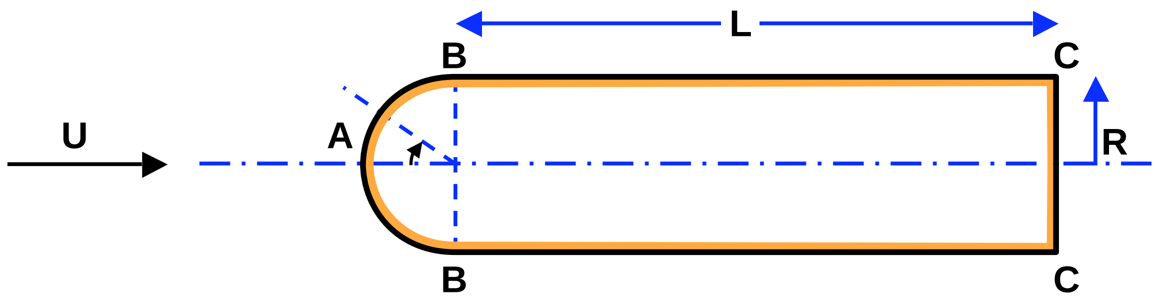
Problem 280E

The sketch below defines the geometry of an axisymmetric underwater body that is quite streamlined in the sense that L/R is large. This body travels through the incompressible water at a velocity, U, parallel to the axis.



It is to be assumed:

- that the velocity distribution over the spherical nose, BAB, is the same as in potential flow, that is to say the velocity outside the boundary layer is $\frac{3}{2}U\sin\theta$.
- that the flow separates at the sharp trailing edge, C, so that the pressure coefficient acting on the circular base, CC, is

  $$C_p = -0.5$$

  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 spherical 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 (πR^2) 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 cylindrical surface of the body (between B and C) to the total drag coefficient, assuming the boundary layer remains laminar. This should be in terms of the Reynolds number, $Re = 2UR/\nu$, where ν is the kinematic viscosity of the fluid.
3. For what aspect ratio, L/R, will the drag be comprised of equal parts of form and skin friction drag if $Re = 10000$?