13.9 (1)

GIVEN: VELOCITY TRAVERSE DATA IN 24 cm OIL PIPE.

r, cm	0	1	2	3	4	5	6	7	8	9	10	10.5	11.0	11.5
V, m/s	8.7	8.6	8.4	8.2	7.7	7.2	6.5	5.8	4.9	3.8	2.5	1.9	1.4	0.7

FIND: FLOW RATE, MEAN VELOCITY, AND RATIO OF MAXIMUM TO MEAN. DOES FLOW APPEAR TO BE LAMINAR OR TURBULENT?

SOLUTION: CONDUCT A NUMERICAL INTEGRATION OF

$2\pi r_i V_i$ FROM $r = 0$ TO $r = 12.0$ cm.

SIMPLEST NUMERICAL INTEGRATION IS RECTANGLE RULE:

$$Q = \sum_{i=1}^{14} 2\pi r_i V_i \Delta r_i$$

$$Q = 2\pi \Big[0 + (.01)(.01)(8.6) + (.02)(.01)\,8.4$$

$$+ (.03)(.01)\,8.2 + (.04)(.01)\,7.7 + (.05)(.01)\,7.2$$

$$+ (.06)(.01)\,6.5 + (.07)(.01)\,5.8 + (.08)(.01)\,4.9$$

$$+ (.09)(.01)\,3.8 + (.10)(.01)\,2.5 + (.105)(.005)\,1.9$$

$$+ (.110)(.005)\,1.4 + (.115)(.005)(0.7) \Big]$$

$$Q = 0.1910 \ \frac{m^3}{s}$$

$$\bar{V} = 4.222 \ \frac{m}{s}$$

$$\frac{V_{max}}{\bar{V}} = \frac{8.7 \ \frac{m}{s}}{4.22 \ \frac{m}{s}} = 2.06$$

ALSO CONDUCTED INTEGRATION BY TRAPEZOIDAL PULE (IN PCSOLVE).

$Q = 0.1937 \frac{m^3}{s}$

$\bar{V} = 4.281 \frac{m}{s}$

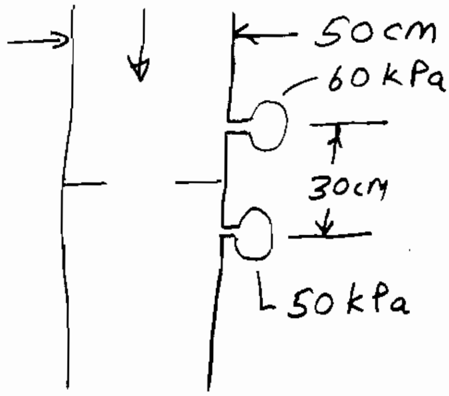
$\frac{V_{MAX}}{\bar{V}} = 2.03$

THE FLOW APREARS TO BE LAMINAR, BECAUSE $\frac{V_{MAX}}{\bar{V}} = 2$ FOR A LAMINAR PIPE FLOW. CF EXAMPLE 7.2 ON PAGE 278, TEXT.

$\frac{V_{MAX}}{\bar{V}} \approx 1.2$ FOR A TURBULENT PIPE FLOW, SEE TABLE 10.1 ON PAGE 414, TEXT.

13.26

GIVEN: WATER (20°C) FLOWING THROUGH THIS 10 cm ORIFICE.



FIND: FLOW RATE

SOLUTION: $Q = K A_0 \sqrt{2g\left[\left(\frac{p_1}{\gamma}+z_1\right)-\left(\frac{p_2}{\gamma}+z_2\right)\right]}$

$\frac{d}{D} = \frac{10}{50} = 0.2 \Rightarrow$ GUESS $K = 0.62$

$Q = (0.62)\frac{\pi}{4}(0.1)^2\sqrt{2(9.8)\left[\frac{10{,}000}{9{,}790} + 0.3\right]}$

$Q = 0.0248 \frac{m^3}{s}$

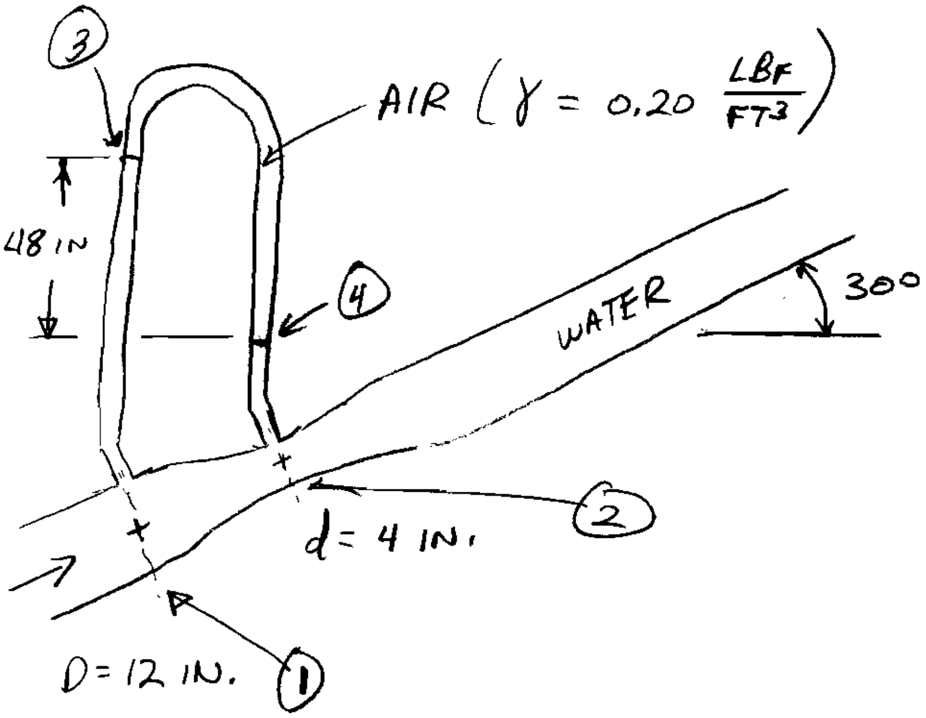
CHECK K. $Re = \frac{4Q}{\pi d \nu}$ $\nu = 10^{-6}\frac{m^2}{s}$

$Re = \frac{4(.0248)}{\pi(0.1)(10^{-6})} = 320{,}000 \Rightarrow K = 0.60$

$Q = 0.240 \frac{m^3}{s}$

13.36 (1)

GIVEN:



FIND: VOLUME FLOW RATE OF WATER

SOLUTION:

$$Q = K A_2 \sqrt{2g\,\Delta h}$$

$$\Delta h = \left(\frac{p_1}{\gamma_w} + z_1\right) - \left(\frac{p_2}{\gamma_w} + z_2\right)$$

USE PIEZOMETRIC HEAD EQUATION ON THE MANOMETER

$$\frac{p_1}{\gamma_w} + z_1 = \frac{p_3}{\gamma_w} + z_3$$

$$p_3 = p_4 \quad \text{(NEGLECT WEIGHT OF AIR}$$

$$\frac{p_4}{\gamma_w} + z_4 = \frac{p_2}{\gamma_w} + z_2$$

— COMBINE THESE TO YIELD Δh.

13.36 (2)

$$\left(\frac{p_1}{\gamma_w} + z_1\right) - \left(\frac{p_2}{\gamma_w} + z_2\right) = \left(\frac{p_3}{\gamma_w} + z_3\right) - \left(\frac{p_4}{\gamma_w} + z_4\right)$$

$$= z_3 - z_4$$

$$\Delta h = 48 \text{ IN}$$

TRY $K = 1$

$$Q = 1 \left(\frac{\pi}{4}\right)\left(\frac{4}{12}\right)^2 \sqrt{2(32.2)\frac{48}{12}}$$

$$Q = 1.4 \ \frac{FT^3}{S}$$

CHECK Re.

$$Re = \frac{4(1.4)}{\pi\left(\frac{4}{12}\right) 1.22 \times 10^{-5}}$$

$$Re = 4.39 \times 10^5$$

FIGURE 13.13 $\frac{d}{D} = .33$, $Re = 439,000$

$\Rightarrow K \simeq 0.99$

CLOSE ENOUGH