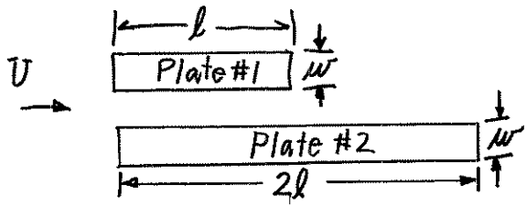
9.35

9.35 Water flows over two flat plates with the same laminar free-stream velocity. Both plates have the same width, but Plate #2 is twice as long as Plate #1. What is the relationship between the drag force for these two plates?

$\mathcal{D} = C_D \frac{1}{2}\rho U^2 A$



Thus,

$\mathcal{D}_1 = C_{D_1} \frac{1}{2}\rho U^2 \ell w$

and

$\mathcal{D}_2 = C_{D_2} \frac{1}{2}\rho U^2 (2\ell w)$ or

$$\frac{\mathcal{D}_2}{\mathcal{D}_1} = \frac{C_{D_2}}{C_{D_1}} \frac{(2\ell w)}{\ell w} = 2\frac{C_{D_2}}{C_{D_1}} \qquad (1)$$

For laminar flow on a flat plate

$C_D = \frac{1.328}{\sqrt{Re_\ell}}$, where $Re_\ell = \frac{U\ell}{\nu}$, so that $C_D = \frac{1.328\sqrt{\nu}}{\sqrt{U\ell}}$

Thus,

$$\frac{C_{D_2}}{C_{D_1}} = \left(\frac{1.328\sqrt{\nu}}{\sqrt{U(2\ell)}}\right) \Big/ \left(\frac{1.328\sqrt{\nu}}{\sqrt{U\ell}}\right) = \frac{1}{\sqrt{2}} \qquad (2)$$

Hence, from Eqs. (1) and (2),

$$\frac{\mathcal{D}_2}{\mathcal{D}_1} = 2/\sqrt{2} = \underline{\underline{1.414}}$$