Devices to measure Pressure

- In chemical and other industrial processing plants it is often important to measure and control the pressure in a vessel or process and/or the liquid level in a vessel.

- Also, since many fluids are flowing in a pipe or conduit, it is necessary to measure the rate at which the fluid is flowing.

- Many of these flow meters depend upon devices to measure a pressure or pressure difference.

- MANOMETERS are mainly used

Manometers

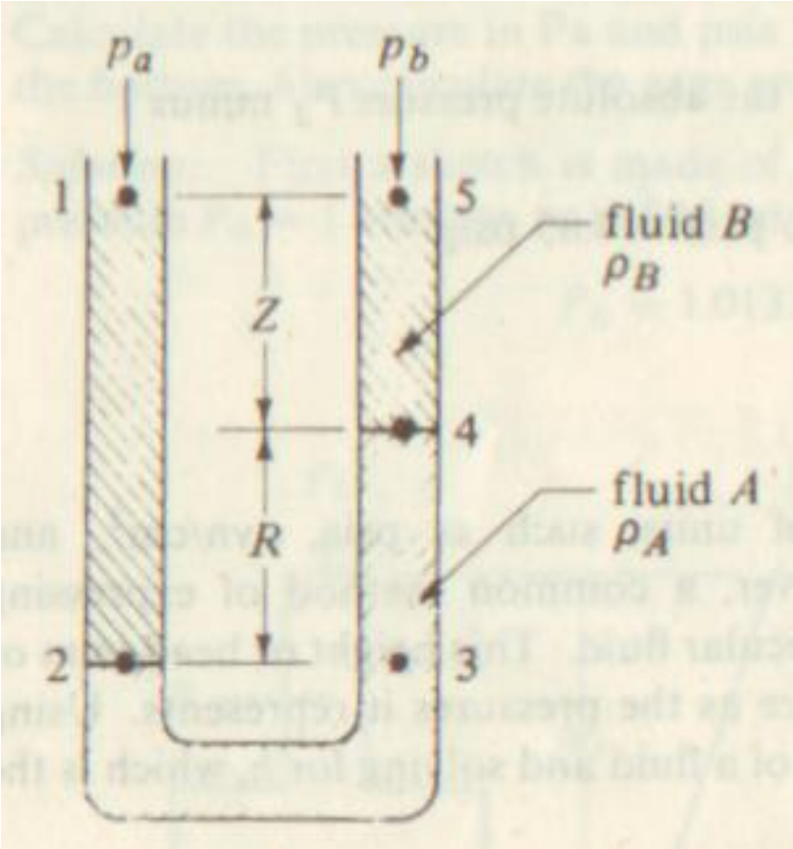
- Manometer is a device for measuring fluid pressure
- Consists of a bent tube containing one or more liquid of different specific gravities.
- In using a manometer, generally a known pressure (which may be atmospheric) is applied to one end of the manometer tube and the unknown pressure to be determined is applied to the other end.
- In some cases, however, the difference between pressure at ends of the manometer tube is desired rather than the actual pressure at the either end.

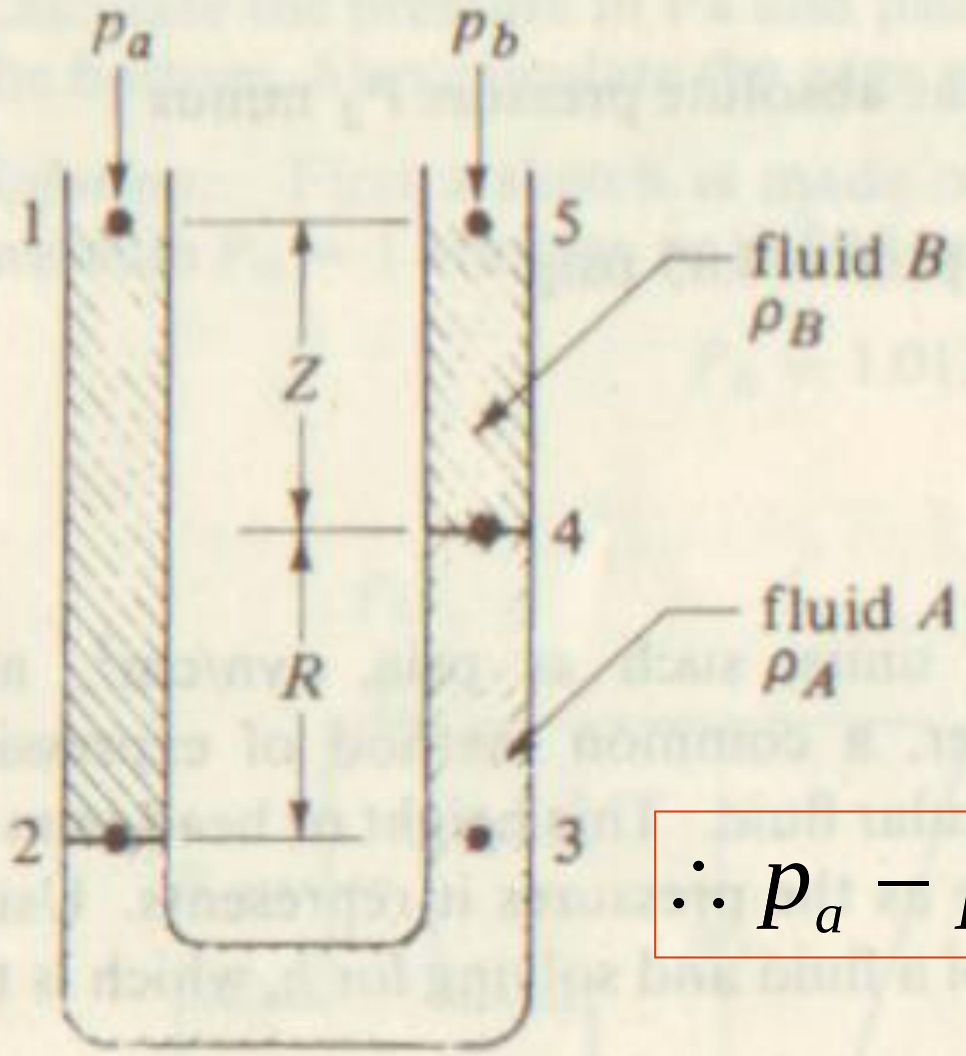
Manometers - Various forms

- *Simple U - tube Manometer*
- Inverted U - tube Manometer
- U - tube with one leg enlarged
- Two fluid U - tube Manometer
- Inclined U - tube Manometer

MANOMETERS

- **Simple U tube manometer**
- Pressure p_a is exerted on one arm of the U tube and p_b on the other arm.
- Both pressures p_a and p_b are pressure taps from a fluid meter
- The top of the manometer is filled with liquid B, having a density of ρ_B, and the bottom with a more dense fluid A, having a density of ρ_A
- Liquid A is immiscible with B.
- To derive the relationship between p_a and p_b ………….





- We know, $p_2 = p_3$

$$p_a + (\cancel{Z} + R)\rho_B g =$$

$$p_b + \cancel{Z}\rho_B g + R\rho_A g$$

$$p_a + R\rho_B g = p_b + R\rho_A g$$

$$\boxed{\therefore p_a - p_b = \Delta P = R(\rho_A - \rho_B)g}$$

Mechanism of Fluid Flow

- When a fluid flows through a pipe or channel, the character of the flow can vary according to the conditions.

- The forms of flow can best be visualized by reference to a classical experiment on the flow of water through a circular tube, first carried out by Osborne Reynolds in 1883.

- Reynolds studied the effect of varying the conditions on the character of flow and on the appearance of the thread of colored liquid. This can be illustrated, for example, by varying the velocity of the water through the tube.

- When the velocity is low, the thread of colored liquid remains undisturbed in the centre of the water stream and moves steadily along the tube, without mixing, this condition is known as s **viscous, or laminar flow**.(**Streamline flow)**

Reynolds' experiment

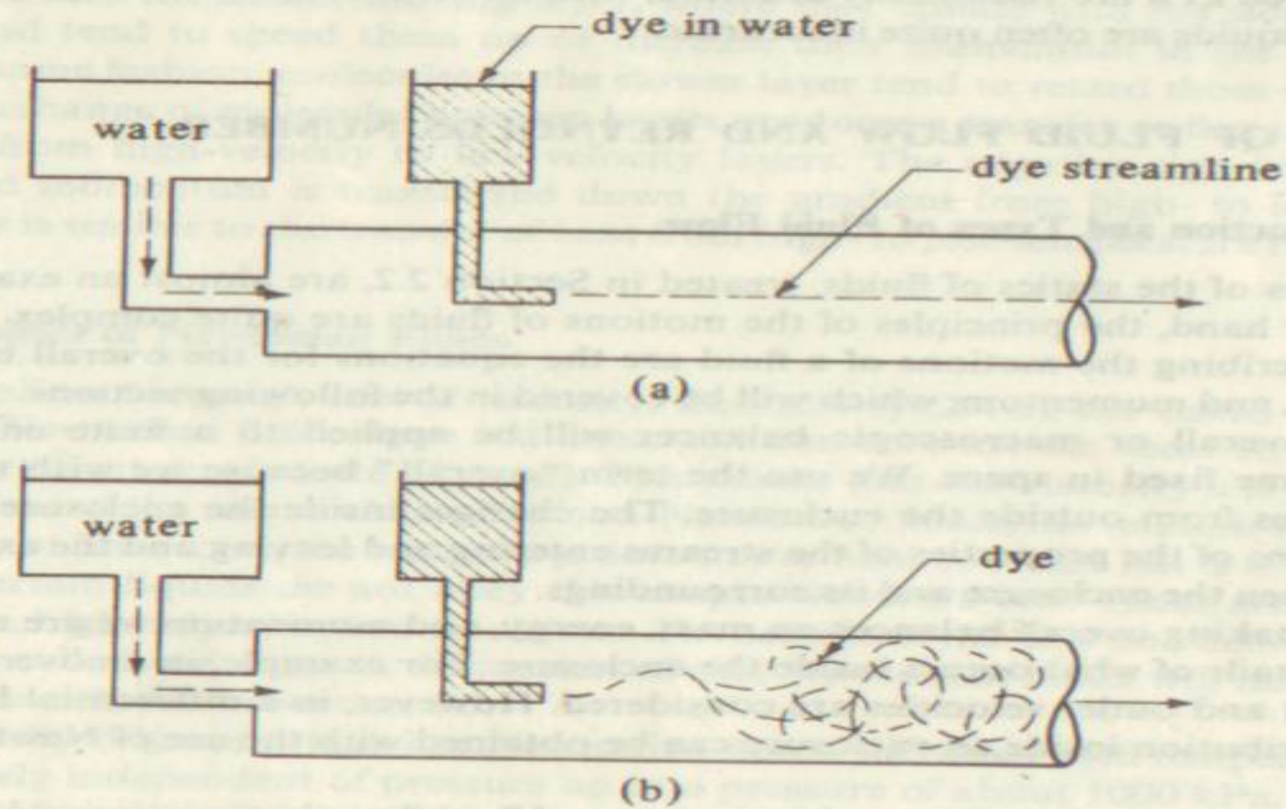


FIGURE 2.5-1. *Reynolds' experiment for different types of flow : (a) laminar flow. (b) turbulent flow.*

- At moderate velocities, a point is reached (the critical velocity) at where the thread begins to waver, although no mixing occurs. This is the phase of **transitional flow**.

- As the velocity is increased to high values eddies begin to occur in the flow, so that the colored liquid mixes with the bulk of the water immediately after leaving the jet. Since this is a state of complete turbulence the condition is known as **turbulent flow**.

- As a result of his experiments Reynold found that flow conditions were affected by four factors:

  - Diameter of pipe
  - Velocity of fluid
  - Density of fluid
  - Viscosity of fluid

These were connected together in a particular way and could be grouped into a particular expression known now as **Reynolds Number**: N_{Re} or Re

N_{Re}

- Reynolds number is given by….

$$N_{\text{Re}} = \frac{Dv\rho}{\mu}$$

- It can be seen that all the units cancel out; i.e. Re is dimensionless.

$$N_{\text{Re}} = \frac{(m)(m/s)(kg/m^3)}{kg/ms}$$

Significance of Re

- For a straight circular pipe

Type of flow	**Reynolds no.**	**Velocity**
Laminar (Streamline)	<2100	Low
Turbulent	>4000	High
Transition	2100<Re<4000	Moderate