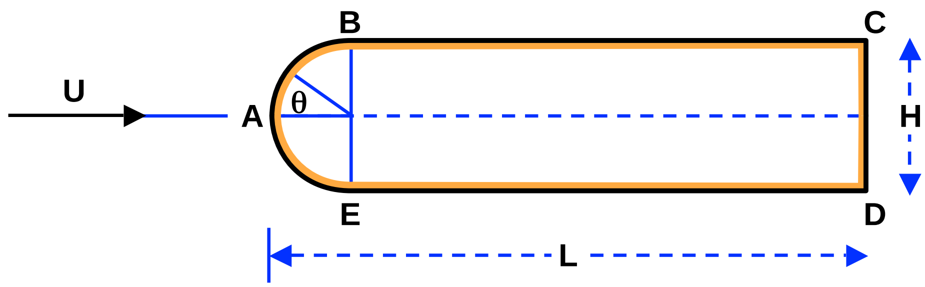
Problem 280C

The sketch below shows the cross-sectional geometry of a supporting strut. The actual strut is quite streamlined, in other words L/H is large. It is intended for use in a uniform stream of incompressible fluid of velocity, U, parallel to the side of length, L. The flow can be considered to be planar.



Further assume:

- that the velocity distribution over the cylindrical nose, BAE, is the same as in potential flow, that is to say the velocity outside the boundary layer is $2U sin\theta$.
- that the flow separates at the sharp trailing edges C and D so that the pressure coefficient acting on the base CD is

$$C_p = -\frac{1}{3} - \frac{3}{2}\frac{H}{L}$$

  Remember that the pressure coefficient is defined as, $C_p = (p - p_\infty)/\frac{1}{2}\rho U^2$ where p is the pressure, p_∞ is the pressure far upstream and ρ is the fluid density.
- that the skin friction forces on the cylindrical nose are negligible.

If the drag coefficient is defined as the drag divided by $\frac{1}{2}\rho U^2$ and the frontal projected area (H times a dimension perpendicular to the sketch), find:

1. The contribution of the form drag to the total drag coefficient (denote this by C_{DF}).
2. An estimate of the contribution of the skin friction on the sides of the strut to the total drag coefficient, assuming the boundary layer remains laminar. This should be in terms of the Reynolds number, $Re = UL/\nu$, where ν is the kinematic viscosity of the fluid.
3. For what aspect ratio, L/H, will the drag be comprised of equal parts of form and skin friction drag if $Re = 1000$?

Footnote:

$$\int_0^{\pi/2} \sin\theta \sin\theta \cos\theta d\theta = 1/3$$