Florida International University
CWR 3201 Fluid Mechanics, Fall 2018

Instructor: Arturo S. Leon, Ph.D., P.E., D.WRE

TA: Thao Do, CEE Undergraduate

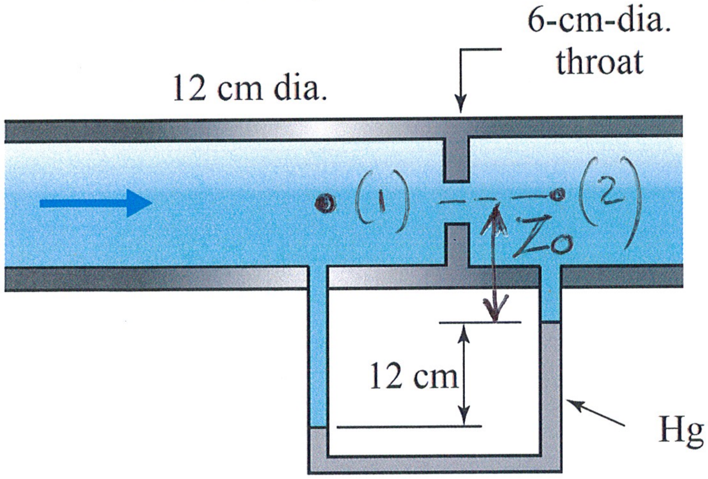
Mid-term # 2 (Type B)

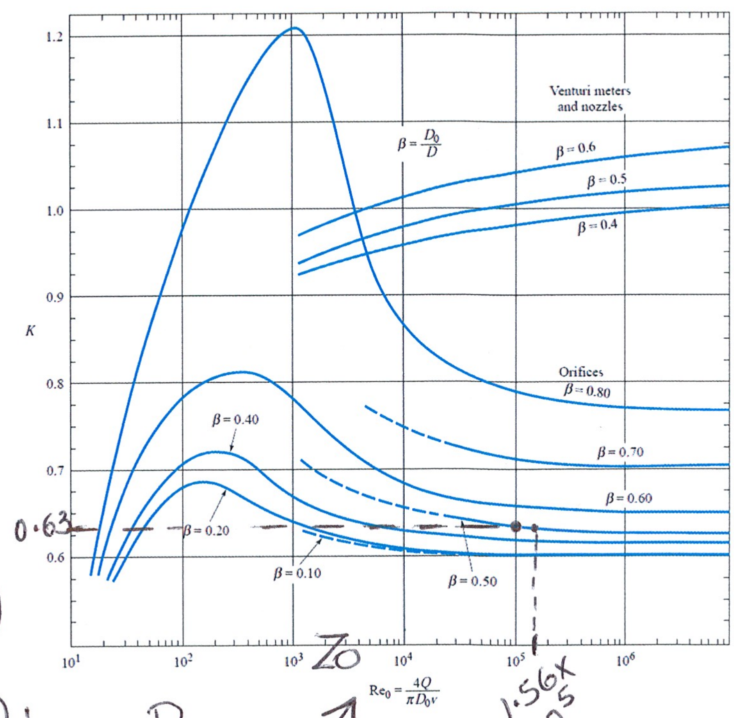
Student Name and ID: Solution **Date:** 10/26/2018

✓ **You will have 1h 15 minutes to complete the exam. The exam is closed book and closed notes**

✓ **Only one page (front and back) with handwritten equations are allowed (no photocopies or artificially reduced text will be allowed.**

1. **(25 points)** Calculate the flow rate of 40°C water in the pipe shown below (kinematic viscosity at 40°C = 0.661x10-6 m²/s)





$$Q_{actual} = K A_0 \sqrt{2g(h_1 - h_2)} \quad \cdots (1)$$

* Manometer

$$P_1 + \gamma_w(\cancel{Z_0} + 0.12) = P_2 + \cancel{\gamma_w Z_0} + 13.6\,\gamma_w (0.12)$$

$$h_1 = \frac{P_1}{\gamma} + \cancel{Z_1}$$

$$h_2 = \frac{P_2}{\gamma} + \cancel{Z_2}$$

$$h_1 - h_2 = \frac{P_1 - P_2}{\gamma}$$

$$\frac{P_1 - P_2}{\gamma_w} = 1.512$$

* Assume $Re = 10^5 \rightarrow K = 0.63$

In (1)

$$Q_{actual} = 0.63\,\pi(0.03)^2\sqrt{2\times 9.81\times 1.512}$$
$$= 0.0097\ m^3/s$$

<u>Verify:</u> $V = \dfrac{0.0097}{\pi \times 0.06^2} = 0.858\ m/s$

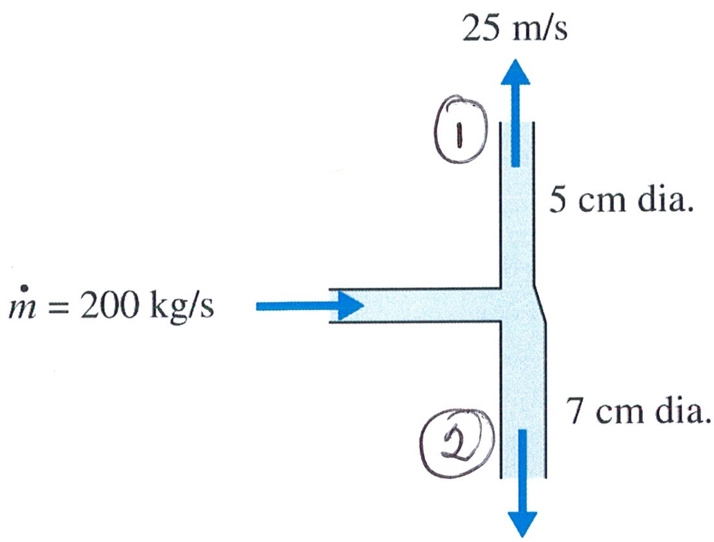
$$Re = \frac{0.858 \times 0.12}{0.661 \times 10^{-6}} = 1.56 \times 10^5$$

$$\downarrow$$

$$K = 0.63$$

$\therefore$ Q_{actual} is correct $\boxed{Q = 0.0097\ \frac{m^3}{s}}$

2. **(20 points)** The pipe below transports 200 kg/s of water. The pipe tees into a 5-cm-diameter pipe and a 7-cm-diameter pipe. If the average velocity in the smaller-diameter pipe (5-cm-diameter pipe) is 25 m/s, calculate the flow rate in the larger pipe (7-cm-diameter pipe).

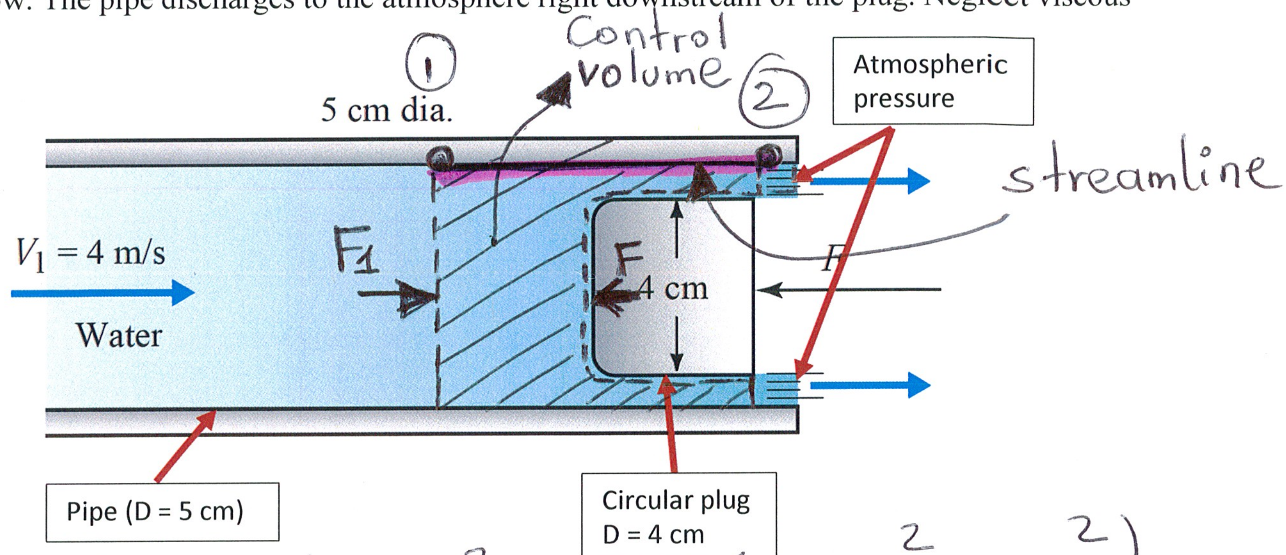


$$\dot{m}_{in} = \dot{m}_{out} = \rho AV$$

$$200 = 1000 \times \pi \times 0.025^2 \times 25 + 1000\, Q_2$$

$$\boxed{Q_2 = 0.1509\ m^3/s}$$

3. (30 points) Assuming uniform velocity profiles, find F needed to hold the **circular plug** in the pipe shown below. The pipe discharges to the atmosphere right downstream of the plug. Neglect viscous effects.



* Continuity $\quad \cancel{\pi} \times 0.025^2 \times 4 = \cancel{\pi}(0.025^2 - 0.02^2) V_2$

$V_2 = 11.11$ m/s

* Momentum

$$F_1 - F - \cancel{F_2}^{\,P_2 A_2 = 0} = \dot{m}(V_2 - V_1) \quad \ldots 1$$

$F_1 = P_1 A$

* Bernoulli

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + \cancel{z} = \cancel{\frac{P_2}{\gamma}}^{\,0} + \frac{V_2^2}{2g} + \cancel{z}$$

$$P_1 = \left(\frac{11.11^2 - 4^2}{2 \times 9.81}\right) 9810$$

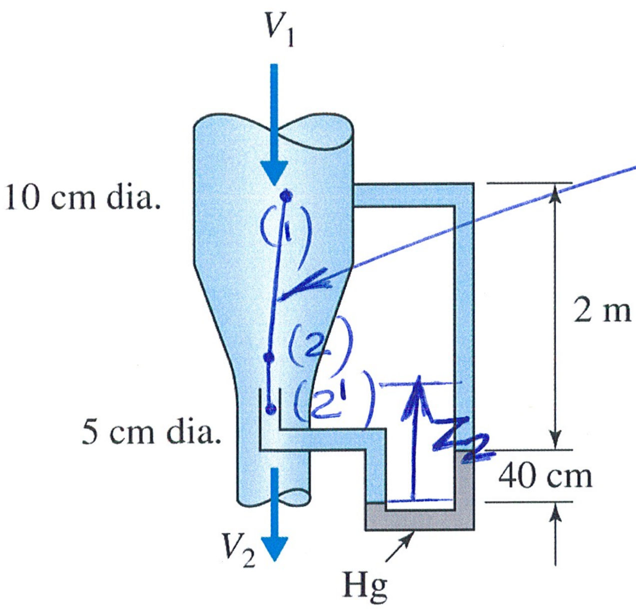
$$P_1 = 53700 \text{ Pa}$$

In 1

$$53700(\pi \times 0.025^2) - F = 1000 \times \pi \times 0.025^2 \times 4 (11.11 - 4)$$

$$\underline{F = 49.6 \text{ N}}$$

4. (**25 points**) Find the velocity V_1 of the water in the vertical pipe shown below. Assume no head losses.



Bernoulli 1 - 2'

$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}+z_1=\frac{P_{2'}}{\gamma}+\cancel{\frac{V_{2'}^2}{2g}}+z_{2'}$$

0 (inside manometer) ... (1)

* Manometer

$$\underline{P_{2'}+\gamma_w(z_2)}=P_1+\gamma_w(2)+\gamma_{Hg}(0.4) \quad \ldots (2)$$

* Eq. (1) $\times \gamma_w$

$$P_1+\rho\frac{V_1^2}{2}+\gamma_w z_1=\underline{P_2'+\gamma_w z_2'}$$

$$\therefore \cancel{P_1}+\rho\frac{V_1^2}{2}+\gamma_w \overset{2.4}{(z_1)}=\cancel{P_1}+2\gamma_w+13.6\gamma_w(0.4)$$

$$\boxed{V_1=9.94\ m/s}$$