PROBLEM 8.78

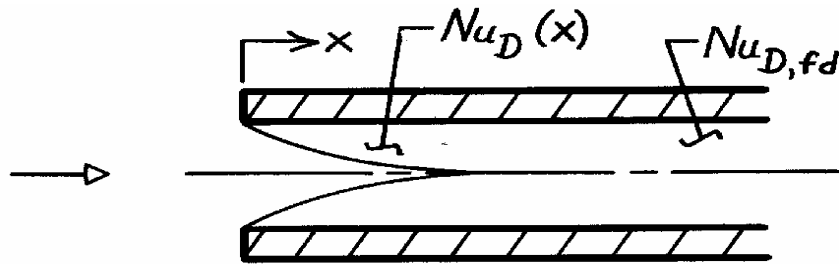**KNOWN:** Effect of entry length on average Nusselt number for turbulent flow in a tube.

FIND: Ratio of average to fully developed Nusselt numbers for prescribed conditions.

SCHEMATIC:

ASSUMPTIONS: (1) Sharp edged inlet, (2) Combined entry region.

ANALYSIS: From Eq. 8.63,

$$\frac{\overline{Nu_D}}{Nu_{D,fd}} = 1 + \frac{C}{(x/D)^m}$$

and with $C = 24Re_D^{-0.23}$ and $m = 0.815 - 2.08 \times 10^{-6} Re_D$,

$$\frac{\overline{Nu_D}}{Nu_{D,fd}} = 1 + \frac{24Re_D^{-0.23}}{(x/D)^{\left(0.815 - 2.08 \times 10^{-6} Re_D\right)}}.$$

It follows that

$\left(\overline{Nu_D} / Nu_{D,fd}\right)$	Re_D	x/D
1.463	10^4	10
1.116	10^4	60
1.420	10^5	10
1.142	10^5	60

COMMENTS: The assumption $\overline{Nu_D} \approx Nu_{fd}$ for $x/D = 10$ would result in underprediction of $\overline{Nu_D}$ by approximately 45%. The underprediction is only approximately 10% for $x/D = 60$.