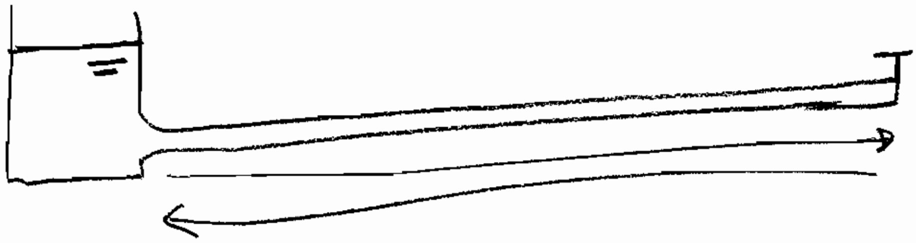
6.92

GIVEN: 20 cm DIAMETER RIDGID PIPE CARRYING 0.15 m^3/s OF WATER. THE VALUE IS CLOSED AND A COMPLETE CYCLE OF PRESSURE FLUCTUATIONS OCCURS IN 3 S.

FIND: PIPE LENGTH

SOLUTION:



A COMPLE CYCLE OF PRESSURE FLUCTUATIONS WILL OCCUR AT:

$$t = \frac{4L}{c} \Rightarrow L = \frac{tc}{4}$$ (SEE FIGURE 6.6)

$$C = \sqrt{\frac{E_v}{\rho}}$$

$$E_V = 2.2 \times 10^9 \ \frac{N}{m^2}$$ (PAGE 23, TEXT)

$$\rho = 998 \ \frac{kg}{m^3}$$

$$C = 1485 \ \frac{m}{s}$$

$$\boxed{L = 1114 \ m}$$

6.93

GIVEN; RIDGID PIPE WITH WATER FLOW AT 8 FT/S.

$L = 5$ MILES, AND A VALVE

THAT CLOSES IN 10 S.

FIND: MAXIMUM WATER HAMMER PRESSURE

SOLUTION: CHECK TO SEE IF 10 S IS LESS THAN OR GREATER THAN CRITICAL TIME OF CLOSURE.

E_v FOR WATER IS FOUND ON PAGE 23 OF TEXT

$$C = \sqrt{\frac{E_v}{\rho}} = \sqrt{\frac{320{,}000 \text{ PSI} \times 144 \frac{\text{IN}^2}{\text{FT}^2}}{1.94 \frac{\text{SLUGS}}{\text{FT}^3}}}$$

$$C = 4874 \text{ FT/S}$$

$$t_c = \frac{2L}{c} = \frac{(10 \text{ MILES})(5280 \frac{\text{FT}}{\text{MILE}})}{4874 \text{ FT/S}}$$

$$t_c = 10.8 \text{ SECONDS}$$

$t < t_c$ SO ESTIMATE WATER HAMMER PRESSURE AS:

$$\Delta p = \rho V c$$

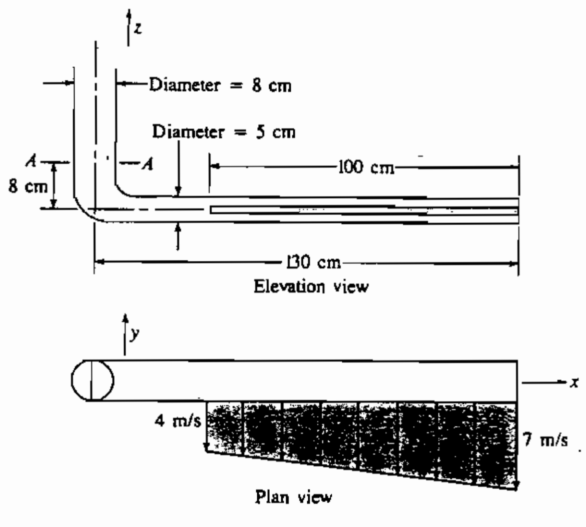
$$\Delta p = (1.94)(8)(4874) = 75{,}600 \text{ PSF}$$

$$\boxed{\Delta p = 525 \text{ PSI}}$$

6.98(1)

4

GIVEN: WATER DISCHARGING FROM SLOT IN PIPE AS SHOWN.



PROBLEM 6.95

FIND: REACTION FORCE AT SECTION A-A.

SOLUTION:

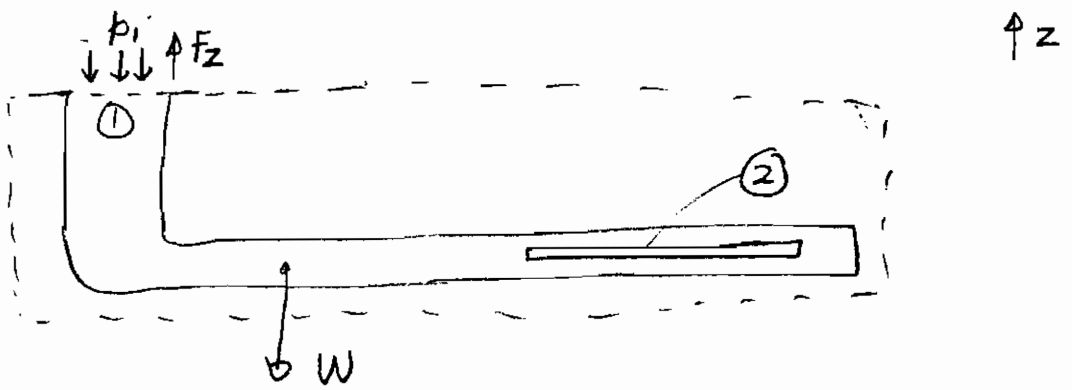
DRAW CONTROL SURFACE AS SHOWN ABOVE.

USE CONSERVATION OF MOMENTUM.

X - COMPONENT

$$F_x + 0 = 0 + 0 \qquad \boxed{F_x = 0}$$

Z - COMPONENT



6,98 (2)

$$-p_1 A_1 + F_z - W = -V_{1z}\,\dot{m} + 0$$

IN OUT

CONSERVATION OF MASS $\dot{m}_1 = \dot{m}_2$, $Q_1 = Q_2$

$$V_1 = \frac{A_2}{A_1} V_2 \qquad A_2 = (1\,m)(.015\,m) = 0.015\,m^2$$

$$A_1 = \frac{\pi}{4} D^2 = \frac{\pi}{4}(.08)^2 = 0.00503\,m^2$$

$V_2 \rightarrow$ MEAN VELOCITY OF WATER DISCHARGING THROUGH SLOT

$$V_2 = \frac{4\,m/s + 7\,m/s}{2} = 5.5\,m/s$$

$$V_1 = 16.4\,m/s$$

$V_{1z} = -16.4\,m/s$ (WATER IS FLOWING IN $-Z$ DIRECTION).

$$F_z = p_1 \frac{\pi}{4} D^2 + \gamma \underbrace{\left[1.3\left(\frac{\pi}{4}\right)(.05)^2 + 0.08\left(\frac{\pi}{4}\right)(.08)^2\right]}_{W} + 16.4\,\dot{m}$$

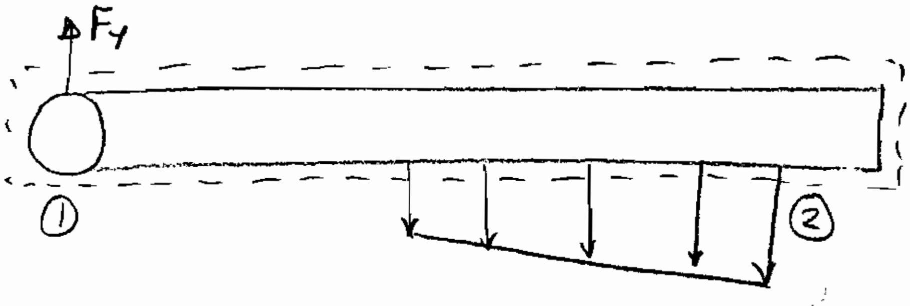
$$F_z = 151\,N + 30\,N + (16.4)^2\, 998\, \frac{\pi}{4}(.08)^2$$

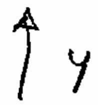
$$F_z = 151\,N + 30\,N + 1349\,N$$

$$\boxed{F_z = 1530\,N}$$

6.98 (3)

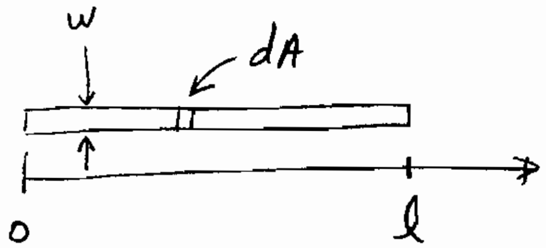
Y- COMPONENT





$$F_y + 0 = \int_{A_2} \rho V_{y2}\, \underset{\sim}{V} \cdot d\underset{\sim}{A} + 0$$

OUTFLOW INFLOW



$w = 0.015\ m$

$\ell = 1\ m$

$V_{y2}(0) = -4\,m/s \qquad V_{y2}(\ell) = -7\,m/s$

$V_{y2} = -(4\,m/s + 3s^{-1}\ell)$

$\underset{\sim}{V} \cdot d\underset{\sim}{A} = V\,w\,d\ell = (4\,m/s + 3s^{-1}\ell)\,w\,d\ell$

$F_y = -\rho w \int_0^1 (4 + 3\ell)^2\, d\ell$

$F_y = -\rho w \int_0^1 (16 + 24\ell + 9\ell^2)\, d\ell$

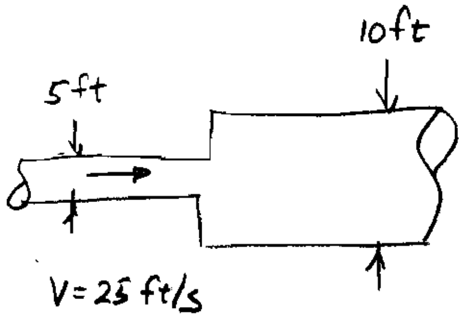
$F_y = -\rho w \left(16\ell + 12\ell^2 + 3\ell^3\right)\Big|_0^1$

$F_y = -\left(998\,\frac{kg}{m^3}\right)(0.015\,m)\left(31\,\frac{m^3}{s^2}\right)$

$\boxed{F_y = -464\ N}$

7.51 (1)

GIVEN: ABRUPT EXPANSION AS SHOWN. $p_1 = 5$ PSIG



FIND: (a) POWER LOST IN EXPANSION

(b) p_2

(c) THE FORCE REQUIRED TO HOLD THE EXPANSION IN PLACE

(d) DRAW THE HGL & EGL

(a) $$h_L = \frac{(V_1 - V_2)^2}{2g}$$ HEAD LOSS (FRICTIONAL LOSSES)

CONVERT h_L TO POWER (SEE PAGE 279, TEXT)

$$\dot{W}_L = \dot{m}\, g\, h_L$$

$$V_2 = \frac{A_1}{A_2} V_1 = \frac{1}{4} V_1 \qquad V_2 = \frac{25}{4} \text{ ft/s}$$

$$h_L = \frac{\left(25 - \frac{25}{4}\right)^2}{2\,(32.2)} = 5.46 \text{ FT}$$

$$\dot{m} = \rho A_1 V_1 = (1.94)\frac{\pi}{4}(5)^2(25) = 952 \ \frac{\text{SLUGS}}{\text{S}}$$

$$\dot{W}_L = (952)(32.2)(5.46) = 1.67 \times 10^5 \ \frac{\text{FT-LBF}}{\text{S}}$$

$$\dot{W}_L = \frac{1.67 \times 10^5}{550} \text{ hp} = 304 \text{ hp} \qquad \boxed{\dot{W}_L = 304 \text{ hp}}$$

7.51 (2)

(b) USE EXTENDED BERNOULLI TO FIND p_2.

$$\frac{p_1}{\gamma} + \cancel{z_1} + \underbrace{\alpha_1}_{\approx 1} \frac{V_1^2}{2g} = \frac{p_2}{\gamma} + \cancel{z_2} + \underbrace{\alpha_2}_{\approx 1} \frac{V_2^2}{2g} + h_L$$

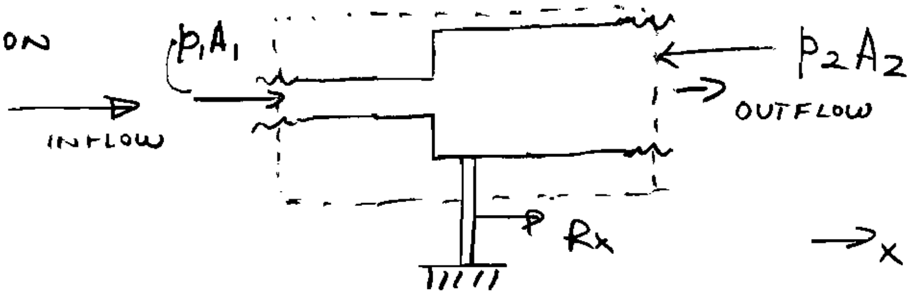
$$p_2 = p_1 + \tfrac{1}{2}\rho\left(V_1^2 - V_2^2\right) - \gamma h_L$$

$$p_2 = 5 \text{ PSIG} + \tfrac{1}{2}(1.94)\left[(25)^2 - \left(\tfrac{25}{4}\right)^2\right] - (62.3)(5.46)$$

$$p_2 = 5 \text{ PSIG} + 3.95 \text{ PSI} - 2.36 \text{ PSI}$$

$$\boxed{p_2 = 6.59 \text{ PSIG}}$$

(c) USE CONSERVATION OF MOMENTUM TO FIND R_x.



$$\sum F_x = -\dot{m} V_{1x} + \dot{m} V_{2x}$$

$$R_x + p_1 A_1 - p_2 A_2 = \dot{m}\left(V_2 - V_1\right)$$

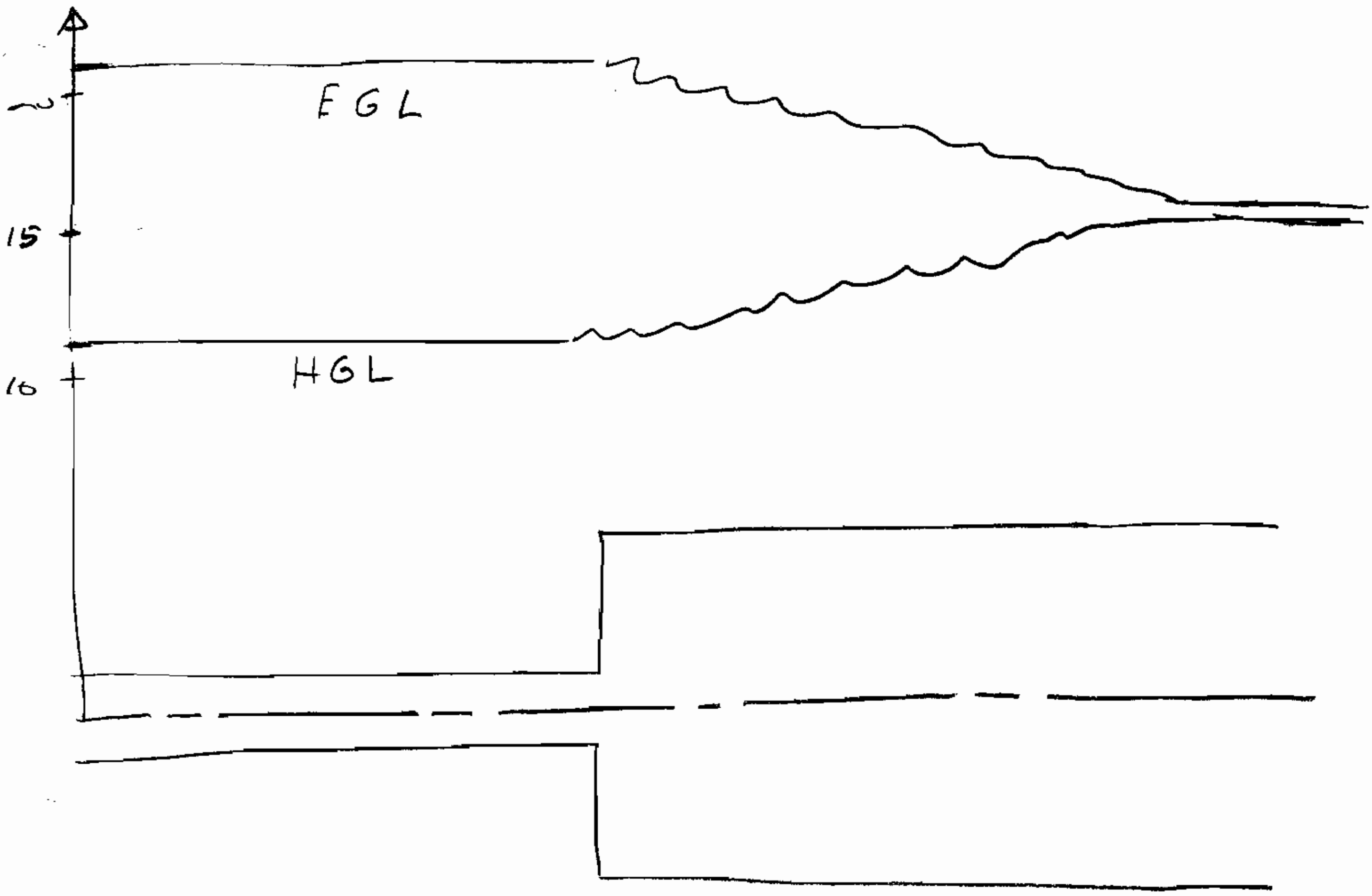
$$R_x = p_2 A_2 - p_1 A_1 + \dot{m}\left(V_2 - V_1\right)$$

$$R_x = (6.59)\left(\tfrac{\pi}{4}\right)(10 \times 12)^2 - (5)\left(\tfrac{\pi}{4}\right)(5 \times 12)^2 + 952\left(\tfrac{25}{4} - 25\right)$$

$$R_x = 75{,}531 \text{ LBf} - 14{,}137 \text{ LBf} - 18{,}088 \text{ LBf}$$

$$\boxed{R_x = 42{,}300 \text{ LBf}}$$

7.51 (3) (d) DRAW HGL & EGL



$$\frac{p_1}{\gamma} = \frac{5\,(144)}{62.4} = 11.5 \text{ FT}$$

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} = 21.2 \text{ FT}$$

$$\frac{p_2}{\gamma} = 15.2 \text{ FT}$$

$$\frac{p_2}{\gamma} + \frac{V_2^2}{2g} = 15.8 \text{ FT}$$