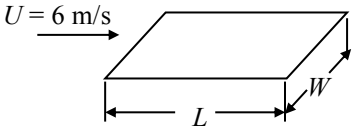
A thin flat plate 55 by 110 cm is immersed in a 6 m/s stream of SAE 10 oil at 20 °C. Compute the total skin friction drag if the stream is parallel to (a) the long side and (b) the short side.

SOLUTION:



$\nu_{\text{SAE 10 oil}} = 1.20*10^{-4}$ m^2/s
$\rho_{\text{SAE 10 oil}} = 870$ kg/m^3

Determine the Reynolds number at the trailing edge of the plate to see if it's laminar.

$$\text{Re}_L = \frac{UL}{\nu} \quad \text{(The flow is considered laminar if } Re < 1*10^6\text{.)} \tag{1}$$

When $L = 1.10$ m then $\text{Re}_L = 55{,}200 \Rightarrow$ laminar flow. When $L = 0.55$ m then $\text{Re}_L = 27{,}500 \Rightarrow$ laminar flow.

Now determine the drag on the plate using the drag coefficient, c_D, for laminar flat plate flow (the Blasius solution).

$$D = \left(\tfrac{1}{2}\rho U^2\right) \underbrace{\left(2LW\right)}_{\substack{\text{top and bottom} \\ \text{faces}}} c_D$$

$$\therefore D = \left(\tfrac{1}{2}\rho U^2\right)\left(2LW\right)\left(\frac{1.328}{\text{Re}_L^{1/2}}\right) \tag{2}$$

When $L = 1.10$ m, $W = 0.55$ m, $\text{Re}_L = 55{,}200$, and $\boxed{D = 107 \text{ N}}$.

When $L = 0.55$ m, $W = 1.10$ m, $\text{Re}_L = 27{,}500$, and $\boxed{D = 152 \text{ N}}$.

Note that the drag is greater when the short side is aligned with the flow. Why? Because from Eqn. (2) we observe that the drag varies with $\sqrt{L}$ but is proportional to W. Hence the drag will increase more rapidly with increasing width than with increasing length.