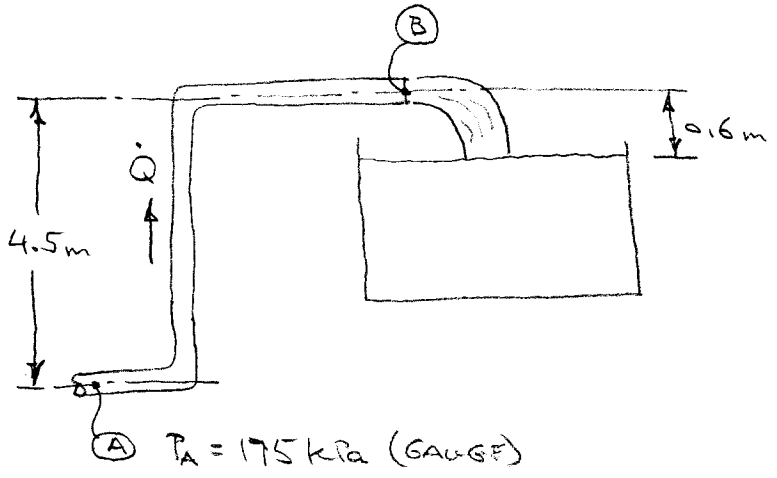
MECH 277

CLASS II - TUTORIAL EXAMPLE



(A) $P_A = 175$ kPa (GAUGE)

PIPE

2" COPPER, TYPE K, 100 m LONG
D = 49.76 mm (APPENDIX K)

FLUID $\epsilon = 1.5 \times 10^{-6}$ m (T9.1)

$S_g = 0.93$

$\mu = 9.5 \times 10^{-3}$ Pa·s

$\gamma = 0.93 \times 9.81$ kN/m³ $= 9.123$ kN/m³ ← APPENDIX A

$\rho = 0.93 \times 1000$ kg/m³ $= 930$ kg/m³

FITTINGS

STANDARD FLOW: $\frac{L_e}{D} = 30$

STEP (1)

$$\frac{P_A - P_B}{\gamma} + (z_A - z_B) + \frac{U_A^2 + U_B^2}{2g} + h_A - h_R - h_L = 0$$

$P_A = 175$ kPa (gauge) $z_A = 0$ $U_A = U_B$

$P_B = 0$ $z_B = 4.5$ m $U_B = U_A$

$h_A = 0$ $h_R = 0$ $h_L = ?$

So $\frac{175k - 0}{9.123k} + (0 - 4.5) + 0 + 0 - 0 - h_L = 0$

$14.68 = h_L$

ALSO $h_L = f\left[\left(\frac{L}{D} + \frac{L_E}{D}\right)\right]\frac{U^2}{2g} = f\left(\frac{100}{49.76 \times 10^{-3}} + 2(30)\right)\frac{U^2}{2(9.81)}$

$h_L = 105.49 f U^2$

So $14.68 = 105.49 f U^2$

$\therefore U = \sqrt{\frac{14.68}{k5.49 f}}$

$U = \sqrt{\frac{0.139}{f}}$ [1]

— END OF STEP (1) —

STEP (2)

$$N_R = \frac{UD\rho}{\mu} = \frac{U(49.76 \times 10^{-3})(93)}{9.5 \times 10^{-3}}$$

$N_R = 4871.24\,U$ [2]

$\frac{D}{\epsilon} = \frac{49.76 \times 10^{-3}}{1.5 \times 10^{-6}} = 33,173.2$

—— END OF STEP (2) ——

STEP (3): $f = 0.02$ (FIRST GUESS).

$f \rightarrow$ [1] $\rightarrow U = 2.64$ m/s $\rightarrow$ [2] $\rightarrow f = 0.029$

[1] $\rightarrow U = 2.19$ m/s $\rightarrow$ [2] $\rightarrow f = 0.0305$

[1] $\rightarrow U = 2.13$ m/s $\rightarrow$ [2] $\rightarrow f = 0.0307$

[1] $\rightarrow U = 2.13$ m/s

U HAS NOT CHANGED BY MORE THAN 1% SO STOP!

$U = 2.13$ m/s

APPENDIX H

$Q = UA = 2.13 \times 1.945 \times 10^{-3}$ m²

$= 0.004143$ m³/s $= 4.14$ L/s $= \dot{Q}$