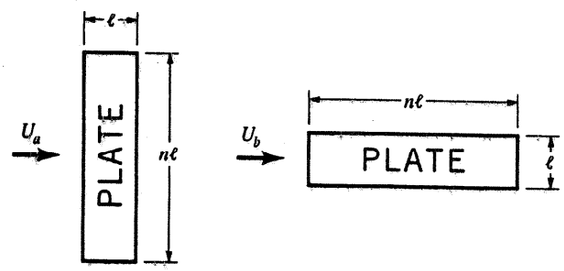
9.29

9.29 The two flat plates shown in Fig. P9.29 are to have the same drag. Determine the upstream velocity U_b in terms of U_a and n. Assume laminar flow. Explain your answer physically.



■ FIGURE P9.29

$D_a = D_b$

or

$\frac{1}{2}\rho U_a^2 A_a C_{D_a} = \frac{1}{2}\rho U_b^2 A_b C_{D_b}$ (1)

where $A_a = A_b = (n\ell)\ell$ and $C_D = \frac{1.328}{\sqrt{Re}}$ or $C_{D_a} = \frac{1.328}{\sqrt{Re_a}}$, $C_{D_b} = \frac{1.328}{\sqrt{Re_b}}$

Thus, Eq. (1) gives

$U_a^2 C_{D_a} = U_b^2 C_{D_b}$

or

$\frac{U_a^2}{\sqrt{Re_a}} = \frac{U_b^2}{\sqrt{Re_b}}$ where $Re_a = \frac{U_a \ell}{\nu}$ and $Re_b = \frac{U_b (n\ell)}{\nu}$

Hence,

$$\frac{U_a^2}{\sqrt{U_a \ell/\nu}} = \frac{U_b^2}{\sqrt{U_b n\ell/\nu}}$$

or

$U_a^{3/2} = U_b^{3/2}/n^{1/2}$

Thus,

$$\underline{\underline{U_b = n^{1/3} U_a}}$$