

9.30

9.30 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 $\mathcal{D} = \frac{1}{2} \rho U^2 C_{Df} A$, where $C_{Df} = \frac{1.328}{\sqrt{\frac{U l}{\nu}}}$
 Thus,

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

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

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