u

Key

Exam No. 1 **CBE 150A** **Spring 2014** **R. B. Eldridge**

Problem No. 1 (30 pts)

Water is flowing into and discharged from a horizontal pipe U-section as shown in Figure P-1. At the flange (1), the total absolute pressure is 200 kPa and 30 kg/s flows into the pipe. At flange (2), the total absolute pressure is 150 kPa. At location (3), 8 kg/s of water discharges to the atmosphere which is at 100 kPa. Determine the x- and y- forces for the two flanges connecting the pipe.

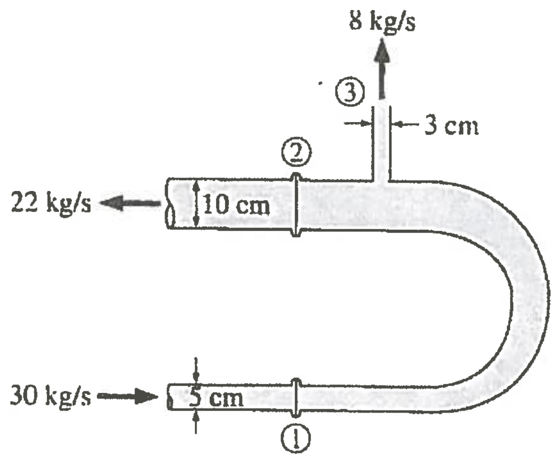


Figure P-1

Problem No. 2 (30 pts)

Freshwater and seawater flowing in parallel horizontal pipelines are connected to each other by a double U-tube manometer as shown in Figure P-2. Determine the pressure differential between the two pipelines. Take the density of the seawater at the location to be 1035 kg/m^3, that of water to be 1000 kg/m^3, and the specific gravity of mercury to be 13.6.

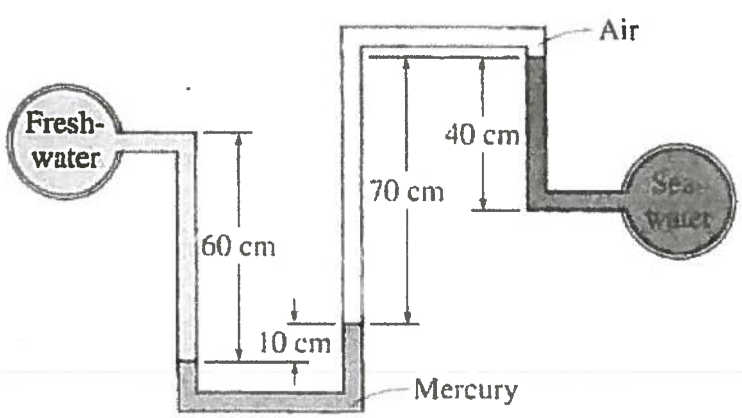


Figure P-2

Problem No. 3 (40 pts)

You are driving home from the "library" late one Friday night when you run out of gas in front of the Kappa Kappa Gamma house. Not wanting to walk home, you decide to siphon some gasoline out of the gas tank of a friendly looking BMW. Give the arrangement shown in Figure P-3, after flow is fully established, how long will it take you to siphon 4 liters (1.057 gallons) of gasoline from the car's tank into your gasoline can.

Assume the liquid level in the BMW gas tank remains constant and both tanks are at atmospheric pressure.
The density of gasoline is 750 kg/m^3.
The viscosity of gasoline is 0.6 cP.
The plastic 1 cm diameter (ID) hose you are using is 5.0 m long and is "smooth".

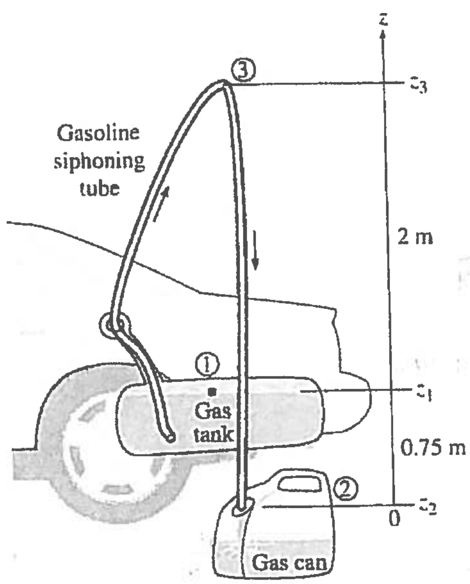
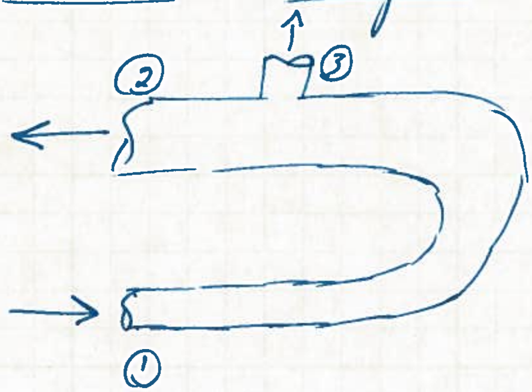
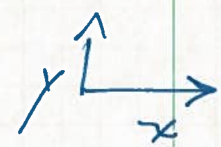


Figure P-3

Problem #1 (30 pts)





$\dot{m}_1 = 30 \frac{kg}{s}$

$\dot{m}_2 = 22 \frac{kg}{s}$

$\dot{m}_3 = 8 \frac{kg}{s}$

$A_1 = \frac{\pi (0.05 m)^2}{4} = 0.00196 \ m^2$

$A_2 = \frac{\pi (0.10 \ m)^2}{4} = 0.00785 \ m^2$

$A_3 = \frac{\pi (0.03 m)^2}{4} = 0.00071 \ m^2$

$\tilde{V}_1 = 30 \frac{kg}{s} \left(\frac{1 m^3}{1000 kg} \right) \left(\frac{1}{0.00196 m^2} \right) = 15.3 \ m/s$

$\tilde{V}_2 = 22 \frac{kg}{s} \left(\frac{1 m^3}{1000 kg} \right) \left(\frac{1}{0.00785 m^2} \right) = 2.80 \ m/s$

$\tilde{V}_3 = 8 \frac{kg}{s} \left(\frac{1 m^3}{1000 kg} \right) \left(\frac{1}{0.00071 \ m^2} \right) = 11.3 \ m/s$

$P_1 = 200{,}000 \frac{kg \ m}{s^2 \ m^2}$, $P_2 = 150{,}000 \frac{kg \ m}{s^2 m^2}$

$P_3 = 100{,}000 \frac{kg \ m}{s^2 m^2}$ (Absolute P)

Y: $\downarrow$ $\phi \frac{kg \ m}{s^2 m^2} (0.00071 m^2) = \phi$ N

$\downarrow$ $8 \frac{kg}{s} \left(11.3 \frac{m}{s} \right) = 90.4 \ N$

$\Sigma F_y = 90.4 \ N$ $\downarrow$ Fitting $\uparrow$

X:

① → $30 \frac{kg}{s} \left(15.3 \frac{m}{s} \right) =$ 459 N →

① → $100{,}000 \frac{kg\,m}{s^2 m^2} \left(0.00196\ m^2 \right) =$ 196 N → ✓

③ → $22 \frac{kg}{s} \left(2.8 \frac{m}{s} \right) =$ 61.6 N →

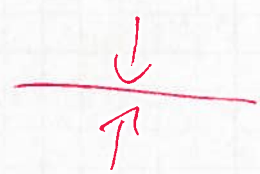
② → $50{,}000 \frac{kg\,m}{s^2 m^2} \left(0.00785\ m^2 \right) =$ 392.5 N →

$\Sigma F_X =$ 1109.1 N → Fitting ←

absolute Fx 2083

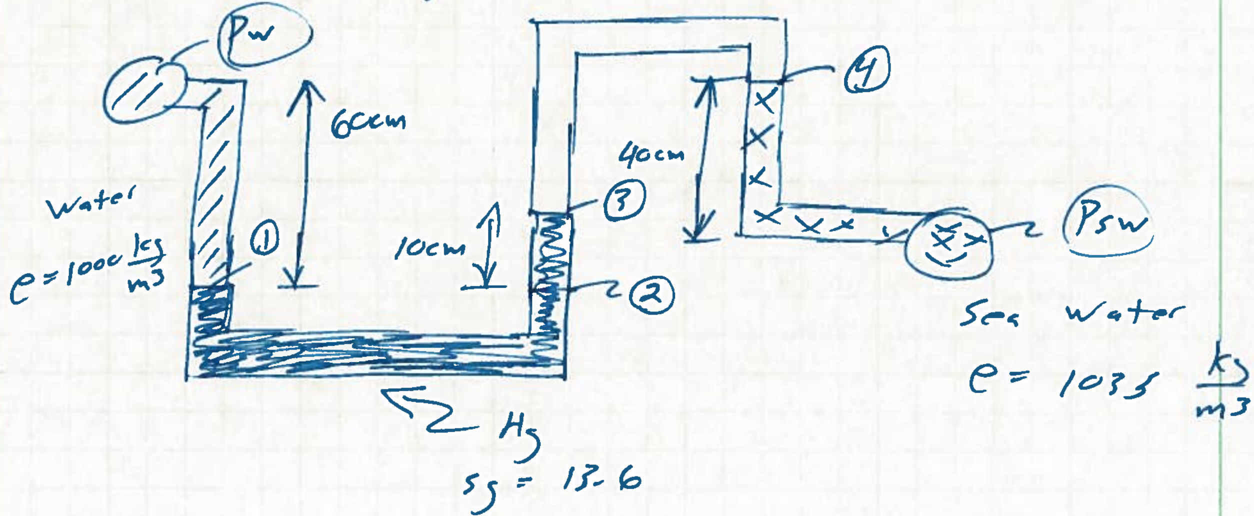
Fy 82.86

1 lbf = 4.448 N



gauge

Problem #2 (30 pts)



$$P_1 = P_2 = P_w + \frac{1000\,kg}{m^3}\left(\frac{9.807\,m}{s^2}\right)(0.60\,m)$$

$$P_3 = P_2 - \frac{13{,}600\,kg}{m^3}\left(\frac{9.807\,m}{s^2}\right)(0.10\,m) \cong P_4$$

$$P_{sw} = P_4 + \frac{1035\,kg}{m^3}\left(\frac{9.807\,m}{s^2}\right)(0.40\,m)$$

$$P_{sw} = \left[P_w + \frac{1000\,kg}{m^3}\left(\frac{9.807\,m}{s^2}\right)(0.60\,m)\right]$$

$$- \frac{13{,}600\,kg}{m^3}\left(\frac{9.807\,m}{s^2}\right)(0.10\,m)$$

$$+ 1035\,\frac{kg}{m^3}\left(\frac{9.807\,m}{s^2}\right)(0.40\,m)\ ]$$

$$(P_{sw} - P_w) = (5884.2 - 13337.5 + 4060.1)\,\frac{kg\,m}{s^2\,m^2}$$

$$\boxed{P_{sw} - P_w = -3393.2\ Pa}$$

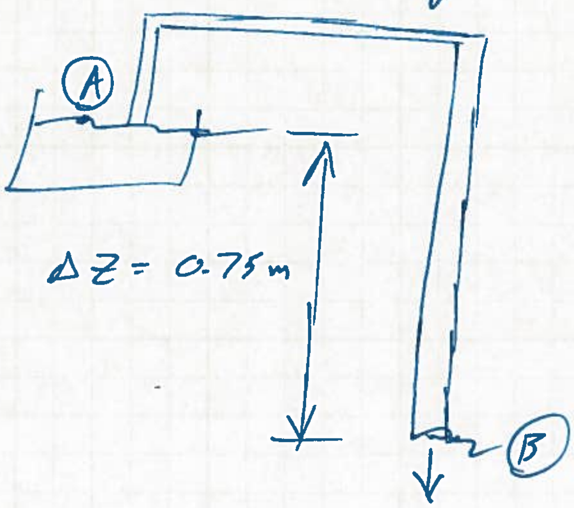
$= 0.492$ psi

$= 0.0335$ atm

$1\ Pa = 0.000145$ psi

$Pa \ (=)\ \frac{kg}{m \cdot s^2}$

Problem #3 (40 pts)



$L = 5$ meters

$P_A = P_B = 1$ Atm

$\mu = 0.6$ cP $= 0.0006 \frac{kg}{m\text{-}s}$

$\rho = 750 \frac{kg}{m^3}$

$D_{Tube} = 1$ cm $(0.01 m)$, $A = \frac{\pi (0.01)^2}{4}$

$A = 7.854 \times 10^{-5}\ m^2$

Bernoulli: $\hat{W} \nearrow 0 = \frac{\Delta P}{\rho} \nearrow 0 + \frac{\Delta V^2}{2} + \Delta Z g + h_f$

$$\Delta Z g = \frac{V_B^2}{2} + 4 f \frac{L}{D} \frac{V_B^2}{2}$$

Assume $V_B = 0.953 \frac{m}{s}$

$$N_{Re} = \frac{0.01\ m \left(0.953 \frac{m}{s}\right)\left(750 \frac{kg}{m^3}\right)}{0.0006 \frac{kg}{m\text{-}s}}$$

$N_{Re} = 11,912.5$, $f_{smooth} = 0.0076$

$0.75\ m \left(\frac{9.807\ m}{s^2}\right) = 7.355 \frac{m^2}{s^2}$ LHS

RHS $\frac{\left(0.953 \frac{m}{s}\right)^2}{2} + 4(0.0076)\left(\frac{5\ m}{0.01 m}\right)\left(\frac{(0.953)^2 \frac{m^2}{s^2}}{2}\right)$

RHS ⇒ 7.356 ✓

time (Θ)

$$\dot{Q} = 0.953 \frac{m}{s} \left(7.854 \times 10^{-5}\ m^2\right)\left(\frac{1000\ L}{m^3}\right)$$

$$\dot{Q} = 0.0748 \frac{L}{s}$$

$$\Theta = 4\ L \left(\frac{1\ s}{0.0748\ L}\right) = \boxed{53.5\ s}$$