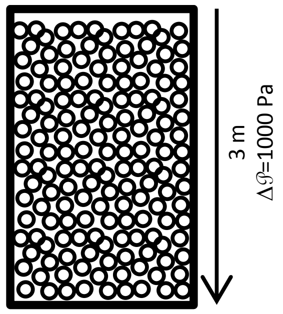
tn4780ta 2013-14
Part 1 Re-Examination - 2 April 2014

Write your solutions *on your answer sheet*, not here. In all cases ***show your work***.
To avoid any possible confusion,
state the equation numbers and figure numbers of equations and figures you use.
Beware of unnecessary information in the problem statement.

1. Bubba works for a company that make baseballs. A baseball is a sphere about 7.5 cm in diameter. A large supply of baseballs has gotten wet, so Bubba wants to blow dry air through the stack of baseballs to help them dry off. The baseballs are packed into a large container, 3 m tall, with a porosity of about 35%; air flows down through the stacked balls in the container. The potential drop across the container is 1000 Pa. What is the superficial velocity (Q/A) of the air going through the stack of baseballs?



properties of air

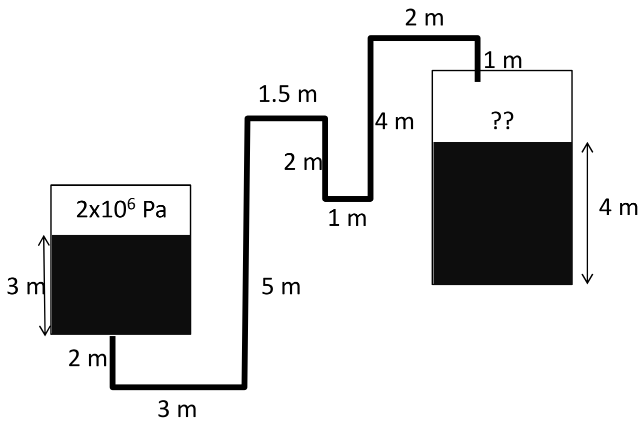
μ = 1.75x10^{-5} Pa s k = 0.025 W/(m K) ρ = 1.26 kg/m^3 C_p = 1006 J/(kg K)

(25 points)

2. A Newtonian liquid is held in a large tank as shown below on the left; there are 3 m of liquid in the tank. The pressure in the vapor space above the tank is 2 x 10^6 Pa. From the bottom of this tank there is an abrupt constriction to a pipe, 10 cm in diameter, that leads off to a second tank as shown below; there are several sharp 90°elbows in the pipe along its length. The scale of roughness on the pipe is 0.4 mm. The pipe enters the second tank at the top and dispenses the liquid into the vapor space above the liquid in the tank. The liquid flow rate through the pipe is 0.01 m^3/s. What is the pressure in the downstream tank at the pipe outlet?
(35 points)

properties of liquid

μ = 0.005 Pa s ρ = 650 kg/m^3

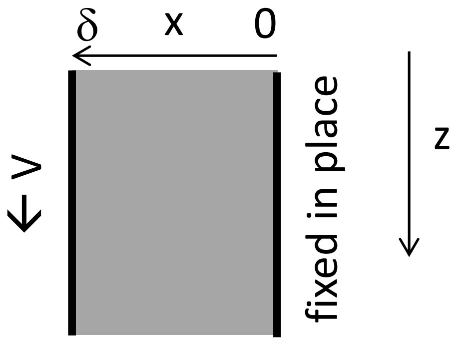


3. A Newtonian fluid with density ρ and viscosity μ fills the gap between two parallel,

vertical plates as shown at right. The right-hand plate, at x = 0, is fixed in place. The plate at x = δ is moving downward with velocity V. There is no applied pressure difference in the vertical direction. Assume laminar flow. The z axis points down.

a. Derive a formula for the velocity of fluid in the gap as a function of position, $v_z(x)$.
b. Derive the a formula of the shear stress on the plate at x = δ, in terms of the parameters of this problem.

(25 points)



4. Rocky is pumping a fluid through a circular tube. At potential difference $\Delta\mathcal{P}_1$ the volumetric flow rate is Q_1. At potential difference $\Delta\mathcal{P}_2 = 2\ \Delta\mathcal{P}_1$, the flow rate decreases to $Q_2 = 0.8\ Q_1$. Which of the following could be an explanation for this behavior? Note the correct answer may be one of the following, or more than one of the following, or none of them. List all that are correct.

a. The fluid is a Newtonian fluid in laminar flow.
b. The fluid is a shear-thinning power-law fluid in laminar flow.
c. The fluid is a shear-thickening power-law fluid in laminar flow.
d. The fluid is a Bingham plastic in laminar flow.
e. The fluid is a Newtonian fluid in highly turbulent flow (*very* large Re).

(15 points)