Two long pipes convey water between two reservoirs whose water surfaces are at different elevations. One pipe has a diameter twice that of the other; both pipes have the same length and the same value of $f$. If minor losses are neglected, what is the ratio of the flow rates through the two pipes?

Eq. 8.13:  
\[ \Delta \text{elev} = h_f = f(L/D)V^2/(2g) \quad \text{where} \quad V = Q/A = Q/((\pi D^2/4)) \]

\[ \therefore \quad h_f = f(L/D)[Q/((\pi D^2/4))]^2/2g = f1.4^2Q^2/(2gD\pi^2 D^4) \]

Thus  
\[ h_f \propto Q^2/D^5; \quad (h_1)_1 = (h_1)_2; \quad Q_1^2/D_1^5 = Q_2^2/D_2^5 \quad \text{and} \quad Q_2/Q_1 = (D_2/D_1)^{5/2} = 2^{5/2} = 5.66 \]

The flow in the larger pipe will be 5.66 times that in the smaller pipe.

Tests were made with 60°F water flowing in a 9-in-diameter pipe. They showed that, when $V = 12$ fps, $\rho = 0.0165$. Find the unit shear at the pipe wall and at radii of 0, 0.25, 0.4, 0.6, 0.85 times the pipe radius.

Table A.1 for water at 60°F:  
\[ \rho = 1.938 \text{ slugs/ft}^3 \]

(a) Eq. 8.19:  
\[ \tau_0 = (0.0165/4)1.938(12^2/2) = 0.576 \text{ psf, at wall} \]

(b) Stress distribution is linear (Eq. 8.18):

<table>
<thead>
<tr>
<th>$\tau$ (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r/r_0$</td>
</tr>
</tbody>
</table>
| 0              | 0
| 0.25           | 0.1439
| 0.4            | 0.230
| 0.6            | 0.345
| 0.85           | 0.489

Sec. 8.6: Friction in Noncircular Conduits – Exercises (2)
For laminar flow between two parallel, flat plates a small distance $d$ apart, at what distance from the centerline (in terms of $d$) will the velocity be equal to the mean velocity?

Let $y_m =$ distance from centerline where $u = V_{\text{mean}}$. From solution to Exer. 8.7.3, $V_{\text{mean}} = (2/3)V_c$.

So when $y = y_m$, $u = (2/3)V_c$, i.e. $(2/3)V_c = V_c(1 - \frac{y_m}{y_0})$; $y_m^2 = (1/3)y_0^2 = (1/3)(d/2)^2$;

$y_m = 0.289d$
8.6. In a 36-in.-diameter pipe velocities are measured as 18.5 fps at r = 0 and 18.0 fps at r = 4.0 in. Approximately what is the flow rate? Assume laminar flow.

Solution

For laminar flow, \( u = Vc \left( 1 - \left( \frac{r}{R} \right)^2 \right) \)

with \( R = 36 \text{ in} \), and \( u = 18.5 \text{ fps at } r = 0 \)
\( u = 18.0 \text{ fps at } r = 4.0 \text{ in} \)

\( \left( A \right) \Rightarrow 18.5 \text{ fps} = Vc \left[ 1 - \left( \frac{0}{36} \right)^2 \right] \Rightarrow 18.5 \text{ fps} = Vc \)

Also, for laminar flow \( \frac{V}{Vc} = 0.5 \Rightarrow V = 0.5 \times 18.5 = 9.25 \text{ fps} \)

\( Q = \pi r^2 V = \pi \times \left( \frac{36}{12 \text{ ft}} \right)^2 \times 9.25 \text{ fps} = 261.54 \text{ cfs} \)