

9.48

9.48 Water flows past a triangular flat plate oriented parallel to the free stream as shown in Fig. P9.48. Integrate the wall shear stress over the plate to determine the friction drag on one side of the plate. Assume laminar boundary layer flow.

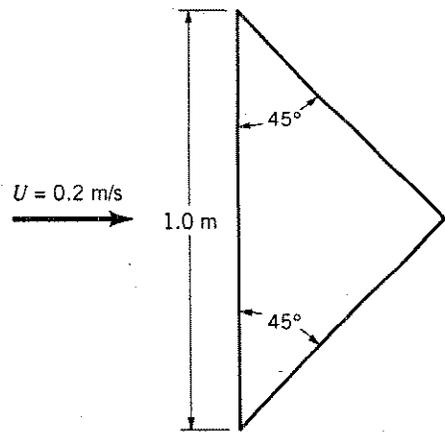
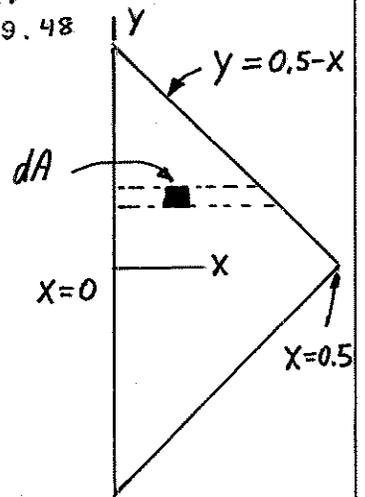


FIGURE P9.48



$$dD = \int \tau_w dA \quad \text{where} \quad \tau_w = 0.332 U^{3/2} \sqrt{\frac{\rho \mu}{x}}$$

Thus,

$$D = 0.332 U^{3/2} \sqrt{\rho \mu} \int \frac{1}{\sqrt{x}} dA$$

$$= 0.332 U^{3/2} \sqrt{\rho \mu} (2) \int_{x=0}^{x=0.5} \int_{y=0}^{y=0.5-x} \frac{dy dx}{\sqrt{x}}$$

$$= 0.332 U^{3/2} \sqrt{\rho \mu} (2) \int_{x=0}^{0.5} \frac{0.5-x}{\sqrt{x}} dx$$

$$= 0.332 U^{3/2} \sqrt{\rho \mu} (2) \left[ 0.5(2)x^{1/2} - \frac{2}{3}x^{3/2} \right]_0^{0.5}$$

$$= 0.664 (0.2 \frac{m}{s})^{3/2} \sqrt{999 \frac{kg}{m^3} (1.12 \times 10^{-3} \frac{N \cdot s}{m^2})} \left[ \sqrt{0.5} - \frac{2}{3}(0.5)^{3/2} \right]$$

or

$$D = \underline{\underline{0.0296 N}}$$