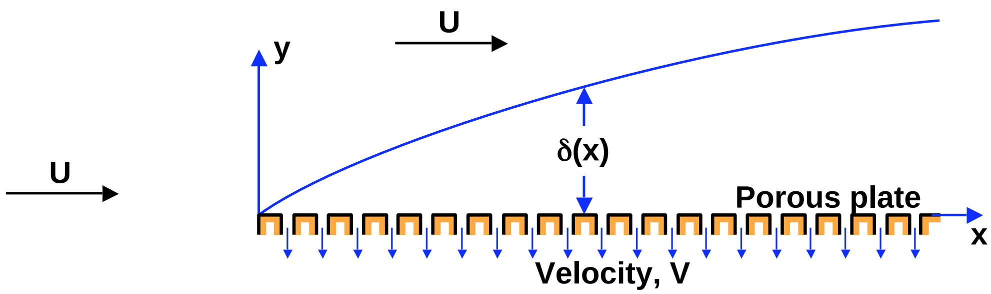
ME19b. HOMEWORK. Feb. 15 Due Feb. 22, 2007

PROBLEM B12.

A laminar boundary layer forms on a **porous** flat plate. Fluid is removed through the porous flat plate at a uniform velocity, V.



In other words, the volume of fluid removed through the porous plate per unit plate length, per unit breadth (perpendicular to figure) and per unit time is equal to V. The thickness of the boundary layer is denoted by $\delta(x)$ and the velocity outside the boundary layer is a constant, U. Using approximate boundary layer methods assuming similarity of the velocity profile (in other words that $u/U = F(y/\delta)$ where the function F is not a function of x) find a relation between the coefficient of friction ($= \tau_w/\frac{1}{2}\rho U^2$) and the quantities V, U, $d\delta/dx$ and α where α is the profile parameter

$$\alpha = \int_0^1 F(1-F)d\left(\frac{y}{\delta}\right)$$

PROBLEM B13.

A laminar boundary layer in a planar, incompressible flow experiences a velocity, U, external to the boundary layer which increases with distance, x, measured along the surface as follows:

$$U = Ax^{\frac{1}{2}}$$

where A is a known constant.

Approximate boundary layer methods (the Karman momentum integral equation) are to be used to find the boundary layer thickness, δ. An approximate velocity profile is assumed and the profile parameters, α, β, and γ, are calculated. Assume that this has been done and that α, β, and γ are known.

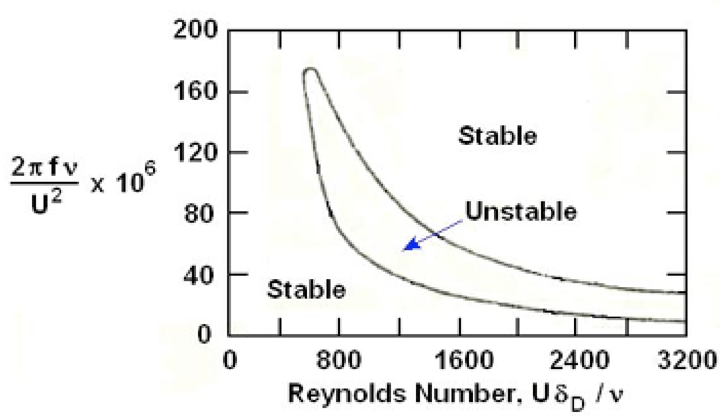
The answer is that the boundary layer thickness is given by

$$\delta = Cx^m$$

where C and m are constants. Determine the index m. Find the constant C as a function of A, α, β, γ, and the kinematic viscosity, ν, of the fluid.

PROBLEM B14.

The stability diagram for a laminar boundary layer on a flat plate with zero pressure gradient (Blasius problem) is given below:



Using the solid, theoretical curve find the distance from the leading edge of the plate to the point where transition to turbulence begins for a flow of water ($\nu = 10^{-6}\ m^2/s$) when $U = 2\ m/s$. What is the frequency of the most unstable disturbances (in Hz) under these conditions?

PROBLEM B15.

Using an infinitesmal control volume of dimensions dx and dy show that turbulent fluctuating velocities give rise to a net time-averaged flux of x-momentum out of the control volume through the sides of length dy. Show that this additional net x-momentum flux may be conceptually converted to an additional normal stress on the sides of length dy and derive an expression for this additional normal stress in terms of the fluctuating or turbulent velocities.