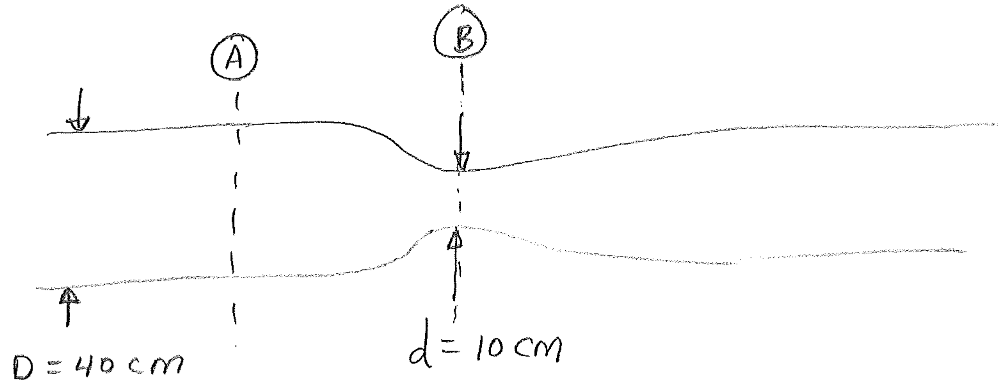
5.75



GIVEN: WATER AT 10°C FLOW THROUGH A VENTURI. $p_{AMB} = 100$ kPa ABSOLUTE AND $p_A = 120$ kPa GAGE.

FIND: FLOW RATE AT WHICH CAVITATION WILL OCCUR.

SOLUTION: APPLY BERNOULLI EQN. FROM A TO B.

$$p_A + \cancel{\gamma z_A} + \frac{1}{2}\rho V_A^2 = p_B + \cancel{\gamma z_B} + \frac{1}{2}\rho V_B^2$$

$p_A = 220$ kPa ABSOLUTE. $p_B = 1.23$ kPa ABSOLUTE (TABLE A.5)

$$V_A = \frac{Q}{A_A}, \quad V_B = \frac{Q}{A_B} \qquad A_A = \frac{\pi}{4}D^2, \quad A_B = \frac{\pi}{4}d^2$$

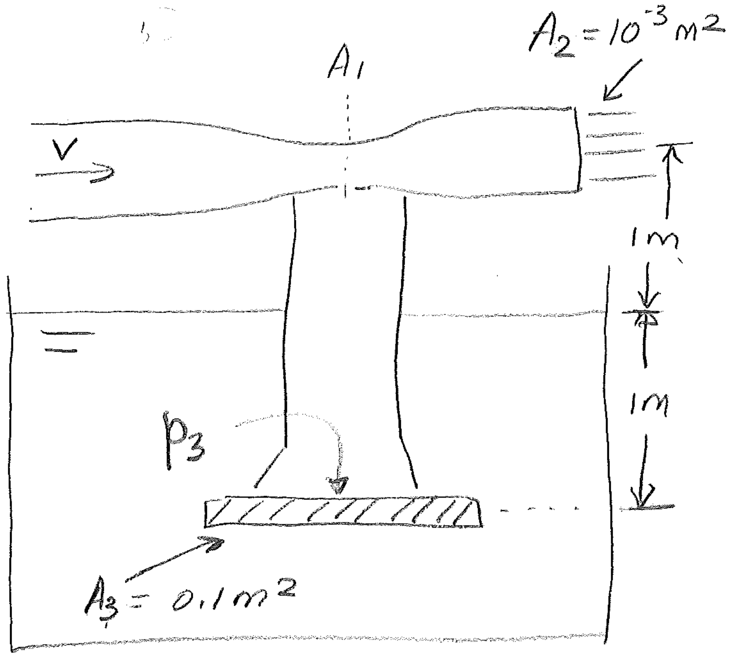
$$\frac{1}{2}\rho Q^2\left(\frac{1}{A_B^2} - \frac{1}{A_A^2}\right) = p_A - p_B$$

$$Q = \left[\frac{2(p_A - p_B)}{\rho}\,\frac{1}{\left(\frac{1}{A_B^2} - \frac{1}{A_A^2}\right)}\right]^{\frac{1}{2}}$$

$$Q = \left[\frac{2\,(220{,}000 - 1230)}{1000}\,\frac{1}{\left(\frac{16}{\pi^2(.1)^4} - \frac{16}{\pi^2(.4)^4}\right)}\right]^{\frac{1}{2}}$$

$$\boxed{Q = 0.165\ \text{m}^3/\text{s}}$$

5.78 GIVEN:



WATER AT 15°C FLOWS THROUGH A SUCTION DEVICE. $\frac{A_1}{A_2} = \frac{1}{4}$

p_{AMB} = 100 kPa ABS.

FIND:

(a) V_2 FOR MAXIMUM SUCTION.

(b) Q FOR MAXIMUM SUCTION.

(c) MAXIMUM LOAD THAT CAN BE SUPPORTED.

SOLUTION: (a) MAXIMUM SUCTION WILL OCCUR AS THE PRESSURE AT A_1 APPROACHES THE VAPOR PRESSURE. $\Rightarrow p_1 = 1{,}700$ Pa ABS.

$$p_1 + \cancel{\gamma z_1} + \frac{1}{2}\rho V_1^2 = p_2 + \cancel{\gamma z_2} + \frac{1}{2}\rho V_2^2$$

1700 Pa ABS $\qquad\qquad$ p_{AMB} = 100 kPa ABS

$$\frac{1}{2}\rho\left(V_2^2 - V_1^2\right) = p_1 - p_2$$

$$Q_1 = Q_2 \rightarrow A_1 V_1 = A_2 V_2 \rightarrow V_1 = \frac{A_2}{A_1} V_2$$

$$\frac{1}{2}\rho V_2^2\left[1 - \left(\frac{A_2}{A_1}\right)^2\right] = p_1 - p_2$$

$$V_2 = \sqrt{\frac{2(p_1 - p_2)}{\rho\left[1 - \left(\frac{A_2}{A_1}\right)^2\right]}}$$

$$V_2 = \sqrt{\frac{2(1700 - 100{,}000)}{999\left[1 - 4^2\right]}} = 3.62\ \frac{m}{s}$$

5.78 CONTINUED

(b) $Q = V_2 A_2$

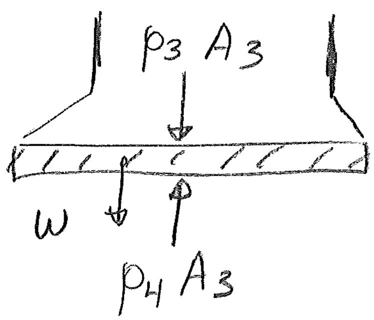
$$Q = \left(3.62\ \frac{m}{s}\right)\left(10^{-3}\ m^2\right)$$

$$\boxed{Q = 3.62 \times 10^{-3}\ \frac{m^3}{s}}$$

(c) $$\frac{p_3}{\gamma} + \cancel{z_3}^{\,0} = \frac{p_1}{\gamma} + \cancel{z_1}^{\,2m}$$

$$p_3 = p_1 + \gamma z_1 = 1700\ Pa + \left(9800\ \frac{N}{m^3}\right) 2m$$

$$p_3 = 21{,}300\ Pa \quad \text{ABS.}$$



$$W = (p_4 - p_3) A_3$$

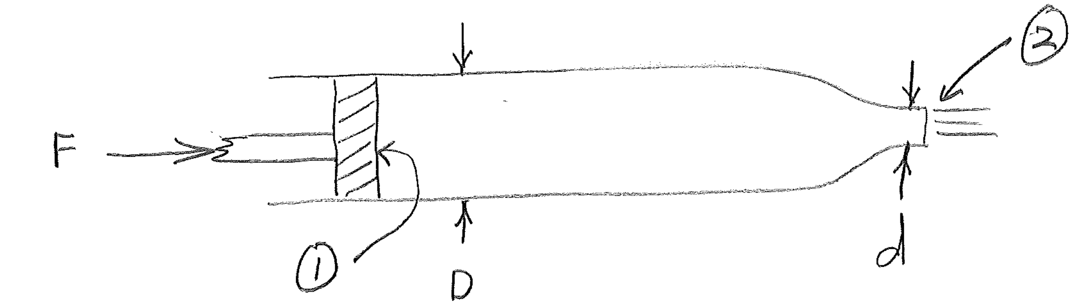
$$p_4 = 100{,}000\ Pa + \left(9800\ \frac{N}{m^3}\right) 1m$$

$$p_4 = 109{,}800\ Pa$$

$$W = (109{,}800 - 21{,}300)\ 0.1$$

$$\boxed{W = 8850\ N}$$

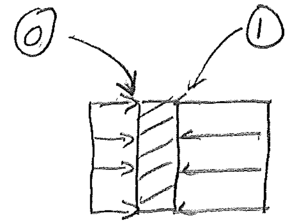
5.80 GIVEN: WATER CANON AS SHOWN.



$V_{PISTON} = 5$ FT/S , $D = 4$ IN. , $d = 2$ IN.

FIND: FORCE TO MOVE PISTON

SOLUTION: $p_0 = 0$ GAGE



$$F = p_1 A_{PISTON} = \frac{\pi}{4} D^2 p_1$$

APPLY BERNOULLI FROM ① TO ② TO FIND p_1.

$$p_1 + \frac{1}{2}\rho V_1^2 + \cancel{\gamma z_1} = \overset{0 \text{ GAGE}}{\cancel{p_2}} + \frac{1}{2}\rho V_2^2 + \cancel{\gamma z_2}$$

HORIZONTAL WATER GUN

$$p_1 = \frac{1}{2}\rho\left(V_2^2 - V_1^2\right)$$

V_1 IS GIVEN. USE CONSERVATION OF MASS TO FIND V_2: $V_2 = \frac{A_1}{A_2} V_1$

$$p_1 = \frac{1}{2}\rho V_1^2\left(\frac{A_1^2}{A_2^2} - 1\right) = \frac{1}{2}\rho V_1^2\left(\frac{D^4}{d^4} - 1\right)$$

$$p_1 = \frac{1}{2}(1.94)(5)^2(16-1) = 364 \text{ PSFG} = 2.53 \text{ PSIG}$$

$$F = \frac{\pi}{4}(4)^2(2.53) = 31.7 \text{ LBf}$$

$$\boxed{F = 31.7 \text{ LBf}}$$