

3.16 An incompressible fluid flows past an impermeable flat plate, as in Fig. P3.16, with a uniform inlet profile $u = U_0$ and a cubic polynomial exit profile

$$u \approx U_0 \left(\frac{3\eta - \eta^3}{2} \right) \quad \text{where } \eta = \frac{y}{\delta}$$

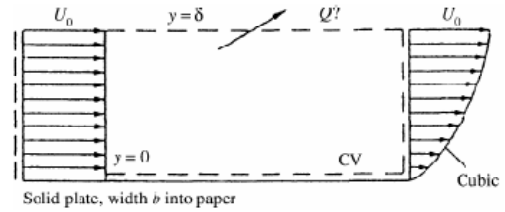


Fig. P3.16

Compute the volume flow Q across the top surface of the control volume.

Solution: For the given control volume and incompressible flow, we obtain

$$0 = Q_{\text{top}} + Q_{\text{right}} - Q_{\text{left}} = Q + \int_0^{\delta} U_0 \left(\frac{3y}{2\delta} - \frac{y^3}{2\delta^3} \right) b \, dy - \int_0^{\delta} U_0 b \, dy$$

$$- Q + \frac{5}{8} U_0 b \delta - U_0 b \delta, \quad \text{solve for } \mathbf{Q = \frac{3}{8} U_0 b \delta} \quad \text{Ans.}$$