9.36

9.36 Fluid flows past a flat plate with a drag force $\mathcal{D}_1$. If the freestream velocity is doubled, will the new drag force, $\mathcal{D}_2$, be larger or smaller than $\mathcal{D}_1$ and by what amount?

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

If you assume that the doubling of U, which will change Re, does not significantly change C_D (see Fig. 9.22), then

$$\frac{\mathcal{D}_1}{\mathcal{D}_2} = \frac{C_D \frac{1}{2}\rho U_1^2 A}{C_D \frac{1}{2}\rho U_2^2 A} = \frac{U_1^2}{U_2^2} \quad \text{where } U_2 = 2U_1$$

$$= \frac{U_1^2}{(2U_1)^2} = \frac{1}{4}$$

So,

$$\underline{\underline{\mathcal{D}_2 = 4\mathcal{D}_1}}$$

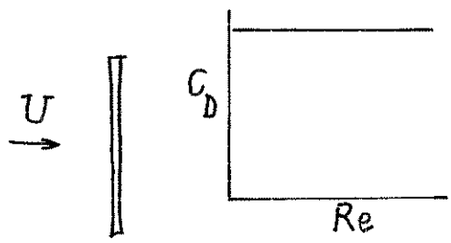


plate normal to flow

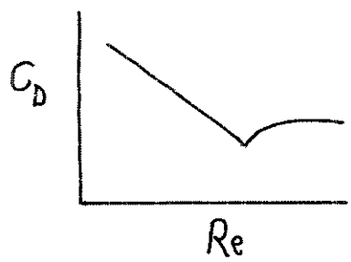
Note:

If the plate is parallel to the flow, then C_D changes with Re. See Fig. 9.22.


plate parallel to flow

Thus,

$$\frac{D_1}{D_2} = \frac{C_{D_1} U_1^2}{C_{D_2} U_2^2}$$



so that a numerical answer could not be obtained without additional data about the value of Re.