

# Design IV

## E232 Fall 07

Class 22

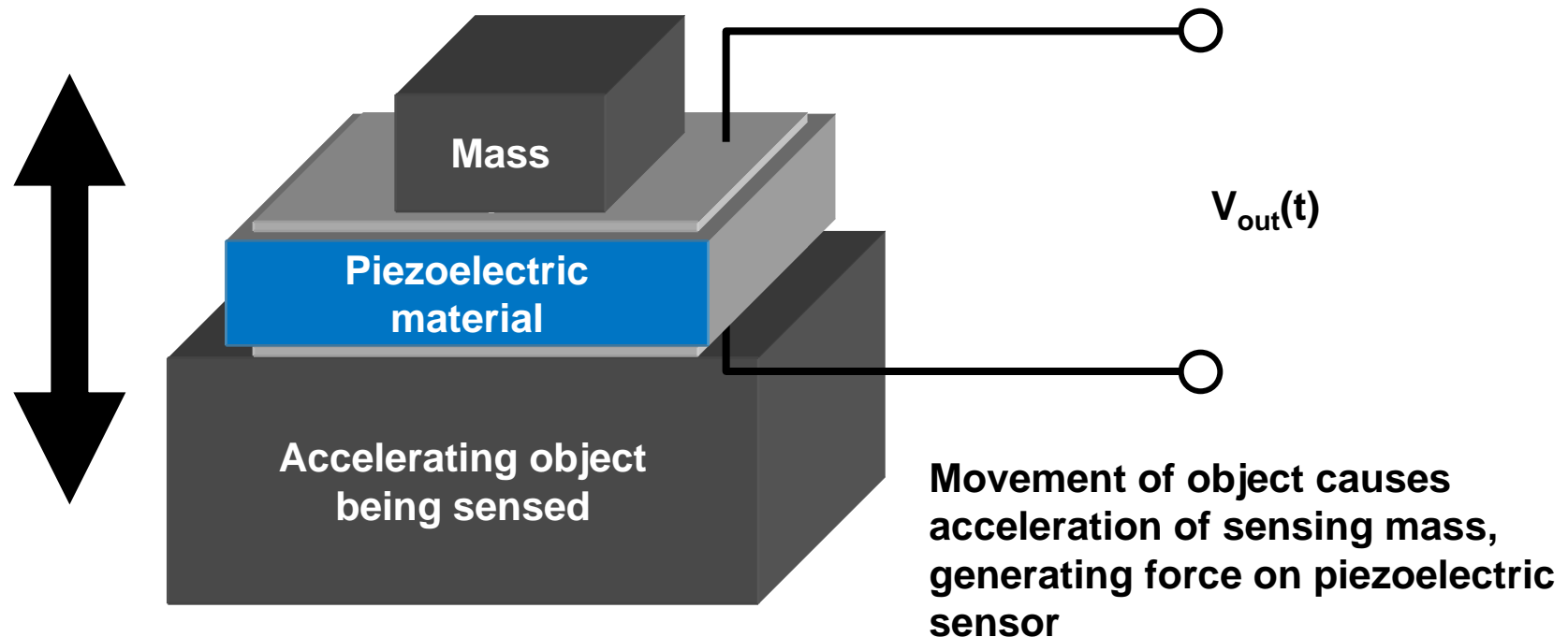
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# Acceleration Sensors

- Piezoelectric ( $F=ma$ ) sensors

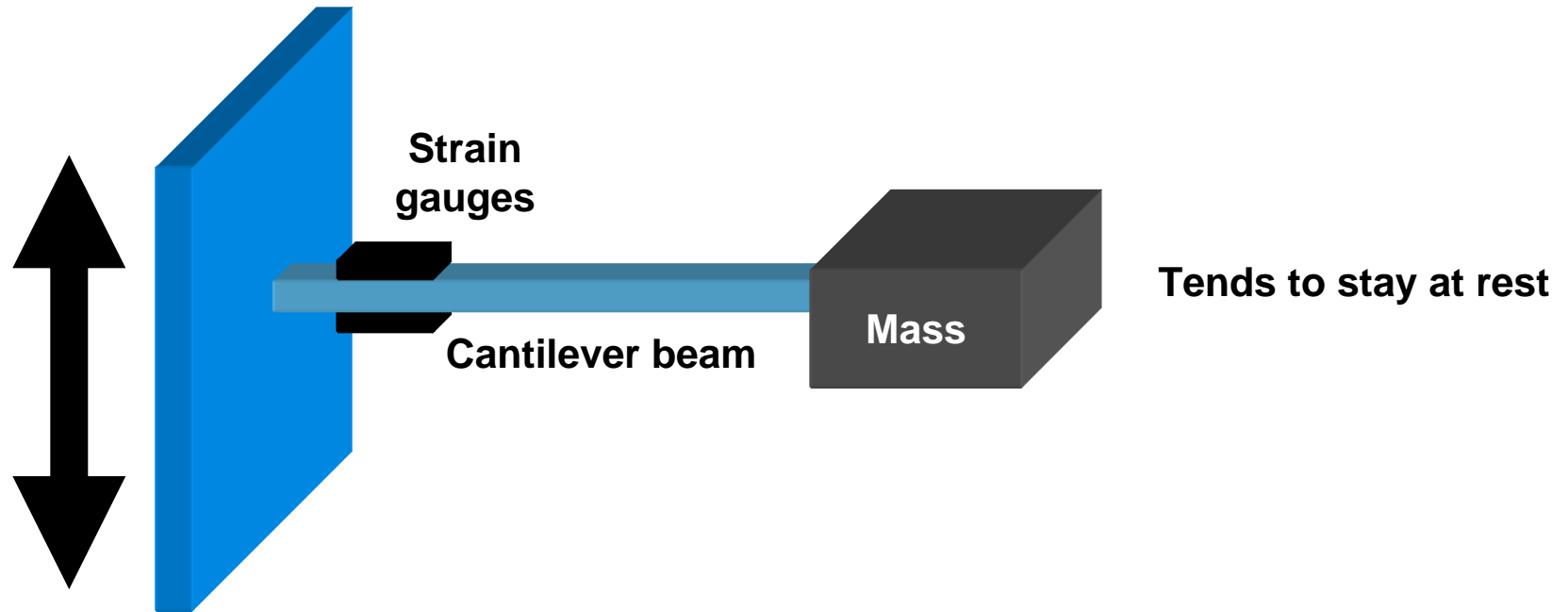
## Other applications:

- Motion sensing game controllers
- Vehicle braking, stability sensors
- Hard disk drop sensors
- Autonomous vehicles



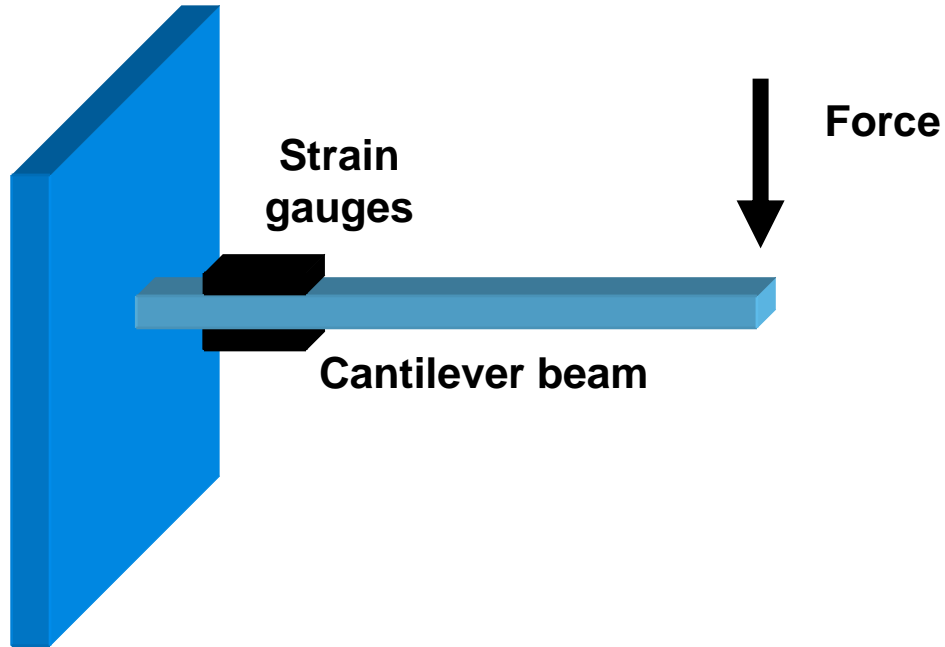
# Acceleration Sensors

- Strain gauge accelerometers



# Force Sensors

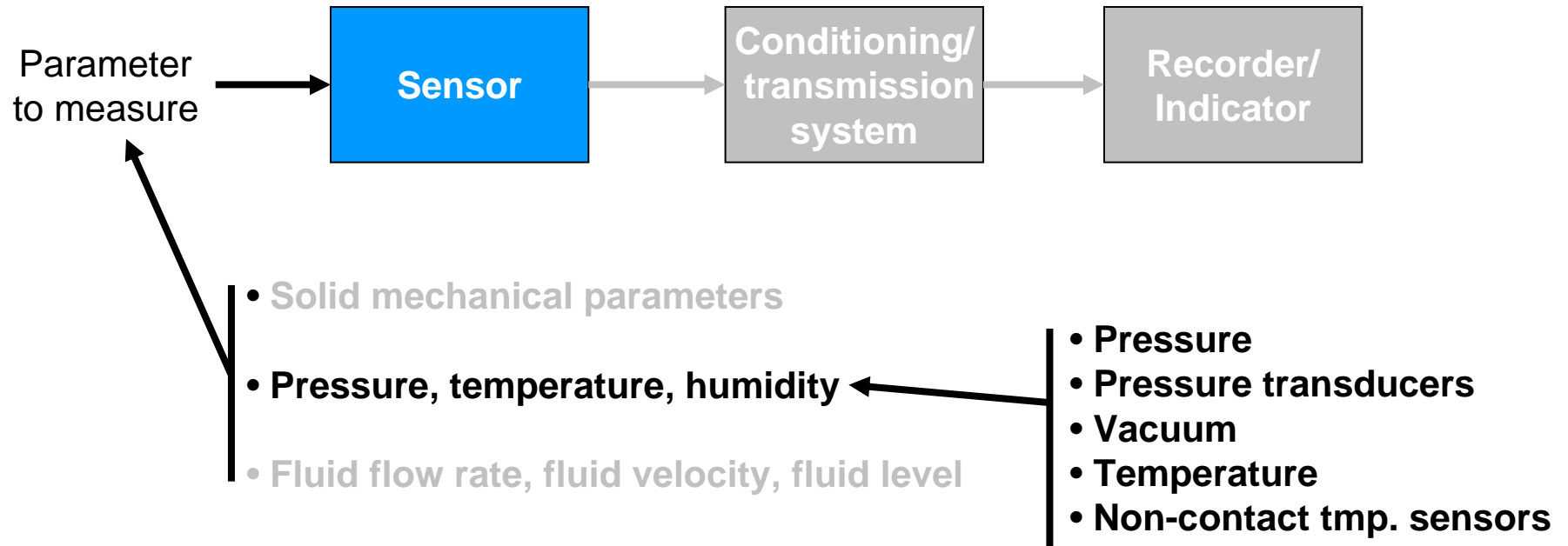
- Cantilever beam



# Today's topics

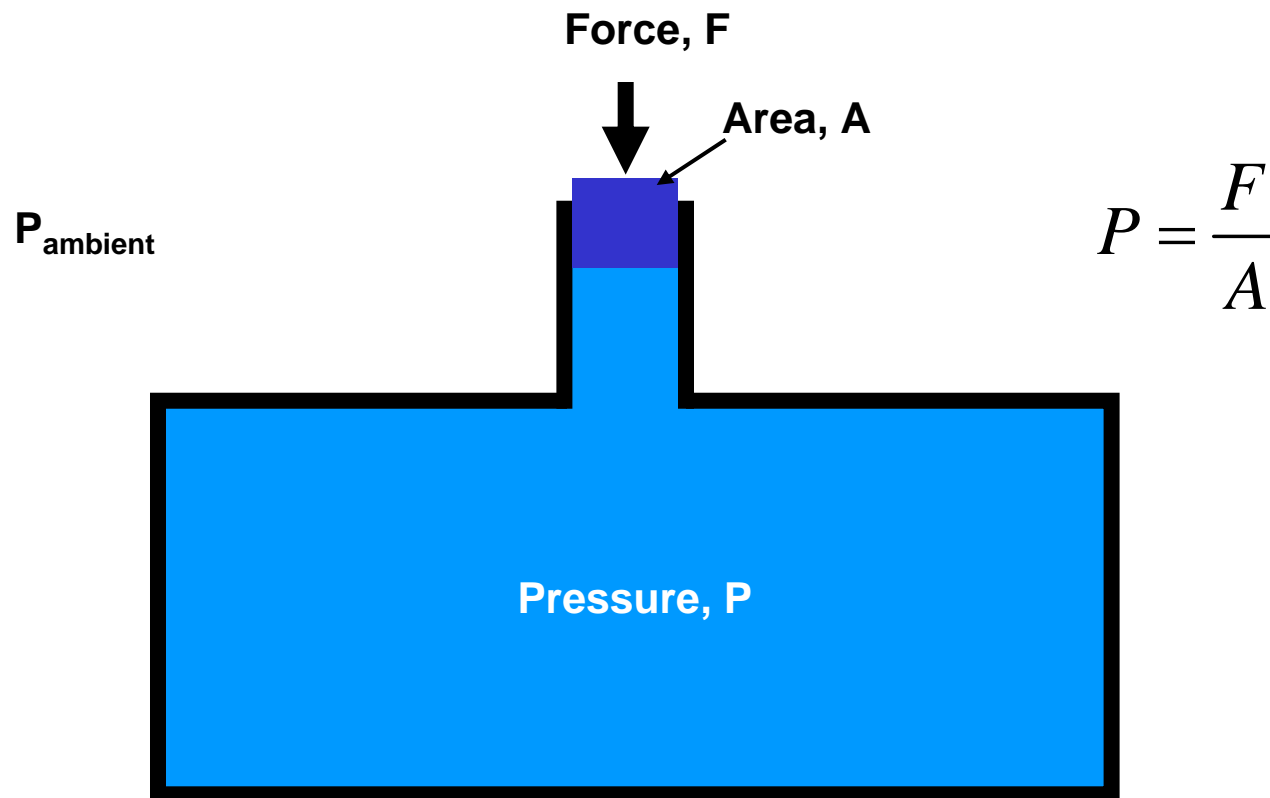
- Measurement sensors
  - **Pressure**
  - **Pressure transducers**
  - **Vacuum**
  - **Temperature**
  - **Non-contact temperature sensors**

# Measurement Systems



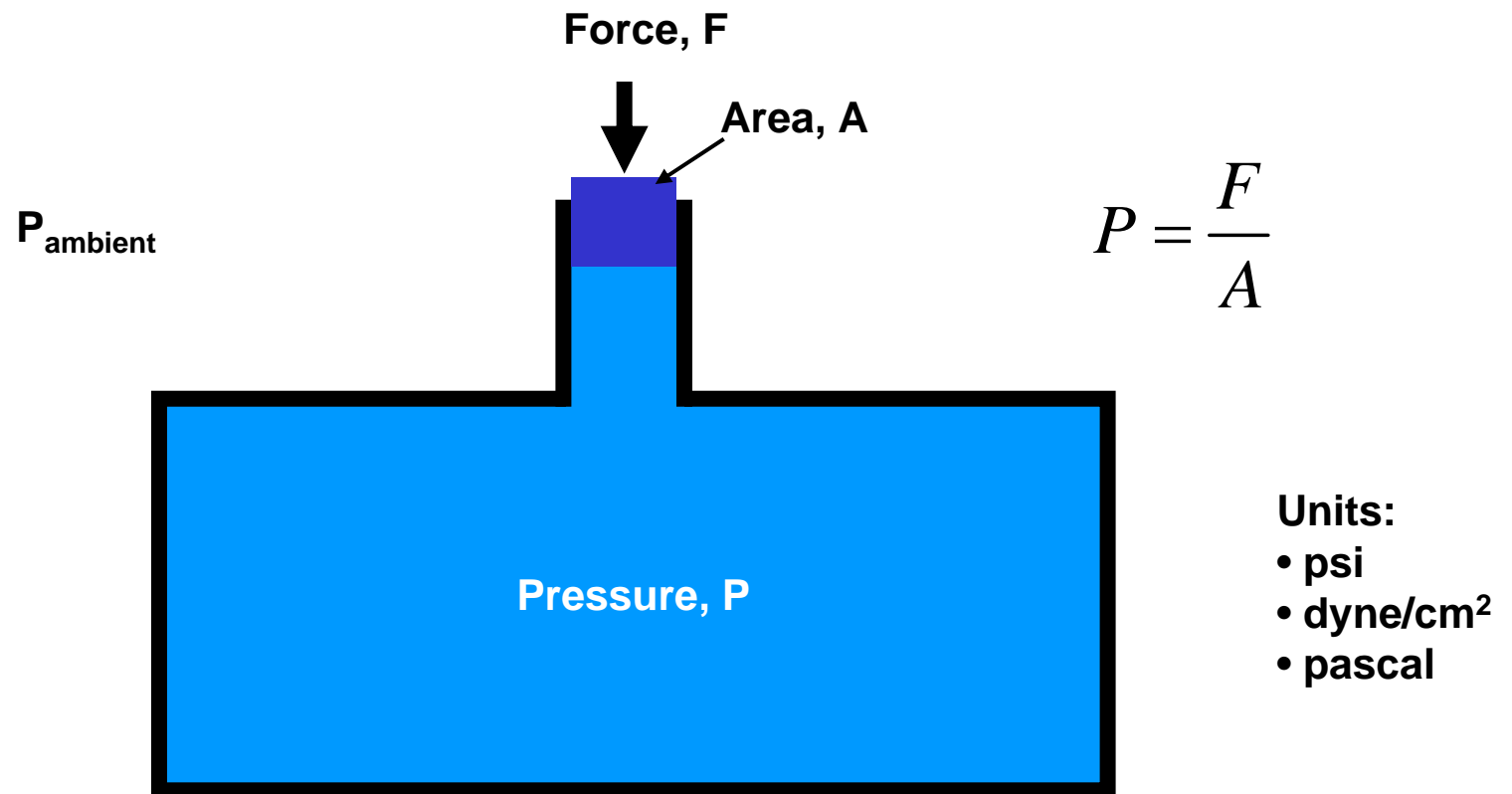
# Measuring Pressure

- Definition of “Pressure”



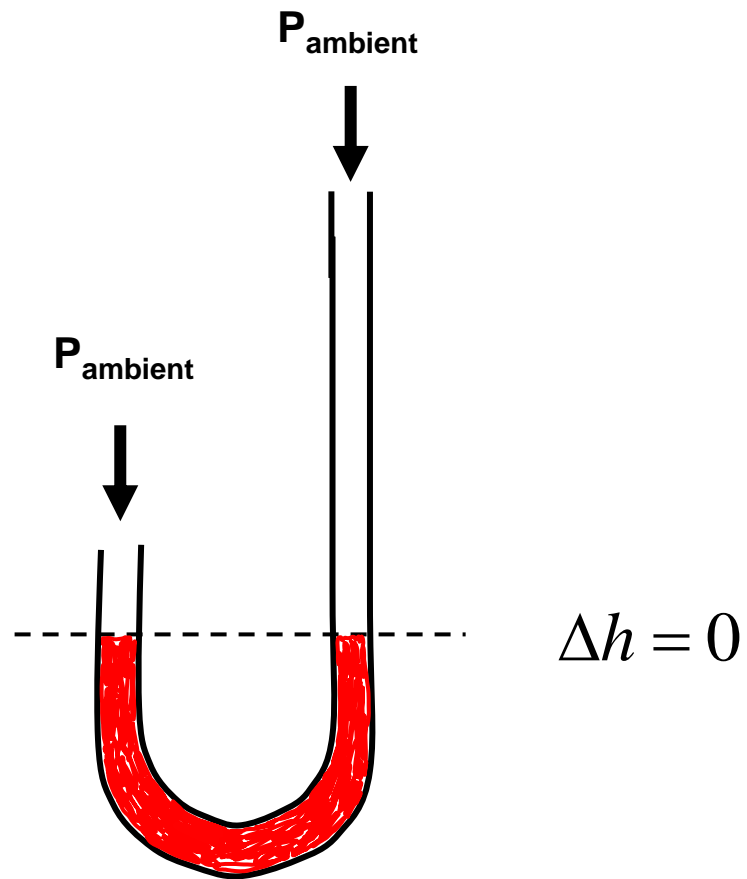
# Measuring Pressure

- Definition of “Pressure”



# Measuring Pressure

- Manometers

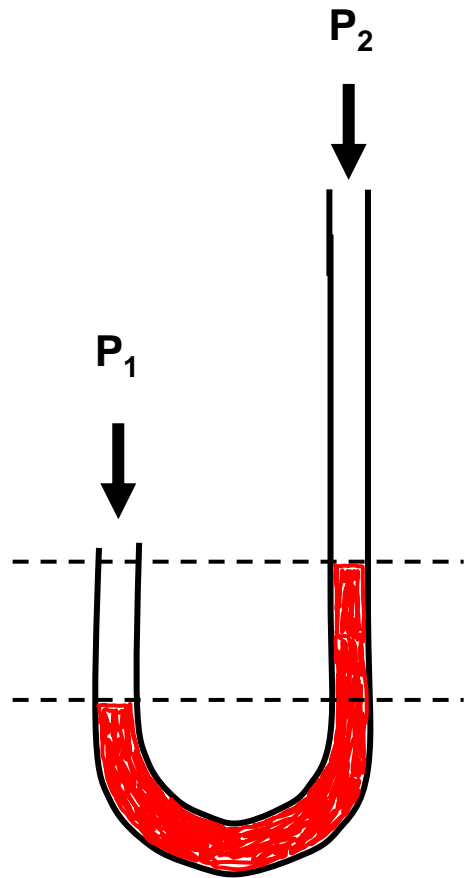


**Units:**

- mm-Hg
- ft-H<sub>2</sub>O
- atm

# Measuring Pressure

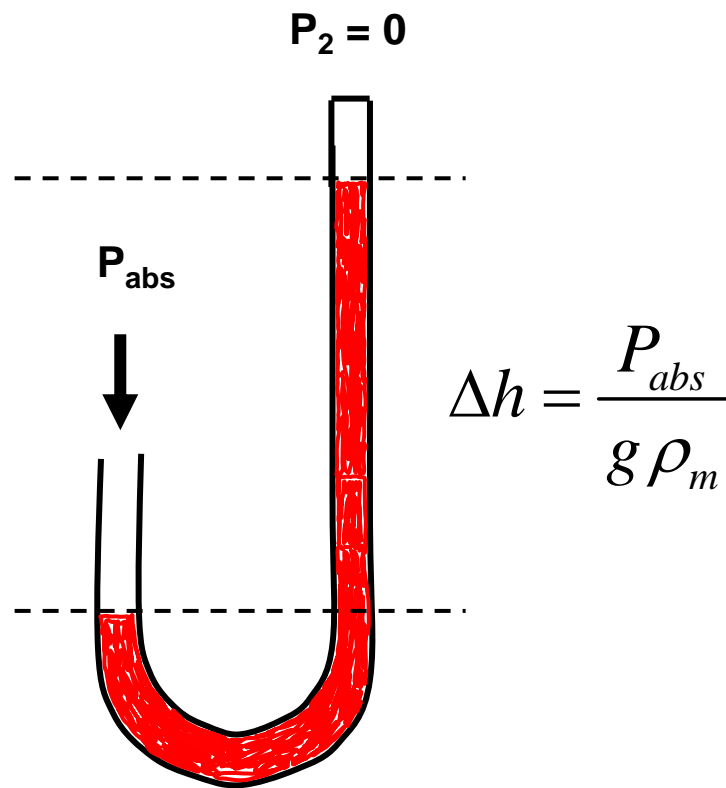
- Manometers



$$\Delta h = \frac{(P_1 - P_2)}{g(\rho_m - \rho_s)} \approx \frac{(P_1 - P_2)}{g\rho_m}$$

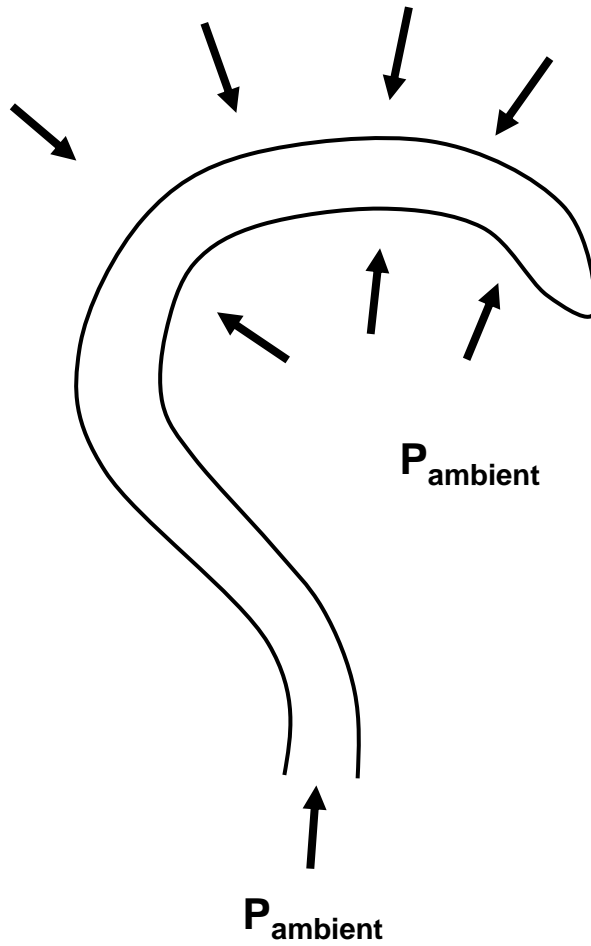
# Measuring Pressure

- Barometers



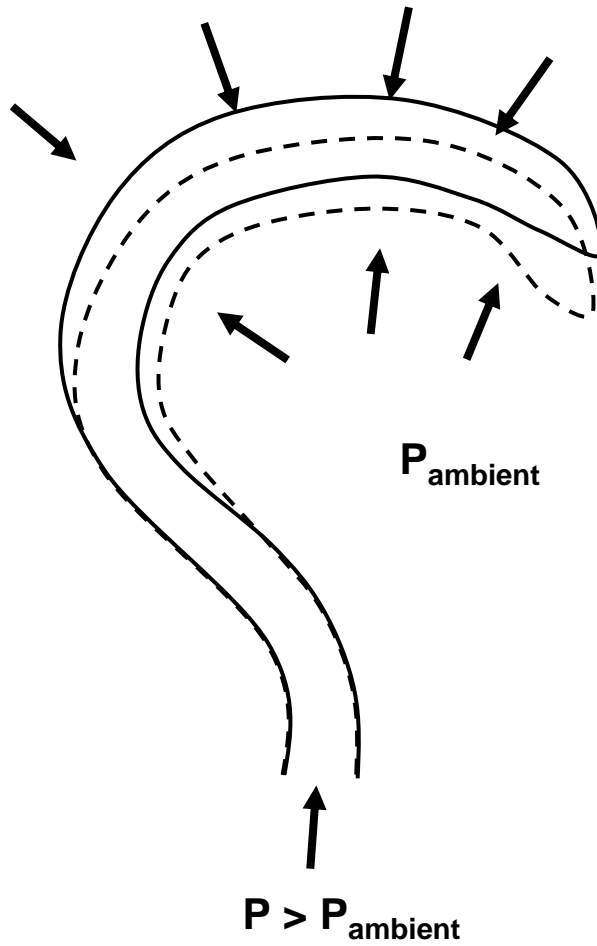
# Measuring Pressure

- Bourdon gauge



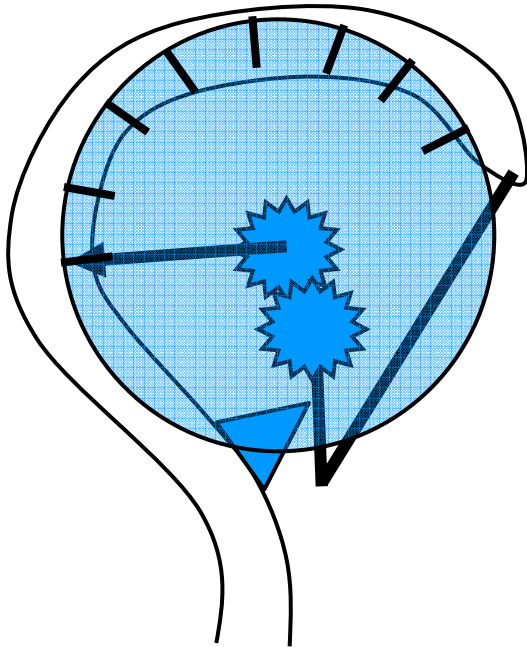
# Measuring Pressure

- Bourdon gauge



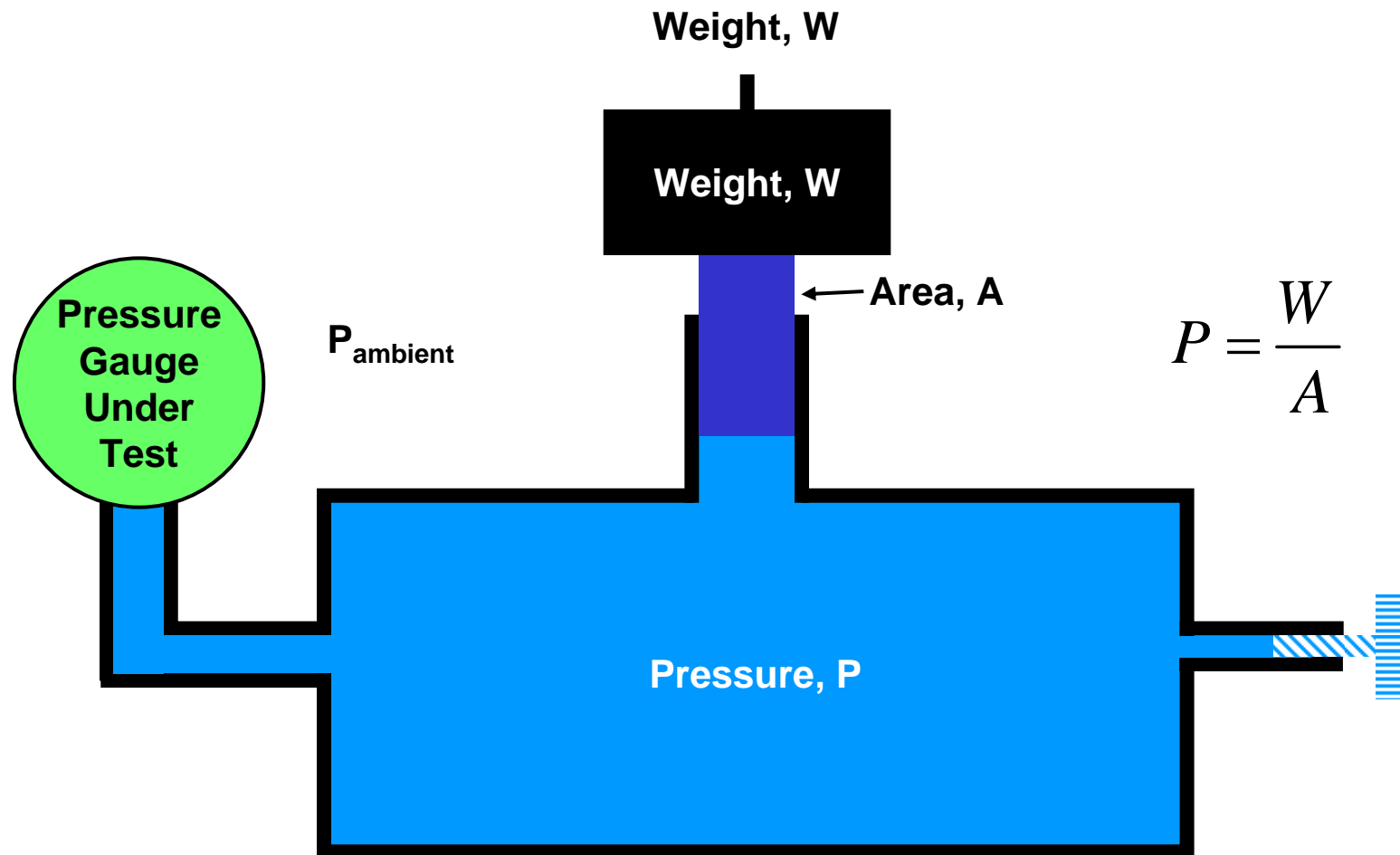
# Measuring Pressure

- Bourdon gauge



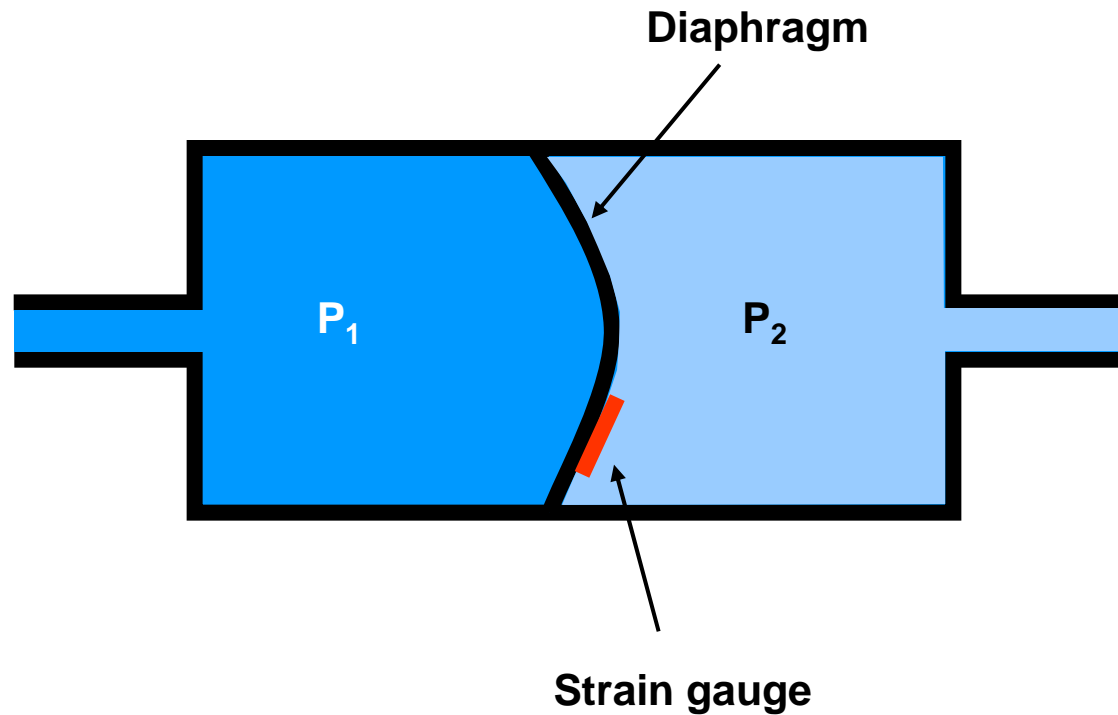
# Measuring Pressure

- Dead-weight tester



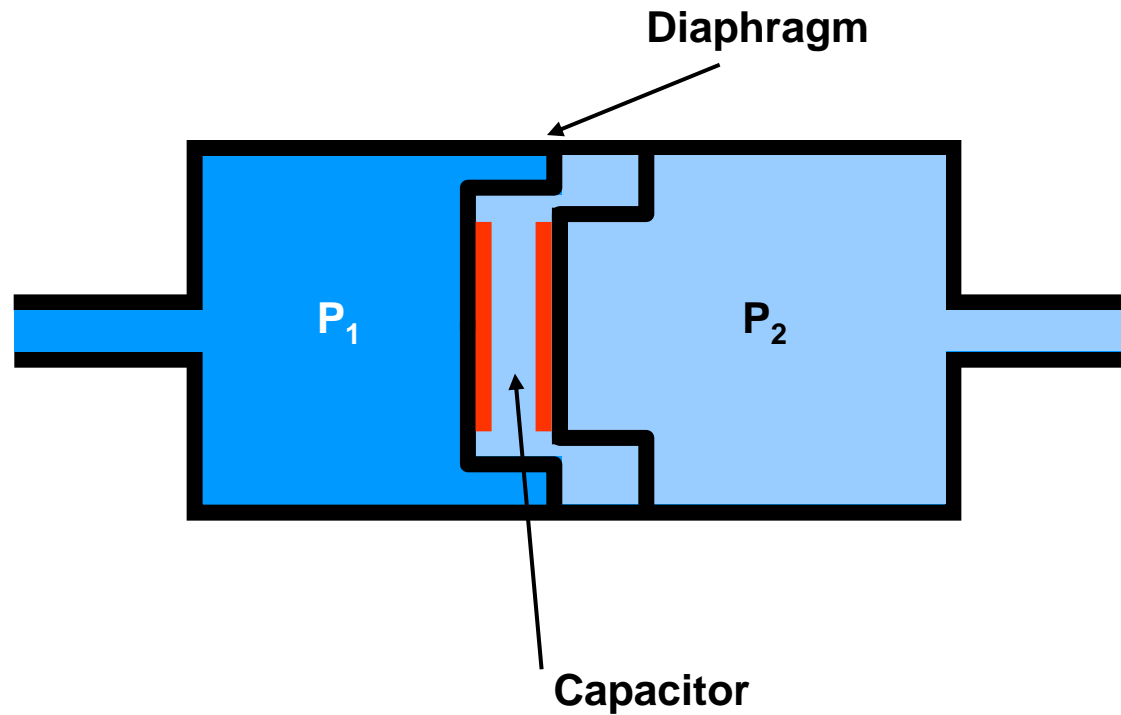
# Measuring Pressure

- Pressure transducers: Strain gauge sensor



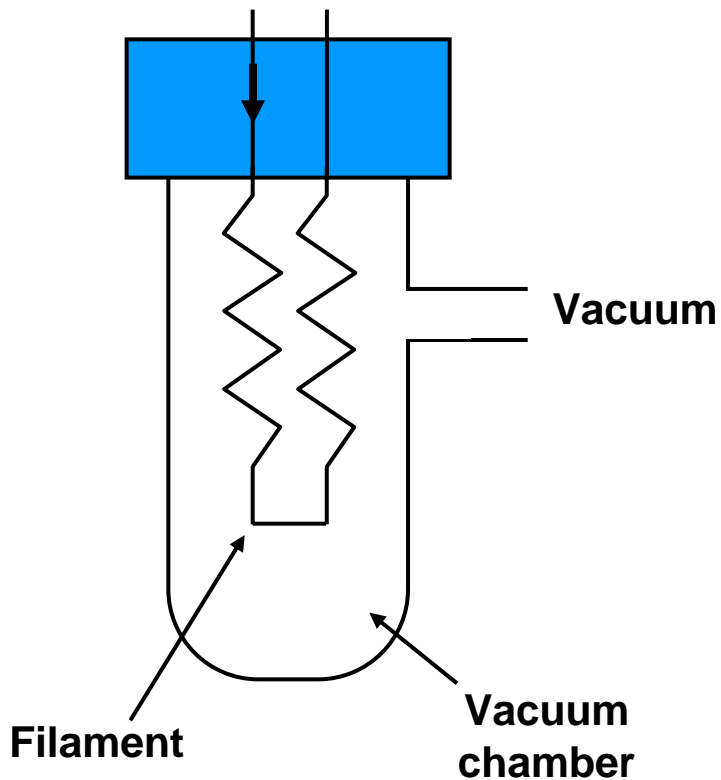
# Measuring Pressure

- Pressure transducers: Capacitive sensor



# Measuring Vacuum

- Thermal conductivity sensor – Pirani gauge

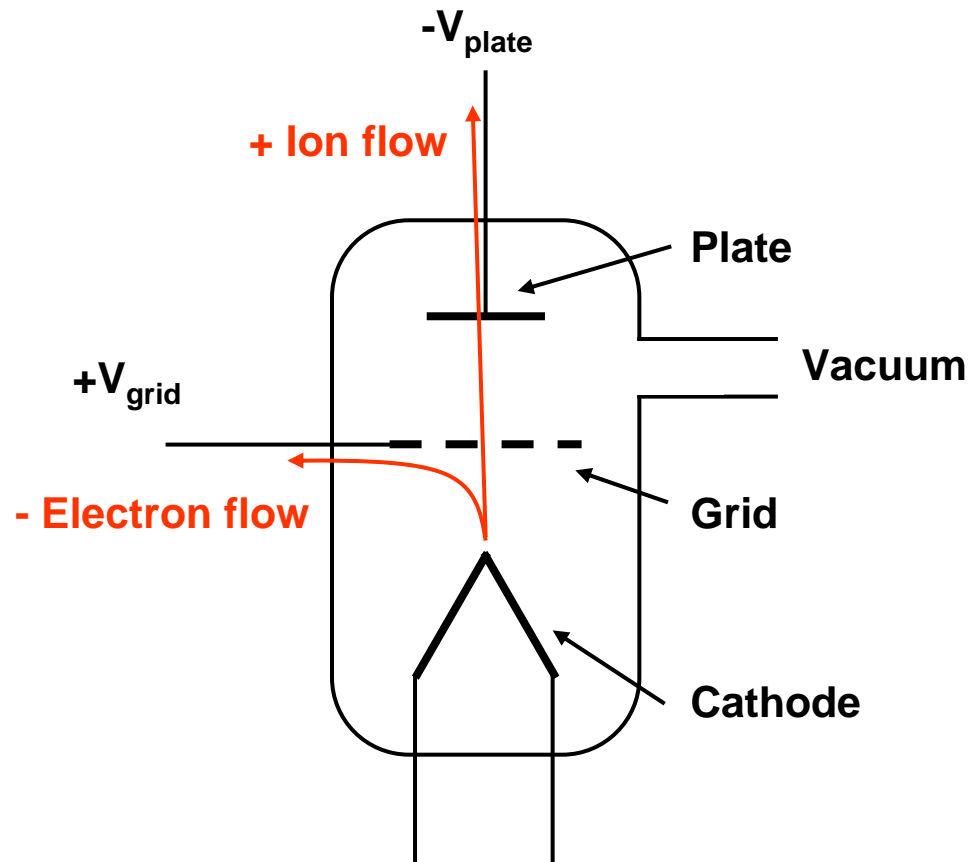


- Current flow through filament causes it to heat up
- Gas inside vacuum chamber allows heat to be transferred away from filament

$$q = C(T_f - T_w)P_{vac}$$

# Measuring Vacuum

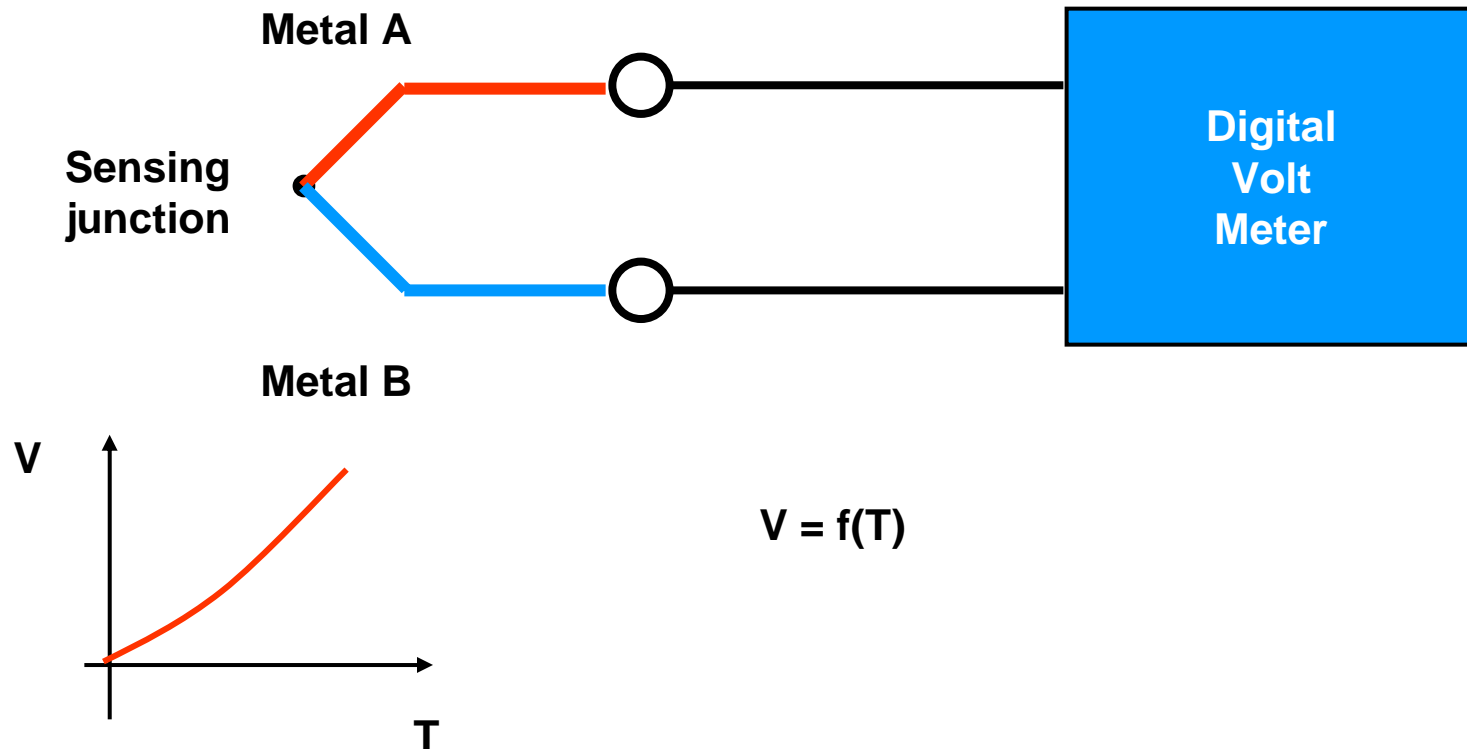
- Ionization vacuum gauge



$$P_{vac} = \frac{i_+}{Si_-}$$

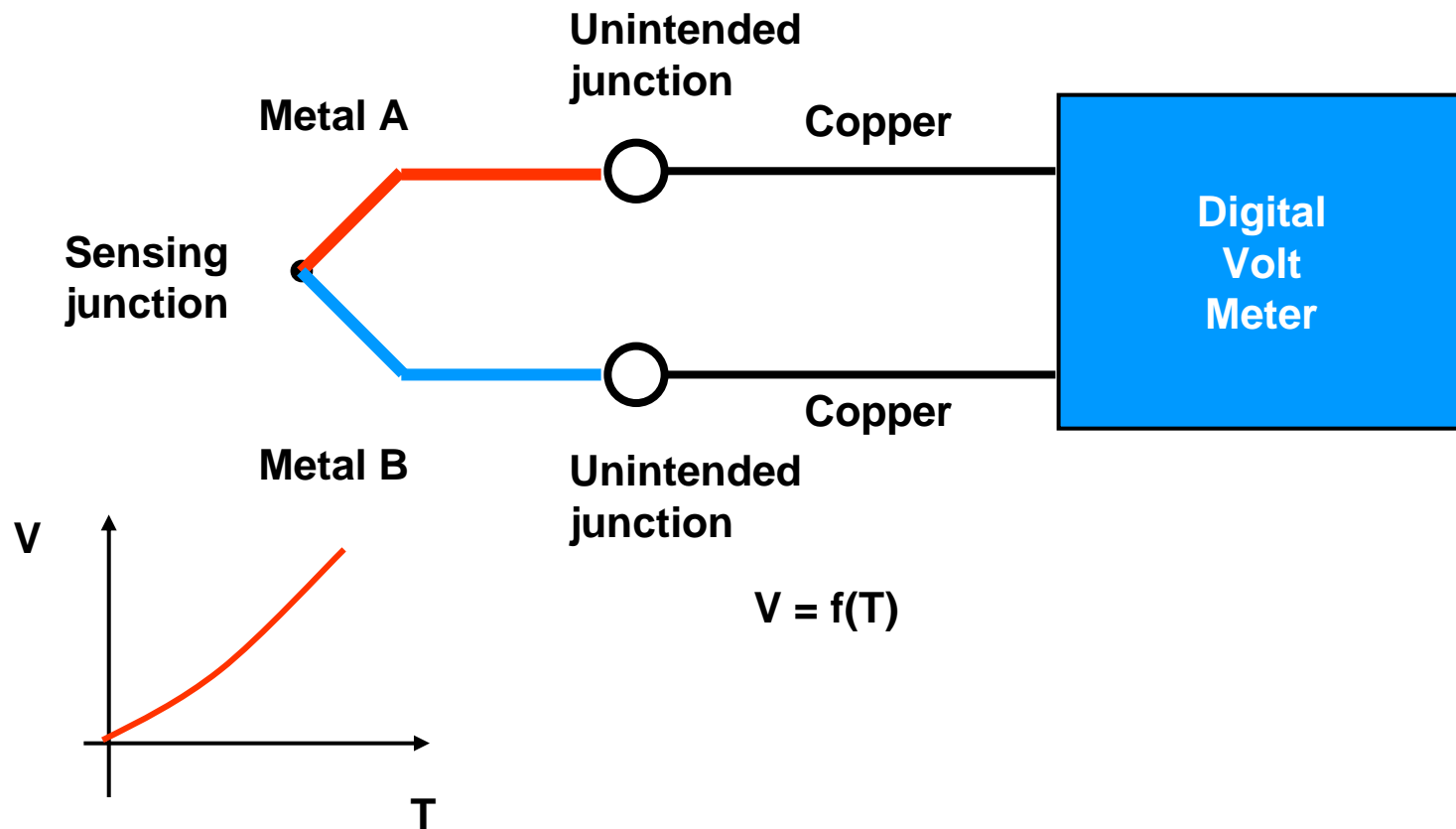
# Measuring Temperature

- Thermocouples



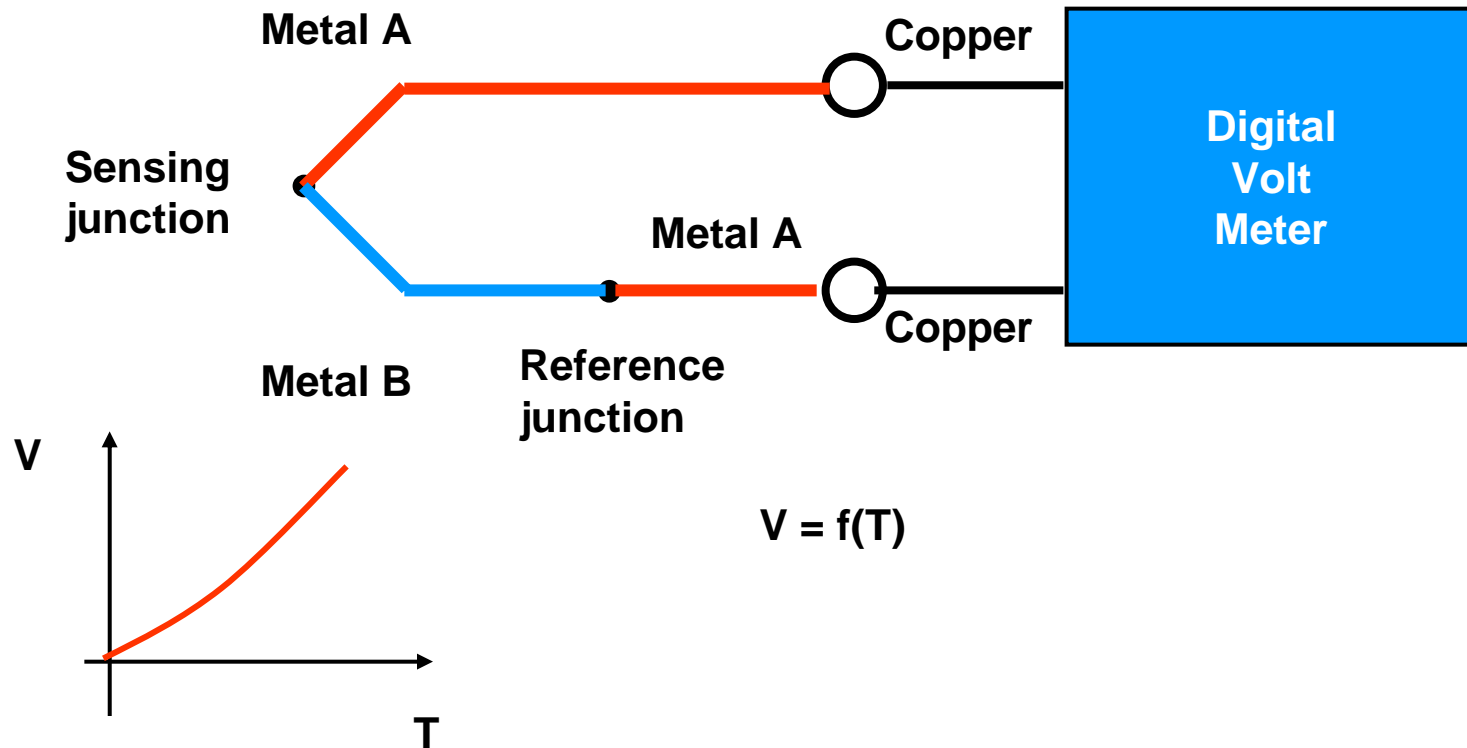
# Measuring Temperature

- Thermocouples



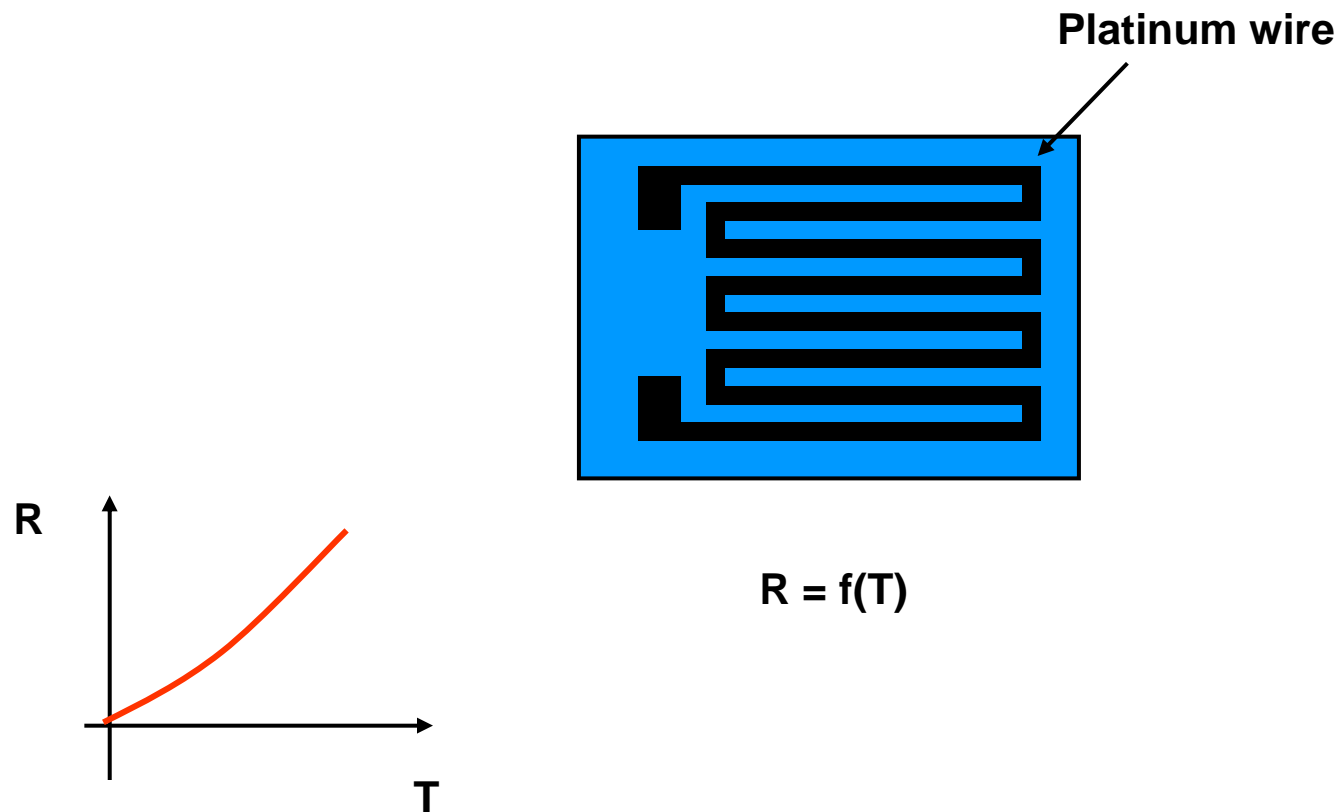
# Measuring Temperature

- Thermocouples



# Measuring Temperature

- Resistance-Temperature Detectors



# Next time

- More measurement sensors