Instrumental Technique

Manometer

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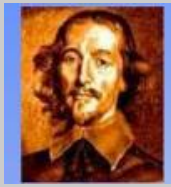
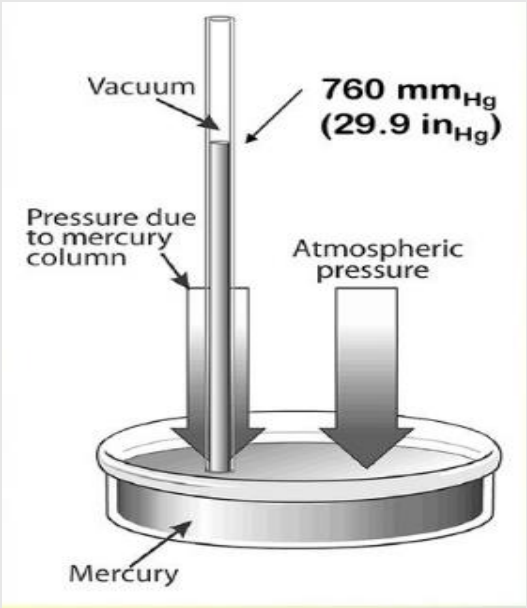
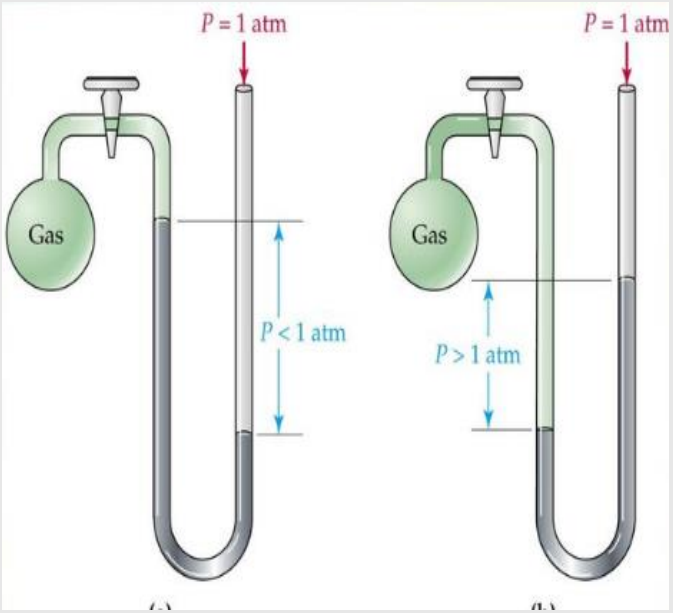
Comparison of pressure measurement instruments

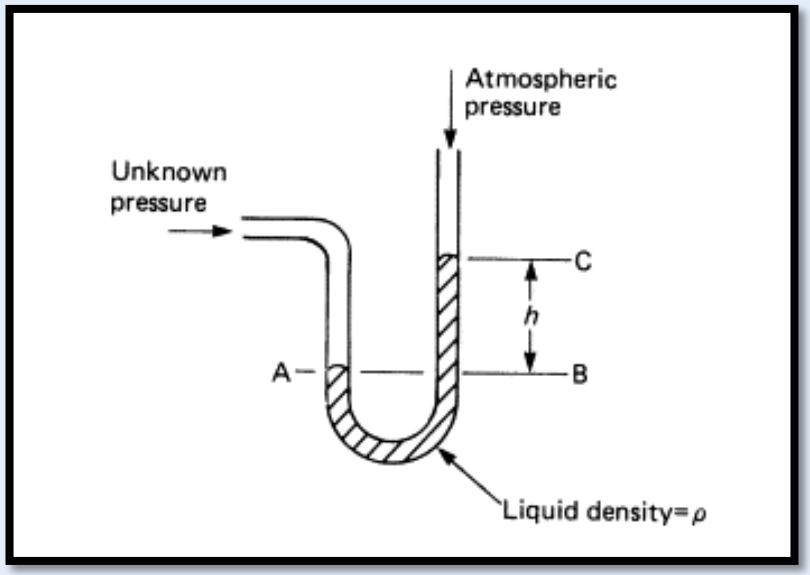
Physical phenomena	Instrument	Governing equation	Limiting factors	Practical pressure range	Ideal accuracy	Response time
Mechanical	Liquid column manometer	$\Delta P = \varrho g h$		atm to 1 mbar		
Mechanical	Capsule dial gauge		Friction	1000 to 1 mbar	±5% of full scale	Slow
Mechanical	Strain gauge			1000 to 1 mbar		Fast
Mechanical	Capacitance manometer		Temperature fluctuations	atm to 10^{-6} mbar	±1% of reading	Slower when filter mounted
Mechanical	McLeod	Boyle's law		10 to 10^{-3} mbar	±10% of reading between $10^{-4}$and $5{\cdot}10^{-2}$ mbar	
Transport	Spinning rotor(drag)			10^{-1} to 10^{-7} mbar	±2.5% of reading between $10^{-7}$and 10^{-2} mbar2.5 to 13.5% between 10^{-2} and 1 mbar	
Transport	Pirani (Wheatstone bridge)		Thermal conductivity	1000 to 10^{-3} mbar (const. temperature)10 to 10^{-3} mbar (const. voltage)	±6% of reading between $10^{-2}$and 10 mbar	Fast
Transport	Thermocouple(Seebeck effect)		Thermal conductivity	5 to 10^{-3} mbar	±10% of reading between $10^{-2}$and 1 mbar	
Ionization	Cold cathode (Penning)		Ionization yield	10^{-2} to 10^{-7} mbar	+100 to -50% of reading	
Ionization	Hot cathode (ionization induced by thermionic emission)		Low current measurement; parasitic x-ray emission	10^{-3} to 10^{-10} mbar	±10% between 10^{-7} and 10^{-4}mbar±20% at 10^{-3} and 10^{-9} mbar ±100% at 10^{-10} mbar	*https://en.wikipedia.org/wiki/Pressure_measurement*

History

Barometer	Manometer
 Created by Evangelista Torricelli in 1646.	 In 1661, **Otto von Guericke** invented the manometer.
	
Barometer-apparatus used to measure atmospheric pressure; derived from the Greek “baros” meaning “weight”.	Manometer-apparatus used to measure the pressure inside of a container relative to atmospheric pressure. https://slideplayer.com/slide/14832319/

Principle

- ✓ **Manometer:** A device for measuring pressure differences, usually by the difference in height of two liquid columns.
- ✓ The simplest type is the U-tube manometer, which consists of a glass tube bent into the shape of a U.
- ✓ If a pressure to be measured is fed to one side of the U-tube and the other is open to the atmosphere, the difference in level of the liquid in the two limbs gives a measure of the unknown pressure.

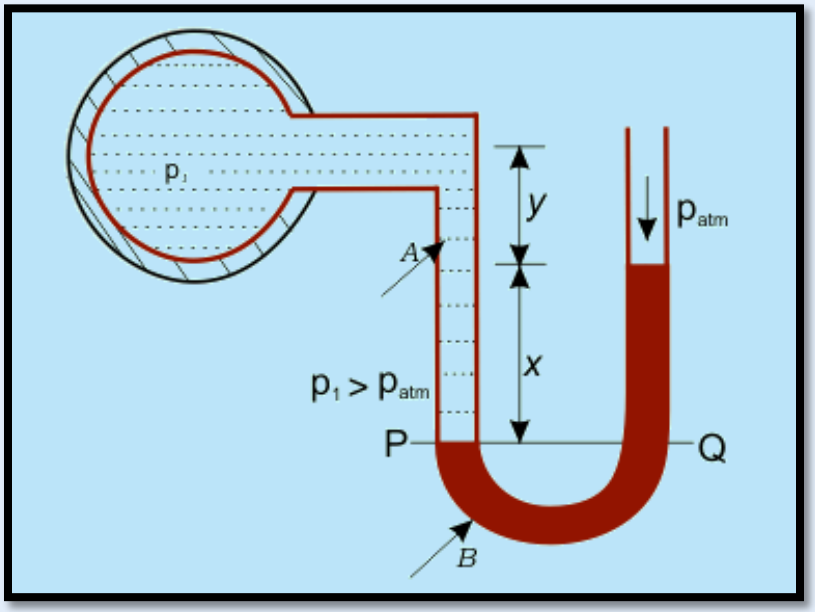


$p = h\rho g$,
Where ρ is the density of the liquid and g is the acceleration due to gravity

Measurement of gauge and vacuum pressure

The pressures at two points *P* and *Q* (Figure) in a horizontal plane within the continuous expanse of same fluid (the liquid B in this case) must be equal.

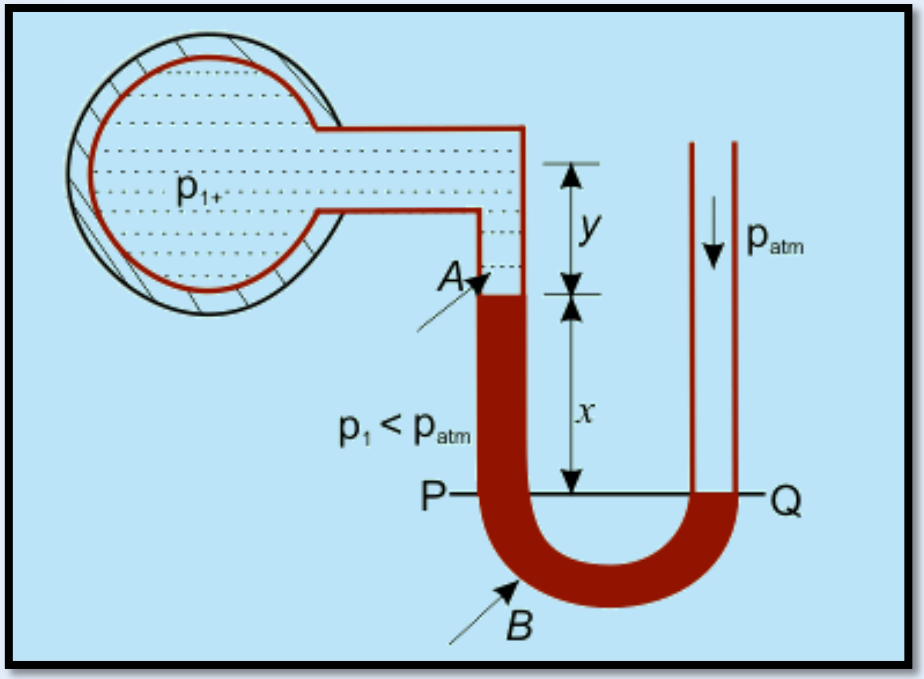
- **A simple manometer to measure gauge pressure**



$$p_1 + \varrho_A g(y+x) = p_{atm} + \varrho_B g x$$

$$p_1 - p_{atm} = (\varrho_B - \varrho_A) g x - \varrho_A g y$$

- **A simple manometer to measure vacuum pressure**



$$p_1 + \varrho_A g y + \varrho_B g x = p_{atm}$$

$$p_{atm} - p_1 = (\varrho_A y + \varrho_B x)\, g$$

Manometers to measure pressure difference

A manometer is also frequently used to measure the pressure difference, in course of flow, across a restriction in a horizontal pipe

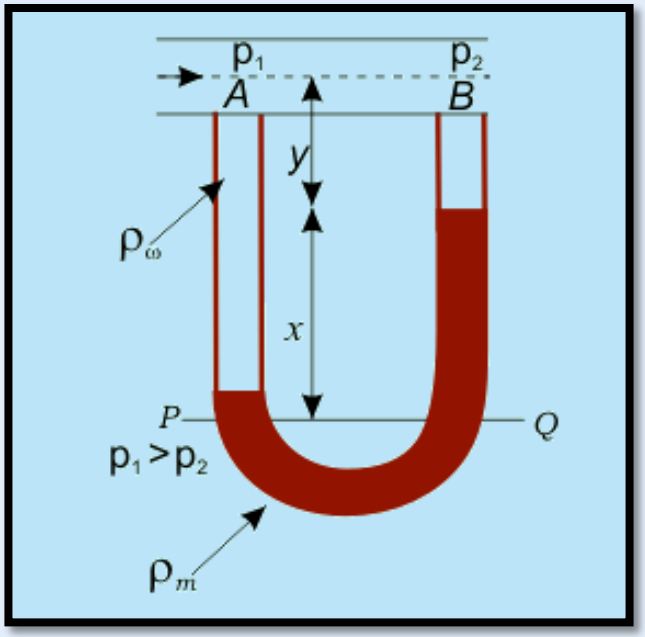


Fig. -Manometer measuring pressure difference

Applying the principle of hydrostatics at P and Q we have,

$$p_1 + (y + x)\varrho_w g = p_2 + y\varrho_w g + \varrho_m g x$$

$$p_1 - p_2 = (\varrho_m - \varrho_w) g x$$

https://nptel.ac.in/courses/Webcourse-contents/IIT-KANPUR/FLUID-MECHANICS/lecture-4/4-8_mano_invert.htm

Thank You