

P7.35 Water at 20°C flows at 5 m/s past a 2-m-wide sharp flat plate. (a) Estimate the boundary layer thickness at $x = 1.2$ m. (b) If the total drag (on both sides of the plate) is 310 N, estimate the length of the plate using, for simplicity, Eq. (7.45).

$$\rho = 998 \text{ kg/m}^3 \quad \mu = 0.001 \text{ kg/m}\cdot\text{s}$$

$$(a) \quad Re_x = \frac{\rho U x}{\mu} = 5,988,000 \quad U = 5 \text{ m/s}$$

turbulent

$$x = 1.2 \text{ m}$$

$$\delta/x = 0.16/Re_x^{1/4} = 0.0172$$

$$\delta = 0.0206 \text{ m} = 21 \text{ mm}$$

$$(b) \quad F_T = 310 \text{ N} \quad F_{\text{one side}} = 155 \text{ N}$$

$$F = 155 = C_D \frac{1}{2} \rho U^2 b L$$

$$155 = \frac{0.031}{Re_x^{1/4}} \frac{1}{2} \rho U^2 b L$$

$$b = 2 \text{ m}$$

$$Re_x = \frac{\rho U L}{\mu}$$

$$155 = 85.42 L^{3/4}$$

$$L = 2 \text{ m}$$

$$\text{or using } C_D = \frac{0.031}{Re_x^{1/4}} = \frac{0.40}{Re_L} \quad \text{including transitional flow}$$

$$L = 2.11 \text{ m}$$