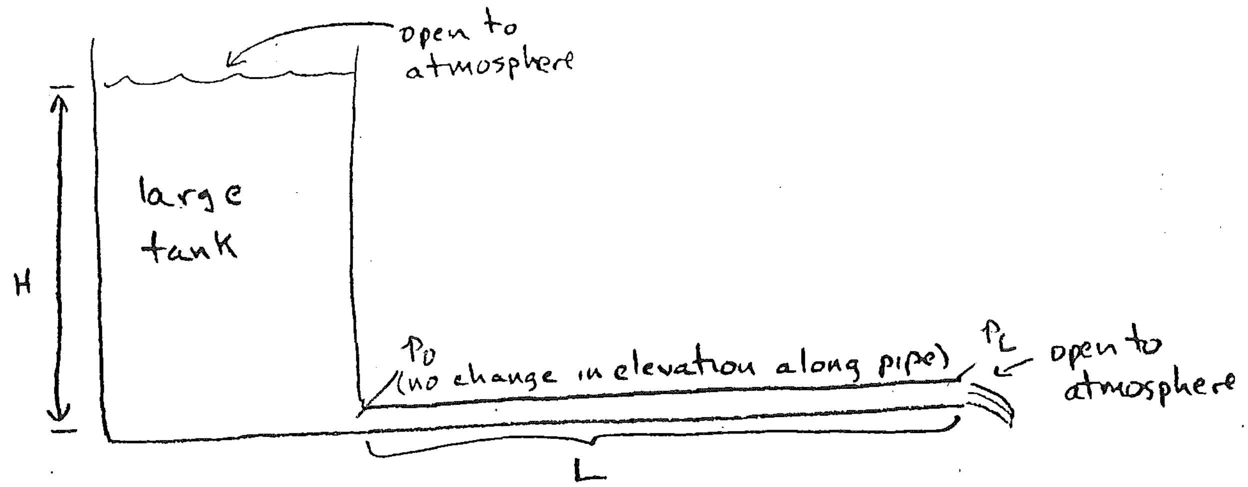
6. Correctly including hydrostatic pressure in flow equations

Consider the following example



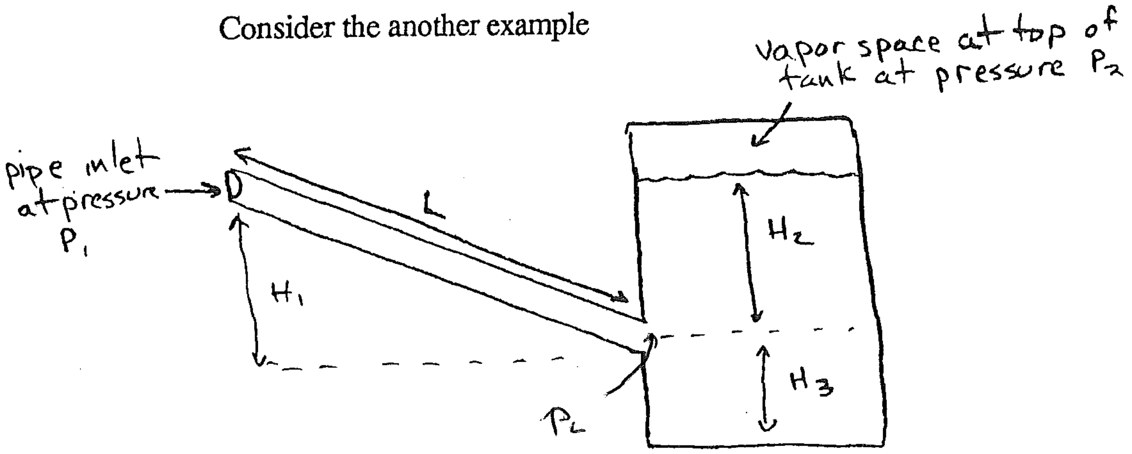
What is $\Delta\mathcal{P}$ across the pipe?

$$P_0 = 1\text{ atm} + \rho g H \quad ; \quad P_L = 1\text{ atm}$$

$$\Delta\mathcal{P} = \left[(1\text{ atm} + \rho g H) - (1\text{ atm})\right] + \rho g (0) = \rho g H$$

↑ no change in elevation along pipe

Consider the another example



What is $\Delta\mathcal{P}$ across the pipe? $P_L = P_2 + \rho g H_2$

$$\Delta\mathcal{P} = \left[P_1 - (P_2 + \rho g H_2)\right] + \rho g H_1$$

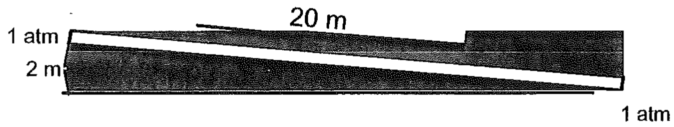
Moral: **include hydrostatic contributions to inlet and outlet pressures in $\Delta\mathcal{P}$**

PGE 322K - TRANSPORT PHENOMENA
Fall 2005
Pop Quiz #4 (1:00 class)
VERSION B

NAME: ________________

For this problem, you only have to answer one question: what is the gradient of total flow potential, ($\Delta P/L$)? The problem statement is as follows:

Oil of density 800 kg/m^3 flows into a pipe. The length of the pipe is 20 m. The outlet of the pipe is 2 m lower than the inlet. Both inlet and outlet are at atmospheric pressure.



Write clearly below a mathematical expression for the overall flow potential gradient driving this flow, ($\Delta P/L$) (including both pressure and gravity). To avoid any ambiguity or possibility of purely mathematical mistake, do not compute the value of this expression; leave it as, say,

(10 x 4 + 15 x 3 - 6) / (5 + 3 x 4)

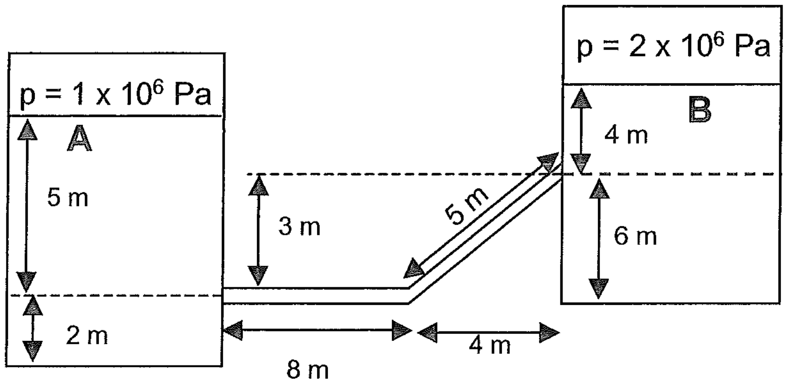
(or whatever).

$$(\Delta P/L) = \frac{[(1atm - 1atm) + 800(9.8)2]}{20}$$

PGE 322K - TRANSPORT PHENOMENA
Fall 2005
Pop Quiz #5 (9:00 class)
VERSION B

NAME: ________________

Consider the piping system below. A liquid of density 1100 kg/m^3 fills the pipes and tanks as shown. Point A is at the top of the liquid in the first tank; the vapor space above this liquid is at pressure 1 x 10^6 Pa. Point B is at the top of the liquid in the second tank, where the pressure is 2 x 10^6 Pa. Determine whether the liquid would flow from A to B, or from B to A, and calculate Δ𝒫/L for the flow.



Write clearly below a mathematical expression for the overall flow potential gradient driving this flow, (Δ𝒫/L) (including both pressure and gravity). To avoid any ambiguity or possibility of purely mathematical mistake, do not compute the value of this expression; leave it as, say,

(10 x 4 + 15 x 3 - 6) / (5 + 3 x 4)

(or whatever).

$$(\Delta\mathcal{P}/L) = \frac{[(10^6 + (1100)9.8\cdot 5) - (2\cdot 10^6 + 1100(9.8)4)] - 1100(9.8)3}{8+5}$$

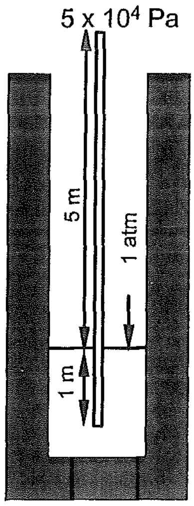
Flow is from: (A to B, or B to A)

PGE 322K - TRANSPORT PHENOMENA
Fall 2005
Pop Quiz #4 (9:00 class)
VERSION A

NAME: ________________

For this problem, you only have to answer one question: what is the gradient of total flow potential, (ΔP/L)? The problem statement is as follows:

Water (density 1,000 kg/m^3) at the bottom of a water well is pumped up a distance of 5 meters. The bottom of the well is open to the atmosphere (1.01×10^5 Pa). Just upstream of the pump (i.e., at the top of the well), absolute pressure is 5×10^4 Pa (7.26 psi below atmospheric pressure). The pipe itself is 6 m long; 1 m of it lies below the water surface, and 5 m above.



Write clearly below a mathematical expression for the overall flow potential gradient driving this flow, (ΔP/L) (including both pressure and gravity). To avoid any ambiguity or possibility of purely mathematical mistake, do not compute the value of this expression; leave it as, say,

(10 x 4 + 15 x 3 - 6) / (5 + 3 x 4)

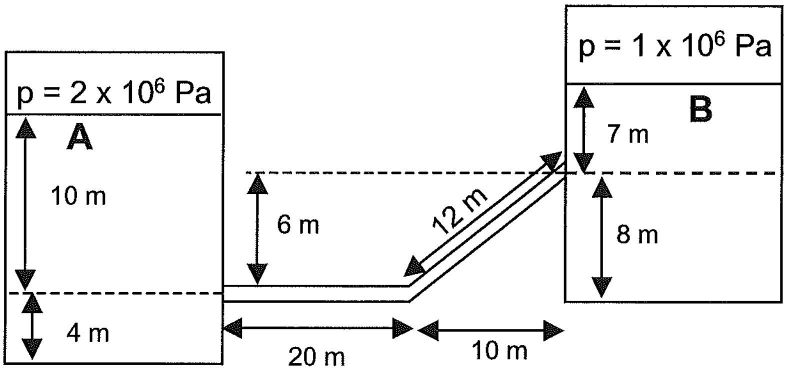
(or whatever).

$$(\Delta P/L) = \frac{\{((1.01\cdot 10^5 + 1000\,(9.8)\,1] - 5\cdot 10^4] - 6\cdot 1000\cdot 9.8}{6}$$

PGE 322K - TRANSPORT PHENOMENA
Fall 2005
Pop Quiz #4 (1:00 class)
VERSION A

NAME: ________________

Consider the piping system below. A liquid of density 900 kg/m^3 fills the pipes and tanks as shown. Point A is at the top of the liquid in the first tank; the vapor space above this liquid is at pressure 2 x 10^6 Pa. Point B is at the top of the liquid in the second tank, where the pressure is 1 x 10^6 Pa. Determine whether the liquid would flow from A to B, or from B to A, and calculate $\Delta\mathcal{P}/L$ for the flow.



Write clearly below a mathematical expression for the overall flow potential gradient driving this flow, ($\Delta\mathcal{P}/L$) (including both pressure and gravity). To avoid any ambiguity or possibility of purely mathematical mistake, do not compute the value of this expression; leave it as, say,

(10 x 4 + 15 x 3 - 6) / (5 + 3 x 4)

(or whatever).

$$(\Delta\mathcal{P}/L) = \frac{\{[(2\cdot 10^6 + 10(9.8)900) - (1\cdot 10^6 + 7(9.8)900)] - 6(900)9.8}{20+12}$$

Flow is from: (A to B, or B to A)

$\Delta\mathcal{P} = \mathcal{P}_0 - \mathcal{P}_L > 0$; flow is from A to B