Exercise 9.

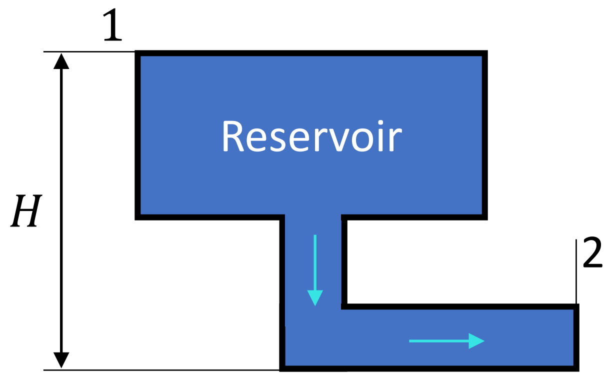
- Pressure drop in pipes:
  - Major losses, friction losses (viscous) = $\Delta p_{\mathrm{f}} = \rho g h_{\mathrm{f}}$
  - Minor losses, one-time losses in the flow path (engångsförluster) = $\Delta p_{\mathrm{m}} = \rho g h_{\mathrm{m}}$
- Bernoulli's Equation with head losses:
  - Follow the streamline from 1 → 2

$$p_1 + \frac{\rho V_1^2}{2} + \rho g z_1 = p_2 + \frac{\rho V_2^2}{2} + \rho g z_2 + \Delta p_{\mathrm{f}} + \Delta p_{\mathrm{m}}$$

(6.7mod or 3.73, on pressure form and no pump/turbine)

$$\Rightarrow p_2 = p_1 + \frac{\rho V_1^2}{2} + \rho g \underbrace{H}_{z_1 - Z_2} - \frac{\rho V_2^2}{2} - \Delta p_{\mathrm{f}} - \Delta p_{\mathrm{m}}$$

- Find p_2 → $V_1 \approx 0$, assume large reservoir
  - $p_2 = p_1 + \rho g H - \frac{\rho V_2^2}{2} - \Delta p_{\mathrm{f}} - \Delta p_{\mathrm{m}}$
- Find V_2 → $p_1 = \mathrm{p}_2$, open to atmospheric pressure
  - $V_2 = \frac{2}{\rho}\sqrt{\rho g H - \Delta p_{\mathrm{f}} - \Delta p_{\mathrm{m}}}$
- For cylindrical pipe: $V = \frac{Q}{A} = \left(\frac{4Q}{\pi d^2}\right)$



Exercise 9.

- $\text{Re} \leq 2300$ → laminar, else transition or turbulent
- Minor losses h_m:
  - Due to bends, valves, area changes etc.
  - $h_\text{m} = \frac{V^2}{2g} \sum k_i$ (6.76)
  - k is the minor loss coefficient, usually tabulated value
- Major losses
  - Wall shear stress (friction) from the pipe
  - $h_\text{f} = \frac{V^2}{2g} \sum \frac{f_i L_i}{d_i}$ Eqs. (6.10, 6.76, or p. 16 in FS)
  - f is the major loss coefficient
  - $f_\text{lam} = \frac{64}{\text{Re}}$ (6.13)
  - f_turb → solve iterative with Eqn. (6.48), estimate with Eqn. (6.49) or Moody-chart Fig. 6.13
- Checkout IFLOW on canvas.

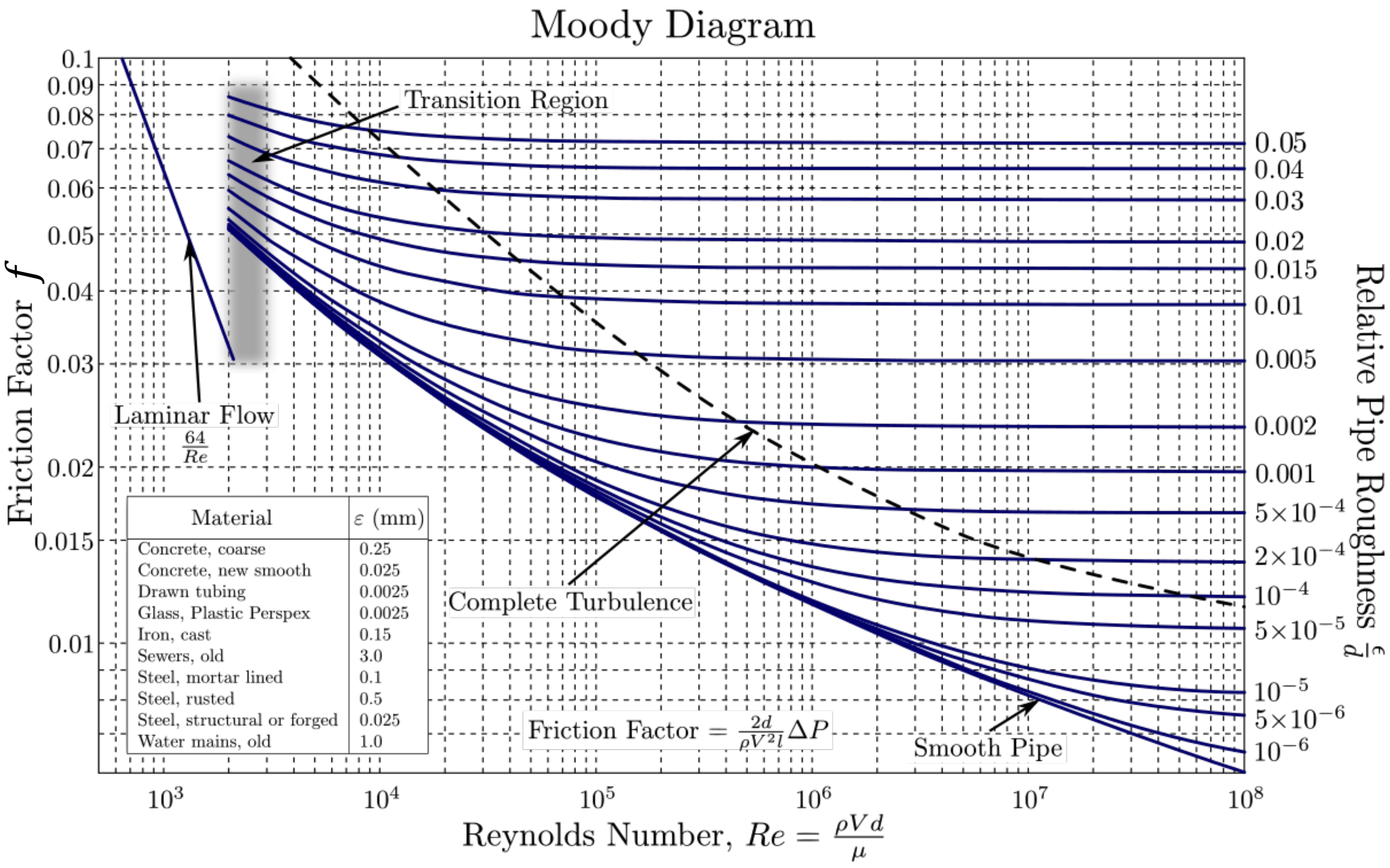


Fig. 6.13

or

$$f = \left[\frac{1}{-2\log\left(\frac{2.51}{\mathrm{Re}\, f^{1/2}} + \frac{\varepsilon/d}{3.7}\right)}\right]^2 \quad \text{Eq. (6.48)}$$

OBS Explicit! (need to iterate)

$$f \approx \left[\frac{1}{-1.8\log\left(\frac{6.9}{\mathrm{Re}} + \left(\frac{\varepsilon/d}{3.7}\right)^{1.11}\right)}\right]^2 \quad \text{Eq. (6.49)}$$

Implicit! (just plug in values)

Exercise 9.

- Hydraulic diameter: $d_{\mathrm{h}} = \frac{4A}{\text{wetted parameter}}$ Eq. (6.56)
  - Wetted parameter = Circumference of water towards the wall
- Total pressure: $p_0 = p + \frac{\rho V^2}{2}$
  - Also referred to as stagnation pressure
  - Describes the pressure if the flow is isentropic retarded to stand-still