P7.32 A flat plate of length L and height δ is placed at a wall and is parallel to an approaching boundary layer, as in Fig. P7.32. Assume that the flow over the plate is fully turbulent and that the approaching flow is a one-seventh-power law

$$u(y) = U_0\left(\frac{y}{\delta}\right)^{1/7}$$

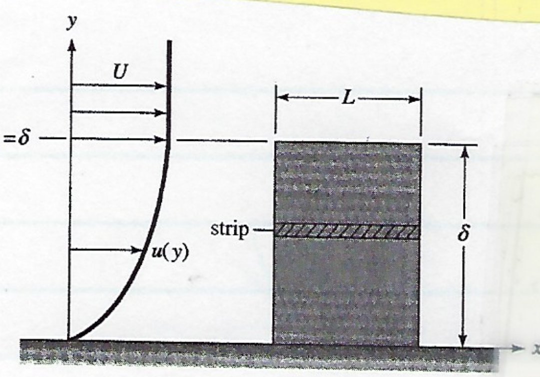

Fig. P7.32

Using strip theory, derive a formula for the drag coefficient of this plate. Compare this result with the drag of the same plate immersed in a uniform stream U_0.

$$C_D = D / \tfrac{1}{2}\rho u^2 A = .031 / \left(\frac{\rho u L}{\mu}\right)^{1/7}$$

$$= .031\, Re_L^{-1/7}$$

$$dF = C_D \times \tfrac{1}{2}\rho u^2 L\, dy \times 2 \text{ (sides)}$$

$$= .031\, \rho\, \nu^{1/7} L^{6/7} u^{13/7}\, dy$$

$$\frac{a^m}{a^n} = a^{m-n}$$

$$F = .031\, \rho\, \nu^{1/7} L^{6/7} \int_0^{\delta} \left[U_0 \left(y/\delta\right)^{1/7}\right]^{13/7} dy$$

$$\int x^n dx = \frac{x^{n+1}}{n+1}$$

$$= .031\, \underbrace{(49/62)}\, \rho\, \nu^{1/7} L^{6/7} U_0^{13/7}\, \delta$$

79% vs $=1$ for $u(y) = U_0$