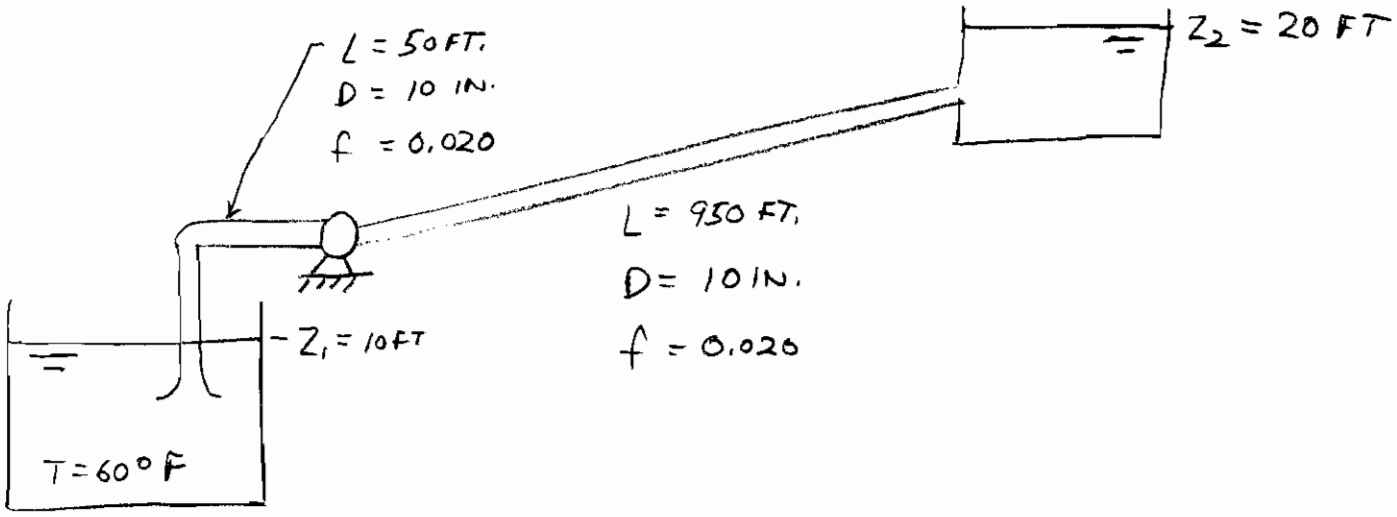
10.86 SOLVED IN CLASS

10.89



GIVEN: FLOW SYSTEM AS SHOWN.

PUMP CURVE ON ATTACHED PAGE.

FIND: FLOW RATE

SOLUTION: APPLY PIPE FLOW ENERGY EQUATION FROM ① TO ②.

$$Z_1 + h_p = Z_2 + h_L$$

ENTRANCE, BEND, SUDDEN EXPANSION

$$h_p = Z_2 - Z_1 + \frac{V^2}{2g}\left[f\left(\frac{L}{D}\right) + K_e + K_b + 1\right]$$

$$V = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

10.89 (2)

$$h_p = 10\ FT + \frac{8Q^2}{\pi^2 g D^4}\left[0.020\left(\frac{1000}{10/12}\right) + 0.03 + 0.20 + 1\right]$$

$$h_p = 10\ FT + \frac{8}{\pi^2(32.2)\left(\frac{10}{12}\right)^4} Q^2 \left[25.23\right]$$

$$h_p = 10\ FT + 1.317\ \frac{S^2}{FT^5}\ Q^2$$

$Q = 1000\ gpm = 2.228\ \frac{FT^3}{S}$ $\quad h_p = 16.5\ FT$

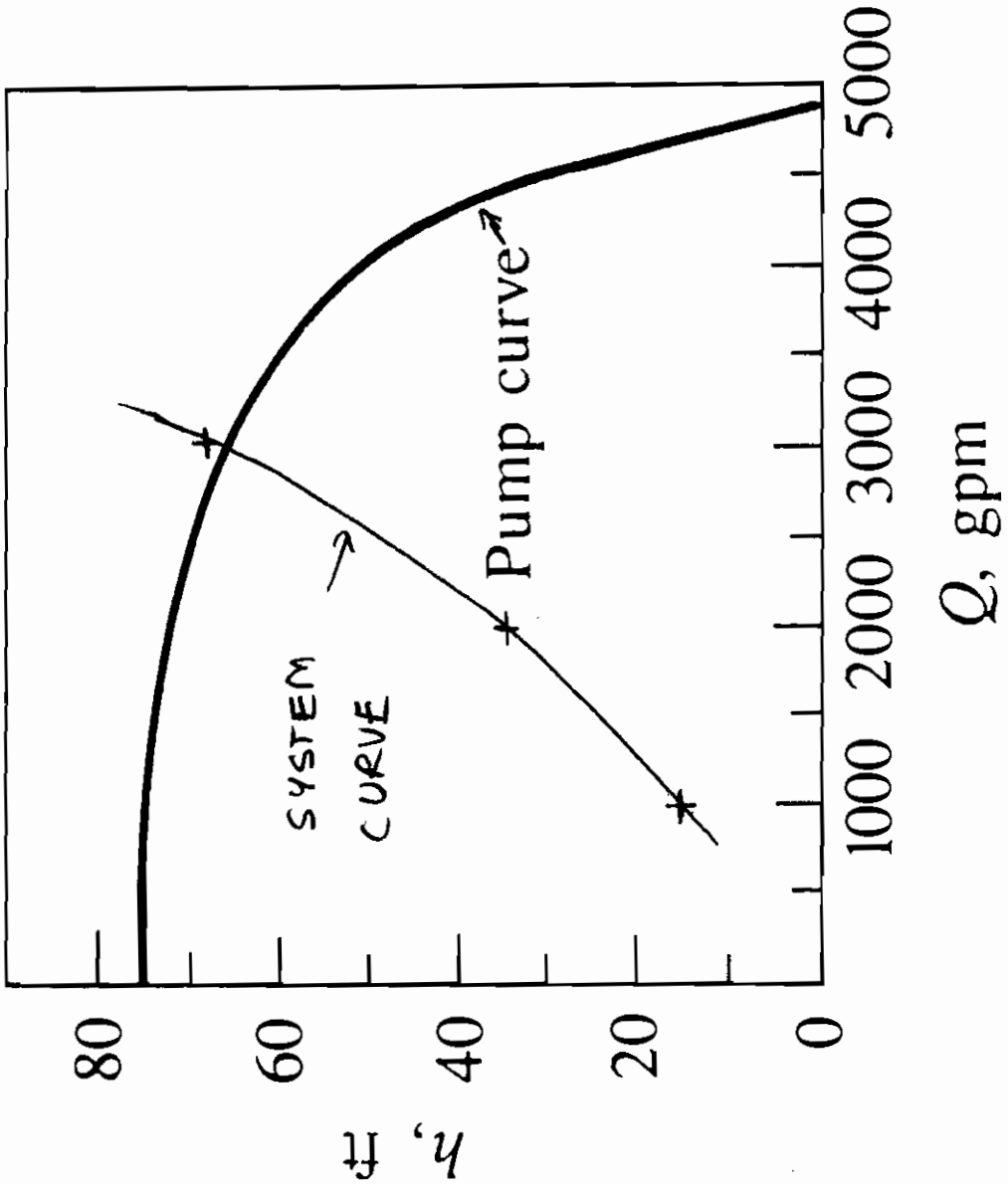
MARK THIS POINT ON GRAPH WITH PUMP CURVE (NEXT PAGE).

$Q = 2000\ gpm = 4.456\ \frac{FT^3}{S}$ $\quad h_p = 36.1\ FT$

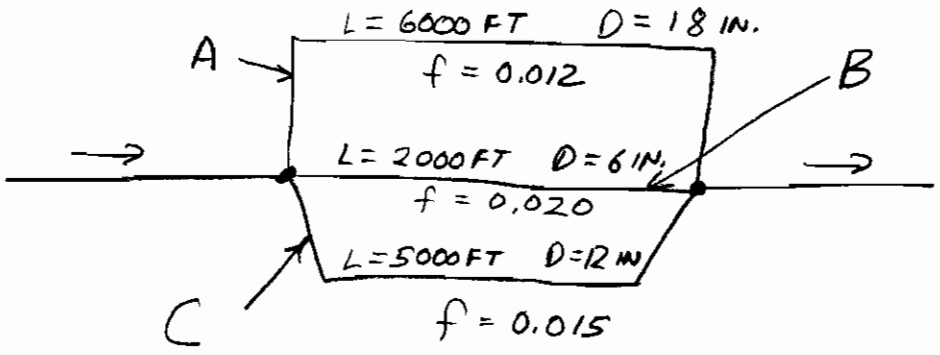
$Q = 3000\ gpm = 6.684\ \frac{FT^3}{S}$ $\quad h_p = 68.8\ FT$

FROM GRAPH IT IS CLEAR THAT THE SYSTEM WILL OPERATE AT JUST UNDER 3000 gpm.

10.89 (3)


h, ft
80
60
40
20
0
1000 2000 3000 4000 5000
Q, gpm
Pump curve
SYSTEM CURVE

10.109



GIVEN: PIPES IN PARALLEL AS SHOWN

FIND: PIPE WITH GREATEST VELOCITY

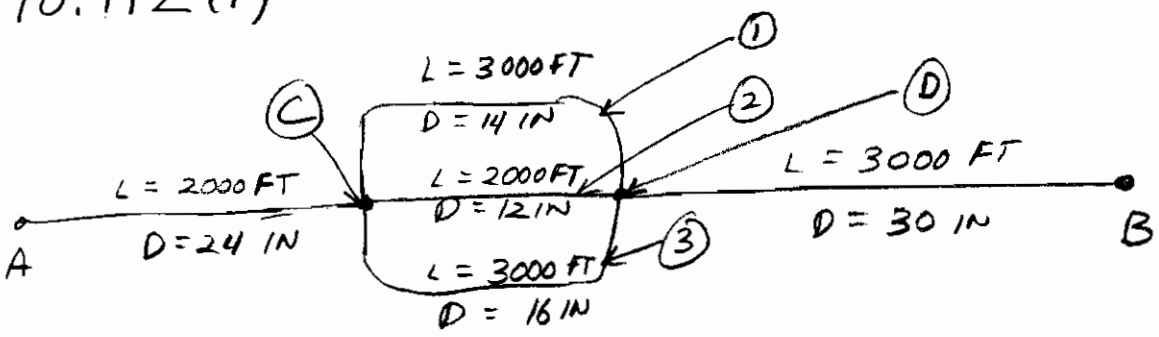
SOLUTION: $h_{LA} = h_{LB} = h_{LC}$

$$\frac{V_A^2}{2g} f_A \left(\frac{L_A}{D_A}\right) = \frac{V_B^2}{2g} f_B \left(\frac{L_B}{D_B}\right) = \frac{V_C^2}{2g} f_C \left(\frac{L_C}{D_C}\right)$$

$$48 V_A^2 = 80 V_B^2 = 75 V_C^2$$

PIPE A HAS THE GREATEST VELOCITY.

10.112 (1)



GIVEN: PIPES IN PARALLEL AS SHOWN.

$f = 0.030$ FOR ALL PIPES.

$Q_A = 25$ CFS

FIND: h_L FROM A TO B.

DIVISION OF FLOW IN PIPES.

FIRST FIND Q_1, Q_2, AND Q_3.

$$h_{L1} = h_{L2} = h_{L3}$$

$$\frac{V_1^2}{2g} f \left(\frac{L_1}{D_1}\right) = \frac{V_2^2}{2g} f \left(\frac{L_2}{D_2}\right) = \frac{V_3^2}{2g} f \left(\frac{L_3}{D_3}\right)$$

$$V = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

$$\frac{16 Q_1^2}{\pi^2 D_1^4}\left(\frac{L_1}{D_1}\right) = \frac{16 Q_2^2}{\pi^2 D_2^4}\left(\frac{L_2}{D_2}\right) = \frac{16 Q_3^2}{\pi^2 D_3^4}\left(\frac{L_3}{D_3}\right)$$

$$\frac{Q_1^2 L_1}{D_1^5} = \frac{Q_2^2 L_2}{D_2^5} = \frac{Q_3^2 L_3}{D_3^5}$$

10.112 (2)

TWO EQUATIONS — 3 UNKNOWNS.

CONSERVATION OF MASS:

$$Q_A = Q_1 + Q_2 + Q_3$$

NOW HAVE 3 EQUATIONS & 3 UNKNOWNS.

① $Q_1 = Q_A - Q_2 - Q_3$

② $Q_1\sqrt{\frac{L_1}{D_1^5}} = Q_2\sqrt{\frac{L_2}{D_2^5}}$ ③ $Q_3\sqrt{\frac{L_3}{D_3^5}} = Q_2\sqrt{\frac{L_2}{D_2^5}}$

COMBINE ① AND ②

④ $(Q_A - Q_2 - Q_3)\sqrt{\frac{L_1}{D_1^5}} = Q_2\sqrt{\frac{L_2}{D_2^5}}$

COMBINE ④ AND ③

$$\left(Q_A - Q_2 - \sqrt{\left(\frac{L_2}{L_3}\right)\left(\frac{D_3^5}{D_2^5}\right)}\,Q_2\right)\sqrt{\frac{L_1}{D_1^5}} = Q_2\sqrt{\frac{L_2}{D_2^5}}$$

$$Q_A\sqrt{\frac{L_1}{D_1^5}} = Q_2\left[\sqrt{\frac{L_2}{D_2^5}} + \sqrt{\frac{L_1}{D_1^5}} + \sqrt{\frac{L_2 L_1}{L_3}\left(\frac{D_3}{D_2 D_1}\right)^5}\right]$$

$$Q_2 = Q_A\sqrt{\frac{L_1}{D_1^5}}\left[\quad\right]^{-1}$$

$$Q_2 = 25\,\text{CFS}\sqrt{\frac{3000}{(14/12)^5}}\left[\frac{1}{\sqrt{\frac{2000}{15}} + \sqrt{\frac{3000}{(14/12)^5}} + \sqrt{\frac{(2000)(3000)}{3000}\left(\frac{16}{12\cdot 14/12}\right)^5}}\right]$$

10.112 (3)

$$\boxed{Q_2 = 6.45 \text{ CFS}}$$

$$Q_3 = Q_2 \sqrt{\frac{L_2}{L_3}\left(\frac{D_3}{D_2}\right)^5} = 6.45 \sqrt{\frac{2000}{3000}\left(\frac{16}{12}\right)^5}$$

$$\boxed{Q_3 = 10.8 \text{ CFS}}$$

$$Q_1 = 25 - 6.45 - 10.8$$

$$\boxed{Q_1 = 7.75 \text{ CFS}}$$

NOW FIND h_L FROM A TO B.

$$h_L = h_{LAC} + h_2 + h_{LDB}$$

$$h_L = \frac{8Q_A^2}{\pi^2 D_A^4 g} f\left(\frac{L_{AC}}{D_A}\right) + \frac{8Q_2^2}{\pi^2 D_2^2 g} f\left(\frac{L_2}{D_2}\right) + \frac{8Q_B^2}{\pi^2 D_B^4 g} f\left(\frac{L_{DB}}{D_B}\right)$$

$$h_L = \frac{8\ 25^2}{\pi^2\ 2^4\ 32.2}(0.030)\left(\frac{2000}{2}\right) + \frac{8\ 6.45^2}{\pi^2\ 1^4\ 32.2}(0.030)\left(\frac{2000}{1}\right) + \frac{8\ 25^2}{\pi^2\ 2.5^4\ 32.2}(0.030)\left(\frac{3000}{2.5}\right)$$

$$h_L = 29.50 \text{ FT} + 62.84 \text{ FT} + 14.50 \text{ FT}$$

$$\boxed{h_L = 107 \text{ FT}}$$