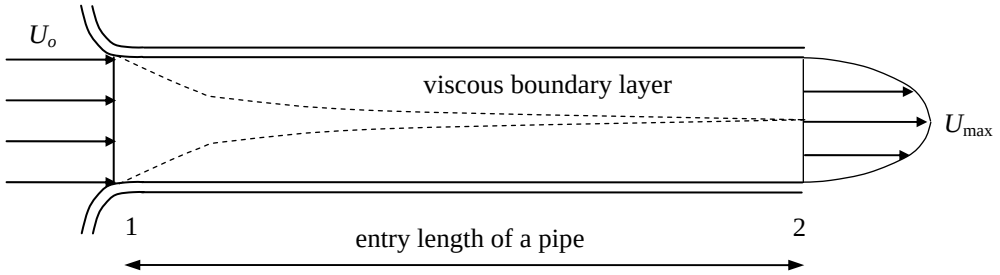
Homework Set #13

Drag analysis over the entry length of a circular pipe

At the entrance of a circular pipe (Station 1), a flow enters with a uniform velocity U_o. As a result of viscous boundary layer formation along the pipe surface, the uniform velocity profile gradually develops into a fully-developed parabolic profile

$$u(r) = U_{\max}\left(1 - \frac{r^2}{R^2}\right)$$

at the end of the entry-length region (Station 2) where R is the internal radius of the circular pipe.



Your task is to determine the total drag force on the pipe internal surface over the entry-length region. You will be guided through a 3-step approach listed below:

a) Apply conservation of mass to an appropriate system. Express $U_{\max}$ in terms of U_o.

b) Apply Bernoulli's equation judiciously from Station 1 to Station 2. Determine the pressure drop from Station 1 to Station 2, *i.e.* $P_1 - P_2$.

c) Apply conservation of linear momentum to an appropriate system. Determine the total drag force on the internal pipe surface over the entry-length section.