

**9.47** A thin plate 1.5 m long and 1.5 m wide is submerged and held stationary in a stream of water ( $T = 10^\circ\text{C}$ ) that has a velocity of 1 m/s. What is the thickness of the boundary layer on the plate for  $Re_x = 500,000$  (assume the boundary layer is still laminar), and at what distance downstream of the leading edge does this Reynolds number occur? What is the shear stress on the plate on this point?

**9.47 Information and assumptions**

provided in problem statement

**Find**

thickness of boundary layer, distance from leading edge and local shear stress

**Solution**

$$Re_x = U_0 x / \nu = 500,000$$

$$x = 500,000 \nu / U_0 = 500,000 \times 1.31 \times 10^{-6} / 1 = \underline{0.655 \text{ m}}$$

$$\delta = 5x / Re_x^{1/2} = 5 \times 0.655 / (500,000)^{1/2} = 4.63 \times 10^{-3} \text{ m} = \underline{4.63 \text{ mm}}$$

$$\tau_0 = 0.332 \mu (U_0 / x) Re_x^{1/2}$$

$$\tau_0 = 0.332 \times 1.31 \times 10^{-3} (2 / 0.655) \times (500,000)^{1/2} = \underline{0.94 \text{ N/m}^2}$$