Three types of pipe flow problems (1)

1. Head loss problem
   - Given L, D Q (or V), and pipe roughness ε
   - Compute f, h_f, Δp, etc.

2. Flow rate problem
   - Given L, D, h_L and ε
   - Compute V, (or Q)
   - Requires iteration

3. Pipe sizing problem
   - Given L, Q (or V), and h_L
   - Compute D required to provide the desired flow

Basic Head Loss Problem

Given L, D, Q (or V), and pipe roughness ε

1. Look up fluid properties ρ, μ
2. Compute Re_D to determine whether the flow is laminar or turbulent
3. If turbulent, look up ε for the pipe material
4. Use the Colebrook equation or the Moody chart to find f
5. Use the Darcy-Weisbach equation to compute h_L
6. Use the steady-flow energy equation to find other terms, e.g. pressure drop

Basic Pipe Sizing Problem

Given L, Q (or V), h_L and ε compute D for a *round pipe*

1. Solve energy equation for h_L
2. Guess D
3. Compute ε/D, Re_D
4. Find f (Colebrook equation or Moody chart)
5. Solve for D by combining Darcy-Weisbach equation and energy equation

$$h_L = f\frac{L}{D}\frac{V^2}{2g} = f\frac{L}{D}\frac{1}{2g}\frac{Q^2}{(\pi/4)^2 D^4} = f\frac{8LQ^2}{\pi^2 g}\frac{1}{D^5} \implies \quad D = \left[\frac{8LQ^2 f}{\pi^2 g h_L}\right]^{1/5}$$

6. If $D_{\text{new}} \approx D_{\text{old}}$, stop, otherwise return to step 3

Note: Choose next larger standard pipe size

Basic Flow Rate Problem

Given L, D, h_L and ε

1. Solve the energy equation for h_L
2. Guess f: use the "wholly turbulent" range to find f for the known value of ε/D.
3. Solve for V with the Darcy-Weisbach equation

$$h_f = f\frac{L}{D}\frac{V^2}{2g} \quad \implies \quad V = \sqrt{\frac{2gh_f D}{fL}}$$

4. Compute Re_D
5. With new Re_D, use the Colebrook equation or the Moody chart to find f
6. If $f\mathrm{new} \approx f_{\text{old}}$ stop, otherwise return to step 3