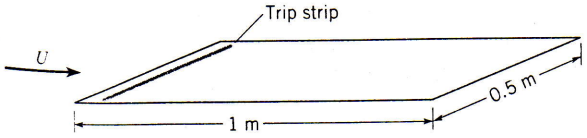
9.66 A flat plate is oriented parallel to a 15 m/s air flow at 20°C and atmospheric pressure. The plate is 1 m long in the flow direction and 0.5 m wide. On one side of the plate, the boundary layer is tripped at the leading edge and on the other side there is no tripping device. Find the total drag force on the plate.



PROBLEM 9.66

9.66 **Information and assumptions**

provided in problem statement

Find

total drag force on plate.

Solution

The force due to shear stress is

$$F_s = C_f \frac{1}{2} \rho U_o^2 B L$$

The density and kinematic viscosity of air at 20°C and atmospheric pressure is 1.2 kg/m^3 and 1.5×10^{-5} N·s/m^2, respectively. The Reynolds number based on the plate length is

$$\mathrm{Re}_L = \frac{15 \times 1}{1.5 \times 10^{-5}} = 10^6$$

The average shear stress coefficient on the "tripped" side of the plate is

$$C_f = \frac{0.074}{(10^6)^{1/5}} = 0.0047$$

The average shear stress on the "untripped" side is

$$C_f = \frac{0.523}{\ln^2(0.06 \times 10^6)} - \frac{1520}{10^6} = 0.0028$$

The total force is

$$F_s = \frac{1}{2} \times 1.2 \times 15^2 \times 1 \times 0.5 \times (0.0047 + 0.0028) = \underline{0.506 \text{ N}}$$