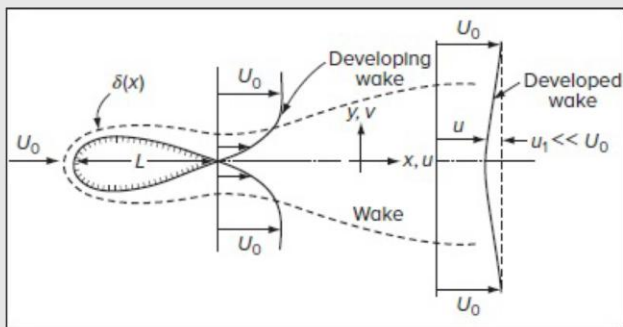


## Plane laminar wake: far-field approximation



Time average  
 $u_1 = \text{wake defect}$

**FIGURE 4-24**

Flow in the wake of a body immersed in a stream.

$$x > 3L$$

wake attains similarity

$$u_1(x, y) = U_0 - u(x, y) \ll U_0$$

BL assumptions:  $uu_x + vu_y = \nu u_{yy}$  with  $p_x = 0$

Also, Oseen approximation, i.e., linearized convection:  $U_0 u_{1x} = \nu u_{1yy}$

$$u_1(x, \pm\infty) = 0 \quad u_{1y}(x, 0) = 0$$

Solution straight forward, as per flat plate far wake solution

$$u_1 = CU_0 \left(\frac{L}{x}\right)^{1/2} e^{-\eta^2/4} \quad \eta = y \left(\frac{U_0}{\nu x}\right)^{1/2} \quad \frac{\eta^2}{4} = y^2 \left(\frac{U}{4\nu x}\right)$$

$$F \approx \rho U_0 \int_{-\infty}^{\infty} u_1 dy = \rho U_0^2 C \left(\frac{L}{x}\right)^{1/2} \underbrace{\int_{-\infty}^{\infty} e^{-\eta^2/4} d\eta}_{2\pi^{1/2}} \quad \text{per unit span}$$

$$\frac{1}{2} C_D \rho U_0^2 L = 2 \rho U_0^2 C \left(\frac{\nu L \pi}{U_0}\right)^{1/2}$$

$$\frac{1}{4} \left(\frac{U_0}{L \nu \pi}\right)^{1/2} C_D L = C = \left(\frac{U_0 L}{16 \nu \pi}\right)^{1/2} C_D = C_D \left(\frac{Re_L}{16 \pi}\right)^{1/2}$$

$$Re_L = \frac{U_0 L}{\nu}$$

$$\frac{u_1}{U_0} = C_D \left(\frac{Re_L}{16 \pi}\right)^{1/2} \left(\frac{L}{x}\right)^{1/2} e^{-\eta^2/4} \propto C_D$$

valid  $x > 3L$