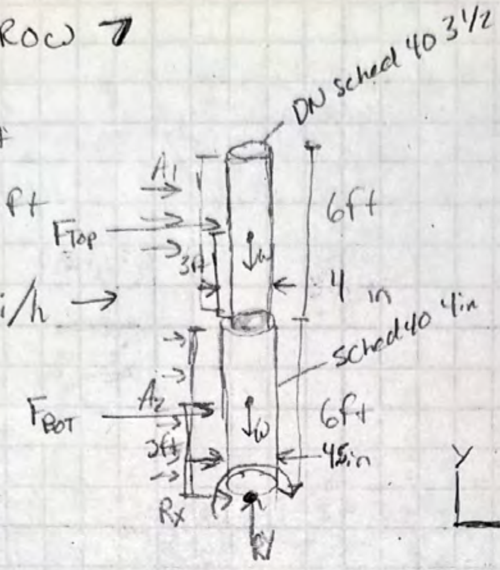
MET330 Test 3 | Joe Munoz

1. Table Row 7 $\qquad$ UIN: 01185657

$L_{Top} = 6\,ft$

$L_{Bottom} = 6\,ft$



Air Temp = 71°F

$\rho = 2.325 \times 10^{-3}\ slugs/ft^3$

$V = 80\,mph \cdot \frac{1.467\ ft/s}{1\,mph} = 117.333\ ft/s$

$\nu = 1.635 \times 10^{-4}\ ft^2/s$

$D_T = 4\,in$

$D_B = 4.5\,in$

$R_x = 0$

$R_y = W$ ignore since @ point of momentum

$\Sigma M:\ F_{Top} \cdot (6ft + 3ft) + F_{BOT} \cdot 3ft$

$$F_{Top} = C_D\left(\frac{\rho V^2}{2}\right)A_1 = 1.1 \cdot \left(\frac{2.325\times10^{-3}\ slugs/ft^3 \cdot (117.333\ ft/s)^2}{2}\right) \cdot 2\ ft^2$$

$$F_{top} = 35.2\ \frac{slugs \cdot ft}{s^2}\ lb \rightarrow$$

$$A_1 = \frac{4\,in}{12\,\frac{in}{ft}} \cdot 6ft = 2\ ft^2$$

$$Re = \frac{VD}{\nu} = \frac{117.333\,ft/s \cdot \frac{3.5\,in}{12\,\frac{in}{ft}}}{1.635\times10^{-4}\ ft^2/s} = 239211$$

2.4×10^5

$C_D = 1.5$

$$F_{BOT} = C_D\left(\frac{\rho V^2}{2}\right)A_2 = .9 \cdot \left(\frac{2.325\times10^{-3}\ \frac{slugs}{ft^3} \cdot (117.333\ ft/s)^2}{2}\right) 2.25\ ft^2 = 32.4\ lbs \rightarrow$$

$$A_2 = \frac{4.5\,in}{12\,\frac{in}{ft}} \cdot 6ft = 2.25\ ft^2$$

$$Re = \frac{117.333\,ft/s \cdot \frac{4\,in}{12\,\frac{in}{ft}}}{1.635\times10^{-4}\ ft^2/s} = 269211$$

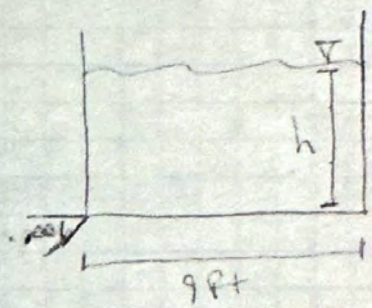
2.7×10^5

$C_D = .9$

$\Sigma M: \quad M_0 = 35.2\text{ lbs} \cdot 9\text{ft} + 32.4\text{lb} \cdot 3\text{ft} = \boxed{414\text{ lb}\cdot\text{ft}}$

2. $w = 9\text{ft}$

$Q = 150\text{ ft}^3/s$



$S = .001$

$n = .015$

- Find height of liquid
- determine if super or sub critical

$A = wh$

$WP = w + 2h$

$$Q = AV = \left(\frac{1.49}{n}\right) A R^{2/3} S^{1/2} \rightarrow \underbrace{AR^{2/3}}_{\text{unknown}} = \underbrace{\frac{nQ}{1.49 S^{1/2}}}_{\text{known}}$$

$$R = \frac{A}{WP} = \left(\frac{9\text{ft}\cdot h}{9\text{ft} + 2h}\right)^{2/3}$$

$A = 9\text{ft}\cdot h$

$$9\text{ft}\cdot h \cdot \left(\frac{9\text{ft}\cdot h}{9\text{ft}+2h}\right)^{2/3} = \frac{.015 \cdot 150\text{ ft}^3/s}{1.49 \cdot .001^{1/2}}$$

$$= 47.75$$

Iterative process in excel

$$\underbrace{9\cdot h \cdot \left(\frac{9\cdot h}{9+2h}\right)^{2/3}}_{LHS} = \underbrace{47.75}_{RHS} \qquad \boxed{h = 3.41\text{ ft}}$$

Crit Flow :

$$N_F = \frac{v}{\sqrt{g\,y_h}} = \frac{4.9\ ft/s}{\sqrt{32.2\ ft/s^2 \cdot 3.4\ ft}} = .468$$

$$V = \frac{Q}{A} = \frac{150\ ft^3/s}{(9\ ft \cdot 3.4\ ft)} = 4.9\ ft/s$$

$$y_h = \frac{9\ ft \cdot 3.4\ ft}{9\ ft} = 3.4\ ft$$

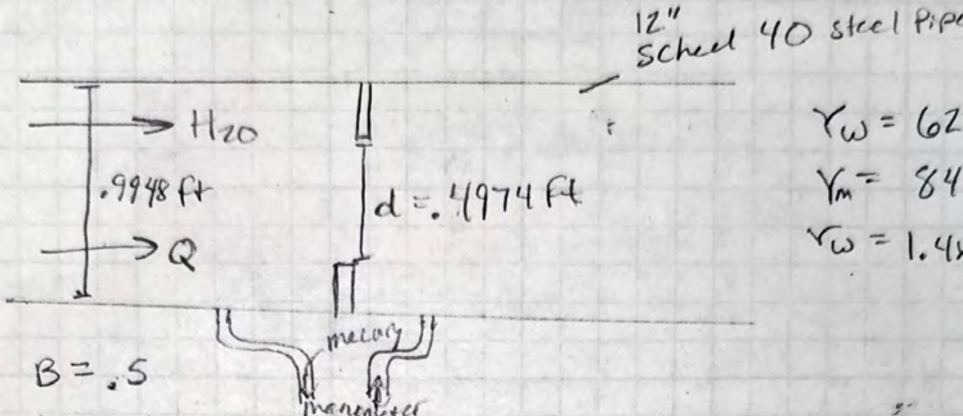
$$\boxed{N_F = .848 \rightarrow \text{Flow is subcritical}}$$

F14 fx

	A	B	C	D
1				
2	47.7525			
3				
4		h (ft)	LHS	% diff
5		1	7.87304	83.51%
6		2	22.361	53.17%
7		3	39.9526	16.33%
8		3.1	41.8258	12.41%
9		3.2	43.716	8.45%
10		3.3	45.6224	4.46%
11		3.4	47.5442	0.44%
12		3.41	47.7372	0.03%

3. $Q = 12000\,gpm \cdot \frac{1\,ft^3/s}{449\,g/m} = 26.726\,ft^3/s$

$D = 12''$



$\gamma_w = 62.4\,lb/ft^3$

$\gamma_m = 844.9\,lb/ft^3$

$\nu_w = 1.4\times10^{-5}\,ft^2/s$

$B = .5$

$\beta = \frac{d}{D}$ $\quad d = \beta \cdot D = .5 \cdot .9948\,ft = .49.74\,ft$

$$V = \frac{Q_n}{A_1} = \frac{26.726\,ft^3/s}{.777\,ft^2} = 34.38\,ft/s$$

$A_1 = \frac{\pi}{4}\cdot(.9948\,ft)^2 = .777\,ft^2$

$A_2 = \frac{\pi}{4}\cdot(.4974\,ft)^2 = .1943\,ft^2 = 3$

$$Re = \frac{VD}{\nu} = \frac{34.38\,\cancel{ft/s}\cdot .9948\,\cancel{ft}}{1.4\times10^{-5}\,\cancel{ft^2}/s} = 2442944$$

2.44×10^{-6}

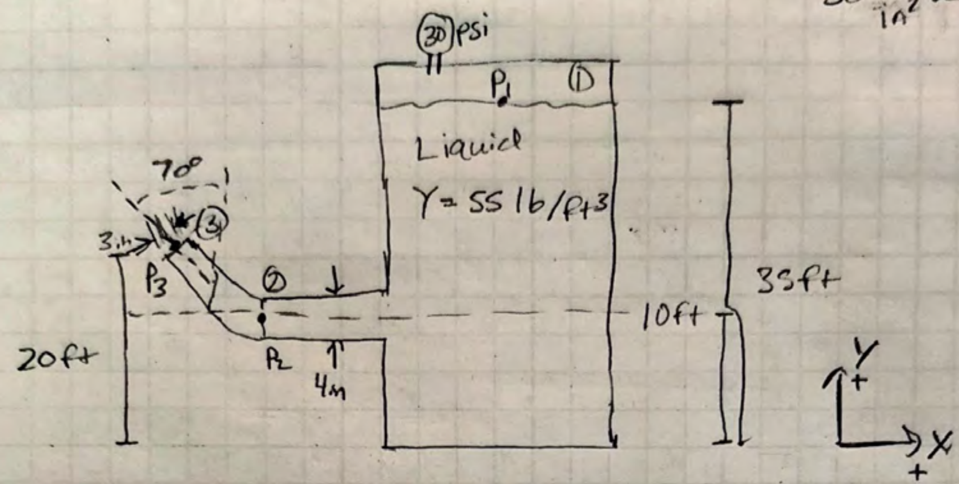
C from ~~tbl~~ Figure 15.7 = .601

$$h = \frac{\left(\frac{Q}{A_1 * C}\right)^2 \cdot \left[\left(\frac{A_1}{A_2}\right)^2 - 1\right]}{2g\left(\frac{\gamma_m}{\gamma_w} - 1\right)}$$

$$h = \frac{\left(\frac{26.726\,ft^3/s}{.777\,ft^2 \cdot .601}\right)^2 \cdot \left[\left(\frac{.777\,ft^2}{.1943\,ft^2}\right)^2 - 1\right]}{2\cdot 32.2\,ft/s^2 \cdot \left(\frac{844.9\,lb/ft^3}{62.4\,lb/ft^3} - 1\right)} = 60.8\,ft$$

4. $L_{curve} = 20\,ft$

$$30\,\frac{lb}{in^2} \cdot \frac{144\ lb/ft^2}{lb/in^2} = 4320\,lb/ft^2$$



P_3 velocity:

$$\frac{P_1}{\gamma_f} + \cancel{\frac{V_1^2}{2g}}^{0} + z_1 = \cancel{\frac{P_3}{\gamma_f}}^{0} + \frac{V_3^2}{2g} + z_3$$

$$V_3 = \sqrt{2g\left(\frac{P_1}{\gamma_f} + z_1 - z_3\right)} = \sqrt{2 \cdot 32.2\,ft/s^2 \cdot \left(\frac{4320\ lb/ft^2}{55\ lb/ft^3} + 35\,ft - 20\,ft\right)}$$

$$V_3 = 77.615\ ft/s$$

$$A_2 = \left(\frac{4\,in}{12\,in}\right)^2 ft \cdot \pi/4 = .0872\,ft^2$$

$$A_3 = \left(\frac{3\,in}{12\,in}\right)^2 ft \cdot \pi/4 = .049\,ft^2$$

Continuity of velocity + Area

$$V_3 A_3 = V_2 A_2$$

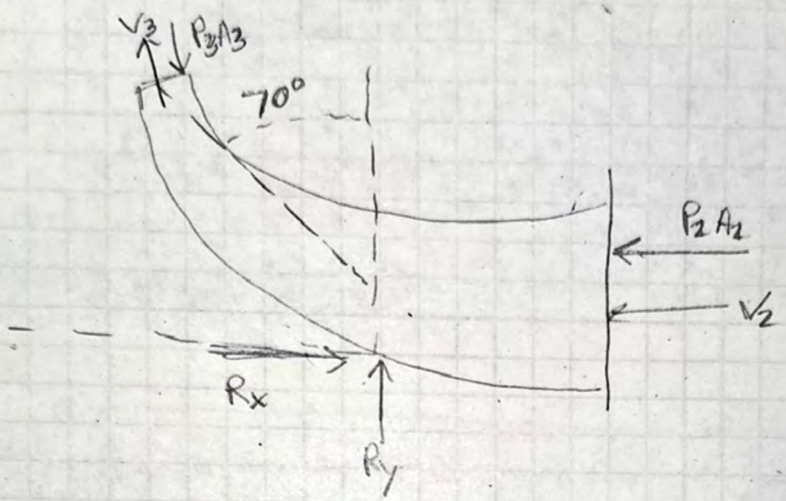
$$V_2 = \frac{V_3 A_3}{A_2} = \frac{77.61\,ft/s \cdot .049\,ft^2}{.0872\,ft^2} = 43.65\,ft/s$$

$$P_2: \frac{P_1}{\gamma_f} + \cancel{\frac{V_1^2}{2g}}^{0} + z_1 = \frac{P_2}{\gamma_f} + \frac{V_2^2}{2g} + z_2$$

$$P_2 = \gamma_f\left(\frac{P_1}{\gamma_f} - \frac{V_2^2}{2g} + z_1 - z_2\right)$$

$$P_2 = 55\,lb/ft^3\left(\frac{4320\,lb/ft^2}{55\,lb/ft^3} - \frac{(43.65\,ft/s)^2}{2 \cdot 32.2\,ft/s^2} + 35\,ft - 10\,ft\right)$$

$$P_2 = 4067.08\,lb/ft^2$$



$\underline{F_x}$: $\quad F_x = \rho Q\,(V_{3x} - V_{2x})$

$$R_x - P_2A_2 + P_3A_3\sin 70° = \rho Q\,(-V_3\sin 70° - (-V_2))$$

$$R_x = P_2A_2 - P_3A_3\sin 70 + \rho Q\,(-V_3\sin 70 - (-V_2))$$

$$Q = A_2V_2 = .0872\,ft^2 \cdot 43.65\,ft/s = 2.14\,ft^3/s$$

$$S_g = \frac{55\,lb/ft^3}{62.4\,lb/ft^3} = .88$$

$$\rho = 1.94\,slugs/ft^3 \cdot .88 = 1.7072\,slugs/ft^3$$

$$R_x = \left(4067.08\,\tfrac{lb}{ft^2} \cdot .0872\,ft^2\right) - 0 + \left(1.7072\,\overset{lb\,s^2/ft}{slug}/ft^3 \cdot 2.14\,ft^3/s \cdot \left(-77.61\,ft/s \cdot \sin 70 - (-43.65\,ft/s)\right)\right)$$

$$R_x = 247.96\,lb \longrightarrow$$

F_y: $F_y = \rho Q\,(V_{3,y}^{\cos 70} - \cancel{V_{2y}}^{0})$

$$R_y - P_3 A_3 \cos 70 - \cancel{P_2 A_2}^{0} = \rho Q\,(V_3 \cos 70 - 0)$$

$$R_y = P_3 A3 \cos 70 + \rho Q\,(V_3 \cos 70°)$$

$$R_y = \left(4067.08\,\tfrac{lb}{ft^2} \cdot .049\,ft^2\right) + \left(1.7072\,\tfrac{slugs}{ft^3} \cdot 2.14\,\tfrac{ft^3}{s} \cdot 77.61\,\tfrac{ft}{s} \cdot \cos 70°\right)$$

$lb \cdot s^2/ft$

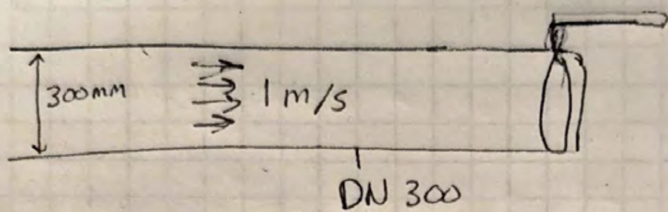
$$R_y = 296.62\ lb \uparrow$$

$$R_F = \sqrt{(296.62\,lb)^2 + (247.96\,lb)^2} = \boxed{386.62\,lb}$$

direction: $\Theta = \tan^{-1}\left(\frac{R_Y}{R_x}\right) = \tan^{-1}\left(\frac{296.62}{247.96}\right) = \boxed{50.1°}$

5. $D = 300mm = .3m$ $\quad E = 2\times10^{7}\ N/cm^2$ $\quad \rho = 1000\ kg/m^3$

$V = 1\ m/s$ $\quad E_o = 2.03\times10^{5}\ N/cm^2$ $\quad \delta = ?$



find pressure increment when valve closes suddenly

$D_1 = 303.2\ mm = .3032m$

$\delta = .01031\ m$

$\Delta P = \rho C V$

$$C = \frac{\sqrt{\frac{E_o}{\rho}}}{\sqrt{1 + \frac{E_o D}{E\delta}}} = \frac{\sqrt{\frac{2.03\times10^{9}\ \frac{N}{m^2} - kg\cdot m^2/s^2}{1000\ \frac{kg}{m^3}}}}{\sqrt{1 + \frac{2.03\cdot10^{9}\frac{N}{m^2}\cdot .3032m}{2\cdot10^{11}\frac{N}{m^2}\cdot .01031m}}} = 1250.33\ m/s$$

$$E = 2\times10^{7}\ \frac{N}{cm^2}\cdot\frac{100cm}{m}\cdot\frac{100cm}{m} = 2\times10^{11}\ N/m^2$$

$$E_o = 2.03\cdot10^{5}\cdot\frac{N}{cm^2}\cdot\frac{100cm}{m}\cdot\frac{100cm}{m} = 2.03\times10^{9}\ N/m^2$$

$$\Delta P = 1000\ \frac{kg}{m^3}\cdot 1250.33\ \frac{m}{s}\cdot 1\ \frac{m}{s} = 1250339.45\ \frac{kg}{m\cdot s^2}$$

$$\boxed{\Delta P = 1.25\ MPa}$$