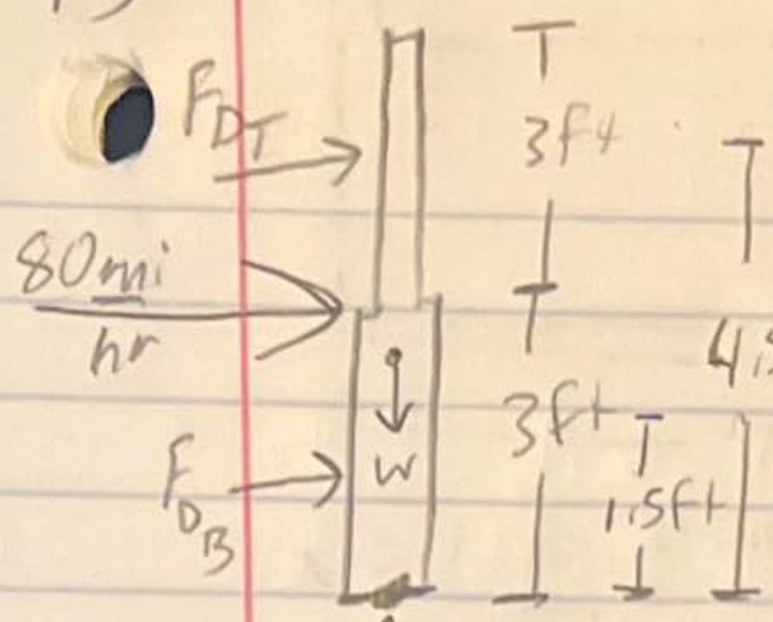
1) MET330 Test 3 Logan Kooy



$F_D = C_D A\left(\frac{V^2\rho}{2}\right)$

$V = 80\frac{mi}{hr}$

$\rho = 2.32\times10^{-3}\frac{Slugs}{ft^3}$

$\nu = 1.63\times10^{-4}\frac{ft^2}{s}$

$Re = \frac{VD}{\nu}$

$D_T = 4ft(\frac{1}{12}) = .333ft$

$D_B = 4.5in = .375ft$

$80\frac{mi}{hr}\times\frac{5280ft}{1mi}\times\frac{1hr}{3600sec}$

$A = D\cdot D\times D\cdot L$

$V = 117.333\frac{ft}{sec}$

$A_T = .333ft\times 3ft$

$A_T = 1ft^2$

$A_B = 1.125ft^2$

$Re_T = \frac{117.333ft}{sec}\times\frac{.333ft}{1.63\times10^{-4}\frac{ft^2}{s}}$

$Re_T = 2.4\times10^5$

$Re_B = \frac{117.333ft/s\times .375ft}{1.63\times10^{-4}ft^2/s}$

$Re_B = 2.7\times10^5$

From 17.4 $\begin{cases} C_{D_{Top}} = 1.1 \\ C_{D_{Bot}} = 0.95 \end{cases}$

$F_{D_T} = 1.1\cdot 1ft^2\left(\frac{(117.333ft/s)^2\times 2.32\times10^{-3}\frac{Slugs}{ft^3}}{2}\right)$

$F_{D_T} = 17.57lbs$

$F_{D_B} = .95\times 1.125ft^2\left(\frac{(117.333ft/s)^2\times 2.32\times10^{-3}\frac{lbs}{ft^3}}{2}\right)$

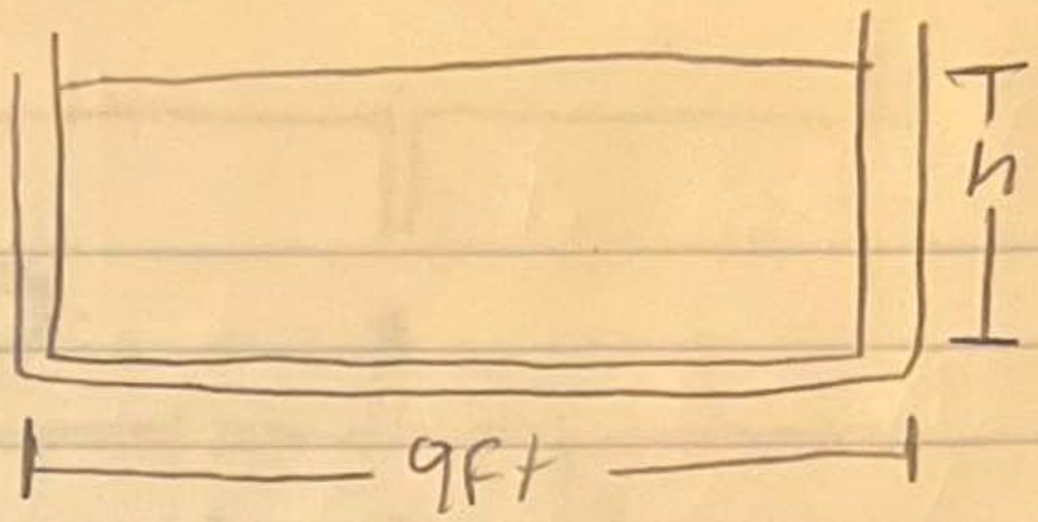
$F_{D_B} = 17.07lbs$

$M_A = F_{D_T}\times d_{Top} + F_{D_B}\times d_{Bottom}$

$M_A = 17.57lbs\times 4.5ft + 17.07lbs\times 1.5ft$

$\boxed{M_A = 104.67ft\cdot lbs}$

2)



$Q = 150 ft^3/s$

$n = .015$

$V = Q/A$

$A = 9h$

$V = 16.667/h$

$S = .001$

$V = \frac{1.49}{n} R^{2/3} S^{1/2}$

$R = \frac{A}{WP} \qquad R = \frac{9h}{2h+9}$

$\frac{16.667}{h} = \frac{1.49}{.015}\left(\frac{9h}{2h+9}\right)^{2/3}.001^{1/2}$ $\qquad 5.306 = h\left(\frac{9h}{2h+9}\right)^{2/3}$

From excel $\boxed{h = 3.42 ft}$

$y_h = A/T = h$

$V = 16.667/3.42$

$V = 4.87 ft/s$

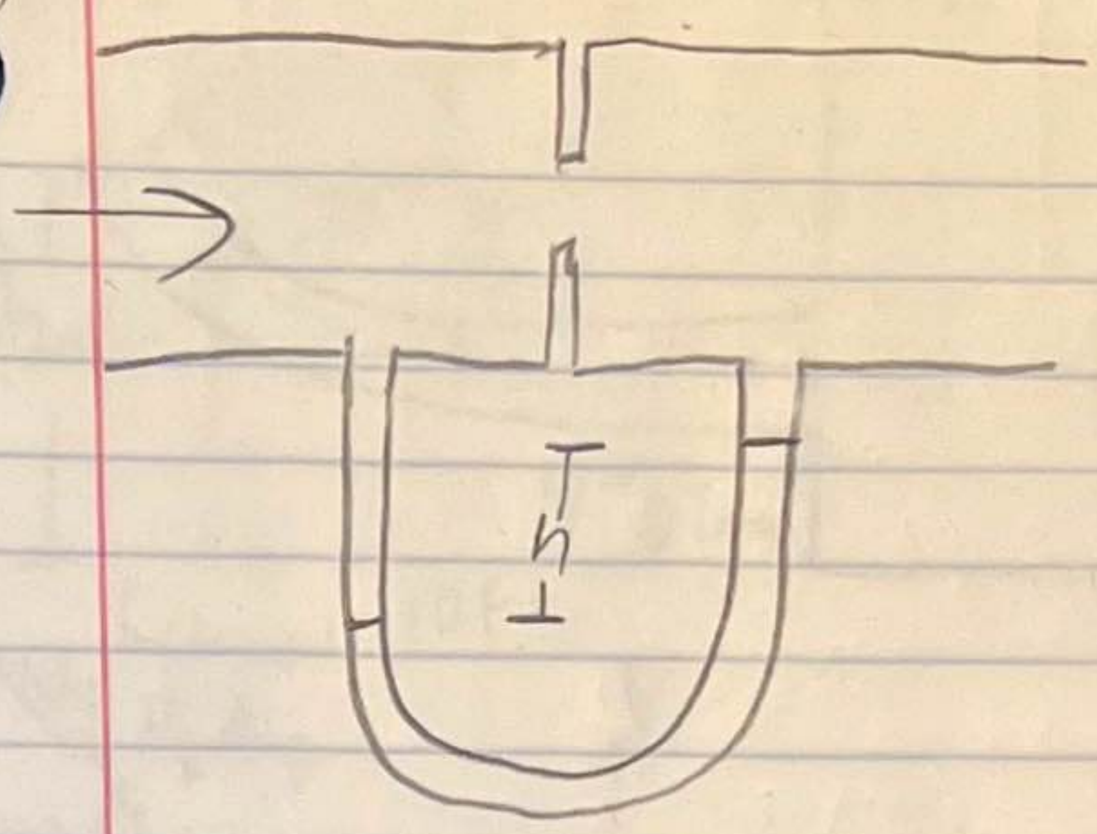
$N_F = \frac{V}{\sqrt{g y_h}}$

$N_F = \frac{4.87 ft/s}{\sqrt{32.2 \frac{ft}{s^2} \times 3.42 ft}}$

$N_F = .464$

$\Rightarrow$ Subcritical

3)



Assume 70°F

$Q = 12,000 gal/m \times \frac{ft^3/s}{449 gal/m}$

$Q = 26.726 ft^3/s$

$\nu = 1.05 \times 10^{-5} ft^2/s$

$\gamma = 62.3 lb/ft^3$

$\rho = 1.44 slugs/ft^3$

$D = 1.886 ft$

$A = \pi/4 D^2 = \frac{\pi}{4}(1.886 ft)^2$

$A_1 = 2.794 ft^2$

$\beta = d/D = .5$

$\gamma_m = 844.9 lb/ft^3$

$V = Q/A = 26.726 \frac{ft^3}{s} / 2.794 ft^2$

$V = 9.565 ft/s$

$d = \beta \cdot D = 1.886 \times .5$

$d = .943 ft$

$C = .601$

$A_2 = \frac{\pi}{4}(.943 ft)^2 \quad A_2 = .698 ft^2$

$Re = \frac{VD}{\nu} = \frac{9.565 ft/s \times 1.886 ft}{1.05 \times 10^{-5} ft^2/s}$

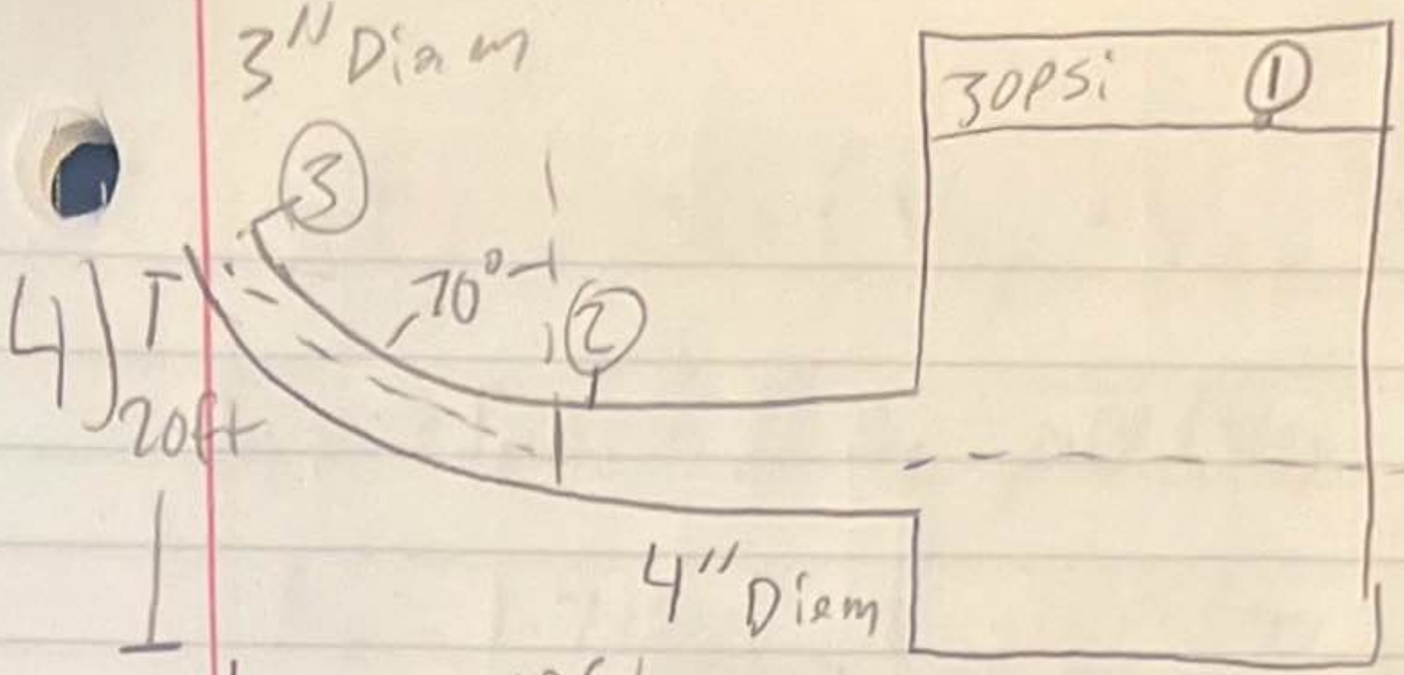
$Re = 1.72 \times 10^6$

$V_1 = C\sqrt{\frac{2gh(\gamma_m/\gamma_f - 1)}{(A_1/A_2)^2 - 1}}$

$\left(\frac{V}{C}\right)^2 \times \left[\left(\frac{A_1}{A_2}\right)^2 - 1\right] = 2gh(\gamma_m/\gamma_f - 1)$

$h = \frac{\left(\frac{V}{C}\right)^2\left[\left(\frac{A_1}{A_2}\right)^2 - 1\right]}{2g(\gamma_m/\gamma_f - 1)} \quad h = \frac{\left(\frac{9.565 ft/s}{.601}\right)^2\left[\left(\frac{2.794 ft^2}{.698 ft^2}\right)^2 - 1\right]}{2 \times 32.2 \frac{ft}{s^2}(844.9/62.3 - 1)}$

$\boxed{h = 4.7 ft}$



$\gamma = 55\ lb/ft^3$

$D_2 = .333ft$

$D_3 = .25ft$

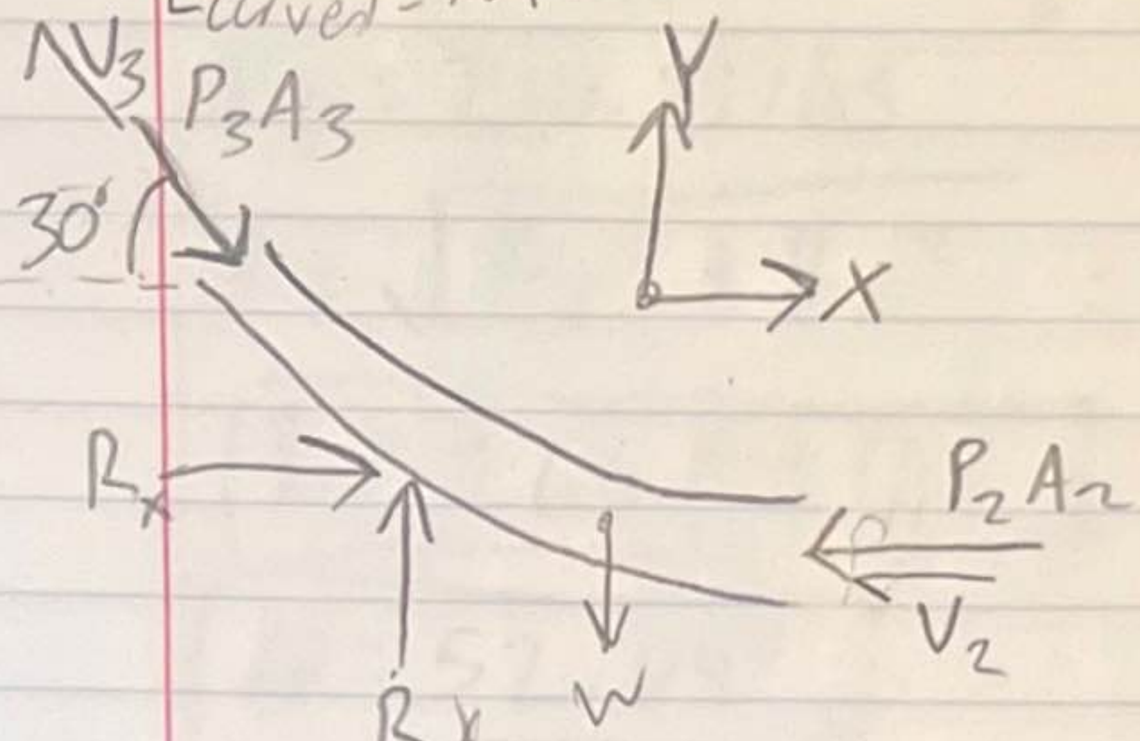
$A = \frac{\pi}{4} D^2$

$A_2 = \frac{\pi}{4}(.333ft)^2$

$A_2 = .0873ft^2$

$A_3 = .0491ft^2$

$L_{curved} = 10ft$



$\Sigma F_x = \rho Q (V_{3x} - V_{2x})$

$\frac{P_1}{\gamma} + \frac{V_1^{\,0}}{2g} + Z_1 = \frac{P_3^{\,0}}{\gamma} + \frac{V_3^2}{2g} + Z_3$

$\frac{V_3^2}{2g} = \frac{P_1}{\gamma} + Z_1 - Z_3$

$V_3 = \sqrt{2 \times 32.2 \frac{ft}{s^2}\left(30 \frac{lb}{in^2} \times \frac{144 in^2}{ft^2} \div 55 lb/ft^3 + 35ft - 20ft\right)}$

$V_3 = 77.617 ft/s$

$Q = V_3 A_3 \quad Q = 77.617 ft/s \times .0491 ft^2$

$Q = 3.811 ft^3/s$

$V_2 = Q/A_2 = 3.811 ft^3/s / .0873 ft^2$

$V_2 = 43.654 ft/s$

$R_x - P_2A_2 + P_3^{\,0} A_3 \cos 30° = \rho Q (V_{3x} - V_{2x})$

$\frac{P_1}{\gamma} + \frac{V_1^{\,2}}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 \quad P_2 = \gamma\left(\frac{P_1}{\gamma} - \frac{V_2^2}{2g} + Z_1 - Z_2\right)$

$P_1 = 55 \frac{lb}{ft^3}\left(\frac{4320 lb/ft^2}{55 N/ft^3} - \frac{(43.654 ft/s)^2}{2 \times 32.2 ft/s^2} + 35ft - 10ft\right)$

$P_1 = 4067.5\ lb/ft^2$

$\rho = \gamma/g = 55 \frac{lb}{ft^3} / 32.2 \frac{ft}{s^2}$

$\rho = 1.71 slug/ft^3$

$R_x = 1.71 \frac{slug}{ft^3} \times 3.811 \frac{ft^3}{s}\left(-77.617 \frac{ft}{s} \cos 20 - (-43.654)\right) + 406716 \frac{lb}{ft^2} \times .0873 ft^2$

$R_x = 164.22 lbs$

$$\Sigma F_y = \rho Q (V_{3y} - V_{2y})$$

$$W = (A_{ave} \times L_{curve}) \cdot \gamma$$

$$W = \left(\frac{.0873 ft^2 + .0491 ft^2}{2}\right) \times 550 \frac{lb}{ft^3}$$

$$W = 37.51 lbs$$

$$R_y - W + P_2 A_2 - P_3 A_3 = \rho Q (V_{3y} - V_{2y})$$

$$R_y = 1.715 \frac{slug}{ft^3} \times 3.811 \frac{ft^3}{s} \left(77.617 \frac{ft}{s} \cos 70^\circ\right) + 37.51 lbs$$

$$R_y = 210.51 lbs$$

$$R = \sqrt{R_y^2 + R_x^2} = \sqrt{210.51 lbs^2 + 164.22 lbs^2}$$

$$\boxed{R = 266.99 lbs}$$

$$\tan\theta = \frac{R_y}{R_x}$$

$$\boxed{\theta = 52.04^\circ}$$

$$\theta = \tan^{-1}\left(\frac{210.51}{164.22}\right)$$

5) $\Delta P = \rho C V$

$$C = \frac{\sqrt{\frac{E_0}{\rho}}}{\sqrt{1 + \frac{E_0 D}{E \delta}}}$$

$N = \frac{kg\,m}{s^2}$

$V = 1\,m/s$

$\rho = 1000\,kg/m^3$

$D = .6\,m$

$E = 2 \times 10^7\,N/cm^2$

$E_0 = 2.03 \times 10^5\,N/cm^2$

$\delta = .01\,m$

$$C = \frac{\sqrt{2.03 \times 10^5 \frac{N}{cm^2} / 1000 kg/m^3 \times \frac{10000 cm^2}{m^2}}}{\sqrt{1 + \frac{2.03 \times 10^5 \frac{N}{cm^2} \times .6m}{2 \times 10^7 \frac{N}{cm^2} \times .01m}}}$$

$$C = \frac{1424.78\,m/s}{1.268} \qquad C = 1123.23\,m/s$$

$$\Delta P = 1000 \frac{kg}{m^3} \times 1123.23 \frac{m}{s} \times 1 \frac{m}{s}$$

$\Delta P = 1.12 \times 10^6\,Pa$
or
$\Delta P = 1.12\,MPa$