Chapter 3

Pressure Measurement

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Overview of Chapter 3

- Define gage, atmospheric and absolute pressures
- Determine changes in pressure versus change in elevation
- Understand manometers, barometers and pressure gauges.

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Absolute and Gage Pressure

- $P_{abs} = p_{gage} + p_{atm}$
- P_{abs} = Absolute pressure (above the vacuum of outer space)
- P_{gage} = gage pressure (tire press.)
- P_{atm} = atmospheric pressure (barometric pressure)

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Pressures typically positive

- Absolute above a vacuum (positive)
- Gage above atm. is positive (psig)
- Gage below atmospheric typically called negative or a partial vacuum
- Normal atmospheric is 14.7 psia or 101 kPa(abs) for this textbook.

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Example of Pressure (English)

- An acetylene tank pressure gauge reads 150 psi. What is the absolute pressure of the gas? (Assuming current air pressure is 14.7 psi.)
- $P_{abs} = p_{gage} + p_{atm}$
- P_{abs} = 150 psi + 14.7 psi
- P_{abs} = 164.7 psia

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Example of Pressure (SI)

- A vacuum impregnation tank pulls a vacuum of –90 kPa on a motor to remove air from its dry insulation prior to being impregnated. Assuming an ambient pressure of 101 kPa, what is the absolute pressure in the tank?
- Pabs = -90 kPa + 101 kPa = 11 kPa(abs)

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Pressure and Elevation

- Assuming a homogeneous liquid, the pressure of the liquid increases linearly as its elevation increases.
- $\Delta p = \gamma h$
- Δp = change in pressure
- γ = specific weight of liquid
- h = change in elevation

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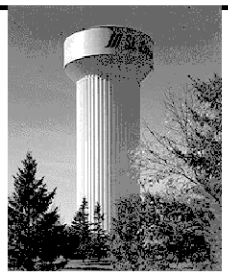
Pressure Due to Elevation

- Water towers built on hilltops provide pressure for city water
- Every 33 ft adds about 1 atm of pressure (15 psig)



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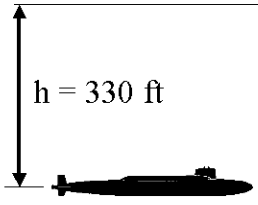
Pressure due to Depth

- Depth is treated as elevation to give positive increase in pressure
- 10 atm's down increases pressure to 150 psig



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Example Problem 3.7, Page 50

- Note that for the liquid at Point F to be higher than Point A, the Air pressure above Point F must be lower than atmospheric pressure.
- Also note that pressure at Point A and Point E must be the same.

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Pressure measurement

- Be careful about units. Specific weight is typically in lbm/ft^3, or kg/m^3, but pressure is in psi or kPa. Watch conversions.

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Pascal's Paradox

- The shape of the column of liquid does not change the amount of pressure at the bottom. (Figure 3.7)
- $\Delta p = \gamma h$ is a function of change in elevation and specific weight of the liquid only.

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Manometers

- Manometers are used to measure small amounts of pressure differential, using $\Delta p \Leftrightarrow \Delta h$
- Used to measure small pressures, like in ventilating ducts, natural gas lines in homes
- Liquid in manometers can be mercury, or water (13.55 times more sensitive)

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Determining Manometer Values

- For multiple liquid manometers, determine the intermediate pressure for each liquid.
- Substitute previously calculated pressure and go on to next liquid.
- Be sure to follow proper algebraic signs for each step

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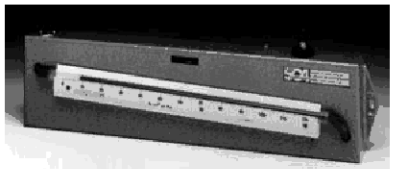
Inclined Manometers

- Inclination of liquid used to get a more accurate reading – calibrated into smaller units along the tube.



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Barometers

- Measures the pressure caused by the weight of the atmosphere.
- At sea level, the pressure can support a column of mercury about 30 inches (760 mm) high (γ_{Hg} x h)
- Each gain of 1000 ft altitude causes pressure to drop "1 inch."

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Pressure Gauges and Transducers

- Bourdon Tube Gauges use the flexing of a bourdon tube to move the needle on the gauge.
- Magnehelic Gauges have a needle attached to a helical spring that is moved magnetically when a diaphragm expands or contracts.

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Pressure measured by liquid column

- Very low pressures (air ducts and natural gas lines in homes) are measured with manometers, and are read directly in "inches of water."
- Use same $\Delta p = \gamma h$ equation to convert to psig, using specific weight of water.

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Natural Gas Pressure Example

- Columbia Gas serviceman measures your main gas supply to have a pressure of "10 inches." What is that in psig?

$$p = \frac{62.4\,lbm}{ft^3} \times (10\,in\,H_2O) \times \frac{1\,ft^3}{1728\,in^3}$$

$$p = 0.361\,psig$$

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Homework – Chapter 3

- Problems, page 67:
- 35, 41, 42, 45, 55
- Chapter 3 Computer Lab Assign.
- Problems 42, 45, and 55 must be solved using spreadsheet format and spreadsheet formulation. Please refer to the example handout.

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