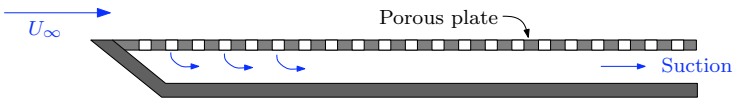
MIT Department of Mechanical Engineering
2.25 Advanced Fluid Mechanics

Problem 9.04
This problem is from "Advanced Fluid Mechanics Problems" by A.H. Shapiro and A.A. Sonin



Consider a flat porous surface with no lengthwise pressure gradient to which suction is applied for the purpose of sucking off the laminar boundary layer. Let us denote by v_0 the downward component of velocity at the surface of the plate ($y = 0$). Then it may be shown that for very small values of v_0/U_∞ compared with unity, the laminar boundary layer becomes constant in both thickness and velocity at large distances from the leading edge, provided that v_0 is constant.

For this case of small v_0/U_∞ and large distance from the leading edge, find:

(a) the velocity profile, by relating u/U_∞ to $v_0 y/\nu$

(b) the displacement thickness Reynolds number, $\delta^* v_0/\nu$.

(c) the skin-friction coefficient, $2\tau_0/\rho {U_\infty}^2$, in terms of v_0, U_∞, and ν.

(d) develop an estimate for the distance (in x) at which the boundary layer thickness approaches the asymptotic constant value found in Parts (a)-(c).

Hint: Start with the differential equations of the laminar boundary layer.

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Fall 2013