

*MEC516/BME516:
Fluid Mechanics I*

Chapter 2: Fluid Statics

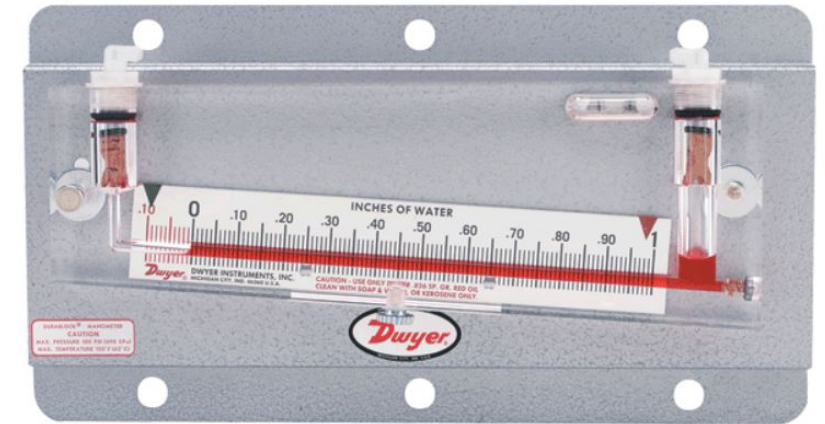
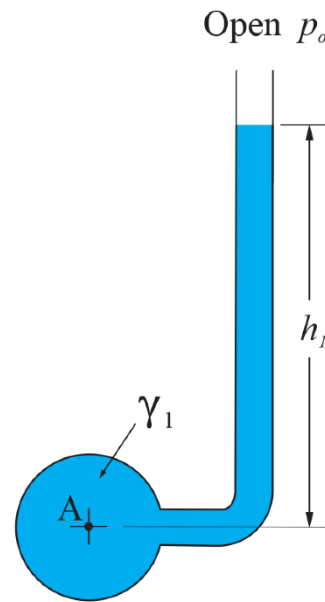
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Overview

- General Manometry: Pressure measurement via a column of liquid
 - Piezometers
 - U-tube manometers
 - Inclined manometers
- Need this skill for Chapter 3



Manometry

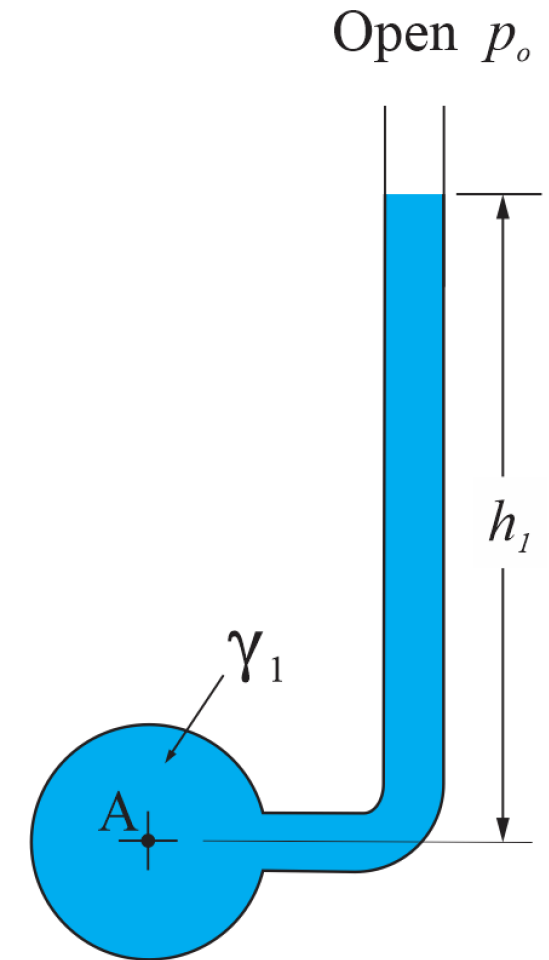
- A manometer is a device that uses a liquid column to measure pressure differences
- The simplest manometer is a vertical tube, open at the top, attached to a pipe. **Absolute pressure** at A:

$$p_A = p_o + \gamma_1 h_1$$

where p_o is the local atmospheric pressure

Thus, the **gauge pressure** at point A is: $p_A - p_o = \gamma_1 h_1$

- A piezometer tube only works for liquids and positive gauge pressures



Piezometer Tube

U-Tube Manometer

- Can be used for gases and negative gauge pressures at point A. Gauge fluid
- Find the gauge pressure at point A:
- Working from point A:

$$p_2 = p_A + \gamma_1 h_1 \quad (1)$$

$$p_2 = p_3 \quad (\text{same depth in same fluid})$$

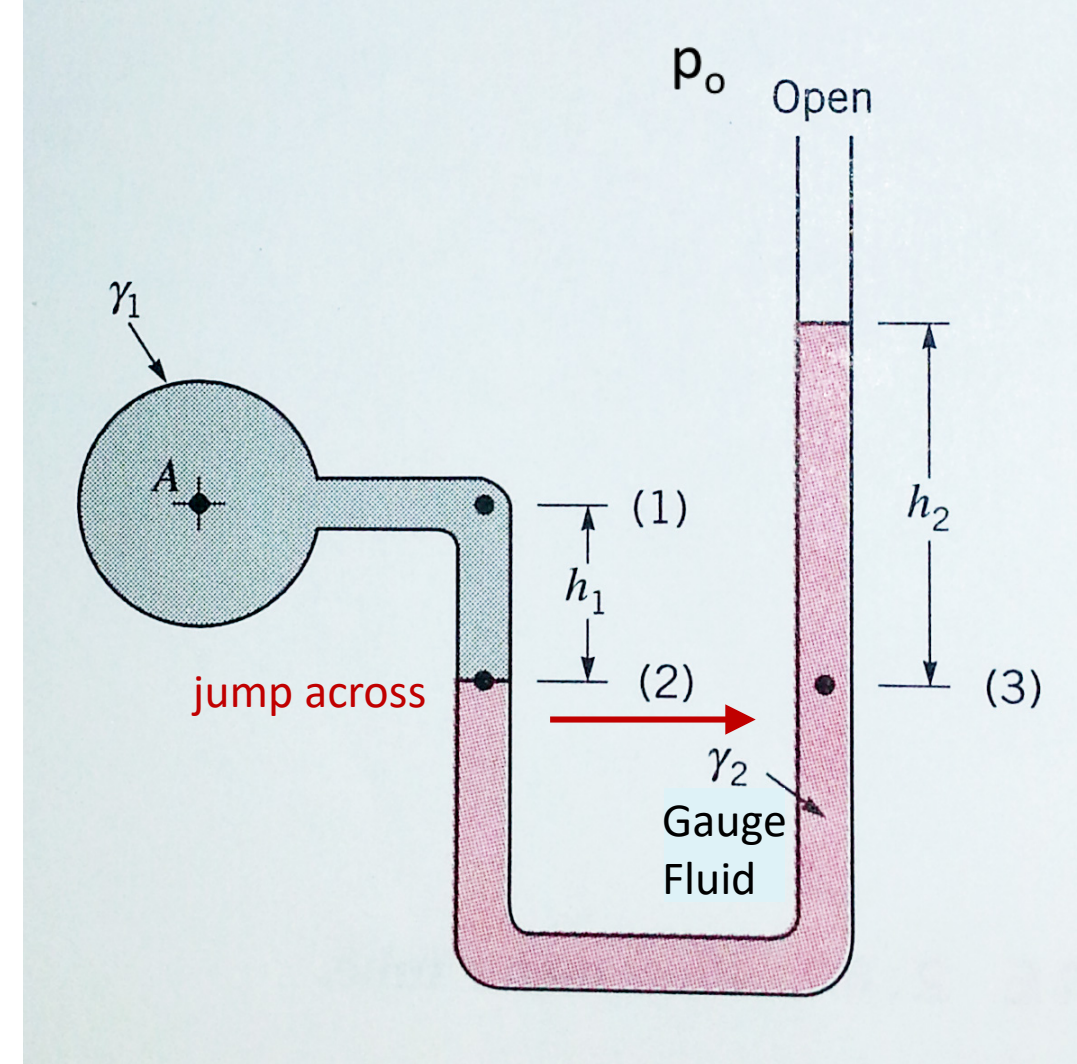
$$p_3 = p_o + \gamma_2 h_2 \quad (2)$$

- Equate (1) and (2):

$$p_A + \gamma_1 h_1 = p_o + \gamma_2 h_2$$

- Gauge pressure at point A: $p_A - p_o = \gamma_2 h_2 - \gamma_1 h_1$

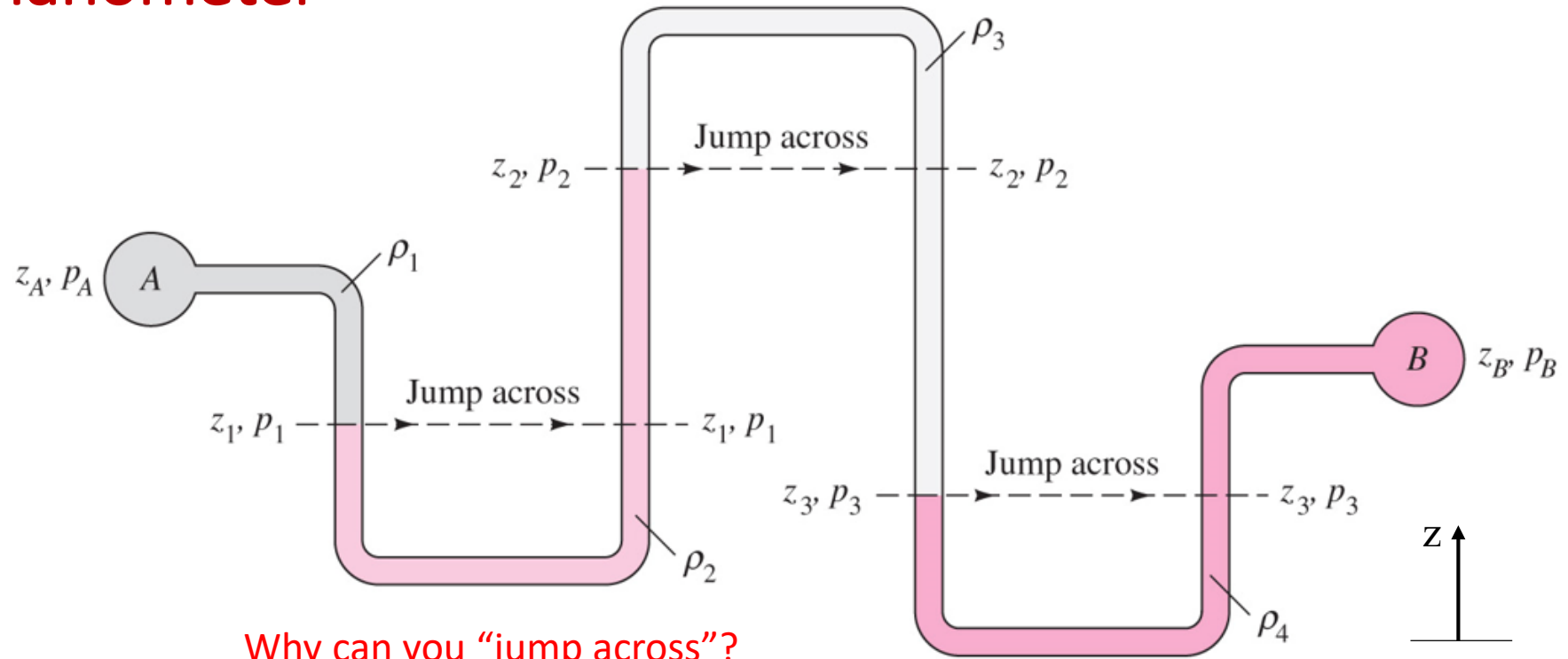
- If the fluid in the pipe is a gas ($\gamma_1 \ll \gamma_2$), then: $p_A - p_o \approx \gamma_2 h_2$



Complex U-Tube Manometer

- Four different fluids
- Find $p_A - p_B$

Work from A to B:



Why can you "jump across"?
Same depth in same fluid = same pressure

$$p_A + \gamma_1(z_A - z_1) - \gamma_2(z_2 - z_1) + \gamma_3(z_2 - z_3) - \gamma_4(z_B - z_3) = p_B$$

Red annotations in the original image show brackets under the terms $\gamma_1(z_A - z_1)$ and $-\gamma_2(z_2 - z_1)$ with a label $= p_1$, and a larger bracket under the entire right-hand side of the equation with a label $= p_3$.

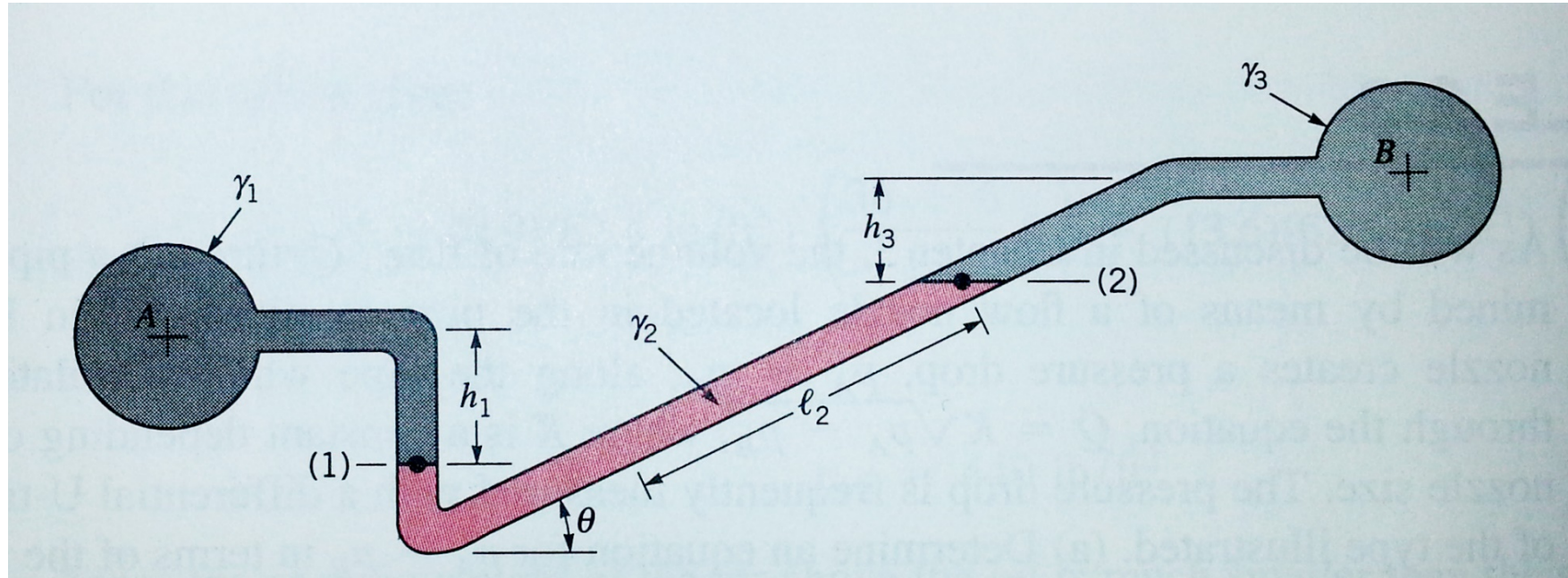
Is $p_A - p_B$ gauge pressure?
No! Just a pressure difference

$$p_A - p_B = -\gamma_1(z_A - z_1) + \gamma_2(z_2 - z_1) - \gamma_3(z_2 - z_3) + \gamma_4(z_B - z_3)$$

Inclined Manometer: For increased sensitivity

- Three different fluids
- Inclination angle, θ
- Find $p_A - p_B$

Work from A to B:



$$\underbrace{\quad}_{=p_1} \quad \underbrace{\quad}_{=p_2}$$

$$p_A + \gamma_1 h_1 - \gamma_2 \ell_2 \sin \theta - \gamma_3 h_3 = p_B$$

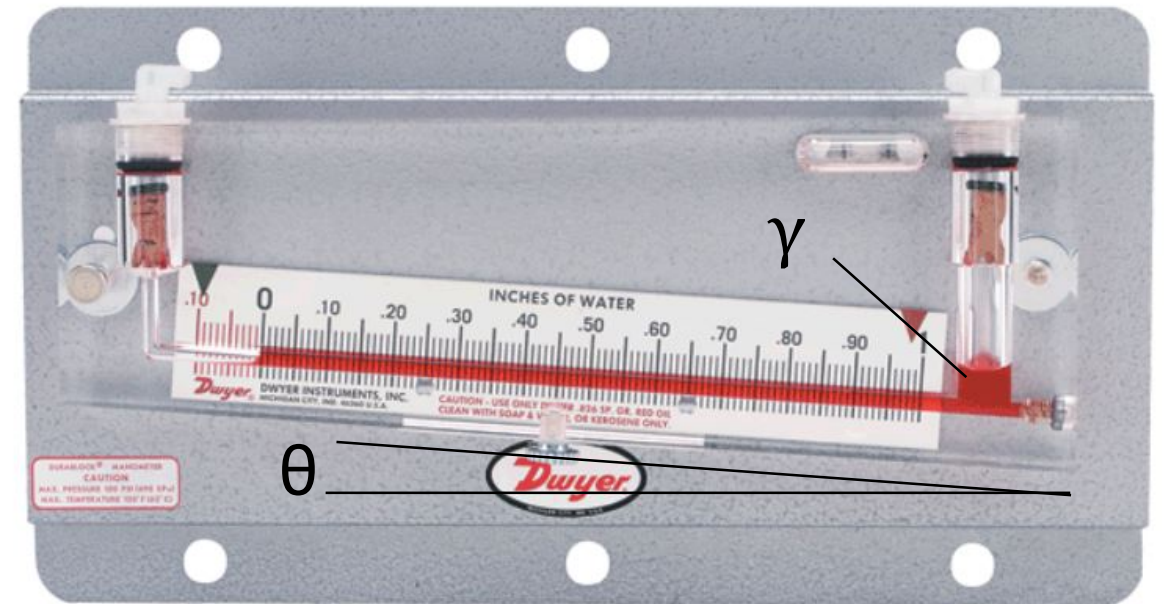
$$p_A - p_B = -\gamma_1 h_1 + \gamma_2 \ell_2 \sin \theta + \gamma_3 h_3$$

For gases at A & B ($\gamma_1 \approx \gamma_3 \approx 0$):

$$p_A - p_B = \gamma_2 \ell_2 \sin \theta$$

Commercial Inclined Manometer

- Several manufacturers make commercial models
- You will use an inclined manometer in Lab 2
- For measuring small pressure differences
- Low inclination angles and light oil gauge fluid increase the sensitivity

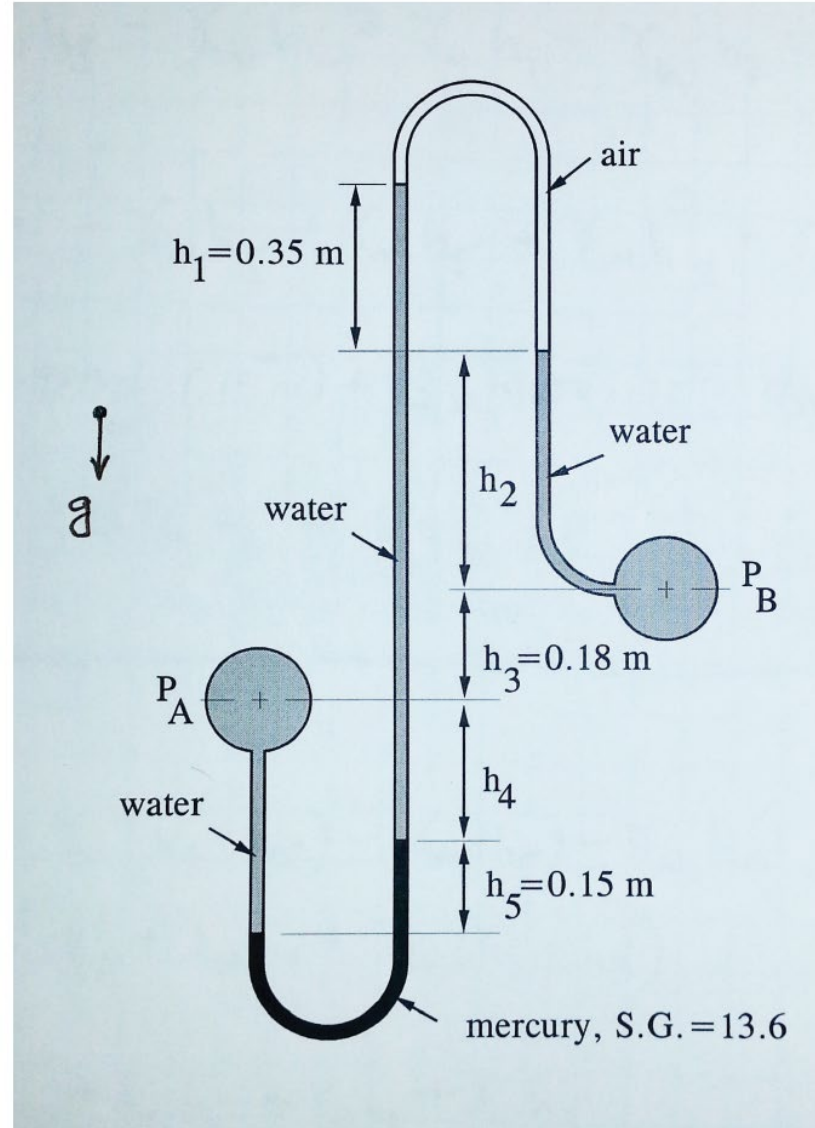


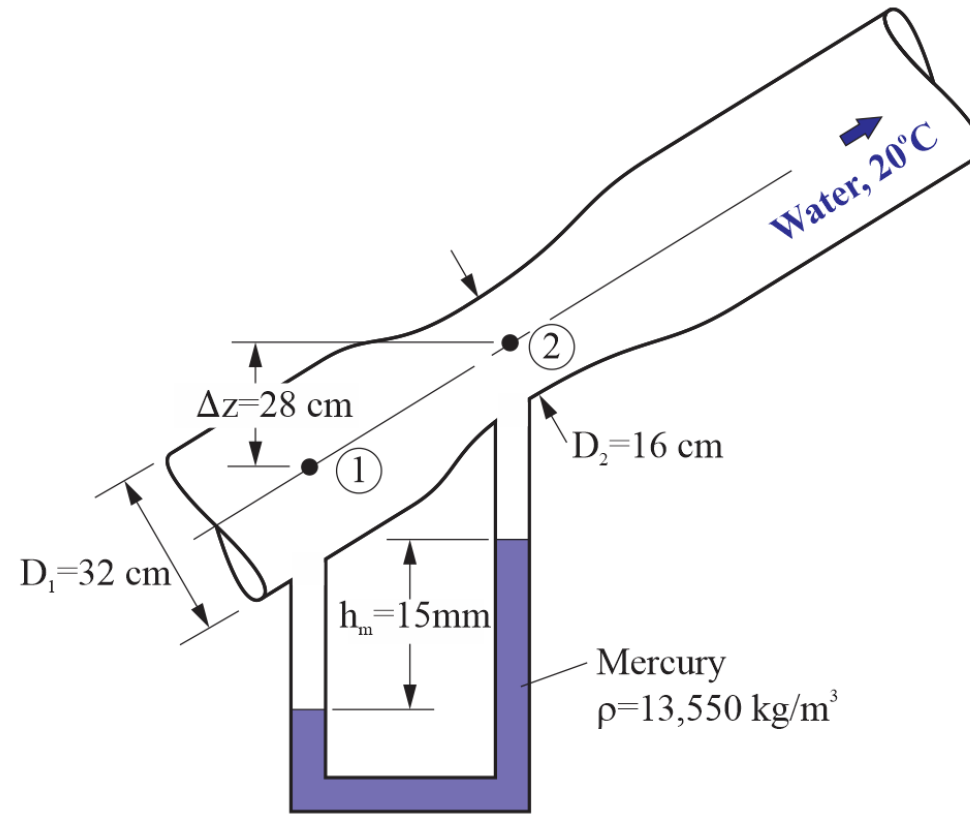
Complex Manometer

- “Midterm calibre” question

Watch the Video Solution

Example: Calculate the pressure difference, $P_A - P_B$.





END NOTES

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