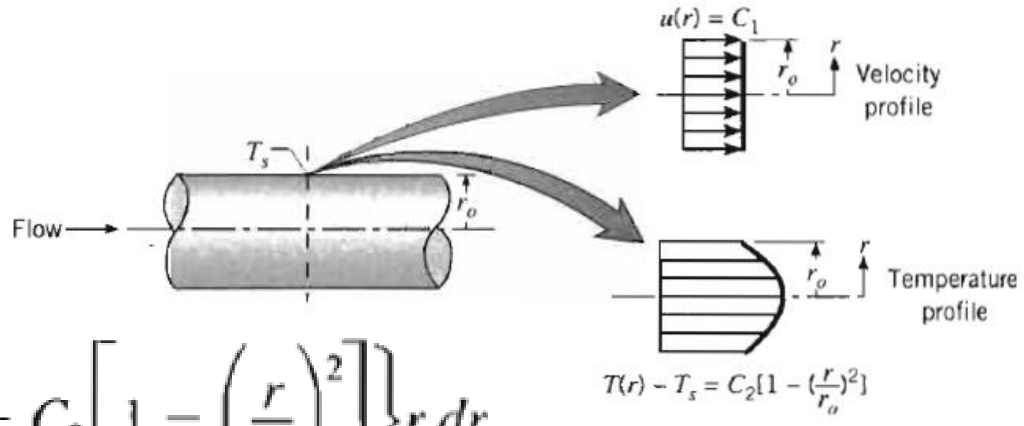
Example 1:

For flow of a liquid metal through a circular tube, the velocity and temperature profiles at a particular axial location may be approximated as being uniform and parabolic, respectively. That is, $u(r) = C_1$ and $T(r) - T_s = C_2[1 - (r/r_o)^2]$, where C_1 and C_2 are constants. What is the value of the Nusselt number Nu_D at this location?



- **Heat Transfer Coefficient:** $h = \frac{q_s''}{(T_m - T_s)}$
- **Average velocity:** $u_m = \frac{2}{r_0^2}\int_0^{r_0} r u(r)dr = C_1$
- **Bulk Mean Temperature:**

$$T_m = \frac{2}{u_m r_o^2}\int_0^{r_o} uTr\,dr = \frac{2C_1}{u_m r_o^2}\int_0^{r_o}\left\{T_s + C_2\left[1-\left(\frac{r}{r_o}\right)^2\right]\right\}r\,dr$$

$$T_m = \frac{2}{r_o^2}\int_0^{r_o}\left\{T_s + C_2\left[1-\left(\frac{r}{r_o}\right)^2\right]\right\}r\,dr = \frac{2}{r_o^2}\left(T_s\frac{r_o^2}{2} + \frac{C_2}{2}r_o^2 - \frac{C_2}{4}r_o^2\right) = T_s + \frac{C_2}{2}$$

- **Wall Heat flux:** $q_s'' = -k\frac{\partial T}{\partial r}\Big|_{r=r_0} = -kC_2 2\frac{-r}{r_0^2}\Big|_{r=r_0} = 2C_2\frac{k}{r_0}$

$$h = \frac{q_s''}{(T_m - T_s)} = \frac{2C_2(k/r_0)}{C_2/2} = \frac{4k}{r_0}$$

$$Nu_D = \frac{hD}{k} = \frac{(4k/r_o)\times 2r_o}{k} = 8$$