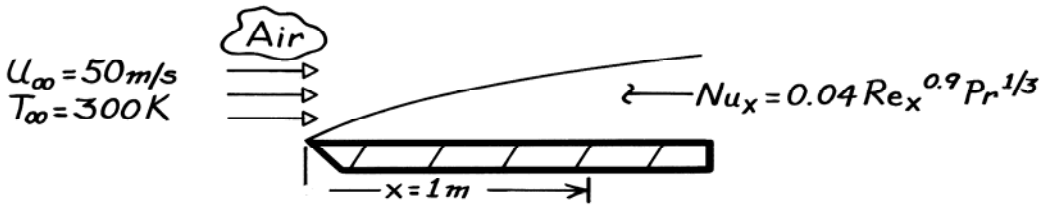
PROBLEM 6.48

KNOWN: Heat transfer correlation associated with parallel flow over a rough flat plate. Velocity and temperature of air flow over the plate.

FIND: Surface shear stress l m from the leading edge.

SCHEMATIC:



ASSUMPTIONS: (1) Modified Reynolds analogy is applicable, (2) Constant properties.

PROPERTIES: *Table A-4*, Air (300K, 1atm): $\nu = 15.89 \times 10^{-6} m^2/s$, Pr = 0.71, $\rho = 1.16$ kg/m^3.

ANALYSIS: Applying the Chilton-Colburn analogy

$$\frac{C_f}{2} = St_x\, Pr^{2/3} = \frac{Nu_x}{Re_x\, Pr} Pr^{2/3} = \frac{0.04\, Re_x^{0.9}\, Pr^{1/3}}{Re_x\, Pr} Pr^{2/3}$$

$$\frac{C_f}{2} = 0.04\, Re_x^{-0.1}$$

where

$$Re_x = \frac{u_\infty x}{\nu} = \frac{50\ m/s \times 1 m}{15.89 \times 10^{-6} m^2/s} = 3.15 \times 10^6.$$

Hence, the friction coefficient is

$$C_f = 0.08 \left(3.15 \times 10^6\right)^{-0.1} = 0.0179 = \tau_s / \left(\rho\, u_\infty^2 / 2\right)$$

and the surface shear stress is

$$\tau_s = C_f \left(\rho\, u_\infty^2 / 2\right) = 0.0179 \times 1.16 kg/m^3 \left(50\ m/s\right)^2 / 2$$

$$\tau_s = 25.96\ kg/m \cdot s^2 = 25.96\ N/m^2. \quad <$$

COMMENTS: Note that turbulent flow will exist at the designated location.