9.46

9.46 If the drag on one side of a flat plate parallel to the upstream flow is $\mathcal{D}$ when the upstream velocity is U, what will the drag be when the upstream velocity is $2U$; or $U/2$? Assume laminar flow.

For laminar flow $\mathcal{D} = \frac{1}{2}\rho U^2 C_{D_f} A$, where $C_{D_f} = \dfrac{1.328}{\sqrt{\frac{Ul}{\nu}}}$

Thus,

$$\mathcal{D} = \frac{1}{2}\rho U^2 \frac{1.328\sqrt{\nu}}{\sqrt{Ul}} A = 0.664\,\rho A \frac{\sqrt{\nu}}{\sqrt{l}} U^{3/2} \sim U^{3/2}$$

Hence,

$$\frac{\mathcal{D}_U}{\mathcal{D}_{2U}} = \frac{U^{3/2}}{(2U)^{3/2}} \text{ or } \underline{\underline{\mathcal{D}_{2U} = 2.83\,\mathcal{D}_U}}$$

and

$$\frac{\mathcal{D}_U}{\mathcal{D}_{U/2}} \quad \frac{U^{3/2}}{\left(\frac{U}{2}\right)^{3/2}} \text{ or } \underline{\underline{\mathcal{D}_{U/2} = 0.354\,\mathcal{D}_U}}$$