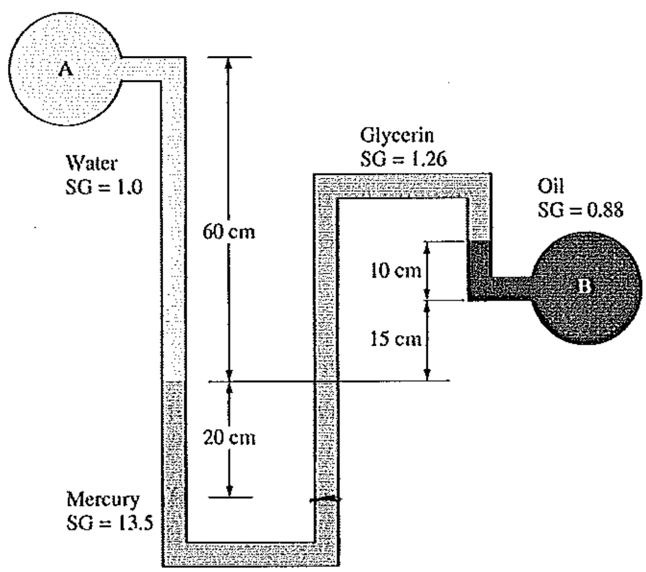
CEE 3040B – Fluid Mechanics – Fall 2014
Georgia Institute of Technology
Instructor: Dr. Hermann M. Fritz

Exam 1
Friday, 09/12/2014
11:05 to 11:55 p.m.

NAME:__________________

This is a closed book exam. 1 additional sheet of US-Letter paper with personal notes/equations on 1 side are allowed. Method of computation (calculator, nomograph, etc.) is up to you, but keep in mind that I cannot give partial credit if you used an equation solver in your calculator and come up with the wrong answer. Hence provide all necessary solving steps to follow through to the result. Show all work on attached pages and/or add additional pages if necessary.

1. (33.3 %) **Measuring Pressure with a Multi-fluid Manometer:**
The pressure difference between an oil pipe and water pipe is measured by a double-fluid manometer, as shown in Figure below. For the given fluid heights and specific gravities, calculate the pressure difference $\Delta P = P_B - P_A$.
Assumptions All the liquids are incompressible.
Properties The specific gravities relative to the density of water are given to be $SG_{Hg} = 13.5$ for mercury, $SG_{Gly} = 1.26$ for glycerin, and $SG_{Oil} = 0.88$ for oil. We take the standard density of water to be ρ_w=1000 kg/m^3.
[Note: 1 Pa = 1 N/m^2]



1 1 1 1 1 1

$$P_A + \rho_w g h_w + \rho_{Hg} g h_{Hg} - \rho_{gly} g h_{gly} + \rho_{oil} g h_{oil} = P_B$$

1

$$P_B - P_A = SG_w \rho_w g h_w + SG_{HG} \rho_w g h_{Hg} - SG_{gly} \rho_w g h_{gly} + SG_{oil} \rho_w g h_{oil}$$

$$= \rho_w \cdot g \cdot \left[SG_w h_w + SG_{Hg} h_{Hg} - SG_{gly} h_{gly} + SG_{oil} h_{oil} \right]$$

2

$$\Delta P = P_B - P_A = \left(9.81 \frac{m}{s^2}\right)\left(1000 \frac{kg}{m^3}\right)\left[1(0.6m) + 13.5(0.2m) - 1.26(0.45m) + 0.88(0.1m)\right] \cdot \left(\frac{1kN}{1000\ kg\frac{m}{s^2}}\right)$$

1

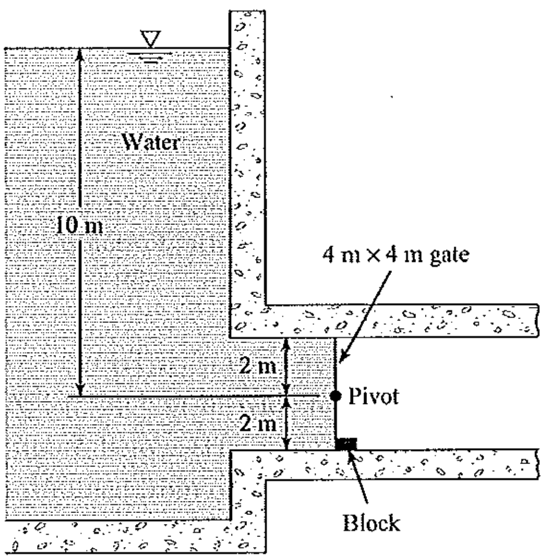
$$\underline{\Delta P = 27.7 \frac{kN}{m^2} = 27.7\ kPa}$$

2. (33.3 %) **Hydrostatic Force Acting on a Rectangular Gate:**

A 4-m-high, 4-m-wide rectangular gate closes the outlet of the freshwater tank, as shown in Figure below. The plate is hinged about a horizontal axis pivot along its centerline and is restrained from opening by a fixed block at lower edge. Determine the force exerted on to the block by the gate.

Assumptions The atmospheric pressure acts on both sides of the plate, and thus it can be ignored in calculations for convenience.

Properties We take the density of water to be ρ_w=1000 kg/m^3 throughout.



$$F_R = p_c \cdot A = \gamma \cdot y_c \cdot A$$ (2)

$$= (10\,m) \cdot \left(9810 \frac{N}{m^3}\right) \cdot (4 \cdot 4)\,m^2$$

$$= 1.5696 \times 10^6\,N$$ (1)

$$y_R - y_c = \frac{I_{xc}}{y_c \cdot A} = \frac{bh^3/12}{y_c \cdot A}$$ (2)

$$= \frac{(4 \times 4^3/12)\,m^4}{(10\,m)(4 \cdot 4)\,m^2}$$

$$y_R - y_c = 0.13333\,m$$ (1)

EQUILIBRIUM (SUM OF MOMENTS ABOUT THE PIVOT)

$$F_R (y_R - y_c) - F_{BLOCK}(2\,m) = 0$$ (2)

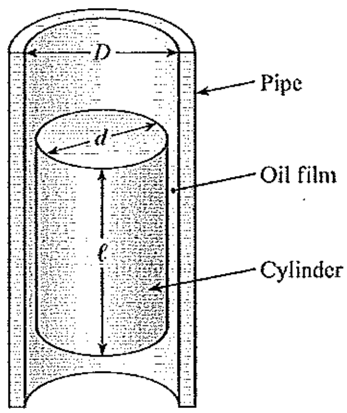
$$(1.5696 \times 10^6\,N)(0.13333\,m) - F_{BLOCK}(2\,m) = 0$$

$$F_{BLOCK} = 1.046 \times 10^5\,N$$ (acts to the left) (1)

$$\underline{F_{GATE} = 105\,kN}$$ (acts to the right) (1)

3. (33.3 %) This problem involves a cylinder falling inside a pipe that is lined with an oil film as shown in Figure below. The small space between the cylinder and the pipe is lubricated with an oil film that has a dynamic viscosity $\mu = 0.35$ Pa·s $= 0.35$ N·s/m^2. The cylinder has a diameter $d = 0.100$ m, length $l = 0.2$ m and a driving weight of $W = 15$ N. The cylinder slides concentric in a pipe with inner diameter $D = 0.105$ m. Find the speed at which the cylinder slides down the pipe.

$$\tau = \mu \frac{dV}{dy}$$ 2



2 $$\frac{W}{\pi d l} = \frac{\mu V_{Fall}}{(D-d)/2}$$ 2

$$V_{FALL} = \frac{W(D-d)}{2\pi d l \mu}$$ 2

$$V_{FALL} = \frac{15N(5 \times 10^{-3} m)}{(2\pi \times 0.1 m \times 0.2 m \times 3.5 \times 10^{-1} Ns/m^2)}$$

2

$$\underline{V_{Fall} = 1.7 \ m/s}$$