Chapter 3 - Fluid Statics

Lecture 3
Section 3.3

Introduction to Fluid Mechanics

Mechanical Engineering and Materials Science
University of Pittsburgh

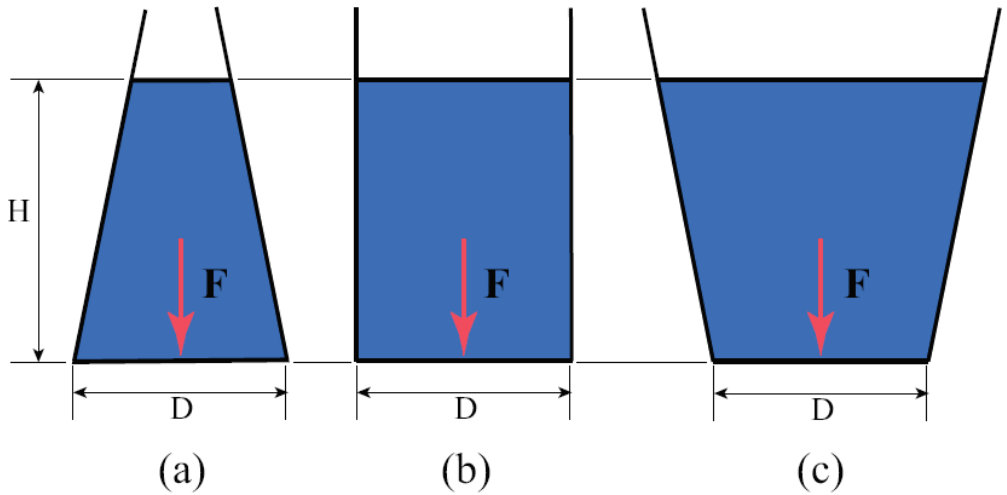
Student Learning Objectives

Students should be able to:

- Understand Pascal's Paradox
- Understand how to apply the variation of pressure as a function of depth to manometers

Pascal's Paradox

- An interesting consequence of pressure only varying with depth is Pascal's Paradox.
- Consider three containers, each with the same fluid (ρ=c), filled to the same height H, each with the same base diameter D,

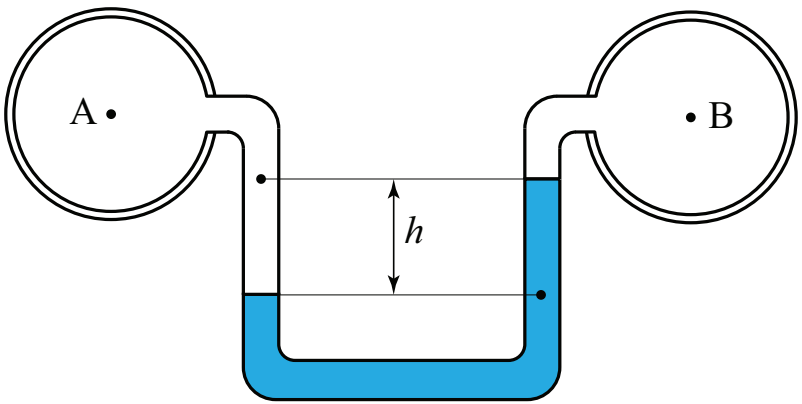


Manometer

- A **manometer** is a pressure measurement device that operates upon a pressure differential.
- Often times one end of the manometer is exposed to atmosphere

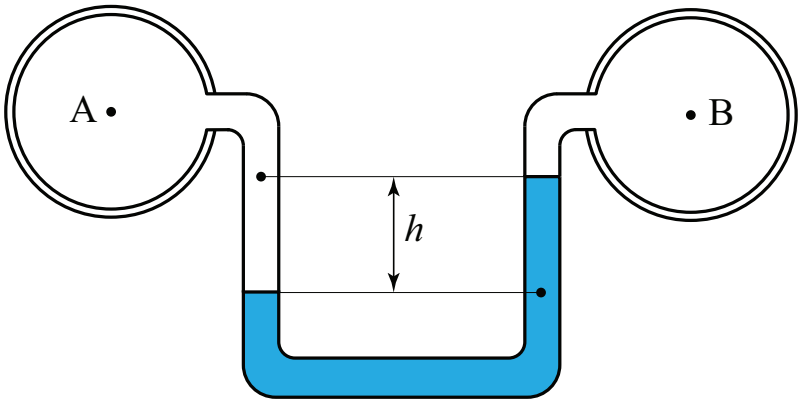
Example #1

- Assuming the blue fluid is water, ρ=998 [kg/m^3], the remaining fluids are air, ρ=1.225 [kg/m^3], and h=20 [cm] create and solve an expression for the pressure difference $\Delta P = P_A - P_B$:



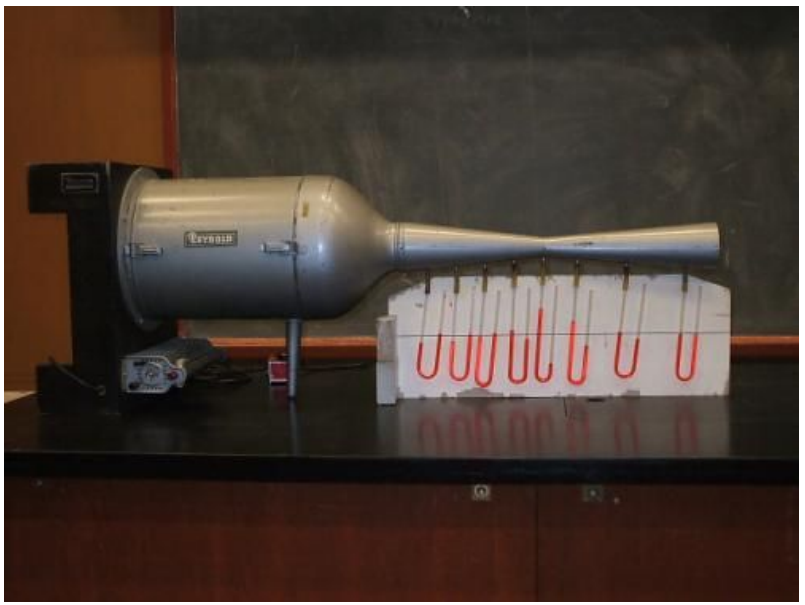
Example #1 Solution

Solution:



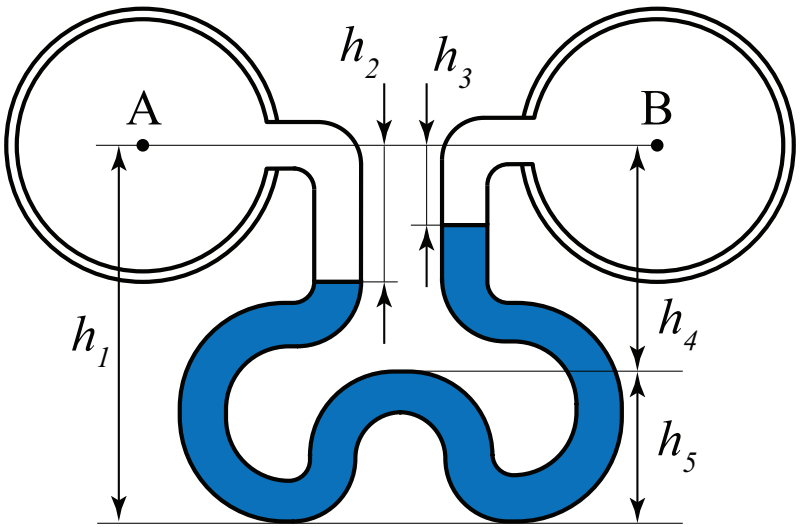
Differential Manometer

- A **differential manometer** is a pressure measurement device that operates upon a pressure differential between two points (both ends are connected to a pressure source/sink)
- Used quite commonly to determine pressure difference in flow to back out flow rate



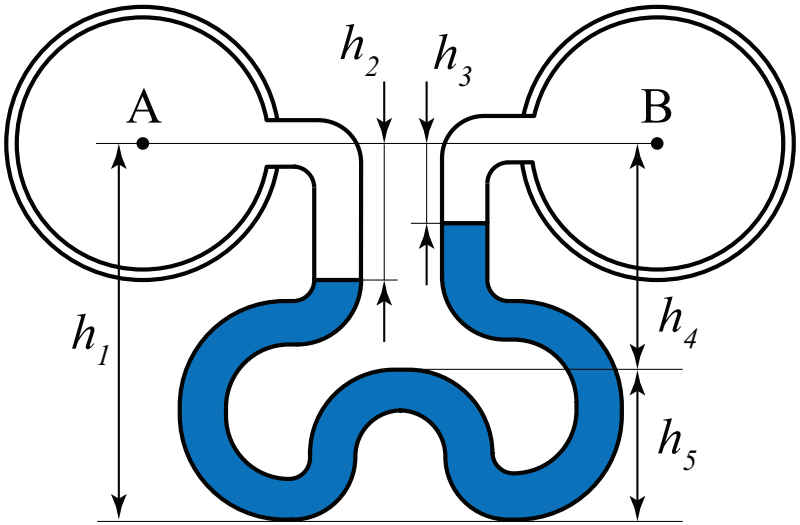
Example #2

- With the white fluid representing air and the blue fluid representing water, given h_1=90 [cm], h_2=32 [cm], h_3=19 [cm], h_4=54 [cm] and h_5=36 [cm], determine the pressure difference $\Delta P = P_A - P_B$:



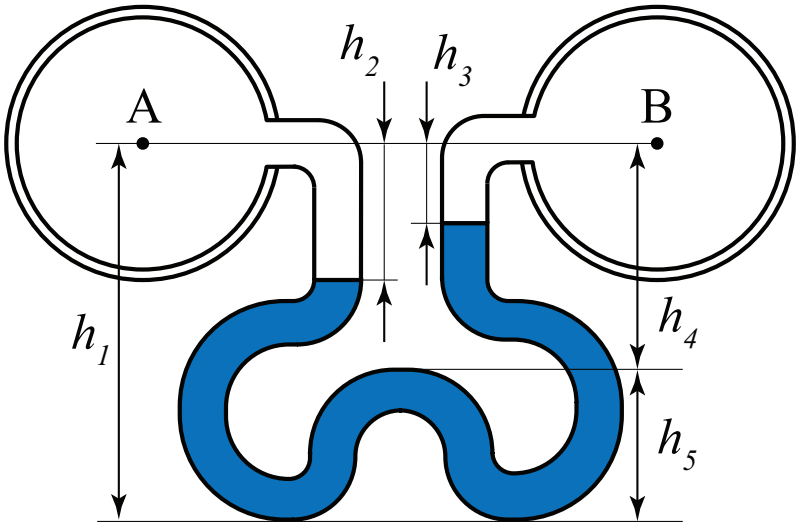
Example #2 Solution

Solution:



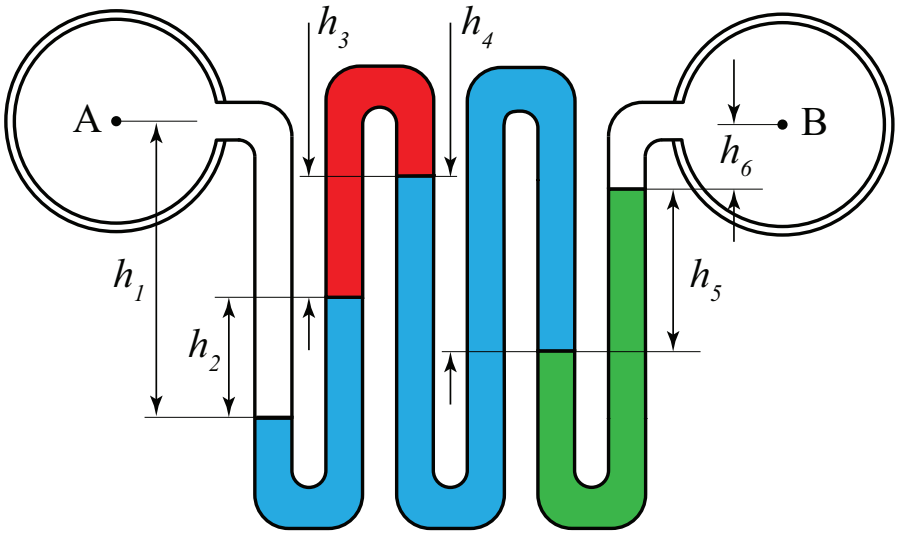
Example #2 Solution

Solution:



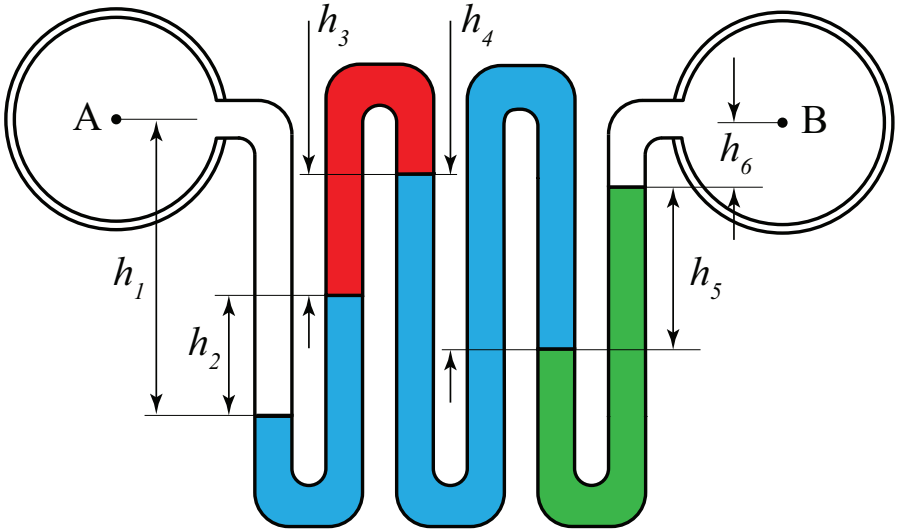
Example #3

- Given the manometer, with the blue fluid representing water, the red fluid representing mercury (SG=13.62), the green fluid representing antifreeze (γ=11,067 [N/m^3]), and the white fluid as air, and the heights measured as h_1=86 [cm], h_2=h_3=35 [cm], h_4=51 [cm], h_5=48 [cm] and h_6=19 [cm], determine the pressure difference ΔP=P$_A$-P$_B$.



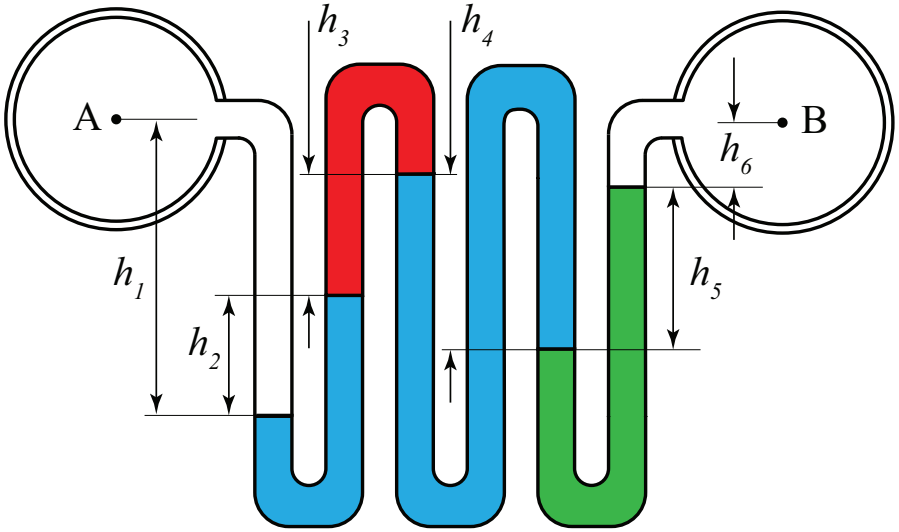
Example #3 Solution

Solution:



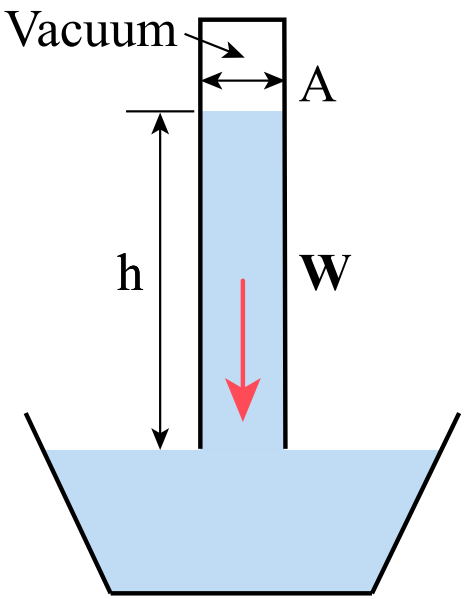
Example #3 Solution

Solution:



The Barometer

- A **barometer** is used to measure atmospheric pressure. Developed by Torricelli (1608-1647) - showed atmospheric pressure can be measured by using an inverted tube filled with Hg that is open to atmosphere
- Standard atmosphere produces a height of 760 mm Hg, 10.3 m H_2O. In honor, the unit mmHg is called a **torr**: 1 atm = 760 torr, 1 torr = 133.3 Pa



Student Learning Objectives - Completed

Students should be able to:

- Understand Pascal's Paradox
  - Pressure is only a function of depth, not the quantity of fluid above the surface
- Understand how to apply the variation of pressure as a function of depth to manometers
  - As you decrease in the fluid, you add the hydrostatic pressure; as you increase in the fluid, you subtract the hydrostatic pressure