ME19b. HOMEWORK. Jan. 25 Due Feb. 1, 2007

PROBLEM B7.

A semi-infinite domain of fluid is bounded only by a single infinite flat plate. The fluid is incompressible with a constant and uniform viscosity, μ, and density, ρ. The plate is then set in accelerating motion, moving in its own plane with an accelerating velocity, Ue^{kt}, where U and k are constants and t is time. If the fluid only reacts by moving parallel with the plate with a velocity, $u(y,t)$, where y is the distance from the plate and if the velocities in the other directions are zero, write down the simplified form of the Navier-Stokes equation that govern this flow and must be solved to find $u(y,t)$. Note that p is uniform; that the velocity far from the plate is zero; and neglect gravitational effects. The result is a partial differential equation for $u(y,t)$ that only includes u, y, t and μ/ρ.

Using separation of variables (or otherwise) solve this equation to find $u(y,t)$ and the vorticity, $\omega(y,t)$, in terms of y, t, U, k, and the fluid properties. If we define a boundary layer next to the plate as the region within which the velocity is at least 10% of the plate velocity, derive an expression for the thickness of the boundary layer as a function of time.