CE 213 - Fluid Mechanics

Basic Equation of Fluid Statics

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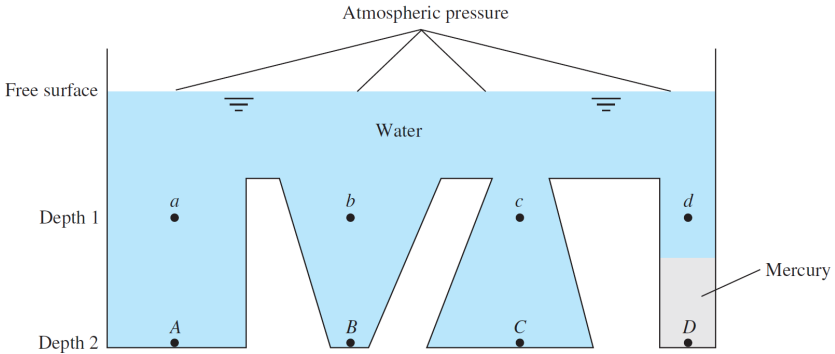
Learning Objectives

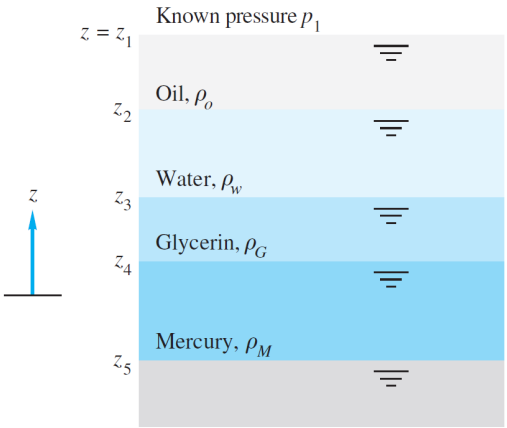
- Pressure variation
- Scales of pressure measurement
- Pressure measurement
  - Piezometer
  - Barometer
  - Manometer

Pressure Variation



Any two points at the same elevation in a continuous mass of the same static fluid will be at the same pressure

Pressure Variation



$$p_2 - p_1 = -\rho_o g(z_2 - z_1)$$

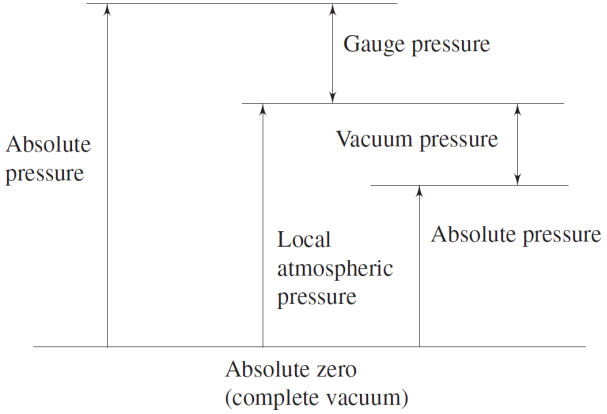
$$p_3 - p_2 = -\rho_w g(z_3 - z_2)$$

$$p_4 - p_3 = -\rho_G g(z_4 - z_3)$$

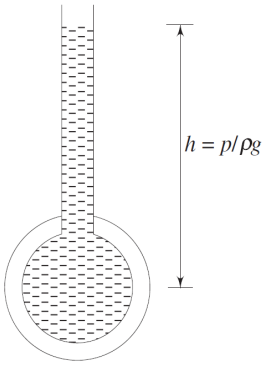
$$p_5 - p_4 = -\rho_M g(z_5 - z_4)$$

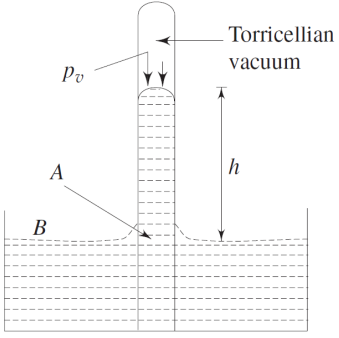
$$\text{Sum} = \overline{p_5 - p_1}$$

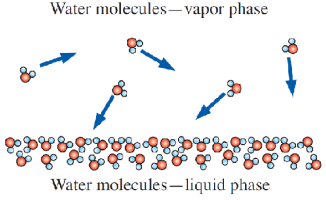
Scales of Pressure Measurement



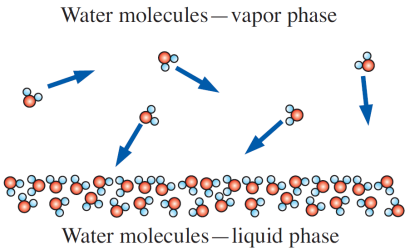
Pressure Measurement







Vacuum Pressure



- At interface, the fluid starts evaporating due to strong adhesion forces
- After some time, fluid molecules starts coming back and strikes surface due to strong cohesive forces
- At one point of time, evaporation and coming back molecules will be balanced - Equillibrium condition

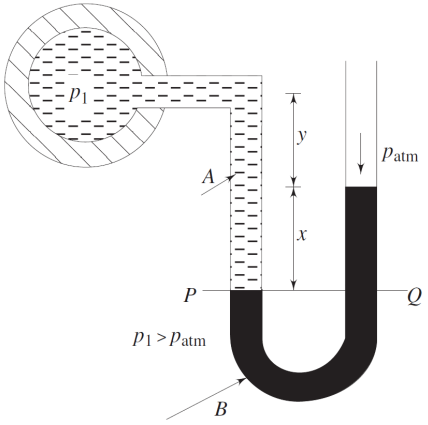
$$P_v = f(T) \quad (1)$$

$$P_v + \rho g h = P_o \quad (2)$$

Vacuum pressure is a function of temperature and fluid type.

Pressure Measurement

Manometers



Manometric liquid

- Depends on range of pressure to be measured
- Lower range - lower specific gravity solutions
- High range - Higher specific gravity solutions
- Mercury, Oil, Salt solution

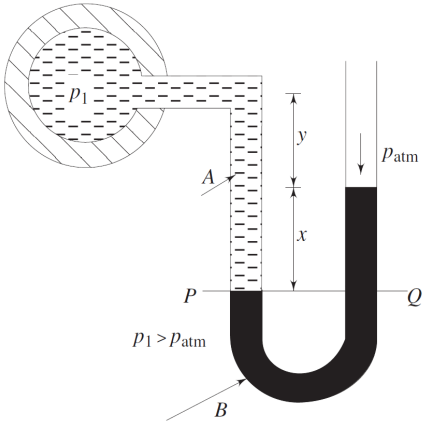
The line PQ is called as Meniscus - line of separation

Pressure Measurement
Manometers

- Simple Manometers - Measure pressure at a point
  - U-tube manometer
  - Single column manometer
- Differential Manometers - Measure difference in pressure between any two points
  - U-tube differential manometer
  - Inverted U-tube differential manometer

Pressure Measurement
Manometers

Measurement of Gauge Pressure



ρ_w - Density of working fluid
ρ_m - Density of manometric fluid

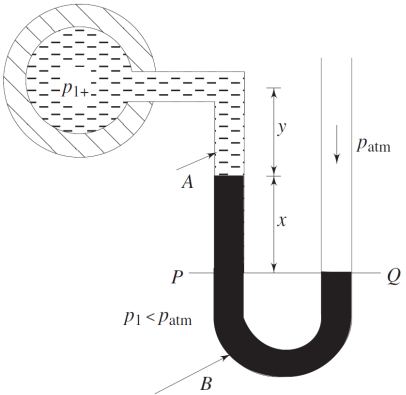
$$P_1 + \rho_w g(x + y) = P_{atm} + \rho_m g x$$

$$P_1 - P_{atm} = \rho_m g x - \rho_w g(x + y)$$

$$P_1 - P_{atm} = (\rho_m - \rho_w) g x - \rho_w g y \qquad (3)$$

Pressure Measurement
Manometers

Measurement of Negative Gauge/Vacuum Pressure



ρ_w - Density of working fluid
ρ_m - Density of manometric fluid

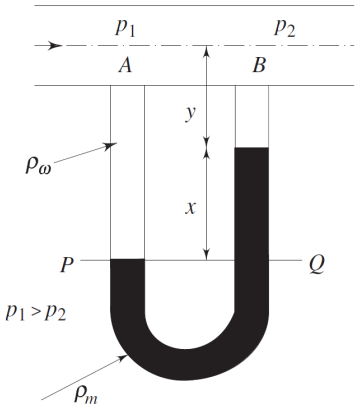
$$P_1 + \rho_w g y + \rho_m g x = P_{atm}$$

$$P_1 - P_{atm} = -(\rho_w y + \rho_m x) g \qquad (4)$$

Pressure Measurement

Manometers

Pressure difference in a flow; $P_1 > P_2$



ρ_w - Density of working fluid
ρ_m - Density of manometric fluid

$$P_1 + \rho_w g(x + y) = P_2 + \rho_w g y + \rho_m g x$$

$$P_1 - P_2 = (\rho_m - \rho_w) g x \qquad (5)$$

THANK YOU !!