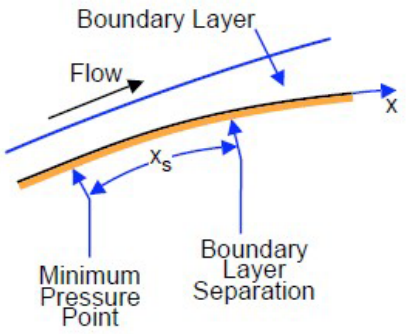
Problem 255B

Near the minimum pressure point in the steady, planar flow of an incompressible fluid past a body, the velocity outside the laminar boundary layer, U, is given by;

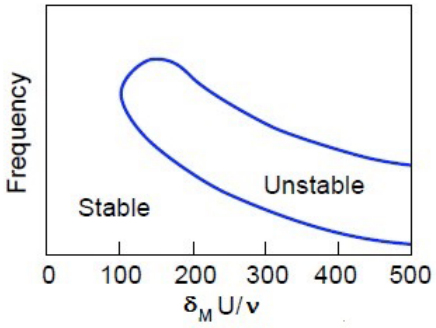
$$U \;=\; U_{max}\left[1 - cx^2\right] \tag{1}$$

where U_{max} and c are constants and x is a coordinate measured along the surface from the minimum pressure point: Estimate the distance, x_s, to the laminar boundary layer separation point assuming that



$cx^2 \ll 1$ and neglecting all but the first order terms in your evaluation. Also assume that the momentum thickness at the minimum pressure point is negligible.

Using the same approximations and the above stability diagram for the boundary layer, find an expression



for the distance from the minimum pressure point to the point at which the boundary layer becomes unstable.

If $d = c^{-1/2}$ represents a typical linear dimension of the body, find the critical Reynolds number, $Re = U_{max}d/\nu$, at which the boundary layer will become unstable just as it is about to separate. In other words the Reynolds number below which the boundary layer will separate before it undergoes transition and above which it will undergo transition before it separates.