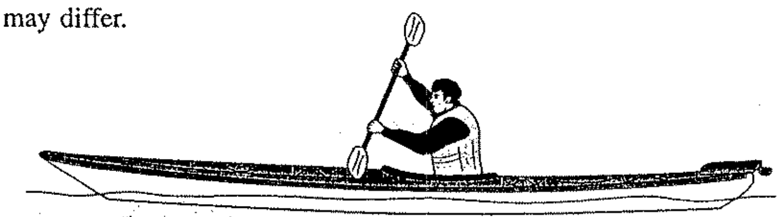
9.51

9.51 As shown in Video V9.2 and Fig. P9.51a a kayak is a relatively streamlined object. As a first approximation in calculating the drag on a kayak, assume that the kayak acts as if it were a smooth flat plate 17 ft long and 2 ft wide. Determine the drag as a function of speed and compare your results with the measured values given in Fig. P9.51b Comment on reasons why the two sets of values may differ.



(a)

For a flat plate $\mathscr{D} = \frac{1}{2}\rho U^2 C_{Df} A$ where (1)

$A = 17\,ft(2\,ft) = 34\,ft^2$ and C_{Df} is a function of $Re_\ell = \frac{U\ell}{\nu}$

Thus,

$$Re_\ell = \frac{17\,ft\; U}{1.21\times10^{-5}\,ft^2/s} = 1.40\times10^6\,U \quad (2)$$

Consider $1 \le U \le 8\,\frac{ft}{s}$, or $1.40\times10^6 \le Re_\ell \le 1.12\times10^7$

From Fig. 9.15 we see that in this Re_ℓ range the boundary layer flow is in the transitional range. Thus, from Table 9.3

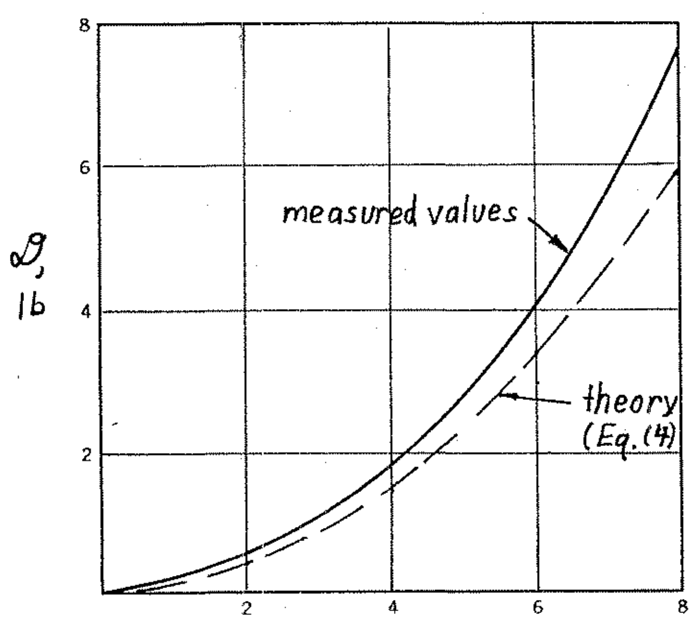
$$C_{Df} = 0.455/(\log Re_\ell)^{2.58} - 1700/Re_\ell \quad (3)$$

By combining Eqs. (1), (2), and (3):

$$\mathscr{D} = \frac{1}{2}\left(1.94\,\frac{slugs}{ft^3}\right)U^2 C_{Df}\,(34\,ft^2) \quad \text{or}$$

$$\mathscr{D} = 33.0\,U^2\left[0.455/(\log(1.40\times10^6 U))^{2.58} - 1700/(1.40\times10^6\,U)\right] \quad (4)$$

The results from this equation are plotted below.



U, ft/s	$\mathscr{D}$, lb
1	0.0986
2	0.410
3	0.909
4	1.58
5	2.42
6	3.43
7	4.59
8	5.90

■ FIGURE P9.51(b)