Test 1

Purpose: Solve for air pressure above water in tank.

$\varnothing$ $1\frac{1}{2}''$ = .01342 ft

Area flow = .01414 ft^2

① $V = \frac{Q}{A} = \frac{.75/449 \ ft^3/s}{.01414 \ ft^2} = .167 ft/s$

$V = 11.81$ ft/s

Water @ 60°F = 1.21×10^{-5} ft^2/s

② $N_R = \frac{vD}{\nu} = \frac{11.81 \ ft/s (.1342 \ ft)}{1.21 \times 10^{-5} \ ft^2/s}$

$= 1.31 \times 10^5$

Energy loss

$h_L = f \cdot L/D \cdot \frac{v^2}{g}$

$.21 \left(\frac{300}{.1342}\right)\left(\frac{11.81^2}{2(32.18}\right)$

= 101.70 ft

(3)

$$P_1 = y\left[h_L + \Delta z\left(\frac{V^2}{2g}\right)\right]$$

$$62.2\left[101.70 + 3\left(\frac{11.81^2}{2(32.18)}\right)\right]$$

$$= 6{,}649.314 \ lb/ft^2$$

$$= 46.2 \ psi$$

B

Find depth in open channel

$T = 2.309y$

$b = 1.155y$

$Q = .167 \ ft^3/s$

$n = .017$

slope $= .001$

$$R = \frac{A}{WP}$$

$$Q = \frac{1.49}{.017} ASR^{2/3}$$

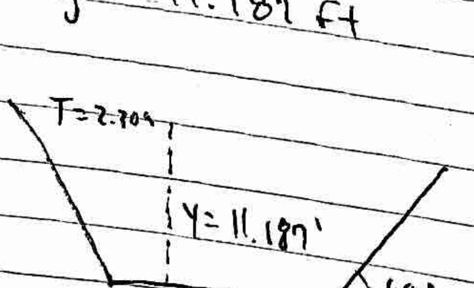
$$= 1.73y^2 \cdot \frac{y}{2}^{2/3} \cdot .001^{1/2}$$

$$= \frac{1.73}{2} y^{4/3} \cdot .0316$$

$$= .167 = .0273^{4/3}$$

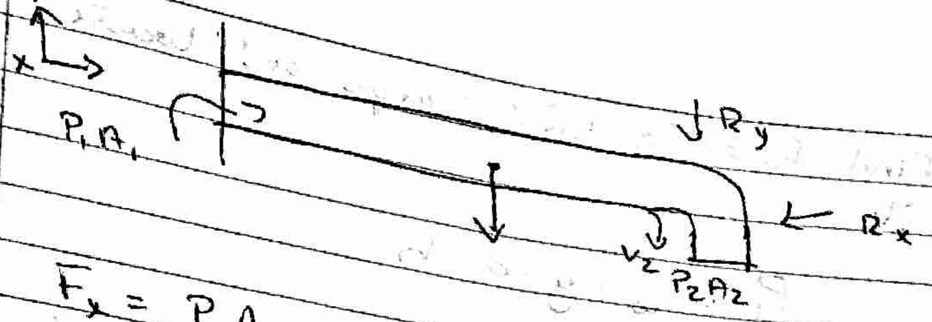
$$\sqrt[3]{(6.1172)^4}$$

$$y = 11.187 \ ft$$



Solve for forces in whole system

C



$$F_x = P_1A_1 - R_x = \rho Q(v_{1x})$$

$$R_x = P_1A_1 \, \rho Q\left(-\frac{Q}{A_1}\right)$$

$$P_1A_1 + \rho \frac{Q^2}{A_1}$$

$$= 6667.198(.01414)(1.94)\left(\frac{.167^2}{.01414}\right)$$

$$\boxed{F_x = 98.1 \text{ lb}}$$

$$F_y : P_2A_2 - R_y - w = \rho Q(-v_{2y})$$

$$-R_y - \frac{\rho g}{A_1 l} = \rho Q(Q/A_2)$$

$$R_y = \frac{1.94(32.2)}{.01414(300)} + 1.94\left(\frac{1.67^2}{.01414}\right)$$

$$\boxed{F_y = -10.89 \text{ lb}}$$

D Find forces in blind flange and locate it.

$$P_f = \rho_w \cdot g \cdot a \cdot h$$

$a = \pi/4 \, \phi^2$

$a = 1.767 \, in^2$

$$P_f = 28.316 \cdot 32.17 \cdot \frac{1.767 in^2}{12^2} \cdot 3 ft$$

$$P_f = 33.53 \; kg \cdot ft/s^2$$

E What is largest hickory that can travel in the open channel

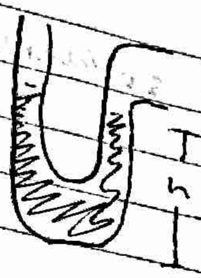
cross section = B·B

$$(B \cdot B) L \cdot \rho_d \cdot g = (B \cdot y) L \cdot \rho_w \cdot g$$

$$y/B = \frac{\rho_d}{\rho_w} \quad y = .83B$$

Yes, it is stable.

f



sg Mercury = 13.54
Sw γ = 847

Find dimension in U-tube to ~~work properly~~

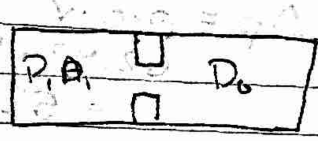
$Pd = \gamma h$
$Pd = P_1 = 46.2$ psi

$\frac{6652.8}{847} = \frac{847h}{847}$

$h = 7.85$ ft

G What is pressure drop across the nozzle

$\phi = .1342$
$L = 300$ft
$T_w = 60°F$
$V = 75$ gal/min



$$\Delta P = \frac{1}{2}\rho(1-\beta^4)\left(\frac{Q}{D_c A_o Y}\right)^2$$

$\beta = D_o / D_1$

$$= \frac{1}{2}(1000)(1-2.72^4)\left(\frac{.167}{.5 \cdot .0414 \cdot 11.19}\right)^2$$

$= -75.04$ psi

h Find cavitation if valve is shut suddenly

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

$$c = \frac{\sqrt{\frac{316000}{62.42}}}{\sqrt{1 + \frac{316000 \cdot .1342}{4.18 \times 10^9 \cdot .12}}}$$

$$c = 71.148$$

$$\Delta p = \rho \cdot c \cdot v$$
$$62.42 \cdot 71.148 \cdot 11.81$$
$$= 52{,}448.89 = 364.09 \text{ psi}$$

There is a possibility of cavitation

Sources: Youtube, Lectures, Textbook

Design Consideration

- $\text{Water}_T = 60°F$
- Incompressible fluid
- friction
- steady state

Summary

Air pressure required in tank above the water is 46.2 psi.

Depth of water is 11.187 ft in the open channel.

Forces in the x direction is 98.1 lbs and the force in the y direction is -10.89 lb.

The force in the blind flange is 83.53 kg ft/s²
located in the 3ft down from
Surface of the fluid.

The largest hickory wood is y = .833
and will be stable.

The dimension of the U-tube is
7.85 ft.

The pressure drop to a .5 φ is
-75.04 psi.

Cavitation is possible w/ Δp = 52.148 = 346 psi

Analysis:

The design will work ✓