11/2/21

Met 330 Test 2 Hannah Wolfe

1) $Q = \frac{1.0}{n} A S^{1/2} R^{2/3}$

$Q = \frac{1.0}{0.013} (2.23m \times 0.61m) (0.001)^{1/2} \left(\frac{2.23 \times 0.61}{2.23 + 2(0.61)} \right)^{2/3}$

$Q = 76.92 (1.31m)(.032)(0.538)$

$Q = 1.8 \ m^3/s$

2) $C_D = \frac{F_D / A}{\rho V^2 / 2}$

* 57 cm chest width, 0.61m water depth
=0.57m

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

$F_D = 1.17 \left(\frac{996.69 V_r^2}{2} \right) 0.3477 m^2$

$\rho = 0.99669 \ g/cm^3$
@ 80°F
$= 996.69 \ kg/m^3$

* C_D used for a rectangle that $a/b = 4$ — b/c it is projected

$A = (0.61)(0.57)$
$A = 0.3477$

$V = \frac{1.0}{0.013} (0.001)^{1/2} (0.538)$

$V = 1.31$

$F_D = 1.17 \left(\frac{996.69 (1.31)^2}{2} \right) (0.3477)$

$F_D = 1.17 (855.21)(.3477)$

$F_D = 347.91 \ N$

height of Syo = 1.09m

3) $F_b = \gamma_w V_d$

$\gamma_w = 9.81 \ kN/m^3$

$V_d =$

$113.4kg + 1.9kg = 115.3kg$

$A_{tube} = \pi/4 (0.96)^2 - \pi/4 (0.35)^2$
$= 0.6276 m^2$

$115.3kg = 1.13kN$

$\frac{F_b}{\gamma_w} = V_d \qquad \frac{1.13kN}{9.81 \ kN/m^3} = \underline{0.115 m}$

$MB = I / V_d \qquad I = 0.96$

* if metacenter is above center of gravity, then it is stable, ran out of time to finish

4) 1m wall height
2.23m width
1m length

$\gamma_{water} = 9.81\ KN/m^3$

depth

Wall A = 1m (0.61m) = $0.61m^2$
floor A = 1m (2.23m) = $2.23m^2$

$F_R = 9.81\left(\frac{0.61m}{2}\right)(0.61m^2)$
$F_R = 1.83\ KN$

$F_R = 9.81\left(\frac{0.61}{2}\right)(2.23) = 6.67KN$

$I_c = \frac{(2.23)(0.61)^3}{12}$

$I_c = 0.069m$

B)

$= 0.222801 \, ft^3/s$

5) Forces in pipe: $F_x = \rho Q \Delta V_x$
$F_y = \rho Q \Delta V_y$
$\cancel{F_z = \rho Q \Delta V_z}$

100 gpm $= 0.006309 \, m^3/s$

$\rho = 789 \, kg/m^3$ + ethyl alcohol

Forces in elbow: $R_x = \rho Q V_1 + P_1 A_1$
$R_y = \rho Q V_2 + P_2 A_2$

$F_x = (789 \, kg/m^3)(0.006309 \, m^3/s)(V_{2x} - V_{1x})$
$F_y = (789)(0.006309)(V_{2y} - V_{1y})$

$R_x = (789)(0.006309)(V_1) +$

$\Rightarrow$ nozzle located at pipe entering left tank

(c) $V_1 = C\sqrt{\frac{2g(P_1-P_2)\gamma}{(A_1/A_2)^2-1}}$

$0.1723\,ft\,(0.5) = 0.08615\,ft$

$C = 0.9975 - 6.53\sqrt{B/N_R}$

$B = 0.5$

$V_1 = 0.9872\sqrt{\frac{2(32.2)(P_1-P_2)(49.01)}{(0.0233/0.0058)^2-1}}$

$C = 0.9975 - 6.53\sqrt{0.5/2\times10^5}$

$C = 0.9872$

$V_1 = 0.9872\sqrt{\frac{64.4(P_1-P_2)(49.01)}{15.14}}$

$\gamma_{EA} = 49.01\,lb/ft^3$

$A_{nozzle}: \pi/4\,(0.08625)^2 = 0.0058\,ft^2$

$(V_1)^2 = 0.9872\,\frac{64.4(P_1-P_2)(49.01)}{15.14}$

$A_{pipe}: \pi/4\,(0.1723)^2 = 0.0233\,ft^2$

$\frac{V_1^2}{P_1-P_2} = \frac{(64.4)(49.01)}{15.14}$

$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_{L_{1-2}}$

$\frac{V_1^2}{P_1-P_2} = 208.47$

$\frac{V_1^2}{208.47} = P_1 - P_2$

$OD = 2.375 in$

7) $\Delta P = \rho c v$

$$\frac{4(0.222801 \frac{ft^3}{s})}{\pi \times (0.1723)^2} = 9.56 \frac{ft}{s}$$

$\Delta P = (1.53 \frac{slugs}{ft^3})(0.9872)(9.56 \frac{ft}{s})$

$\Delta P = 14.44 psf$

$P_1 + P_2 = 14.44 + 5760 = 5774.44$

$P_{total} = 5774.44 psf = 40.1 psi$

$$t = \frac{PD}{2(SE + pY)}$$

$$t = \frac{40.1(2.375)}{2(20000psi \times 0.85 + 40.1 \times 0.40)}$$

$$t = \frac{95.2375}{2(17016.04)} = \frac{95.2375}{34032.08} = 0.0028 in$$

t is less than the actual pipe thickness, therefore it will not fail

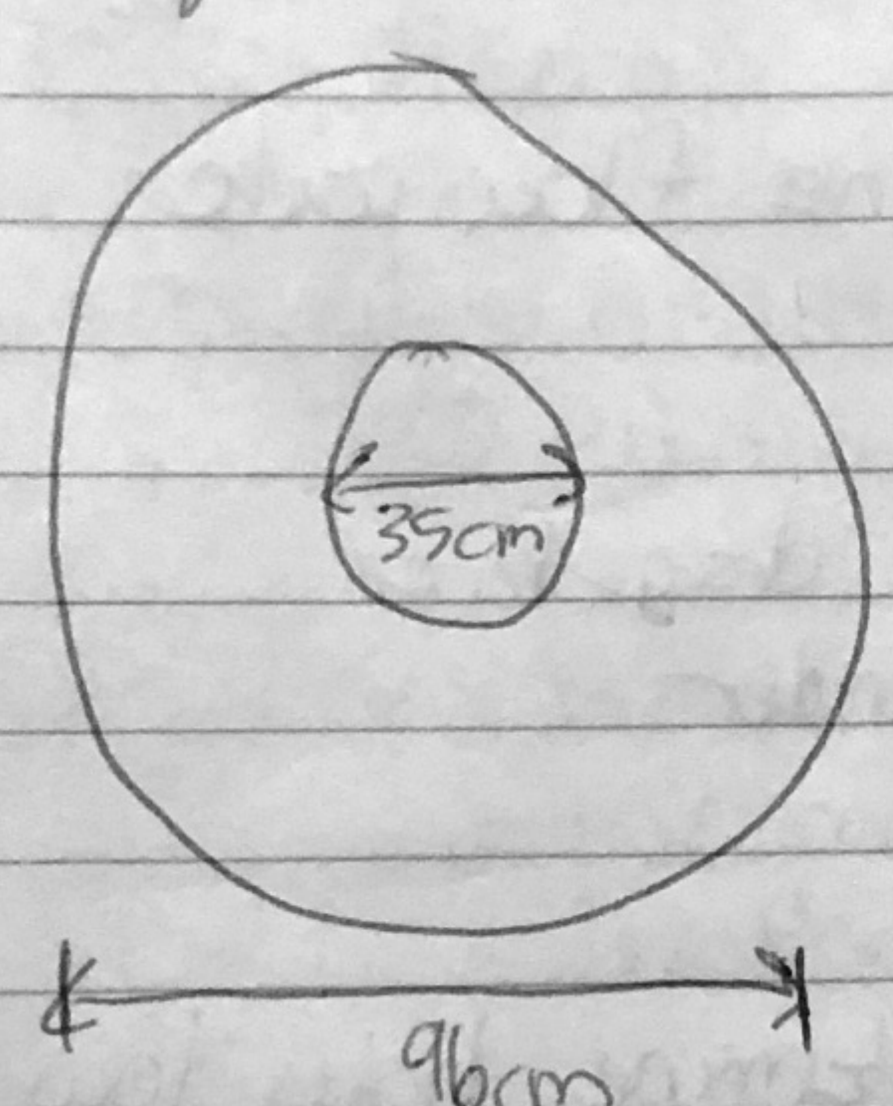
no cavitation will occur b/c the lowest pressure E.A. will reach higher than 0.863 psi considering no pumps; in order for cavitation to occur the pressure must drop below vapor pressure which is 0.863 psi for E.A.

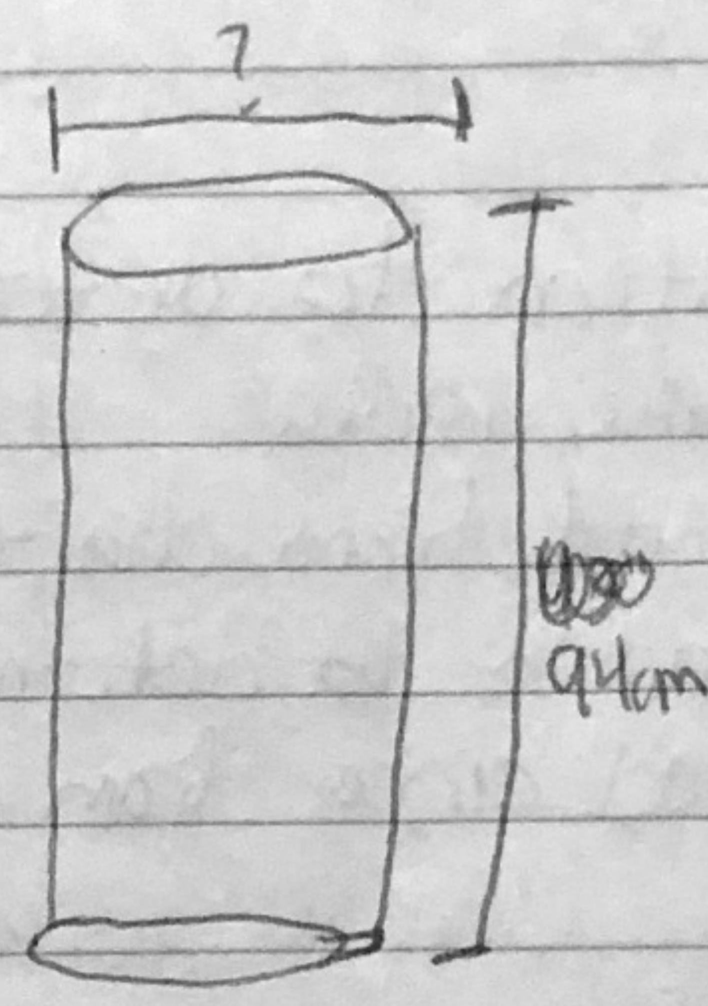
Part A:

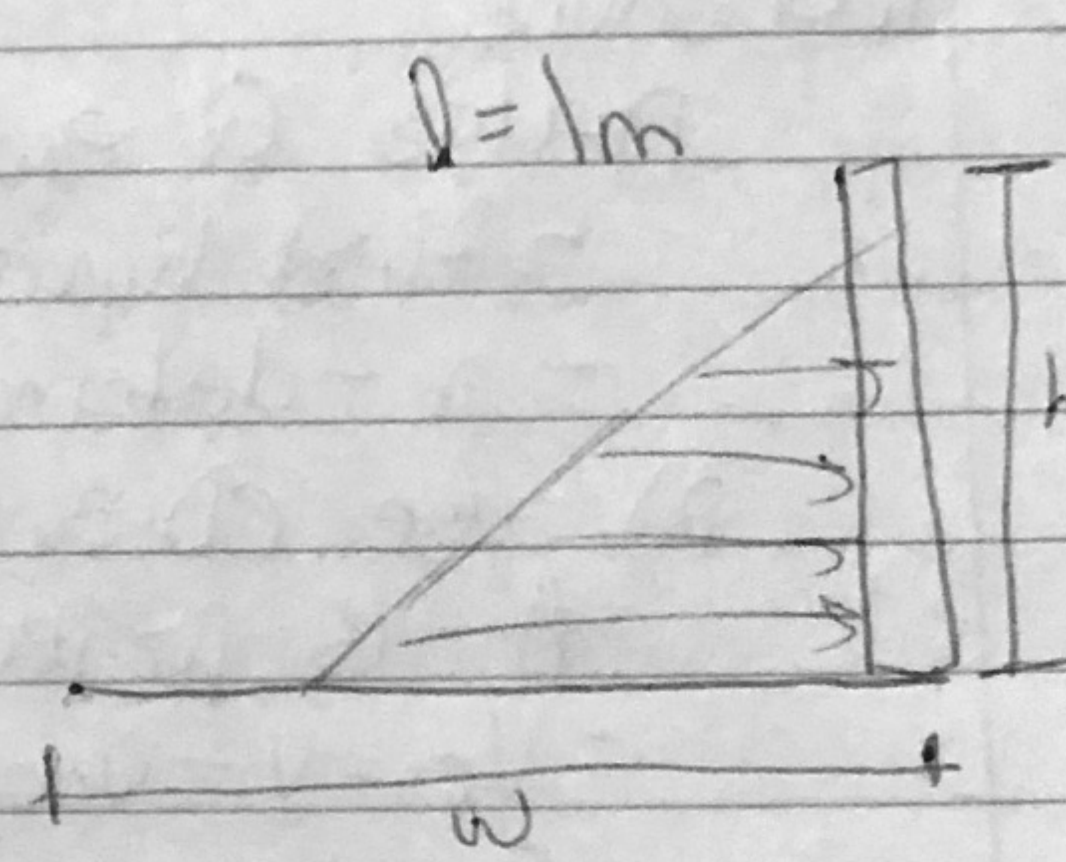
Purpose:

1) determine flow rate required for the lazy river
2) determine drag force for a 5 year old "cylinder child"
3) determine how far into the water the tube would go if carrying a 250 lb person. Determine if the person on the tube is stable
4) Determine force magnitude in a 1m-length section & its location on walls & floor of channel

Drawing:







Sources: Mott and Untener, Applied Fluid Mechanics 7th edition, pearson, 2015

Design consideration:

- incompressible fluid
- 3yr old girl height 94cm
- 5yr old kid height 39-48"
- width of 5yr old
- 250 lb person
- rectangle open channel
- temperature

Part A)

Summary: The flow rate required is $1.8 m^3/s$, drag force is 347.91 N, and tube sinks 0.115m into the river. Forces for number 4 were 1.83 KN + 6.67 KN @ 0.069m.

Part B)

Summary: Not sure how to summarize question 5, it stumped me. Question 6, I was able to get to the point of needing to find V and one pressure, but was unsure how to proceed. Question 7, I got that $\Delta P = 14.44 psf$ and $t = 0.0028 in.$

Materials:

A) - Single rider tube
- trowel concrete

B) - 2" steel pipe
- nozzle
- Valve

Analysis:

A) In summary, I believe that my flow rate is an appropriate number b/c it is equal to ≈ 3mph which is in the range for an average lazy river. The drag force was found using correct measurements of a 5yr old, so there should be no reason for it to be inaccurate. The tube sinks about 1/3 of its height. The forces were found using calculations from wall, floor, + water depth dimensions.

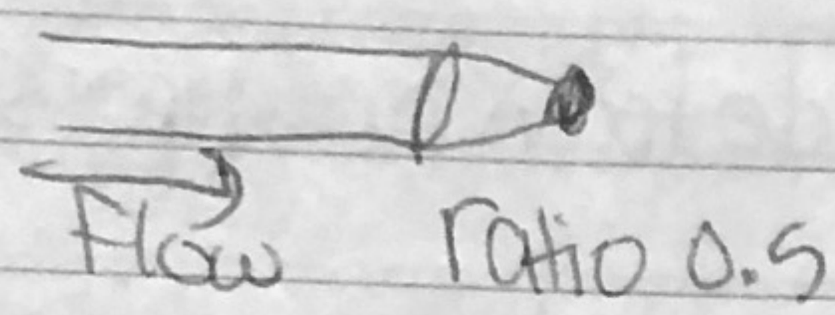
B) I am finding it difficult to analyze Part B of the test. I was able to begin 5 + 6, but not fully complete them in order to give a proper analysis. Question 7 had many variables assumed from the book, which led to finding t.

B) Purpose:

5) Calculate total forces in the whole pipe system
6) Determine pressure drop across the nozzle
7) Determine pressure change after a sudden valve closing. Determine if the pipe will fail.

Drawings:

☆ refer to drawing on test 1 (will include in final test submission)



Sources: Mott and Untener, Applied Fluid Mechanics, 7th edition, Pearson, 2015

Design considerations:

- incompressible fluids
- isothermal

Data & Variables:

- ratio of 0.5
- modulus of Elasticity 200GPa
- P_1 - inlet pressure, P_2 - outlet pressure
- A_1 - area of pipe, A_n - area of nozzle
- V - velocity
- t - wall thickness

Procedure: 5) -use equations for forces in an elbow (R_x + R_y) and forces in a pipe

not 100% sure on this

- combine them to find total horizontal + vertical forces

6) - Use V_i equation to determine pressure drop
- fine C using β=0.5 to find Ne
- use A_1 = pipe area A_2 = nozzle area

7) - use ΔP equation to determine pressure increment
- use equation 11-9 to determine the status of the pipe failure

5) what course objectives:
- Identify and solve for different very

Data & Variables:

- width & height of channel
- 3yr old girl height 94cm
- 250 lb person
- 1m length section
- height & width of 3yr old
- Q - flow rate
- A - area
- V - velocity

P - pressure
γ - density
S - slope

Procedure:

1) - Use Q equation to determine flow rate
   - find hydraulic radius
   - n - determined from chart
2) - use CD equation to determine drag force
   - A - is projected area from cylinder
   - $V_r = V - V_{obj}$
   - F_D - drag coefficient
3) - use $F_b = \gamma_F V_d$ to determine how low the tube will sink into water
   - determine metacenter to see if the person is stable
   - if center of gravity is below metacenter, then they are stable

5) 1) What course objectives?
   - Identify and solve for different very specific industrial problems
   - Bu...