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Prob. 1

Information and assumptions

Provided in problem statement
Open channel flow down a 30^o incline.
Vertical depth is 1m. Width is 2m.
Velocity profile is $u = y^{1/3}$ m/s.

Find

Discharge: Q.

Solution

$$Q = \int u dA \qquad \text{(Eqn. = 2)}$$

$$= \int_0^{1\cdot\cos 30^o} y^{1/3}(2dy)$$

$$= 2\int_0^{0.866} y^{1/3} dy$$

$$= 2 \times \frac{3}{4} \times y^{4/3}\Big|_0^{0.866} \qquad \text{(Inter. = 2)}$$

$$= 1.24\, m^3/s \qquad \text{(Ans. = 1)}$$

$$\tau_{y=0.433} = \mu \frac{du}{dy} \qquad \text{(Eqn. = 3)}$$

$$= \mu \frac{1}{3} y^{-2/3}\Big|_{y=0.433}$$

$$= 1.00\times10^{-3} \times \frac{1}{3} y^{-2/3}\Big|_{y=0.433} \qquad \text{(Inter. = 1)}$$

$$= 5.82\times10^{-4}\ N/m^2 \qquad \text{(Ans. = 1)}$$

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Prob. 2

Information and assumptions

Provided in problem statement
The side tube samples the pressure for the undisturbed flow and the central tube senses the stagnation pressure

Find

Air flow rate

Solution

Bernoulli equation

$$p_0 + \rho V_0^2/2 = p_{stag} + 0$$

Or

$$V_0 = \sqrt{(2/\rho)\left(p_{stag} - p_0\right)}$$ (Eqn. = 6)

But

$$p_{stag} - p_0 = (0.067 - 0.023)\sin 30^o \times 0.7 \times 9810$$

$$= 151.1 Pa$$ (Eqn. + Inter. + Ans. = 1)

$$\rho = p/RT = 150{,}000/(287 \times (273 + 20))$$

$$1.784\, kg/m^3$$ (Eqn. + Inter. + Ans. = 1)

Then

$$V_0 = \sqrt{(2/1.784)(151.3)} = 13.02\, m/s$$ (Inter. + Ans. = 1)

$$Q = VA = 13.02 \times (\pi/4) \times 0.10^2 = 0.1022\, m/s$$ (Inter. + Ans. = 1)

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Prob. 3

Information and assumptions

Provided in problem statement

From Table A.3 $\nu = 1.41\times10^{-5}\, m^2/s$ and $\rho = 1.25\, kg/m^3$

Find

Power required to pull sign

Solution

Drag force

$$F_x = 2C_f BL\rho U_0^2/2$$ (Eqn. = 4)

$$\mathrm{Re}_L = V_0 L/\nu = 30\times30/\left(1.41\times10^{-5}\right)$$

$$\mathrm{Re}_L = 6.38\times10^7$$ (Inter. + Ans. = 2)

Then from Fig 9-14

$$C_f = 0.00225$$ (Inter. + Ans. = 2)

$$F_x = 0.00225\times2\times30\times2.0\times1.25\times30^2/2$$

$$= 151.9N$$ (Inter. + Ans. = 1)

$$P = F_x V = 151.9\times30 = 4.56kW$$ (Inter. + Ans. = 1)

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Prob. 4

Information and assumptions

Provided in problem statement

From Table 10.2, $k_s = 4.6\times10^{-5}\,m$

Find

(a) Laminar or turbulent flow

(b) Pressure at point A

Solution

$$\text{Re} = VD/\nu = 4Q/(\pi D\nu)$$ (Eqn = 2)

$$= 4\times0.03/\left(\pi\times0.15\times\left(10^{-2}/820\right)\right)$$

$$= 2.09\times10^4$$

Turbulent flow. (Inter.+ Ans. = 1)

$$V = Q/A = 0.03/\left(\pi\times0.15^2/4\right) = 1.698\,m/s$$

$$k_s/D = 4.6\times10^{-5}/0.15 = 3.1\times10^{-4}$$

From Fig. 10.8:

$$f = 0.027$$

$$h_f = f\,(L/D)\left(V^2/2g\right)$$ (Eqn. = 2)

$$= 0.027\times(1000/0.15)\left(1.698^2/(2\times9.81)\right)$$

$$= 26.4m$$ (Inter.+ Ans. = 1)

Energy equation:

$$p_A/\gamma + V_A^2/2g + z_A = p_B/\gamma + V_B^2/2g + z_B + h_f$$ (Eqn. = 3)

$$p_A = 0.82\times9810\times\left[\left(250000/(0.82\times9810)\right) + 20 + 26.4\right]$$

$$p_A = 623kPa$$ (Inter.+ Ans. = 1)

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Prob. 5

Information and assumptions

Provided in problem statement

From Table 10.2, $k_s = 5\times10^{-4}\ ft$

From Table A.5, $\nu = 1.41\times10^{-5}\ ft^2/s$

From Table 10.3, $K_b = 0.9$, $K_v = 10$, $K_e = 0.5$, $K_E = 1.0$

Find

Pressure at point A

Solution

Energy equation:

$$p_A/\gamma + V_1^2/2g + z_1 = p_2/\gamma + V_2^2/2g + z_2 + \sum h_L$$

$$p_A/\gamma + 0 + 20 = 0 + 0 + 90$$

$$+V^2/2g\left(K_e + 2K_b + K_v + f\left(L/D\right) + K_E\right)$$ (Eqn = 6)

$$V = Q/A = \left(50\times0.002228\right)\Big/\left(\pi\times\left(2/12\right)^2/4\right) = 5.1$$

$$V^2/2g = 5.1^2/64.4 = 0.404$$

$$\mathrm{Re} = 5.1\times\left(2/12\right)\Big/\left(1.41\times10^{-5}\right) = 6\times10^4$$

$$k_s/D = 5\times10^{-4}/\left(2/12\right) = 0.003$$

From Fig. 10.8:

$$f = 0.028$$ (Inter.+ Ans. = 2)

$$p_A = \gamma\left[70 + 0.404\left(0.5 + 2\times0.9 + 10 + \left(0.028\times240/\left(2/12\right)\right) + 1.0\right)\right]$$

$$= 62.4\times91.7 = 5722\ psfg = 39.7\ psig$$ (Inter.+ Ans. = 2)

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Prob. 6

Information and assumptions

Provided in problem statement

From Table A.3, $\rho = 1.2\, kg/m^3$

Find

Reduction in drag force

Solution

$$F_D = C_D A_p \rho V^2/2 \quad \text{(Eqn. = 6)}$$

$$F_{D_{reduction}} = 0.25 \times 0.78 \times 8.36 \times 1.2 \times (100000/3600)^2/2$$

$$F_{D_{reduction}} = 755 N \quad \text{(Inter.+ Ans. = 4)}$$
