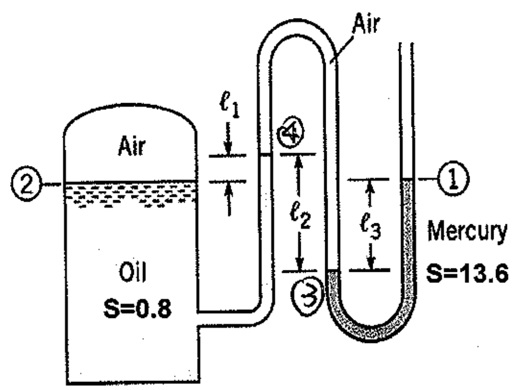
CEE 3040 Spring 2010 Exam#1 Name:__________________

(Do not write your answer on the back of the pages. Please use the extra papers.)

Problem 1 (6 pts)

What is the pressure of the air in the tank if l_1 = 40cm, l_2 = 100cm, and l_3 = 80cm? (S is specific gravity)



1' $\gamma_{oil} = S\gamma_{water}$

$= 0.8 \times 9810\ N/m^3$

$= 7850\ N/m^3$

1' $\gamma_M = S\gamma_{water}$

$= 13.6 \times 9810\ N/m^3$

$= 133,000\ N/m^3$

1' $P_3 = P_1 + \gamma_M \cdot \ell_3$

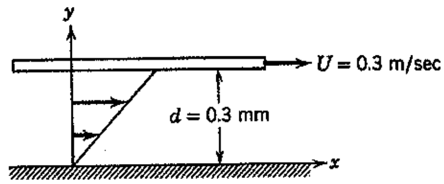
1' $P_2 = P_3 + \gamma_{oil} \cdot \ell_1 = P_1 + \gamma_M \cdot \ell_3 + \gamma_{oil} \cdot \ell_1$ $(P_3 = P_4)$ 1'

$= 0 + (133,000\ N/m^3)(0.8m) + (7850N/m^3) \cdot (0.4m)$

1' $= 110\ kPa$ (gage)

Problem 2 (6 pts)

A plate is moved at a rate of $U = 0.3$ m/s over a second plate with liquid trapped in the gap, as shown. For a small gap width, d, we assume a linear velocity distribution in the liquid. The properties of the liquid are ($S = 0.88$, $\mu = 0.65\times10^{-3}$ Ns/m^2, $g = 9.81$ m/s^2). Find (a) the kinematic viscosity of the liquid, (b) the shear stress on the upper plate, (c) the shear stress on the lower plate, and (d) indicate the direction of the shear stress calculated in parts (b) and (c).



(a) $\nu = \frac{\mu}{\rho} = \frac{\mu}{S\rho_{H_2O}}$

1' $= \frac{0.65\times10^{-3}\,N\cdot s/m^2}{0.88\times1000\,kg/m^3}$

$= 7.39\times10^{-7}\,m^2/s$

(b) $\tau_u = \mu\frac{du}{dy} = 0.65\cdot10^{-3}\,N\cdot s/m^2 \cdot \frac{0.3\,m/s - 0}{0.3\times10^{-3}\,m}$ 1'

1' $= 0.65\,N/m^2$

1' (c) $\tau_\ell = \tau_u = \mu\frac{du}{dy} = 0.65\,N/m^2$

(d) 1' $\leftarrow \tau_u$

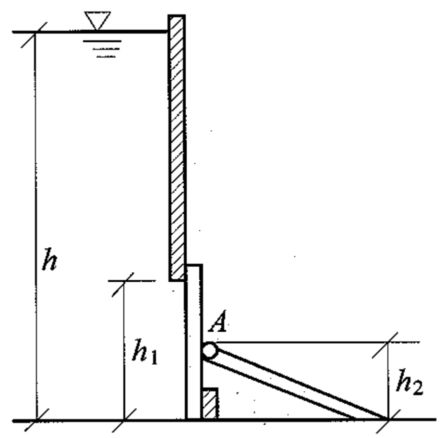
1' $\rightarrow \tau_\ell$

Problem 3 (8 pts)

The security gate shown is 0.6m-wide (into the paper) and 1m-high (h_1 = 1m), and is hinged at point A (h_2 = 0.4m). The gate can rotate about the hinge A (clockwise).

(a) Find the expression of the resultant force on the gate as a function of water level, *h*.
(b) Find the expression of the line of action of the resultant force as a function of *h*.
(c) What is the maximum water level can be held by the gate, i.e., what is the level of *h* in order to open the gate?

(second moment about centroid for a rectangular board: $I_{cx} = \frac{1}{12}BH^3$)



(a) $F = \gamma h_c A$ 1'

$= \gamma(h - h_1/2) A$

$= \gamma(h-0.5)\cdot(0.6\cdot 1)$

$= 0.6\gamma(h-0.5)$ 1'

(b)
$$\begin{cases} h_R - h_c = \dfrac{I_{xc}}{h_c A} & 1' \\ h_c = h - 0.5 & 1' \end{cases}$$

$$\Rightarrow h_R - h_c = \frac{\frac{1}{12}\cdot 0.6\cdot 1^3}{(h-0.5)(0.6\cdot 1)} = \frac{1}{12h-6}$$

$$\Rightarrow h_R = h - 0.5 + \frac{1}{12h-6} \quad 1'$$

(c) 2' $h_R < h - h_2 = h - 0.4$

$$\Rightarrow h - 0.5 + \frac{1}{12h-6} < h - 0.4$$

1'

$$\Rightarrow \frac{1}{12h-6} < 0.1 \Rightarrow 12h - 6 > 10 \Rightarrow h > 1.33\,m$$