SPC 307 - Aerodynamics
Sheet 6
Boundary Layer

1. Water flows past a flat plate that is oriented parallel to the flow with an upstream velocity of 0.5 m/s. Determine the approximate location downstream from the leading edge where the boundary layer becomes turbulent. What is the boundary layer thickness at this location?
2. A viscous fluid flows past a flat plate such that the boundary layer thickness at a distance 1.3 m from the leading edge is 12 mm. Determine the boundary layer thickness at distances of 0.20, 2.0, and 20 m from the leading edge. Assume laminar flow.
3. Approximately how fast can the wind blow past a 0.25- in.-diameter twig if viscous effects are to be of importance throughout the entire flow field (i.e., Re = 1)? Explain. Repeat for a 0.004 in. diameter hair and a 6-ft-diameter smokestack.
4. Air enters a square duct through a 1-ft opening as is shown in Fig. 1. Because the boundary layer displacement thickness increases in the direction of flow, it is necessary to increase the cross-sectional size of the duct if a constant U = 2 ft/s velocity is to be maintained outside the boundary layer. Plot a graph of the duct size, d, as a function of x for $0 \leq x \leq 10$ ft if U is to remain constant. Assume laminar flow.

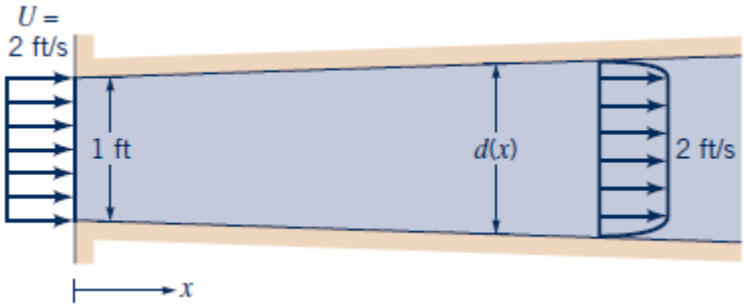

Fig.1

5. An atmospheric boundary layer is formed when the wind blows over the Earth's surface. Typically, such velocity profiles can be written as a power law: $u = ay^n$, where the constants a and n depend on the roughness of the terrain. As is indicated in Fig. 2, typical values are n = 0.40 for urban areas, n = 0.28 for woodland or suburban areas, and n = 0.16 for flat open country.
(a) If the velocity is 20 ft/s at the bottom of the sail on your boat (y = 4 ft), what is the velocity at the top of the mast (y = 30 ft)?
(b) If the average velocity is 10 mph on the tenth floor of an urban building, what is the average velocity on the sixtieth floor?

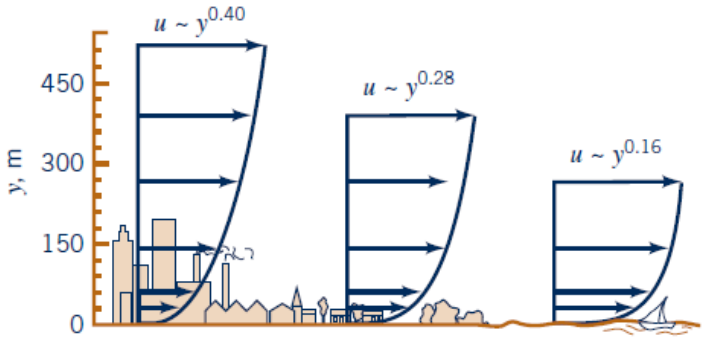

Fig.2