96

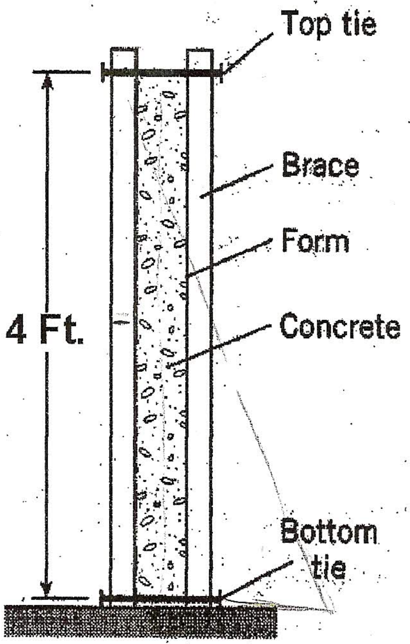
ENCE 3318
PRINCIPLES OF HYDRAULICS

TEST 2

20

1. Assume that wet concrete ($\gamma = 150$ lbf/ft^3) behaves as a liquid. Determine the force per unit foot of length exerted on the forms. If the forms are held in place as shown, with ties between vertical braces spaced every 3 ft, what force is exerted on the bottom tie?

$p = \gamma d$



$F = pA$

$F = 150(2)(4)(3)$

$F = 3600\ \text{lb}_f$

$y_{cp} = 4\left(\frac{2}{3}\right) = \frac{8}{3} = 2.667$

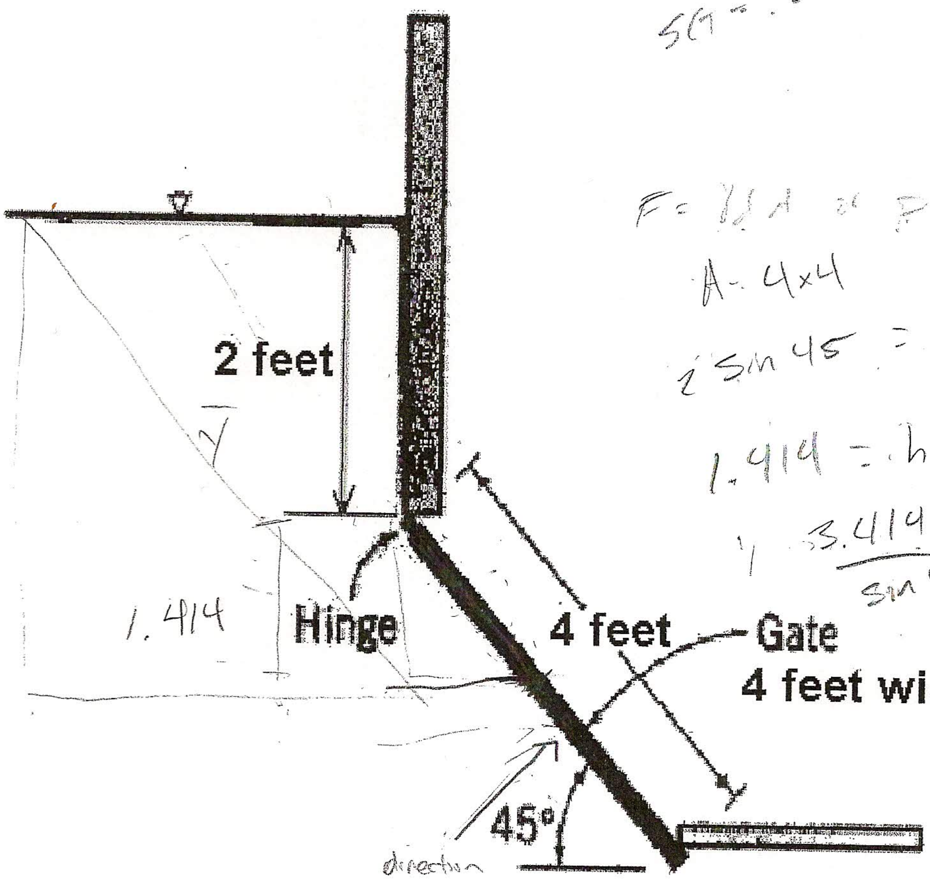
$\circlearrowleft M = 0 = [-(3600)(2.667) + 4F_B]$

$F_B = \left[\frac{(3600)(2.667)}{4}\right]$

$F_B = 2400.3\ \text{lb}_f$

✓

2. Find the magnitude, direction, and line of action of the force exerted by the liquid on the 4 ft by 4 ft gate. The liquid is oil with a specific gravity of 0.8.



$F = \gamma \bar{h} A$

$A = 4 \times 4$

$2 \sin 45 = h$

$1.414 = h$

$\frac{3.414}{\sin 45} = \bar{y}$

$F_r = .8(62.4)(2+1.414)(4\times4)$

$F_r = 2726.88$ lbs

$\sin 45 = \frac{3.414}{\bar{y}}$

$\bar{y} = 4.828$ ft

$y_{cp} = \frac{I_{xx}}{\bar{y}A} + \bar{y}$

$y_{cp} = \frac{21.33}{(4.828)(4\times4)} + 4.828$

$I_{xx} = \left(\frac{1}{12}\right) 4 \times 4^3$

$I_{xx} = 21.33$

$y_{cp} = 5.104$ ft

angle = 45°

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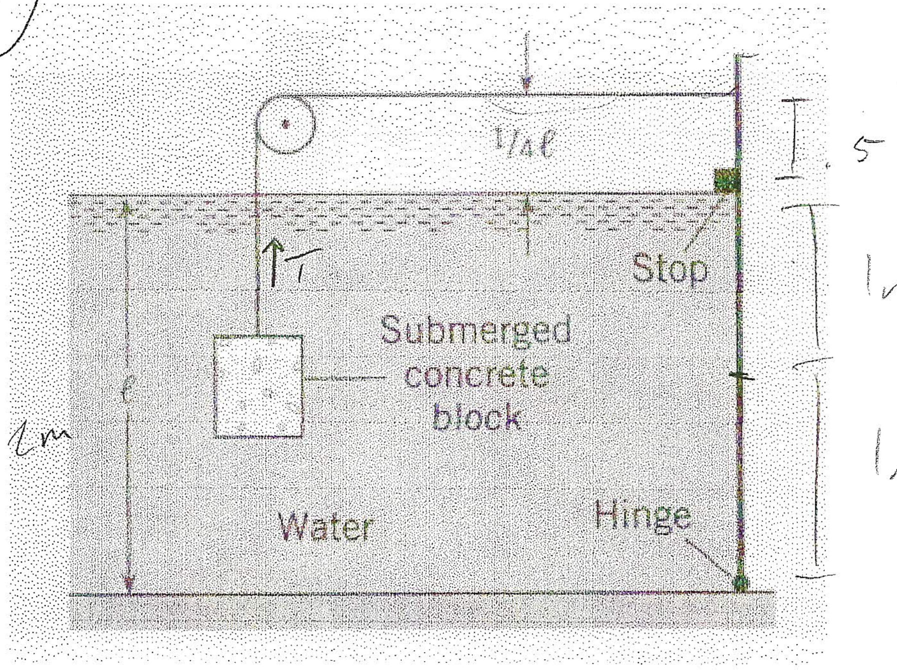
3. Determine the minimum volume of concrete ($\gamma = 23.6\ \text{kN/m}^3$ in air) needed to keep the gate (2 m wide) in a closed position; $\ell = 2$ m. Note the hinge at the bottom of the gate.



$F = pA = (9810)(1)(2\times 2)$

$F = 39240\ N$

$y = 2\left(\frac{1}{3}\right) = \frac{2}{3}$

$\Sigma M_H = 0 = -39240\,m\left(\frac{2}{3}\right) + 2.5T$

$T = 10464\ N$

Concrete

$\uparrow \Sigma F_y = 0 \rightarrow T - W = 0 \quad W = T$

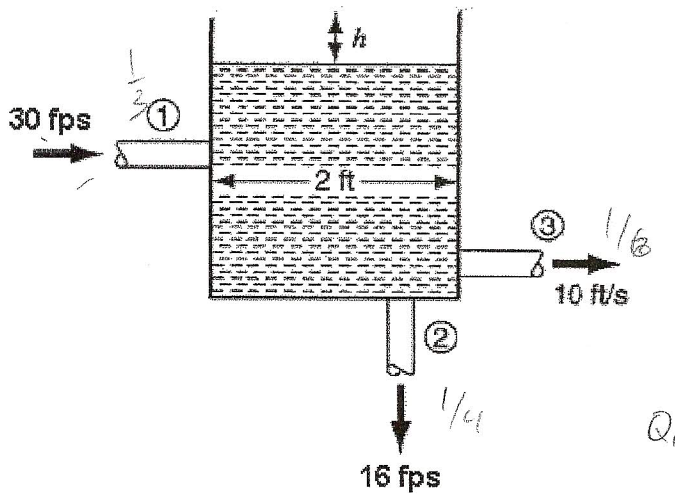
$W = 10464\ N$

$V = \dfrac{10464}{(23600 - 9810)}$

$V = .7588\ m^3$ ✓

(20)

4. Water flows into a cylindrical tank at a steady velocity of 30 ft/s through pipe 1 and leaves through pipes 2 and 3 at rates of 16 ft/s and 10 ft/s, respectively. Determine the rate of change of the free surface (indicate if it is going up or down). $D_1 = 4$ in.; $D_2 = 3$ in.; $D_3 = 2$ in.



$4 \text{ in} = \frac{4 \text{ in} \cdot 1 \text{ ft}}{12 \text{ in}}\ 3 = \frac{1}{3} \text{ ft}$

$3 = \frac{3 \text{ in} \cdot 1 \text{ ft}}{12 \text{ in}}\ 4 = \frac{1}{4} \text{ ft}$

$2 = \frac{2 \text{ in} \cdot 1 \text{ ft}}{12 \text{ in}} = \frac{1}{6} \text{ ft}$

$Q_{in} = 30\left(\frac{\pi\left(\frac{1}{3}\right)^2}{4}\right) = 2.618 \text{ ft}^3/\text{s}$

$Q_{out} = 16\left(\frac{\pi\left(\frac{1}{4}\right)^2}{4}\right) + 10\left(\frac{\pi\left(\frac{1}{6}\right)^2}{4}\right) =$

$= .7853 + .2182 = 1.003 \text{ ft}^3/\text{s}$

because $Q_{in} > Q_{out}$ then water rises

$V = \frac{2.618 - 1.003 \text{ ft}^3/\text{s}}{\frac{\pi(2)^2}{4} \text{ ft}^2}$

$V = 1.514 \text{ ft/s}$

✓

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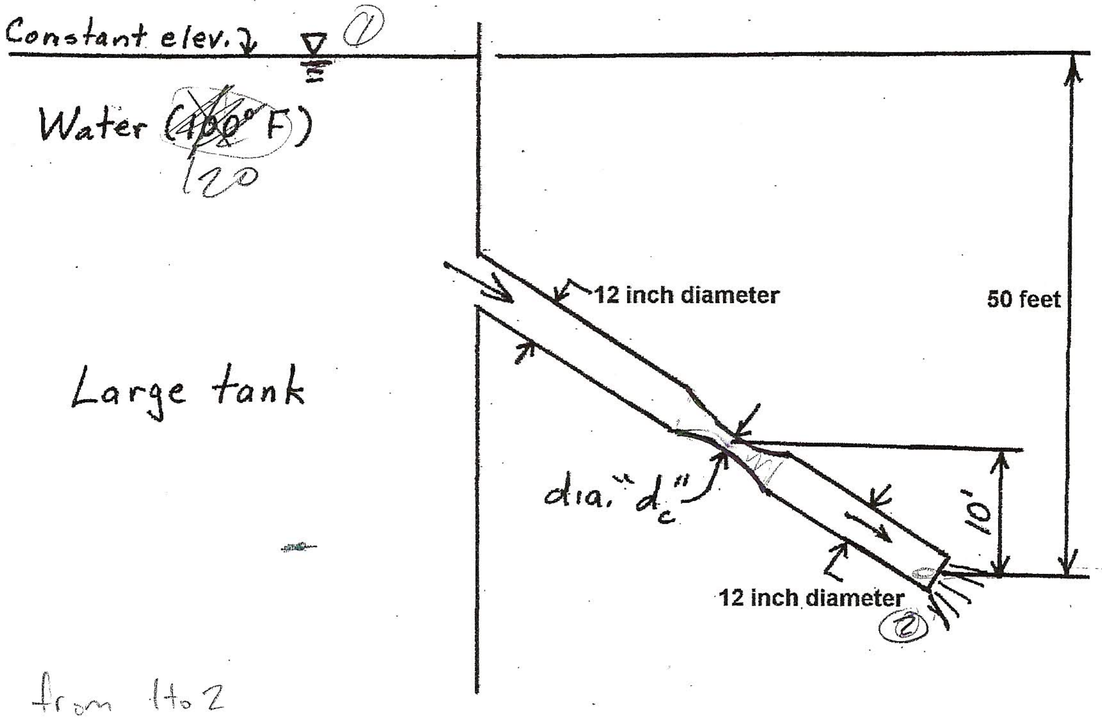
5. For the situation shown below, what diameter of constriction can be expected to produce incipient cavitation at the throat of the constriction? Water at 120°F is discharging into the atmosphere which has a barometric pressure of 14.0 psia. Assume that there is no energy losses. Give your answer in inches.



from 1 to 2

$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$$

$$\frac{14 \times 144}{62.4} + 50 = \frac{14 \times 144}{62.4} + \frac{V_2^2}{2g}$$

$$\sqrt{V_2^2} = \sqrt{50(2g)}$$

$V_2 = 56.75$ ft/s

$Q_2 = A_2 V_2 = (\pi/4 (12)^2)(56.75)$

$Q_2 = 44.57$ ft³/s

From 1 to 3

$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{P^2}{\gamma} + z_3 + \frac{V_3^2}{2g} = \frac{14 \times 144}{62.4} + 50 = \frac{1.69 \times 144}{61.71} + 10 + \frac{V_3^2}{2g}$$

$V_3 = \sqrt{(82.31 - 12.22)\, 2g}$

$V_3 = 66.36$ ft/s

$Q = A_3 V_3$

$A_3 = \frac{Q}{V_3}$

$\frac{44.57}{66.36}$

$A_3 = .672$ ft²

$d_c = \sqrt{(4/\pi)(.672)} = .925$

$= .925 \times 12 = 11.10$ in