MET 330 TEST 2 | M. VAUGHN

PURPOSE: I WILL CONTINUE THE DESIGN OF THE SYSTEM SHOWN IN THE PICTURE BELOW. THIS REQUIRES; ADDING A SPHERICAL BUOY (DETERMINE SIZE OF BUOY), CALCULATE THE HORIZONTAL & VERTICAL FORCES OF THE DISCHARG PIPE FOR A SUPPORT, DETERMINE WHAT THE PRESSURE DROP IS ACROSS THE NOZZLE, DETERMINE HOW DEEP A TRAPEZOIDAL OPEN CHANNEL SHOULD BE TO HANDLE 400 GPM, DETERMINE IF WATER HAMMER AND/OR CAVITATION WOULD OCCUR & SEE IF THE PIPE WOULD FAIL BASED ON THE DIAMETER & WALL THICKNESS, AND FINALLY DETERMINE A MAXIMUM WEIGHT OF AN OBJECT IF IT WERE TO SLIDE ALONG THE BOTTOM SURFACE OF THE OPEN CHANNEL

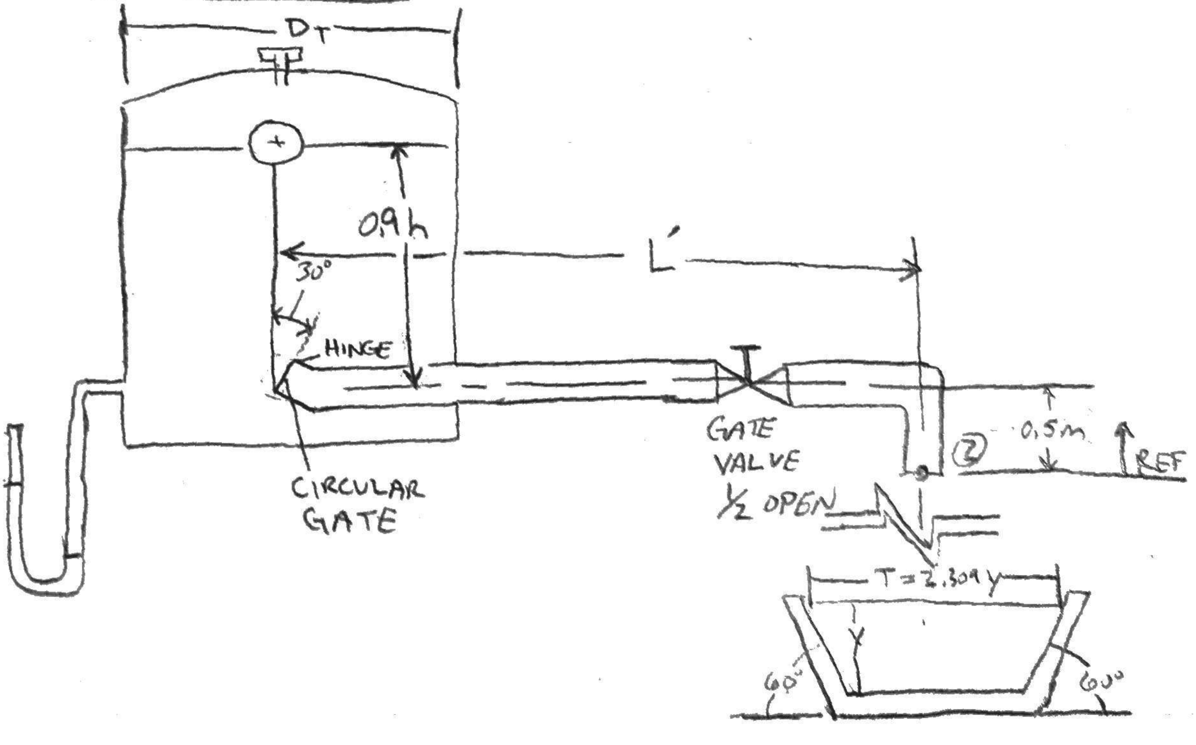
SOURCES

MOTT, R., UNTENER, J.A, "APPLIED FLUID MECHANICS", 7TH EDITION, PEARSON EDUCATION INC (2015)

DESIGN CONSIDERATIONS

- CONSTANT PROPERTIES
- INCOMPRESSIBLE FLUIDS
- ISOTHERMAL CONDITION @ 25°C

DRAWINGS & DIAGRAMS



PROCEDURE

FOR PART A, I WILL DETERMINE THE SIZE OF THE BODY WHEN THE GASOLINE LEVEL REACHES 0.9 h AND OPENS THE GATE SEAL DOING THE SUM OF MOMENTS EQUATION ON THE GATE SEAL. FOR PART B, I WILL APPLY THE SUM OF FORCES EQUATION WITH FLUIDS TO FIGURE OUT THE HORIZONTAL & VERTICAL FORCES FOR THE WHOLE DISCHARGE PIPE-ELBOW-VALVE SYSTEM. FOR PART C, I WILL DETERMINE THE PRESSURE DROP ACROSS THE NOZZLE USING THE PIPE DIAMETER RATIO OF 0.5. FOR PART D, I WILL DETERMINE THE DEPTH OF A TRAPEZOIDAL OPEN CHANNEL ABLE TO HOLD SPILLAGE OF 400 GPM. FOR PART E, I WILL DETERMINE THE LOCATIONS OF WHERE WATER HAMME AND/OR CAVITATION COULD OCCUR AND DETERMINE IF THE PIPE WOULD FAIL. FOR PART F, I WILL DETERMINE THE MAXIMUM WEIGHT OF AN OBJECT SO FLUID FLOW DRAGS IT BY SLIDING ALONG THE BOTTOM SURFACE WITH A 0.6 COEFFICENT OF FRICTION.

DATA & VARIABLES

$h = 3.65 m$

$L = 2.25 m$

$h' = (0.9)(h) = 3.285$

$L' = 10.37 m$

$D_T = 16.239 m$

$D_i = 90.1 \times 10^{-3} m$

$A_i = 6.381 \times 10^{-3} m^2$

TABLE F.1

MATERIALS:

GASOLINE @ 25°C

MECURY @ 25°C

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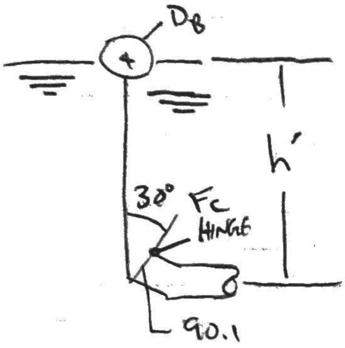
CALCULATIONS:

a)



$y = \frac{D}{2} \cos\theta = \frac{90.1 \times 10^{-3}}{2} \cos 30$

$y = 0.039\ m$

$h' = 3.285\ m$

$h_c = 3.324$

$L_c = \frac{h_c}{\cos\theta} = \frac{3.324}{\cos 30}$

$L_c = 3.84\ m$

$A_i = 6.381 \times 10^{-3}\ m^2$

$\gamma_{GAS} = 6.67\ KN/m^3$

$F_R = \gamma h_c A$

$F_R = (6.67)(3.324)(6.381 \times 10^{-3})$

$F_R = 0.141\ KN$

$I_c = \frac{\pi D^4}{64} = \frac{\pi (101.6)^4}{64}$

$I_c = 5.23 \times 10^6\ mm^4$

$L_p - L_c = \frac{I_c}{L_c A} = \frac{52.3 \times 10^6}{(3.84)(6.381 \times 10^{-3})}$

$\Sigma m = F_R \left[D/2 + (L_p - L_c) \right] - \left[F_c \times D/2 \right] = 0$

$0.141 \left[\frac{101.6}{2} + (2.13 \times 10^8) \right] - \left[F_c \times \frac{101.6}{2} \right] = 0$

$3 \times 10^7 - F_c (50.8) = 0$

$F_c\ 50.8 = 3 \times 10^7$

$\boxed{F_c = 591\ kN}$ GATE SEAL

$\boxed{D_B = 3.5 m}$ $\rho_G = 680\ KN/m^3$

$V_B \left(\frac{4}{3} \pi 3.5^3 \right) = \frac{179.6}{2}$

$V_{B/2} = 89.8$

$F = (89.8)(680)(9.81)$

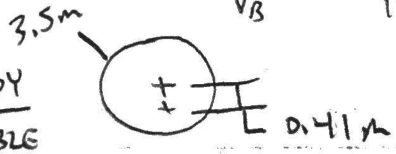
$F = 599019\ N.$

$\boxed{F = 600\ KN}$ (BUOY)

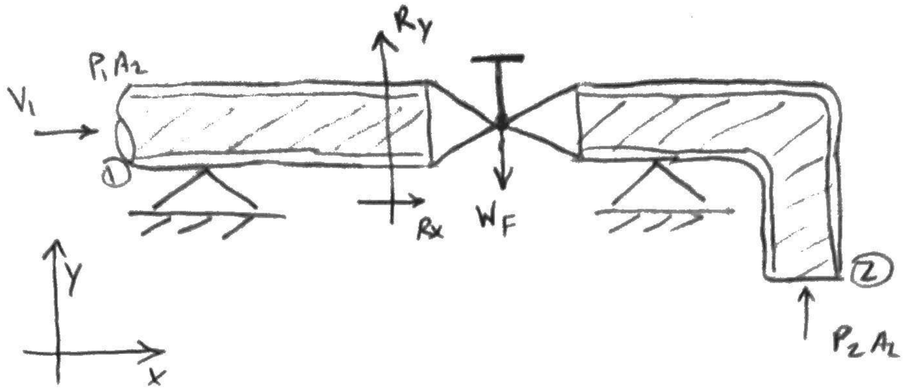
$I = \frac{\pi 3.5^4}{64} = 7.366\ m$

$MB = \frac{I}{V_B} = \frac{7.366}{179.6} = 0.41\ m$

BUOY STABLE



b)



$\Sigma F_x = \rho Q(V_{2x} - V_{1x})$

$R_x = \rho Q[0-(-V_1)] = \rho Q v_1$

$R_x = (680)(0.0252)(3.95)$

$\boxed{R_x = 67.7\ N}$

$R_y = W_f$ $\gamma_{gas} = 6.67\ kN/m^3$

$\boxed{R_y = 6.67\ KN/m^3}$

c) FLOW NOZZLE - RATIO 0.5

$N_R = Re = 8.433 \times 10^5$

$C = 0.605$ (FIG 15.7)

$$v_1 = C\sqrt{\frac{2g(P_1-P_2)/\gamma}{(A_1/A_2)^2-1}}$$

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

$C = 0.9975 - 6.53\sqrt{0.5/8.433\times10^5}$

$C = 0.992$

$$A_2 = \frac{A_1}{\sqrt[2]{\frac{2gh\left(\frac{\gamma_g}{\gamma_w}-1\right)}{\left(\frac{Q}{A_1 \times C}\right)^2}+1}}$$

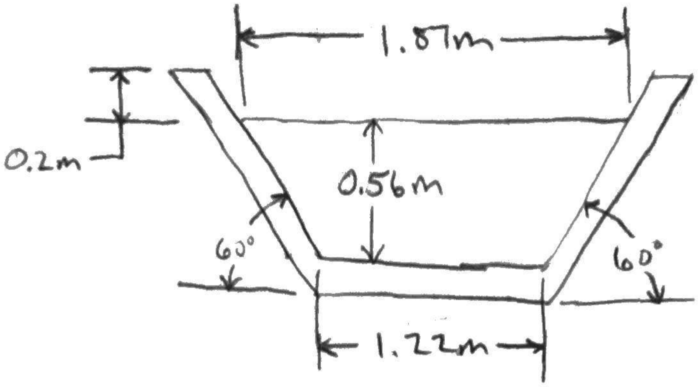
$$A_2 = \frac{6.381\times10^{-3}}{\sqrt[2]{\frac{2(9.81)(90.1)\left(\frac{6.67}{9.78}-1\right)}{\left(\frac{0.0252}{6.381\times10^{-3}(0.605)}\right)^2}+1}}$$

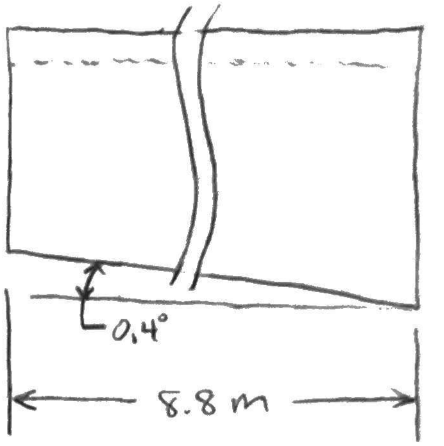
$A_2 = 0.0064\ m^2$

$\boxed{A_2 = 6.423\times10^{-3}\ m^2}$

d) <u>TRAPEZOIDAL</u> <u>OPEN</u> <u>CHANNEL</u>

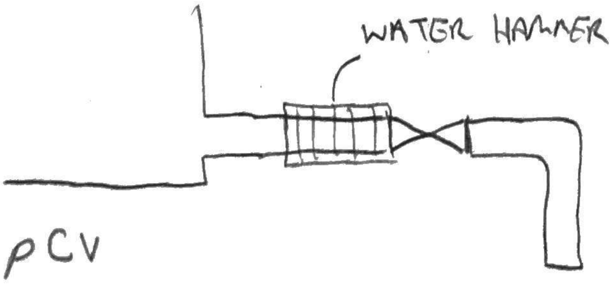
TANK VOLUME = 7.56 m^3





WITH CAD USING THE VOLUME OF THE TANK THE TRAPEZOIDAL OPEN CHANNEL ABOVE WILL HOLD 8.00 m^3

e)



WATER HAMMER COULD OCCUR BEFORE THE GATE VALVE IF SUDDENLY CLOSED

$\Delta P = \rho C V$

$\Delta P = (680)(0.0417)(0.0252)$

$\boxed{\Delta P = 0.715}$

$$C = \frac{\sqrt{\frac{E_o}{\rho}}}{\sqrt{1+\frac{E_o}{E}\frac{D}{8}}}$$

$$C = \frac{\sqrt{\frac{1.3}{680}}}{\sqrt{1+\frac{1.3}{200}\frac{(90.1)}{(5.74)}}}$$

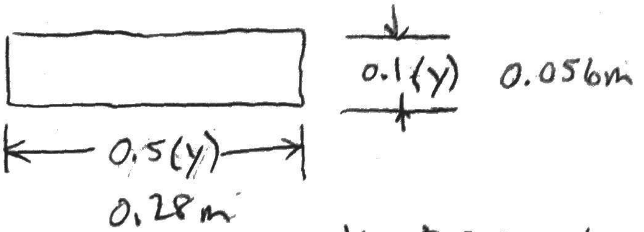
$C = 0.0417$

CAVITATION TYPICALLY OCCURS IN PUMPS, AND PROPELLERS. THIS SYSTEM DOES NOT HAVE EITHER

f) IF AN OBJECT WAS ON THE BOTTOM SURFACE OF TRAPEZOIDAL OPEN CHANNEL WOULD THE FLUID SLIDE IT. WHAT IS THE MAX WEIGHT THE OBJECT COULD BE?

$y = 0.56 m$

$\mu = 0.6$



$V = 3.95\ m/s$

$\rho = 680\ kN/m^3$

$A = 0.01568\ m^2$

$N_R = 8.433 \times 10^5$

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

$$F_D = \frac{(2)(680)(3.95)^2(0.01568)}{2}$$

$F_D = 166.36\ N$

$$W = \frac{F}{f} \qquad \frac{166.36}{0.6}$$

$\boxed{W = 277.3\ N}$ THE OBJECT WILL NOT SLIDE IN THE OPEN CHANNEL BASE ON THE FLUID FORCE

SUMMARY

TO USE A BOUY IN THIS GRAVITY DRIVEN SYSTEM, THE BUOY IS SIZED TO 3.5m DIAMETER TO HAVE THE SAME FORCE TO BE ABLE TO OPEN THE GATE SEAL. THE HORIZONTAL FORCE IN THE PIPE IS 67.7N & THE VERTICAL FLUID FORCE IS 6.67 kN/m^3, SO THE CIVIL ENGINEER CAN DETERMINE THE PIPE SUPPORT. THE FLOW NOZZLE WILL HAVE A PRESSURE DROP AND WILL PROBABLY REDUCE THE FLOW IF THE GATE VALUE STAYS HALF OPEN. THE OPEN CHANNEL TRAPEZOIDAL IN SHAPE IS DESIGNED TO HOLD 8.00 m^3, WHICH IS MORE THAN THE VOLUME THAT THE TANK CAN HOLD. WATER HAMMER CAN HAPPEN BEFORE THE VALUE IF IT WAS SUDDENLY SHUT OFF WITH A ΔP OF 0.715 AN CAVITATION SHOULD NOT OCCUR SINCE THERE IS NOT A PUMP IN THE SYSTEM. IF AN OBJECT IS AT THE BOTTOM OF THE CHANNEL IT WILL NOT SLIDE.

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BASED ON ON A MAX SIZE OF 0.28m x 0.056 m WITH AN AREA OF 0.01568 m^2. THE OPEN CHANNEL MAY NEED TO BE REVIEWED IF THE OBJECT NEEDS TO SLIDE TO THE END OF THE SLOPE OF THE CHANNEL.

ANALYSIS:

A THOUROUG DISCUSSION WILL NEED TO HAPPEN WITH THE CLIENT TO MAKE SURE EVERYTHING FOLLOWS THEIR NEEDS FOR THIS GRAVITY DRIVEN SYSTEM.