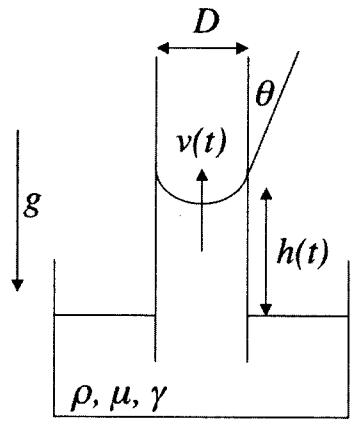
Unified Engineering Name: _____
Fluids Quiz 1 September 24, 2008

Problem 1F

This problem is about the fluid dynamics process in a capillary-liquid system like that in the figure. Answer the following:



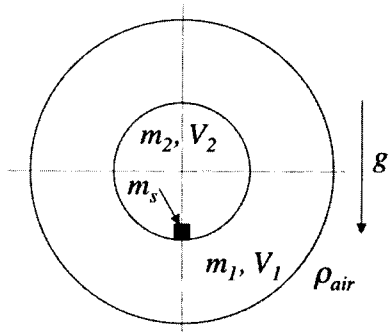
(a) What forces influence the dynamics of the liquid meniscus rise?
(b) Given the set of parameters, how many non-dimensional Π-groups can be formed?
(c) What are these non-dimensional Π-groups, and what do they physically mean? Be clear.
(d) From an order-of-magnitude analysis, obtain from your Π-groups an estimate of the flow velocity, v, in the capillary when viscous stresses are of the same order than surface tension forces. Include your analytical expression (formula) and numerical value.
(e) Is inertia important when compared to viscous forces? How did you reach this conclusion?

Assume the liquid is Ethylene Glycol: $\rho = 1.1$ g/cm^3, $\mu = 0.021$ Pa·s and $\gamma = 0.048$ N/m. Take also a perfectly wetting situation with $\theta = 0$ and $D = 0.5$ mm.

Hint: remember that combinations of Π-groups can form additional non-dimensional parameters.

Problem 2F

Consider the concentric, spherical pair of balloons in the figure to be in perfect buoyant equilibrium (both balloons are neutrally buoyant). The larger balloon is filled with a mass m_1 of helium gas and is rigid, *i.e.*, its spherical volume is fixed. The smaller balloon is filled with a mass m_2 of hydrogen gas and encloses a tiny pellet of mass m_s of solid hydrogen. The outside gas is air. Neglect the balloon material mass and neglect the volume occupied by the tiny solid hydrogen pellet.



(a) Write down the conditions for neutral buoyancy in this system in terms of the mass of the gasses and the volumes V_1 and V_2 occupied by them.
(b) For $m_1 = 4m_2$ and $m_2 = m_s$, find expressions for V_1 and V_2 in terms of m_s and ρ_{air}.

Assume the pellet gasifies, making the volume occupied by the gas in the small balloon to increase by a factor of 3/2. How does this situation change the balance of forces in:
(c) The small balloon.
(d) The big balloon.