ABE 20100
Biological Thermodynamics 1

Pressure and Temperature
Absolute vs Relative Scales

Absolute vs Relative Scales

- Absolute = all values ≥ 0

- Relative = values may be negative

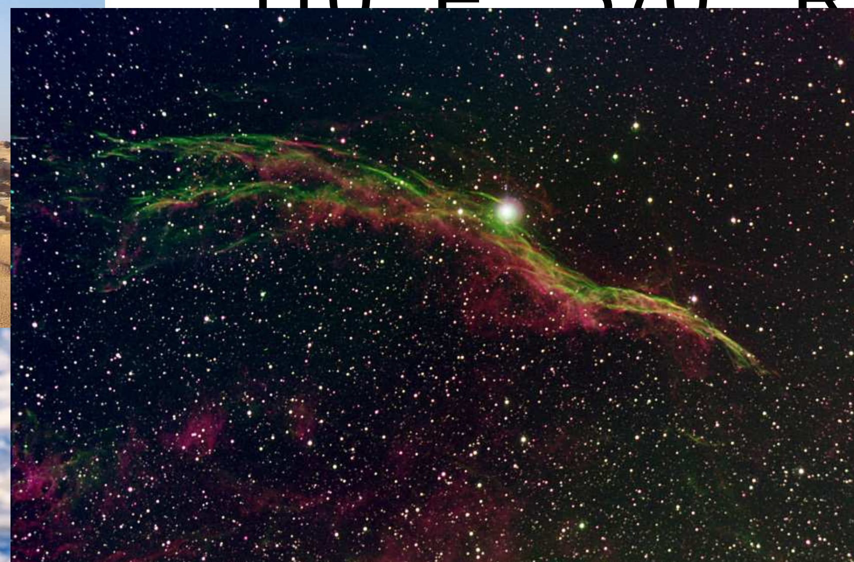
= scale values are relative to a base case (basis)

Celsius is a relative measurement scale

0 = freezing point of pure water

100 = boiling point of pure water at atmospheric pressure

Relative vs Absolute Temperature



110 °F, 570 ° R

-30 °F, 430° R

-34 °C, 239 K

-441 °F, 19° R

-263 °C, 10 K

Temperature

- **Temperature** is a measure of the average kinetic energy contained within the molecules of a substance.

- *Rankine vs. Fahrenheit*

  $$T(°R) = T(°F) + 459.67$$

- *Kelvin vs. Celsius*

  $$T(K) = T(°C) + 273.15$$

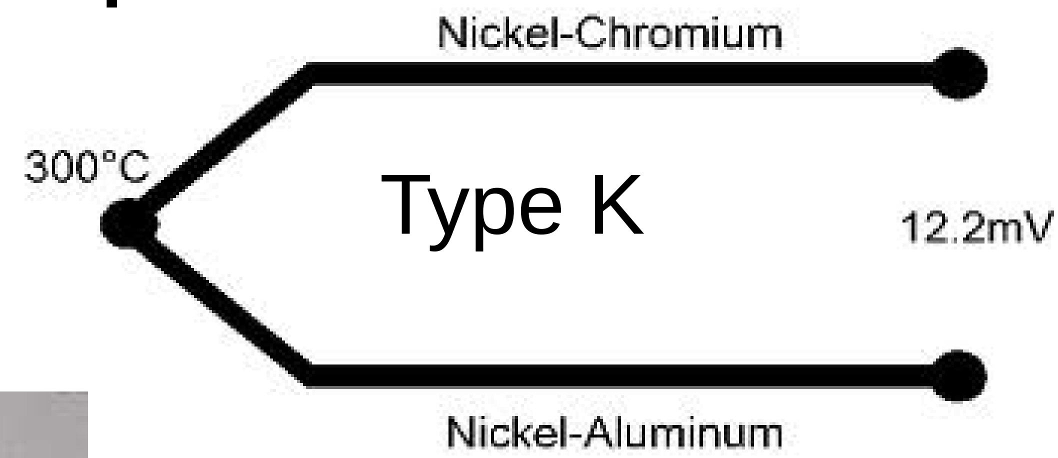
- *Fahrenheit vs. Celsius*

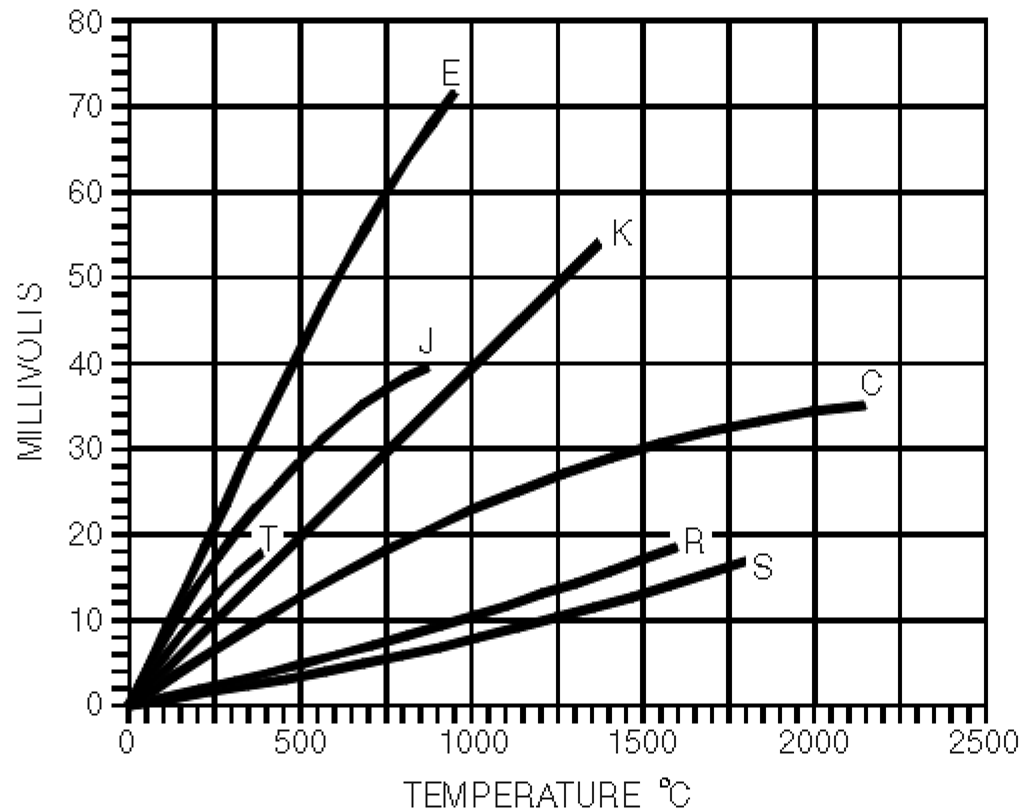
  $$T(°F) = 1.8T(°C) + 32$$

- *Rankine vs. Kelvin*

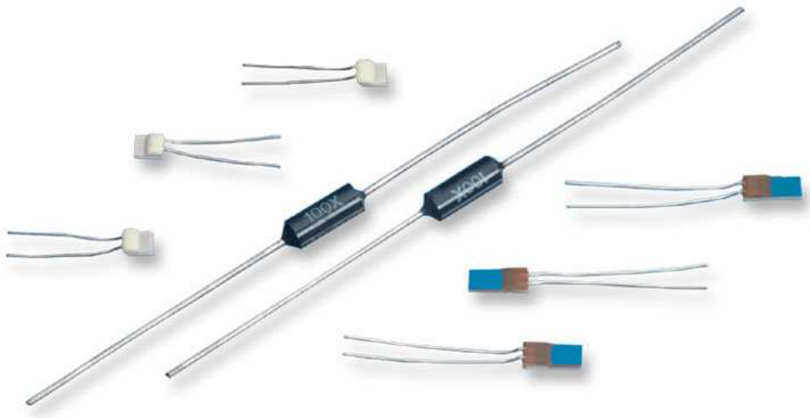
  $$T(°R) = 1.8T(K)$$

Thermocouple

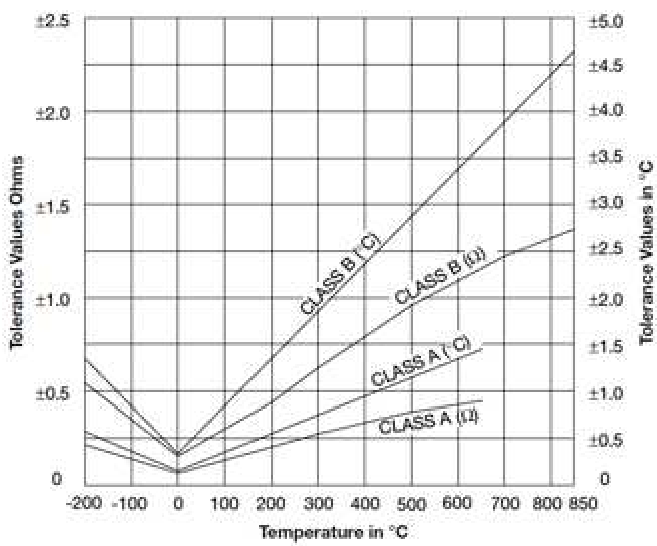




Resistance Temperature Detectors (RTDs)



Tolerance Values as a Function of Temperature for 100Ω RTD's



Absolute vs Relative Pressure

$$P = F / A$$

Absolute Pressure ≥ 0 (pure vacuum)

Relative Pressure = pressure relative to atmospheric pressure

Absolute Pressure = Gauge Pressure + Atmospheric Pressure

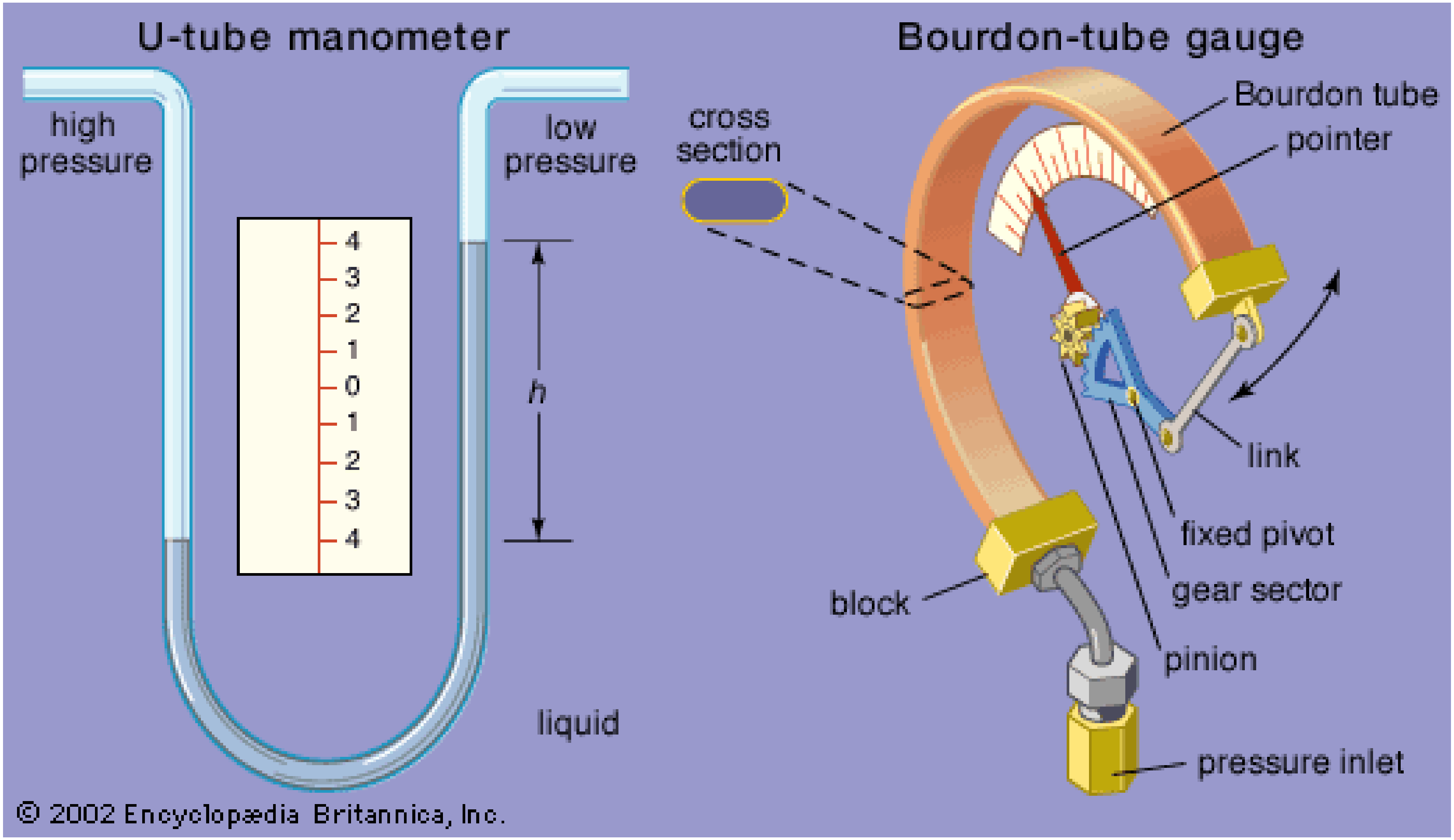
$P_a = P_g$ + Atmospheric Pressure

Gauge Pressure

- Can be positive (higher than atmosphere) or negative number (lower than atmosphere)

- Like temperature, thermodynamics requires absolute pressure (ideal gas law)

- Gauge pressure more common in everyday and engineering applications.


U-tube manometer
high pressure
low pressure
4
3
2
1
0
1
2
3
4
h
liquid
Bourdon-tube gauge
cross section
Bourdon tube
pointer
link
fixed pivot
gear sector
pinion
block
pressure inlet
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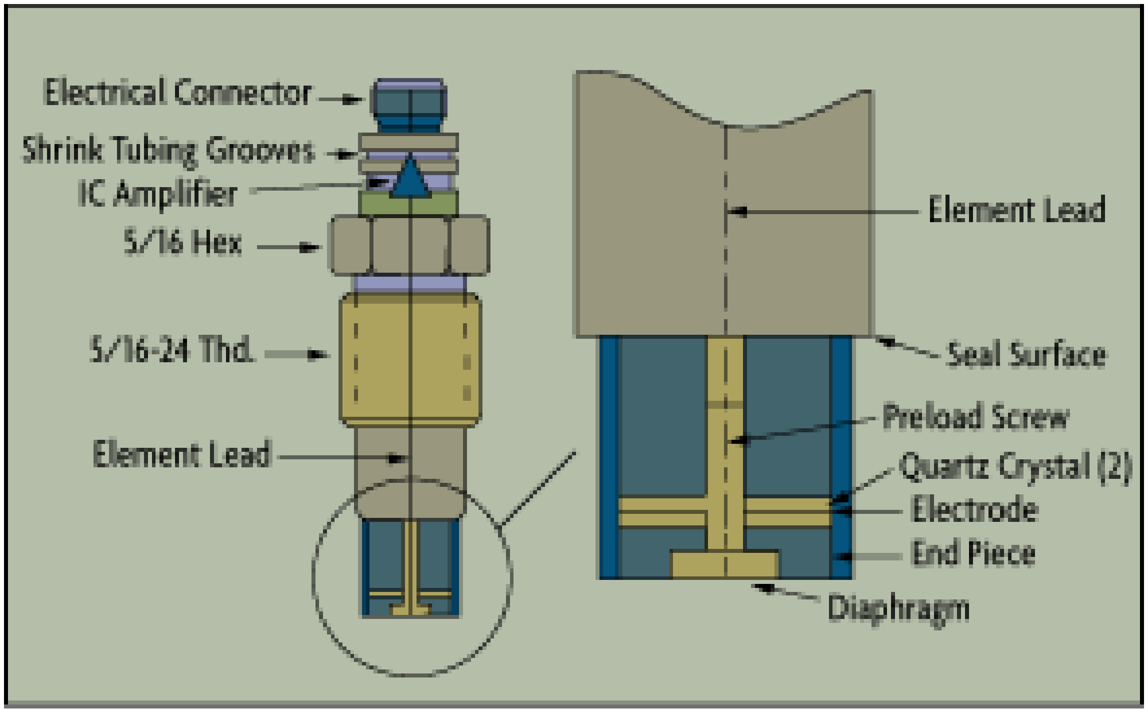
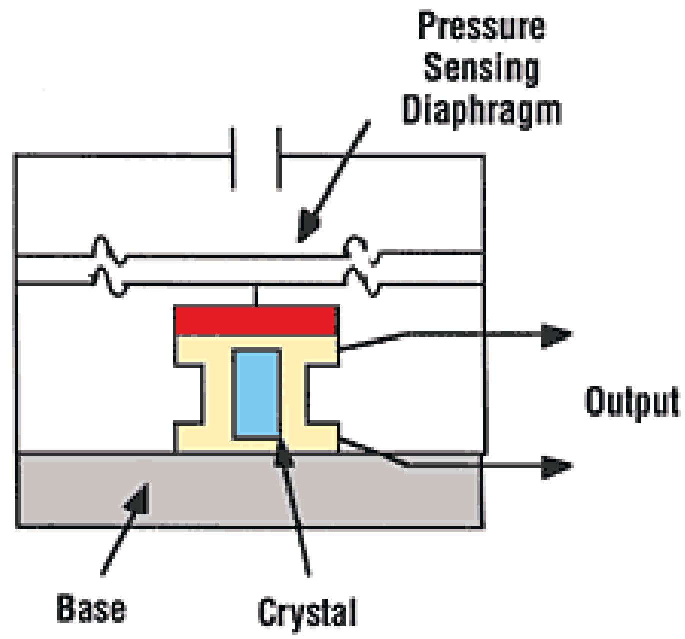
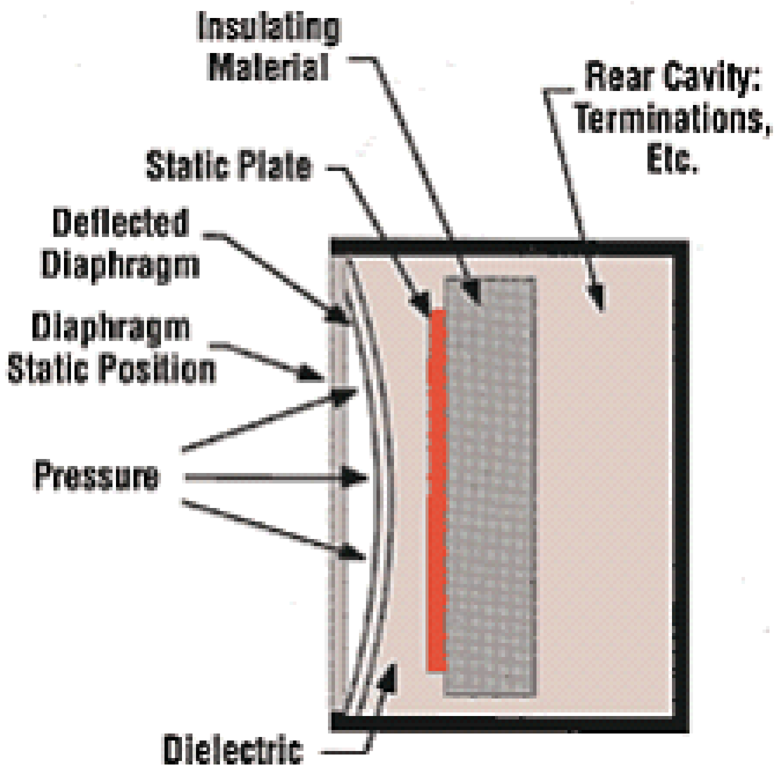
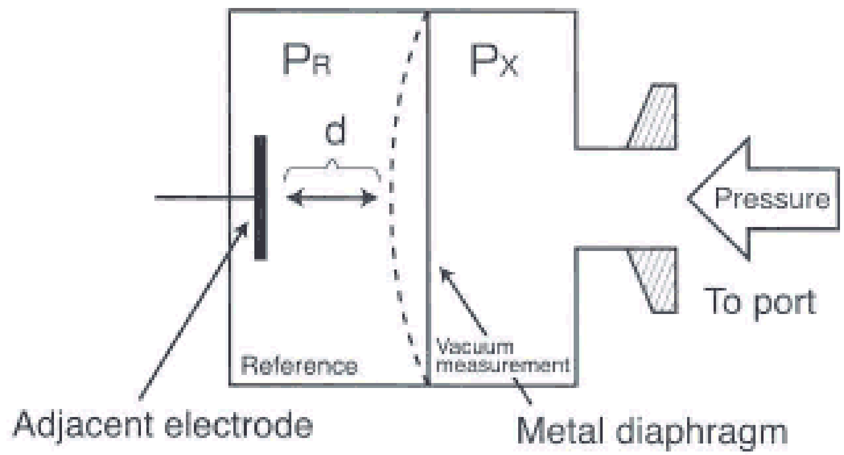
Piezoelectric Pressure Gauge





Capacitance Pressure Gauge



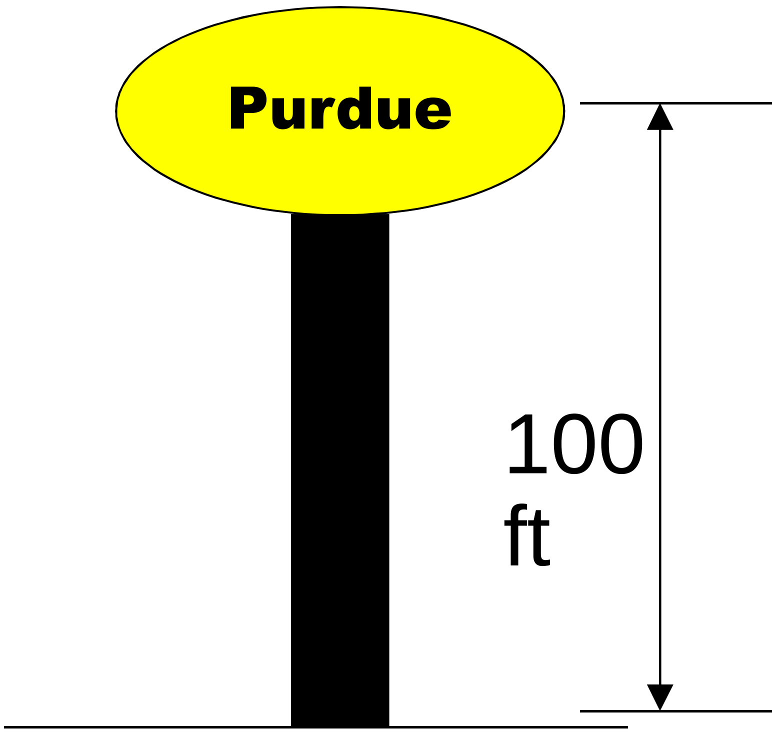


Head and Hydrostatic Pressure

- **Hydrostatic pressure** is the pressure at a location created due to the weight of the material (usually fluid).

- **Head (P_h)** is the hypothetical height of a column that would exert the given hydrostatic pressure at its base, usually a gauge pressure.

Example – Purdue Water Tower



- What is the “head” in terms of ft of water?
    - 100 ft of H_2O
- What is the hydrostatic pressure (in psia)?
    - $P = \rho g h$

$$P = \frac{\left(\frac{62\ \text{lbm}}{\text{ft}^3}\right)\left(\frac{32.2\ \text{ft}}{\text{s}^2}\right)\left(\frac{100\ \text{ft}}{1}\right)}{\left(\frac{32.2\ \text{lbm-ft}}{\text{lbf}-\text{s}^2}\right)} + 14.7\text{psi(atm)} = 6200\ \frac{\text{lbf}}{\text{ft}^2}\left(\frac{1\ \text{ft}^2}{144\ \text{in}^2}\right) + 14.7\text{psi(atm)} = 57.7\ \text{psia}$$

Summary

- Temperature and Pressure measured on both relative and absolute scales
- Thermodynamic equations (e.g. ideal gas law) require absolute scales
- Gauge pressure – pressure relative to atmospheric (barometric) pressure
- Negative gauge pressures sometimes called “vacuum” – e.g. a vacuum of 25 kPa