

Design IV

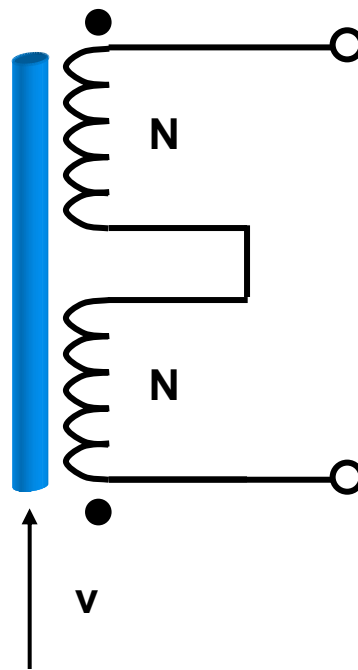
E232 Spring 07

Class 19

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Velocity Sensors

- A changing magnetic field induces a current in a coil of wire proportional to the rate of change of the magnetic field and the number of windings



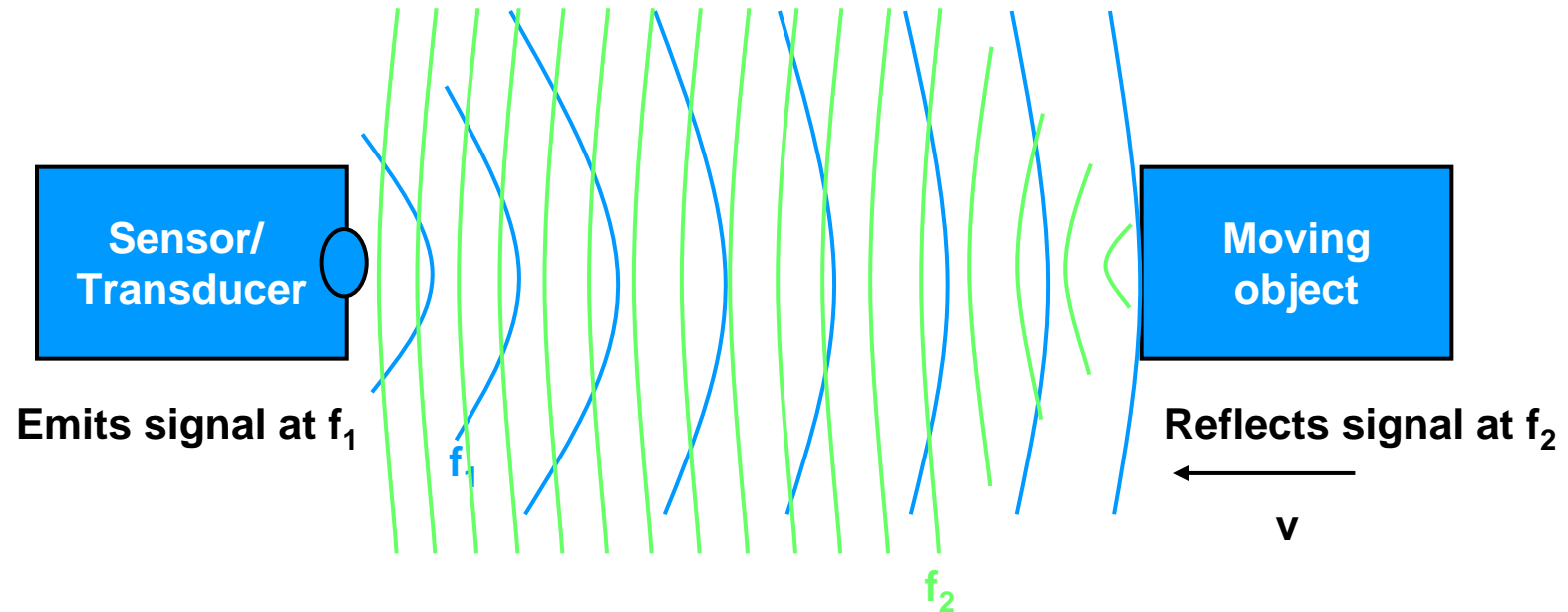
$$V_o(t) = f(v(t))$$

Issues:

- Effects of displacement, as well as velocity
- Linearity
- Measurement range

Velocity Sensors

- Doppler shift



$$|f_1 - f_2| = \frac{2v}{\lambda}$$

Where v is the component of velocity in line with sensor

v_0 for sound is ~1 ft/millisecond
 v_0 for light/RF is ~1 ft/nanosecond

$$f\lambda = v_0$$

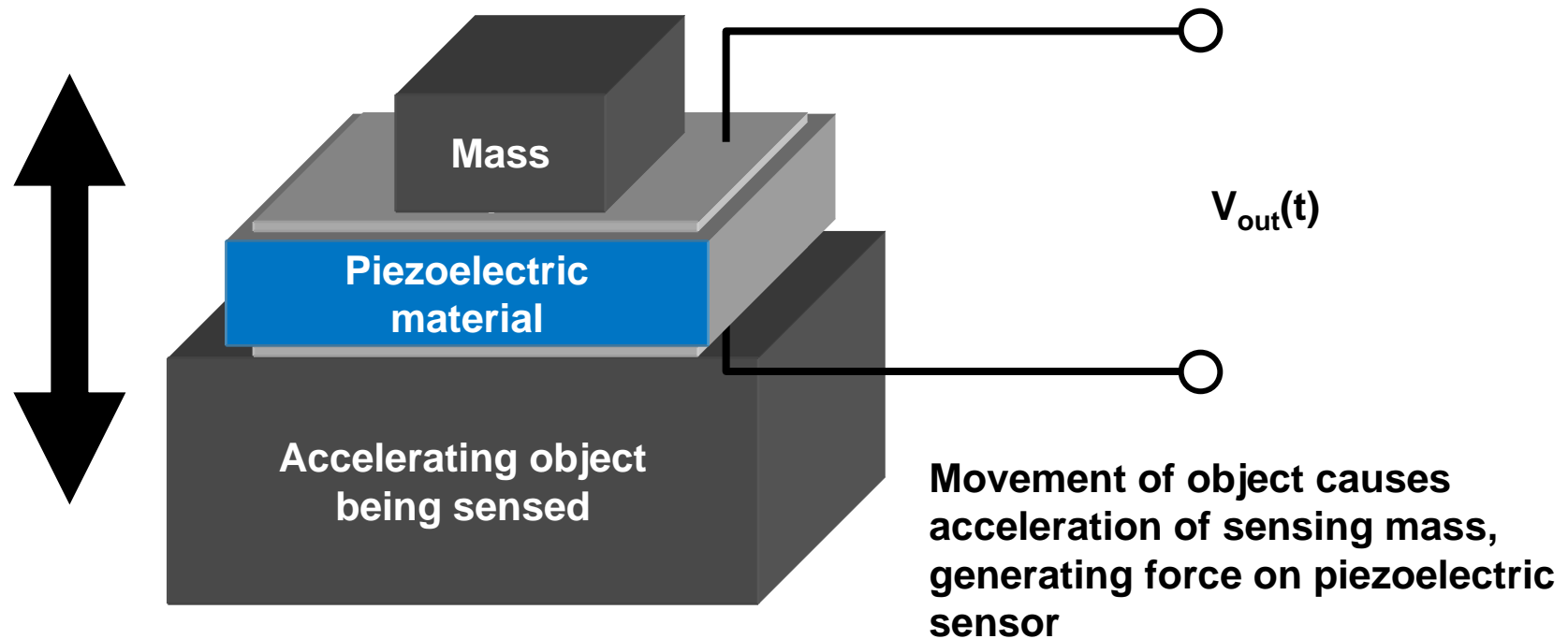
Where v_0 is velocity of wave in media

Acceleration Sensors

- Piezoelectric ($F=ma$) sensors

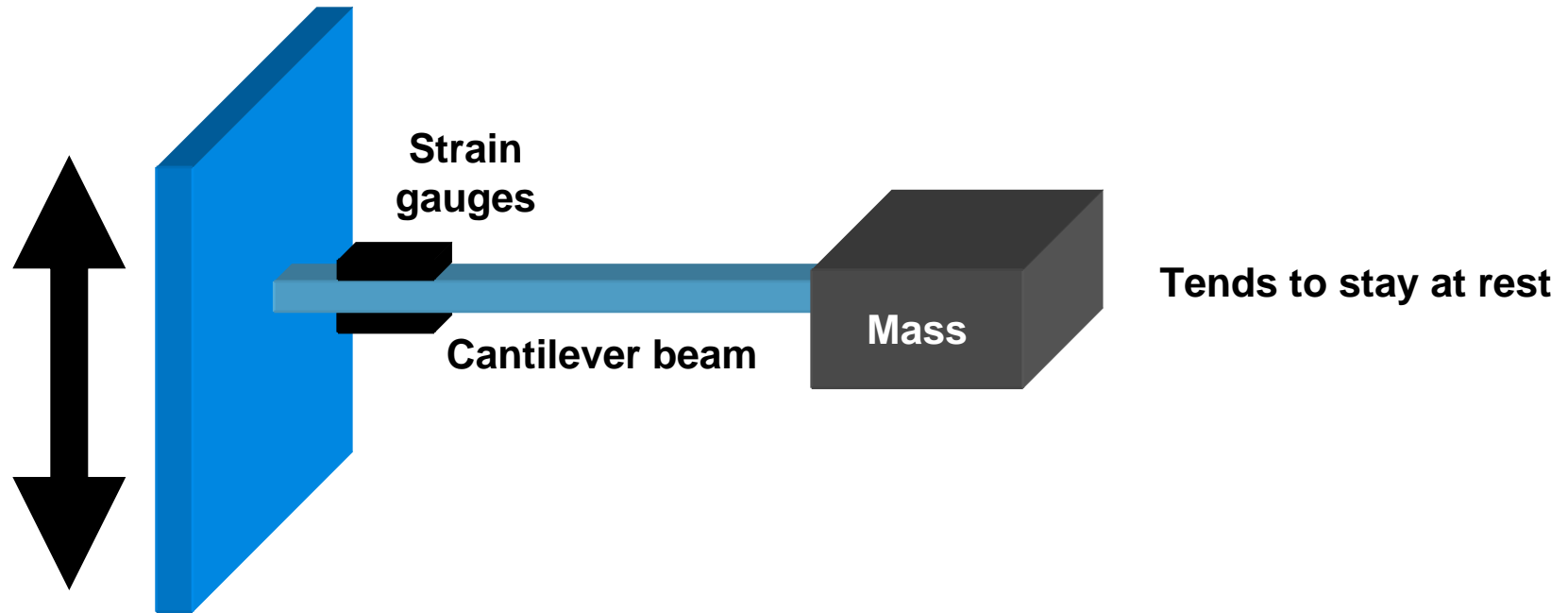
Other applications:

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



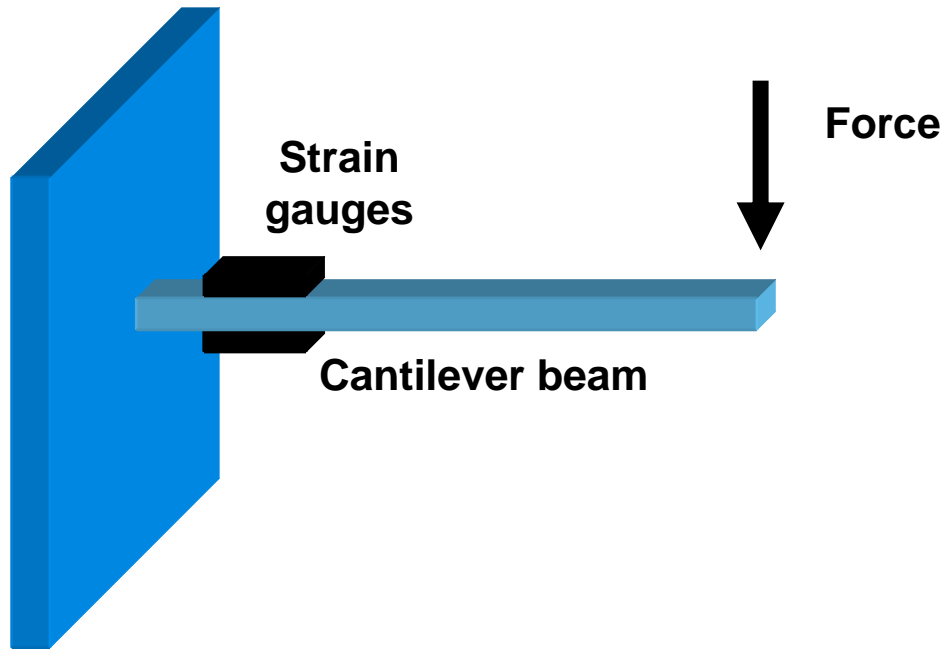
Acceleration Sensors

- Strain gauge accelerometers



Force Sensors

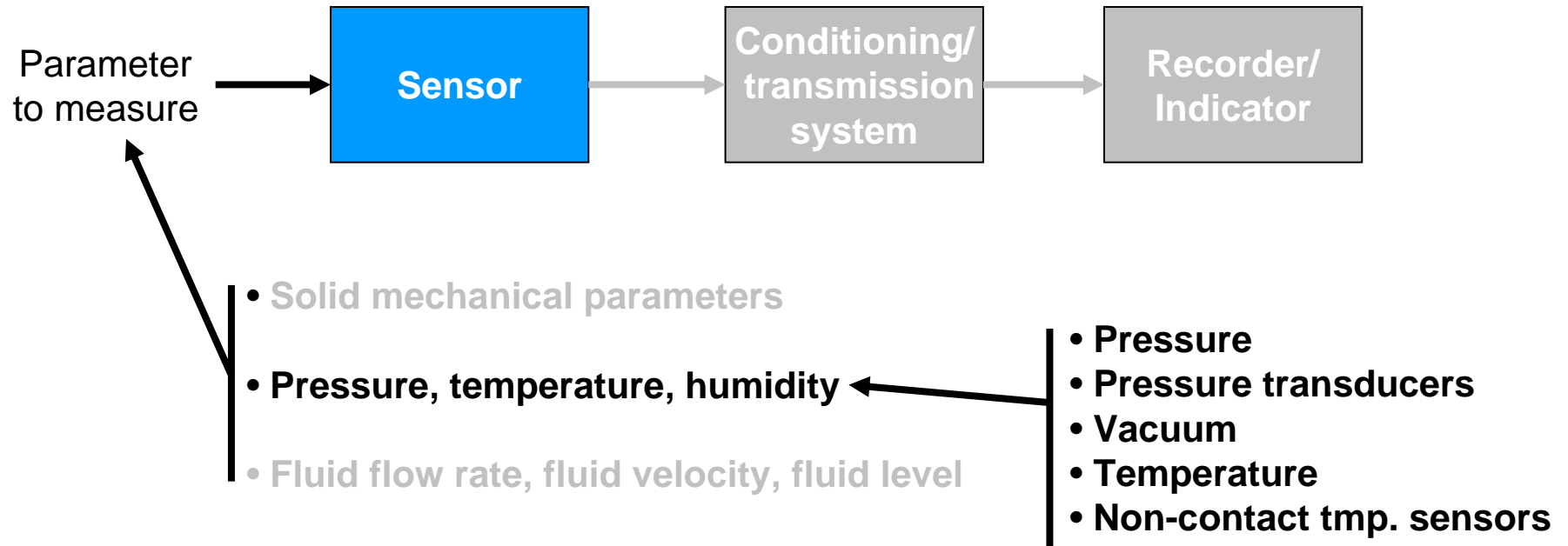
- Cantilever beam



Today's topics

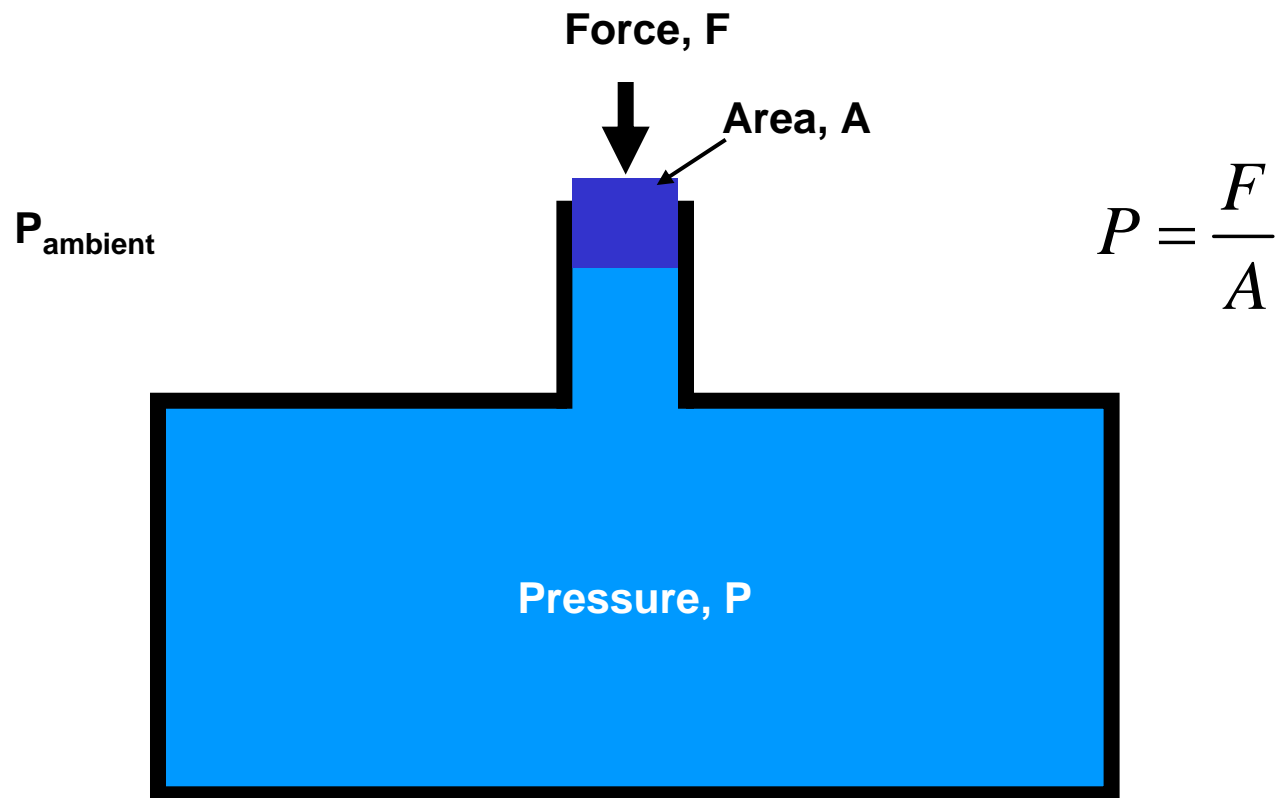
- Measurement sensors
 - **Pressure**
 - **Pressure transducers**
 - **Vacuum**
 - **Temperature**
 - **Non-contact temperature sensors**

Measurement Systems



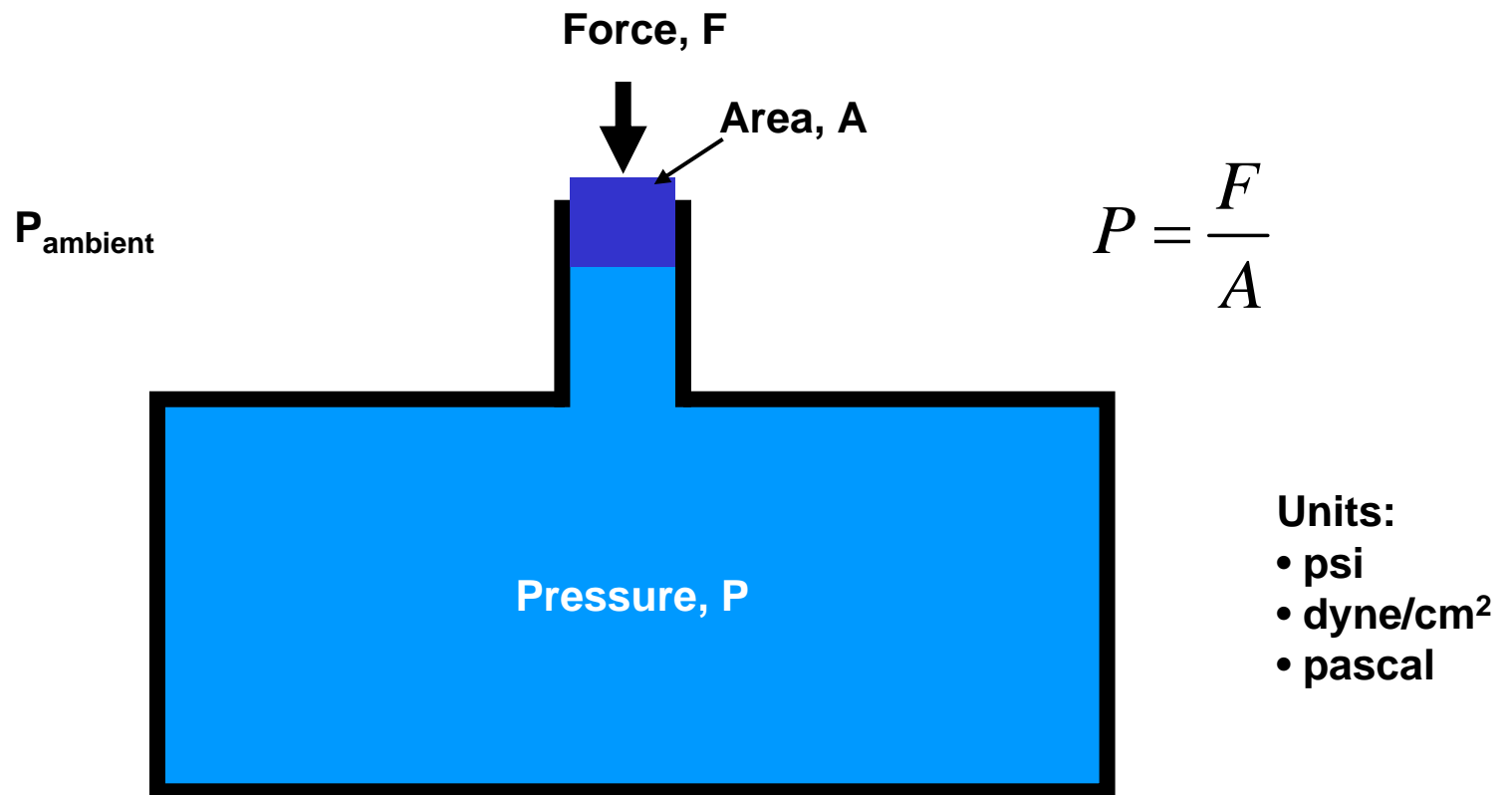
Measuring Pressure

- Definition of “Pressure”



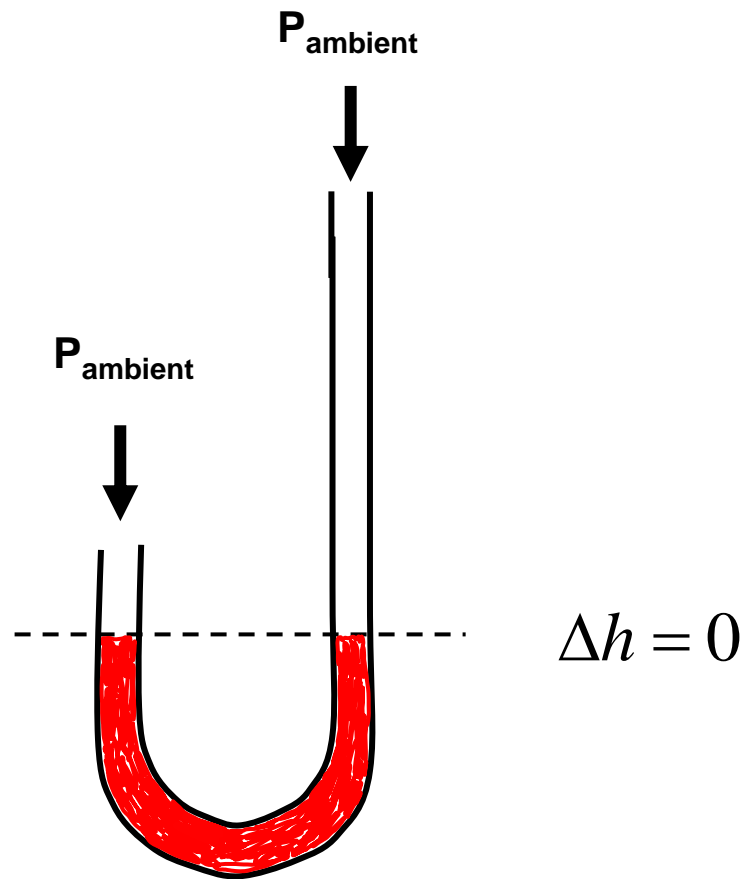
Measuring Pressure

- Definition of “Pressure”



Measuring Pressure

- Manometers

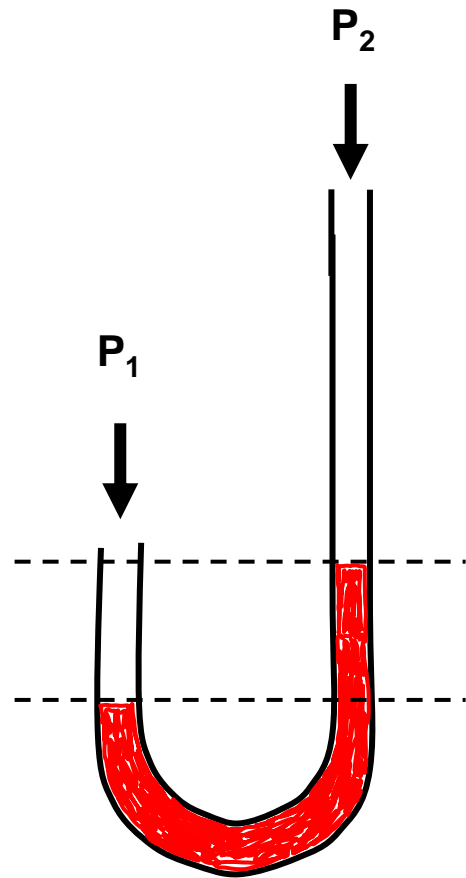


Units:

- mm-Hg
- ft-H₂O
- atm

Measuring Pressure

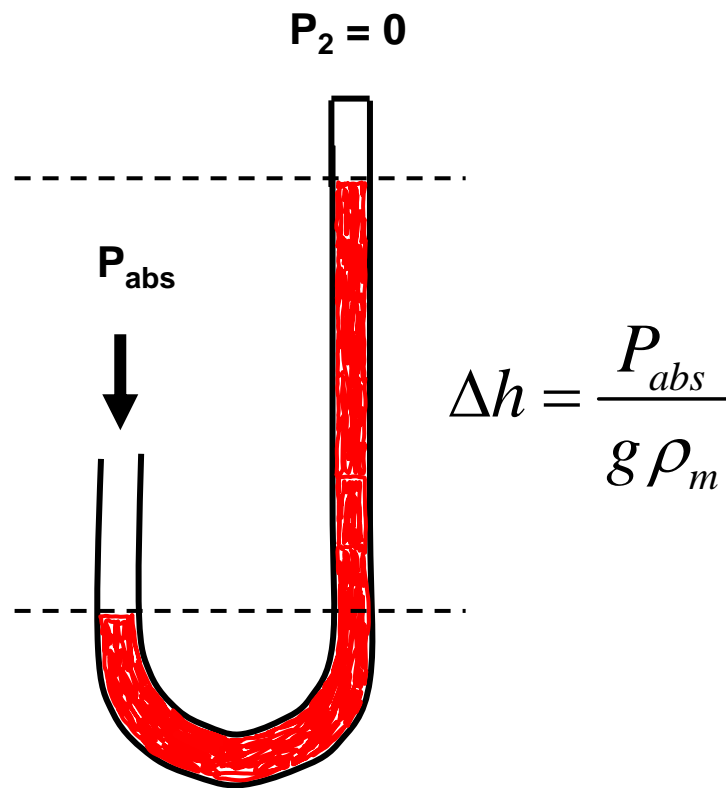
- Manometers



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

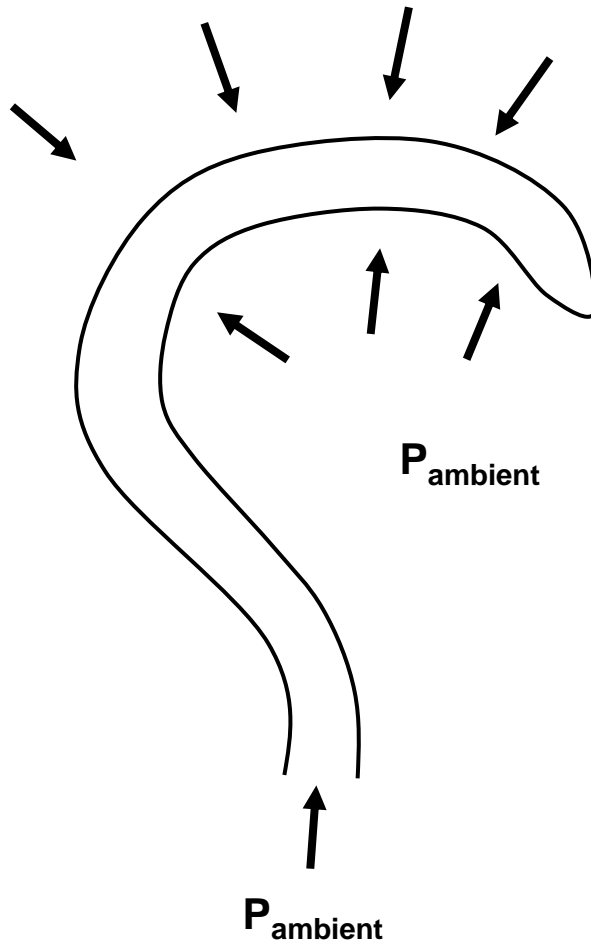
Measuring Pressure

- Barometers



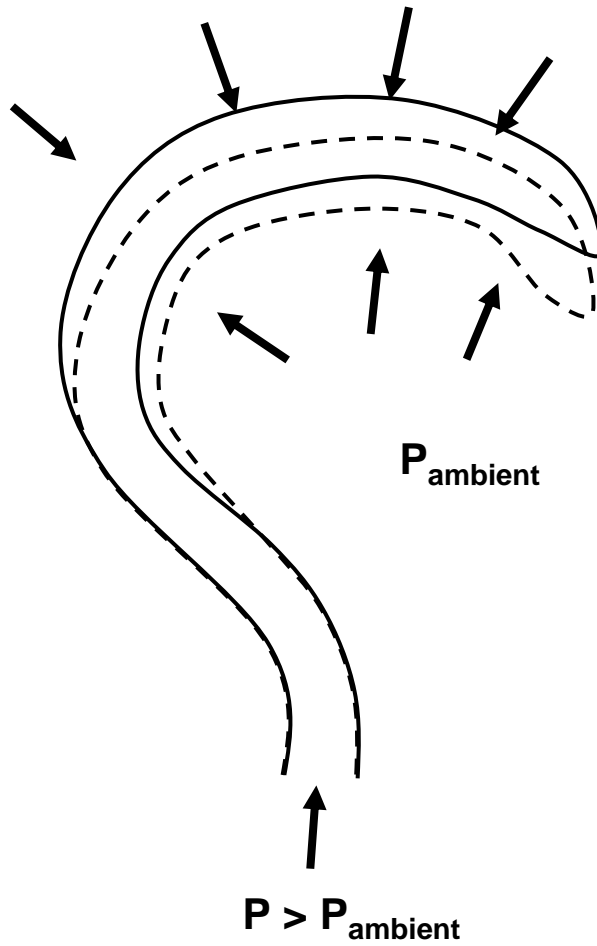
Measuring Pressure

- Bourdon gauge



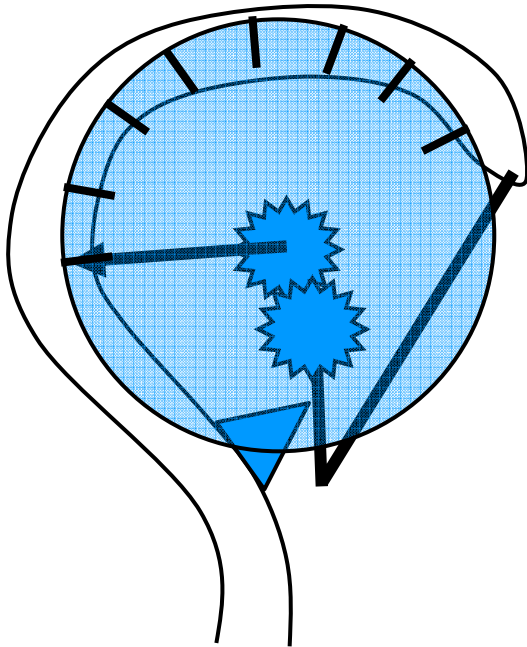
Measuring Pressure

- Bourdon gauge



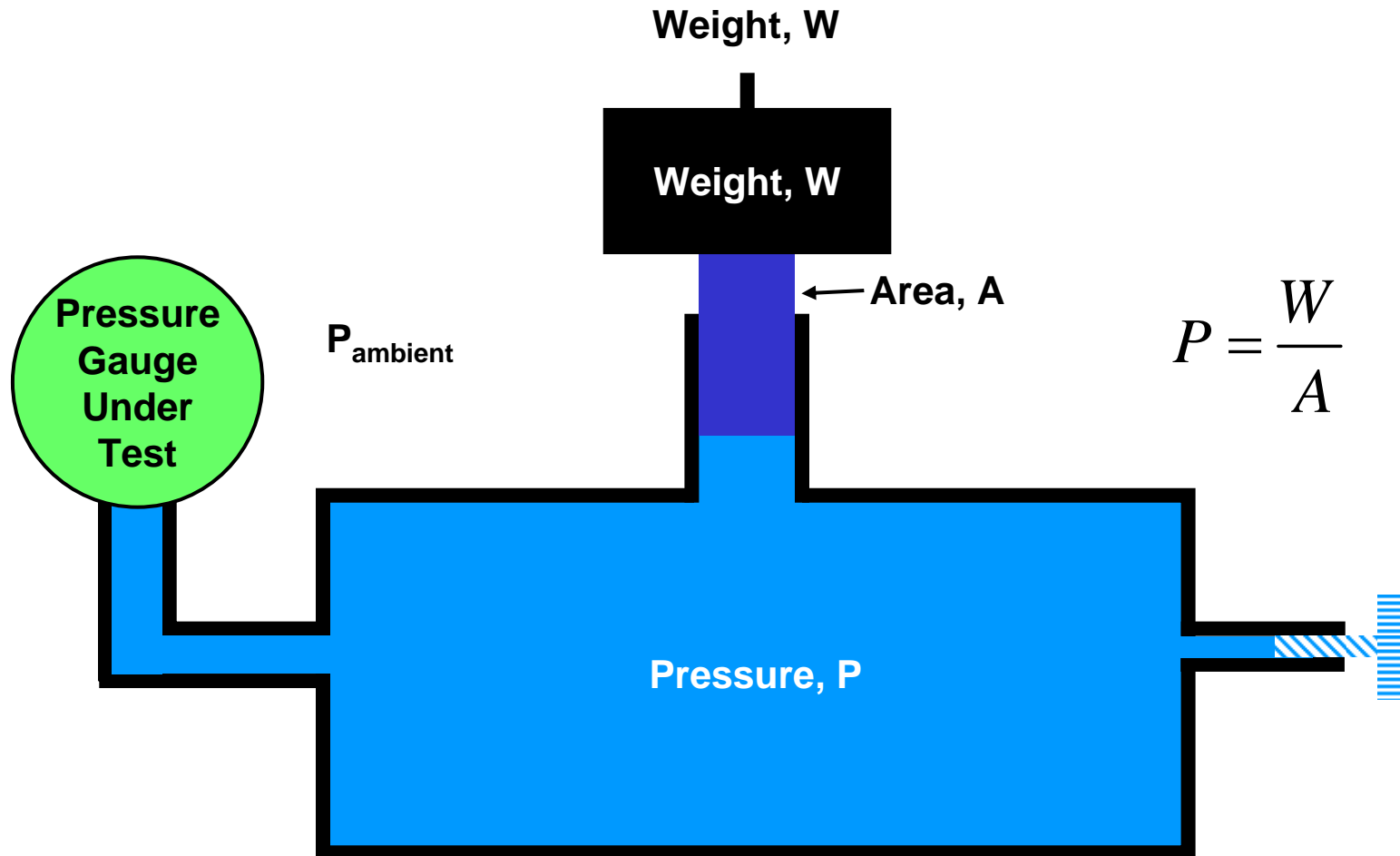
Measuring Pressure

- Bourdon gauge



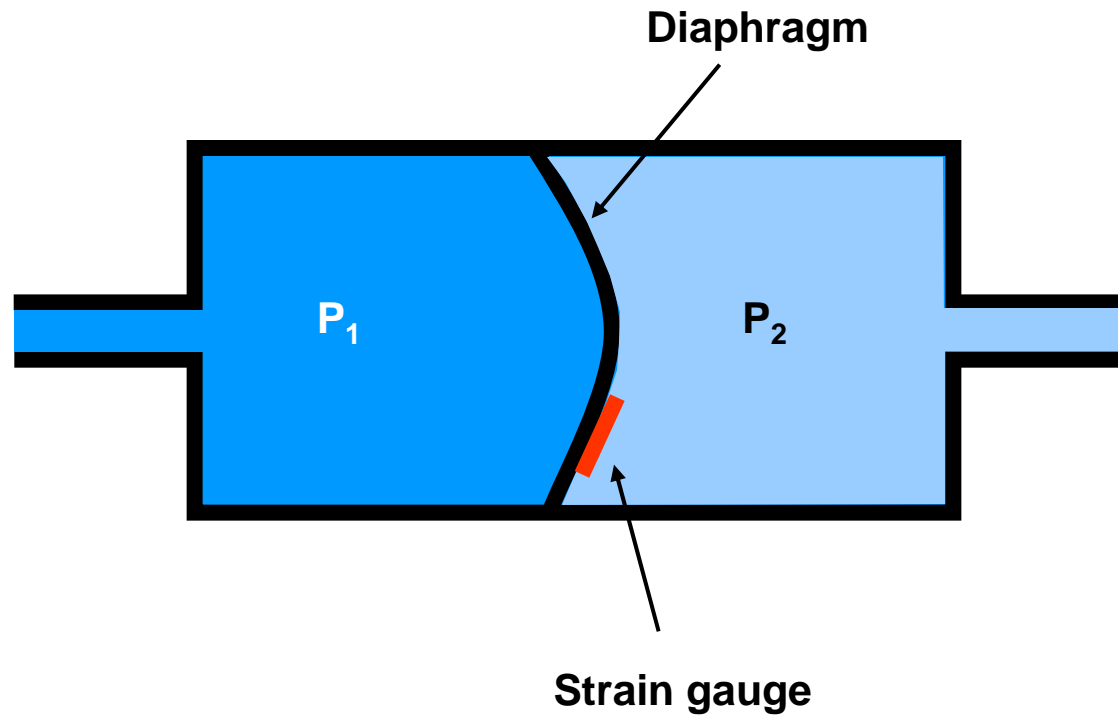
Measuring Pressure

- Dead-weight tester



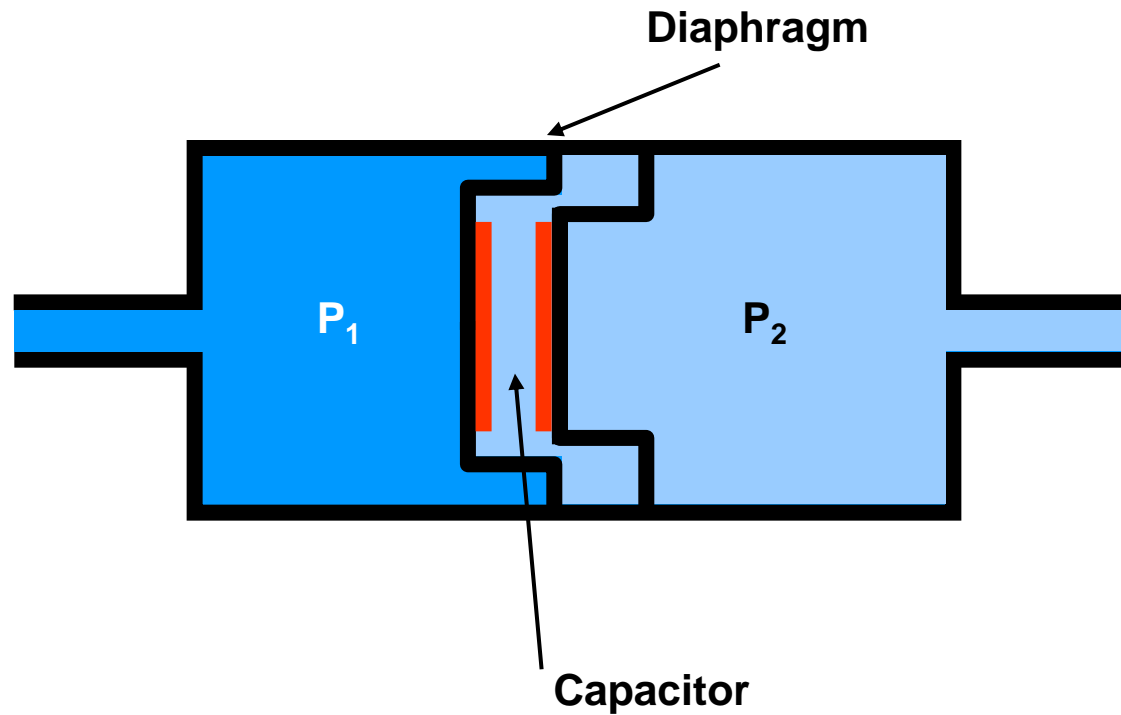
Measuring Pressure

- Pressure transducers: Strain gauge sensor



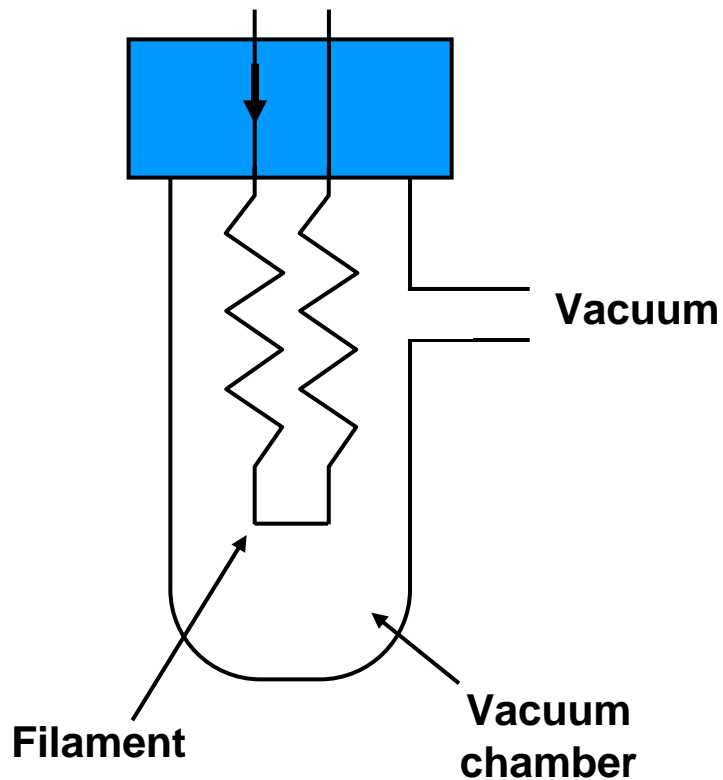
Measuring Pressure

- Pressure transducers: Capacitive sensor



Measuring Vacuum

- Thermal conductivity sensor – Pirani gauge

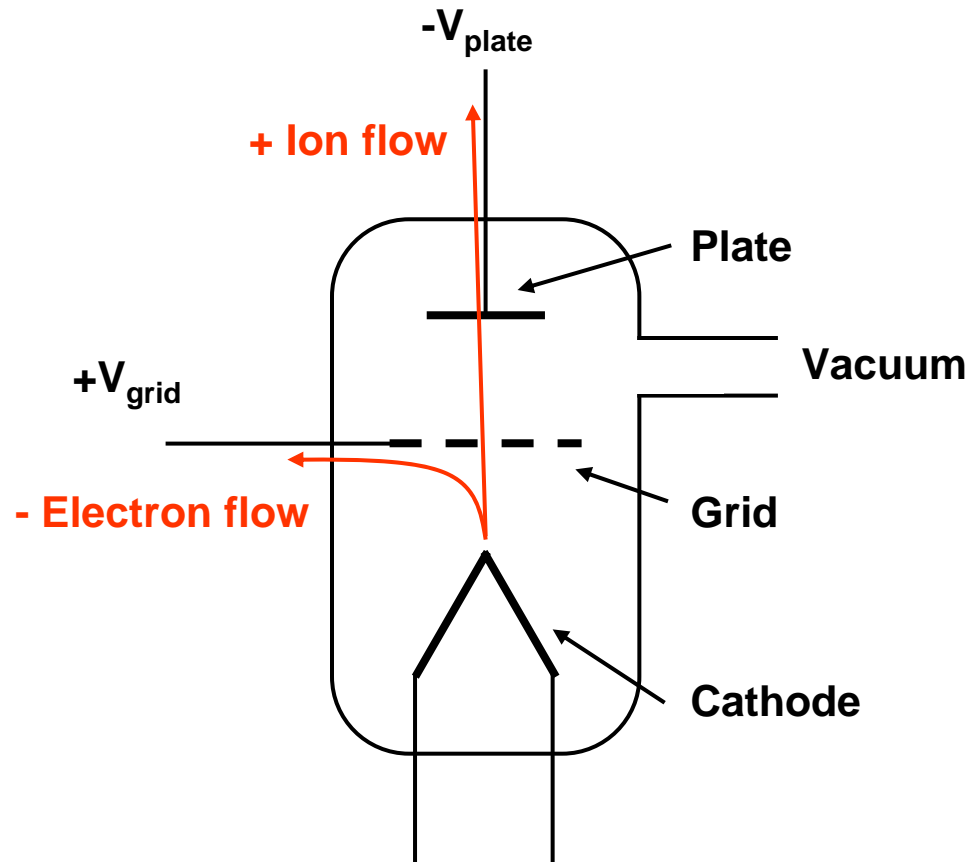


- Current flow through filament causes it to heat up
- Gas inside vacuum chamber allows heat to be transferred away from filament

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

Measuring Vacuum

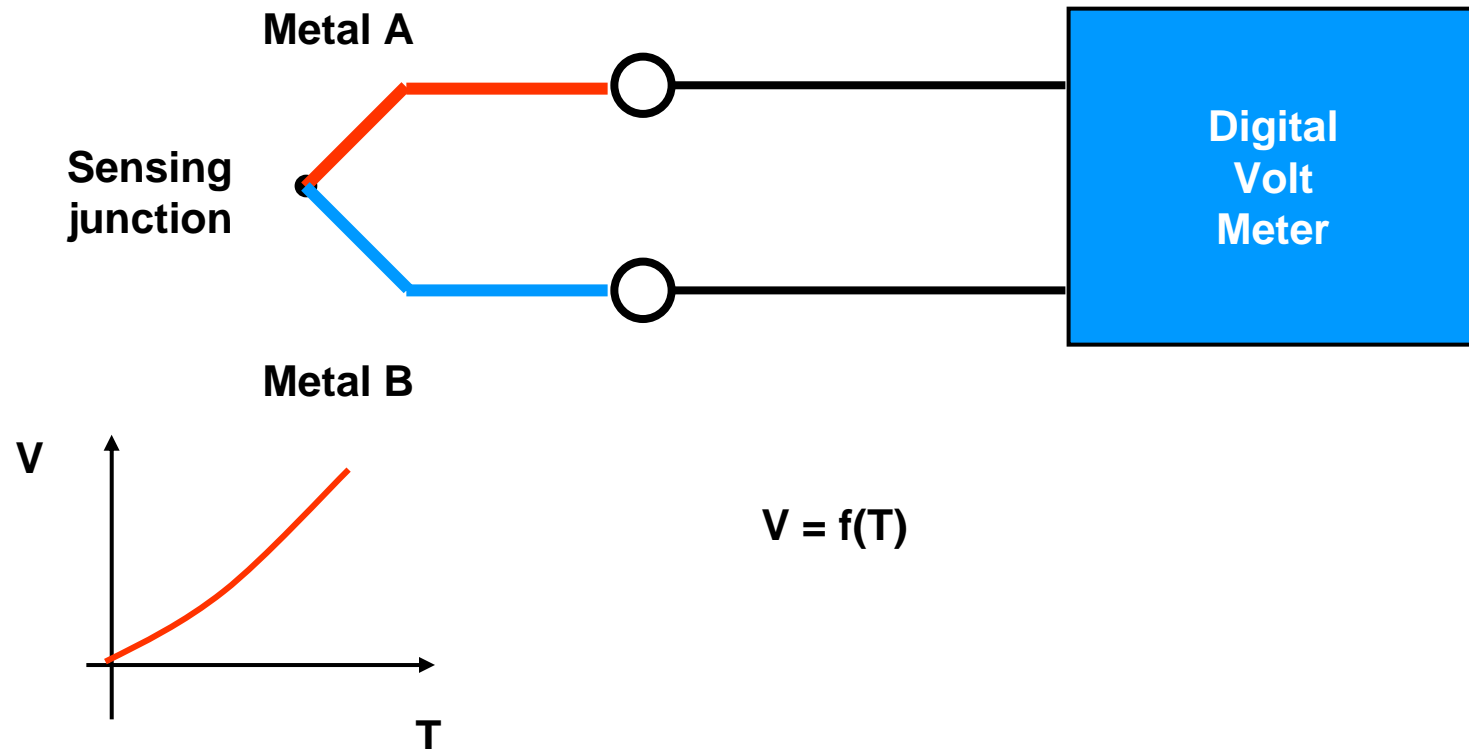
- Ionization vacuum gauge



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

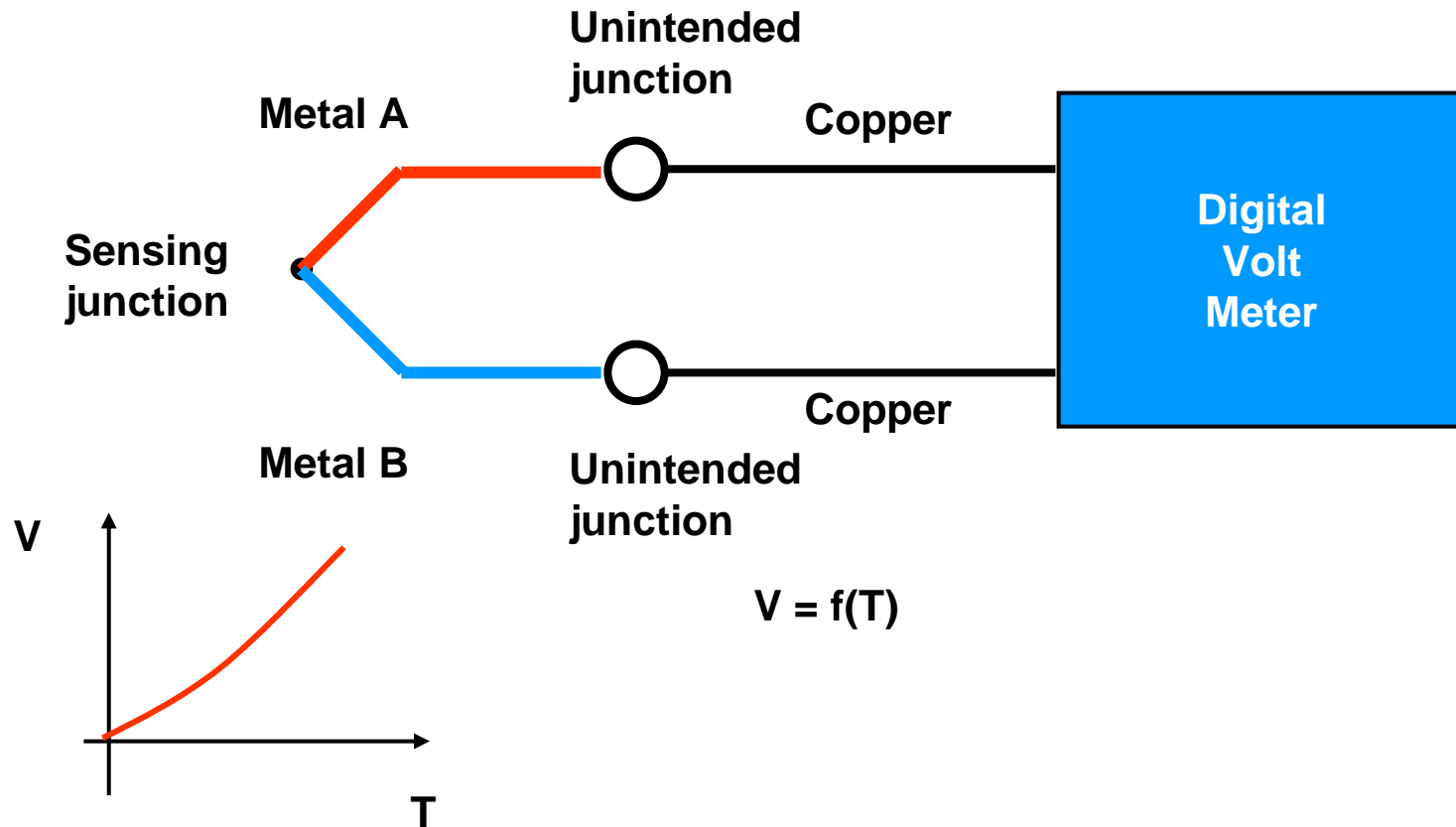
Measuring Temperature

- Thermocouples



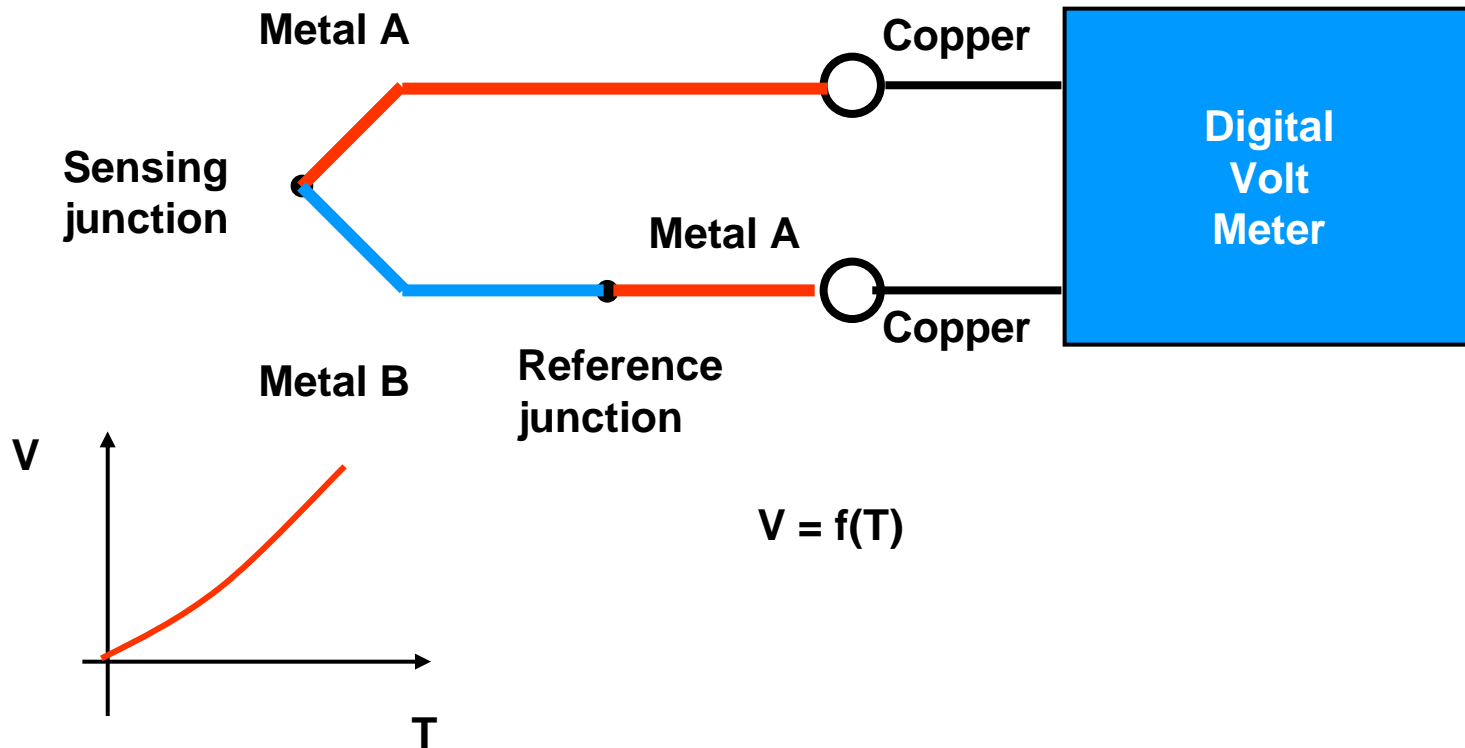
Measuring Temperature

- Thermocouples



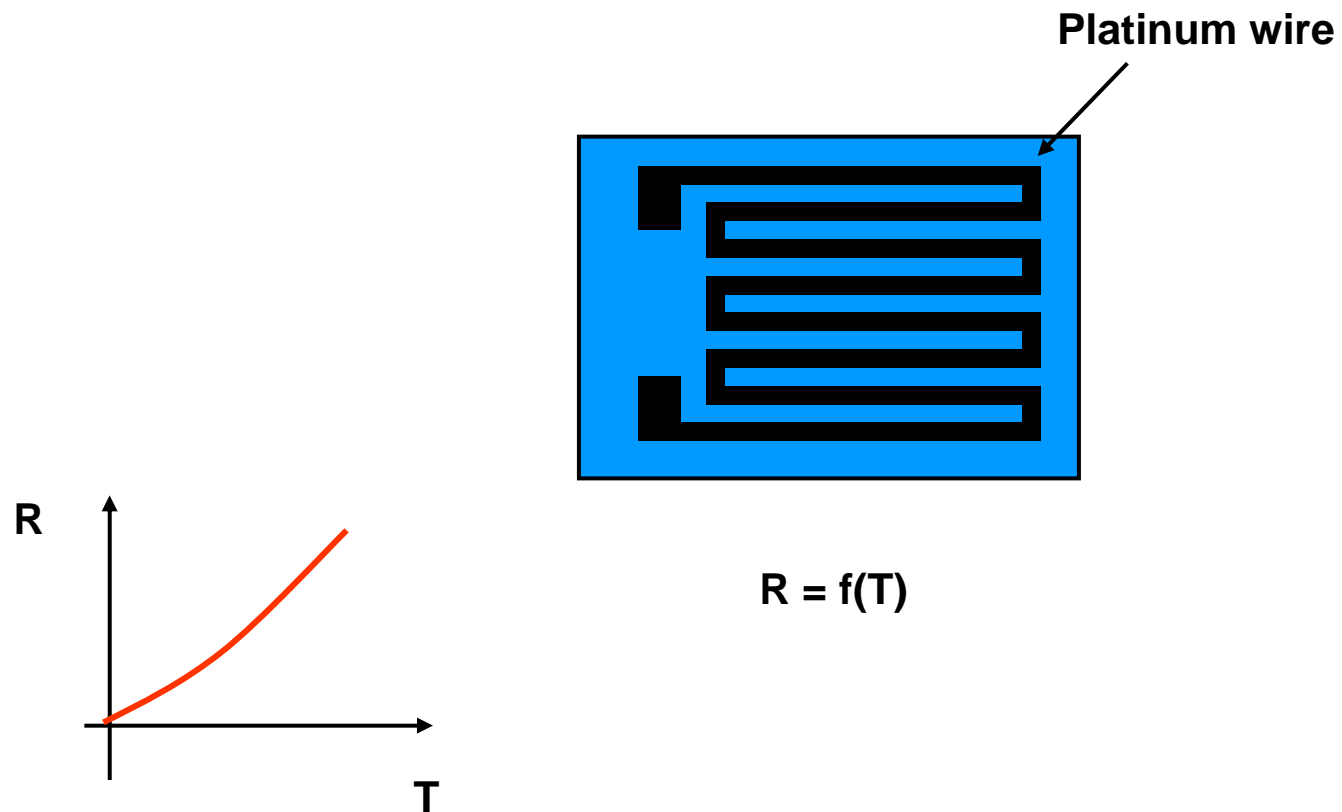
Measuring Temperature

- Thermocouples



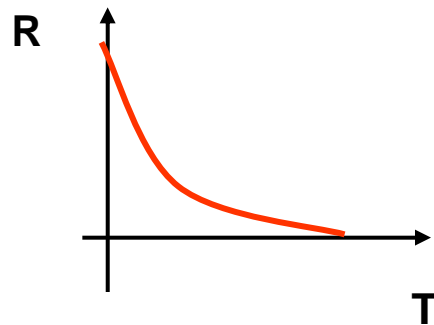
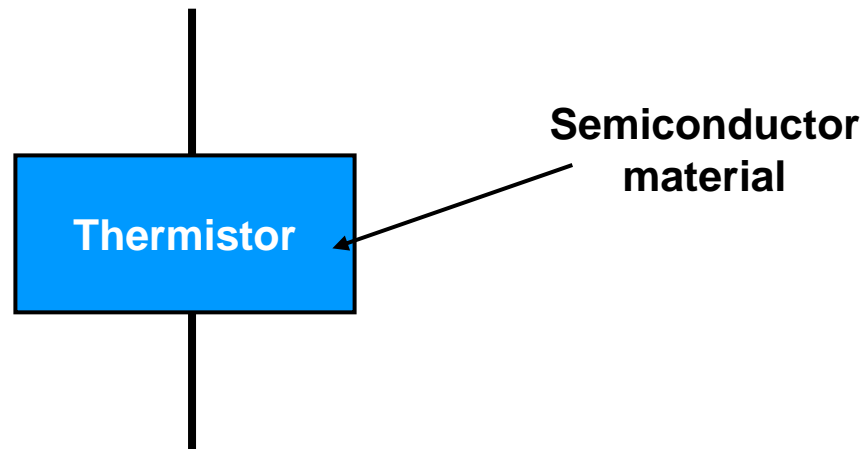
Measuring Temperature

- Resistance-Temperature Detectors



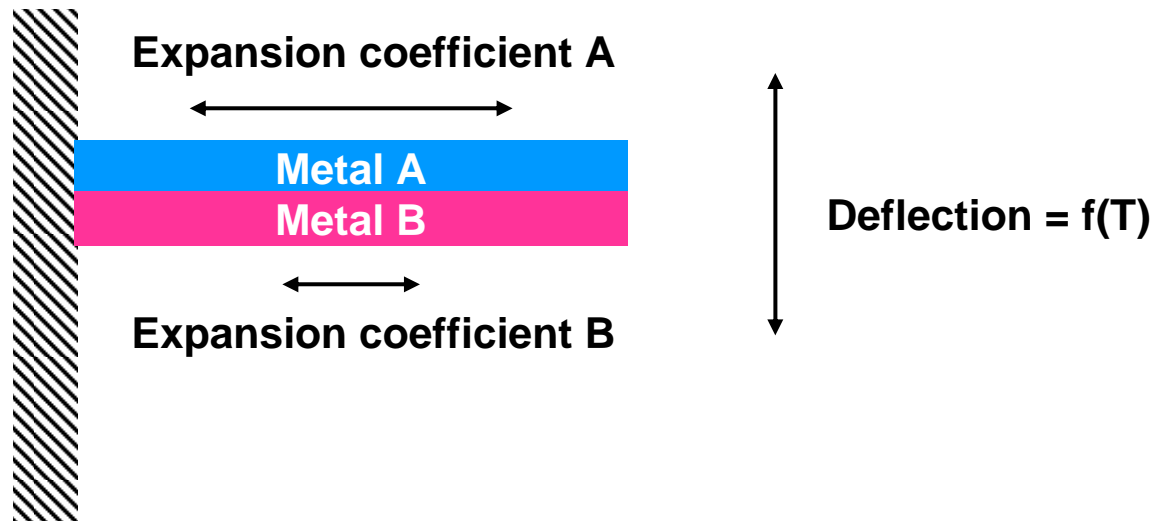
Measuring Temperature

- Thermistors



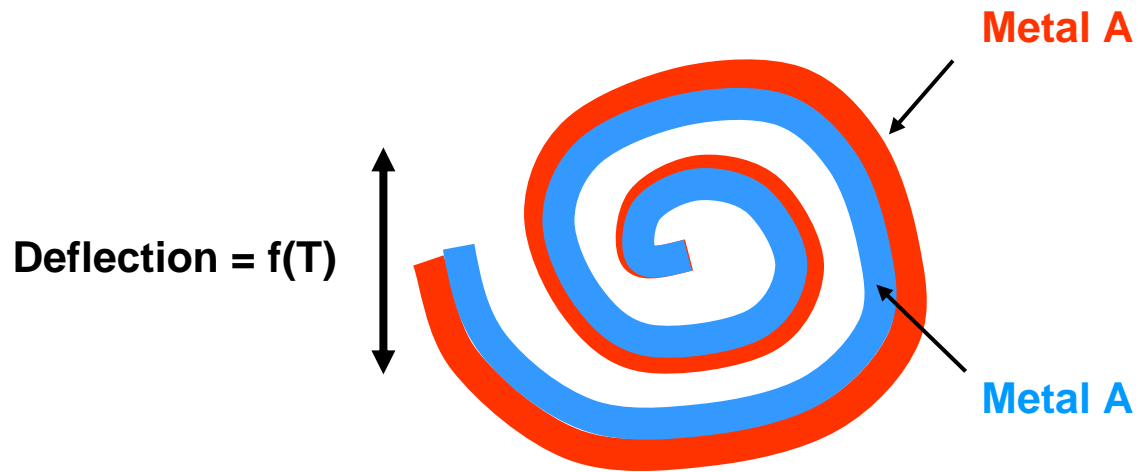
Temperature Measurement

- Linear bi-metallic strip



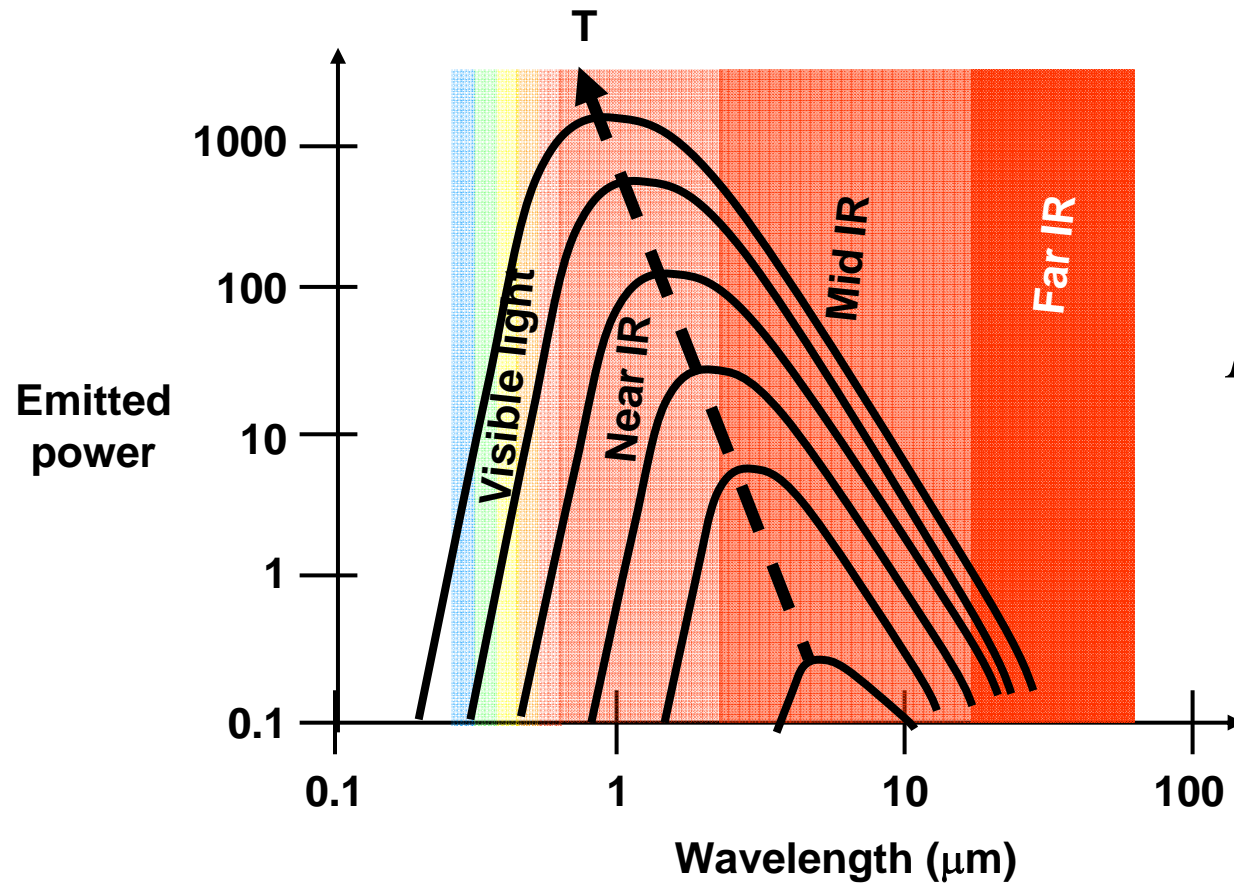
Temperature Measurement

- Spiral bi-metallic strip



Non-contact Temperature Measurement

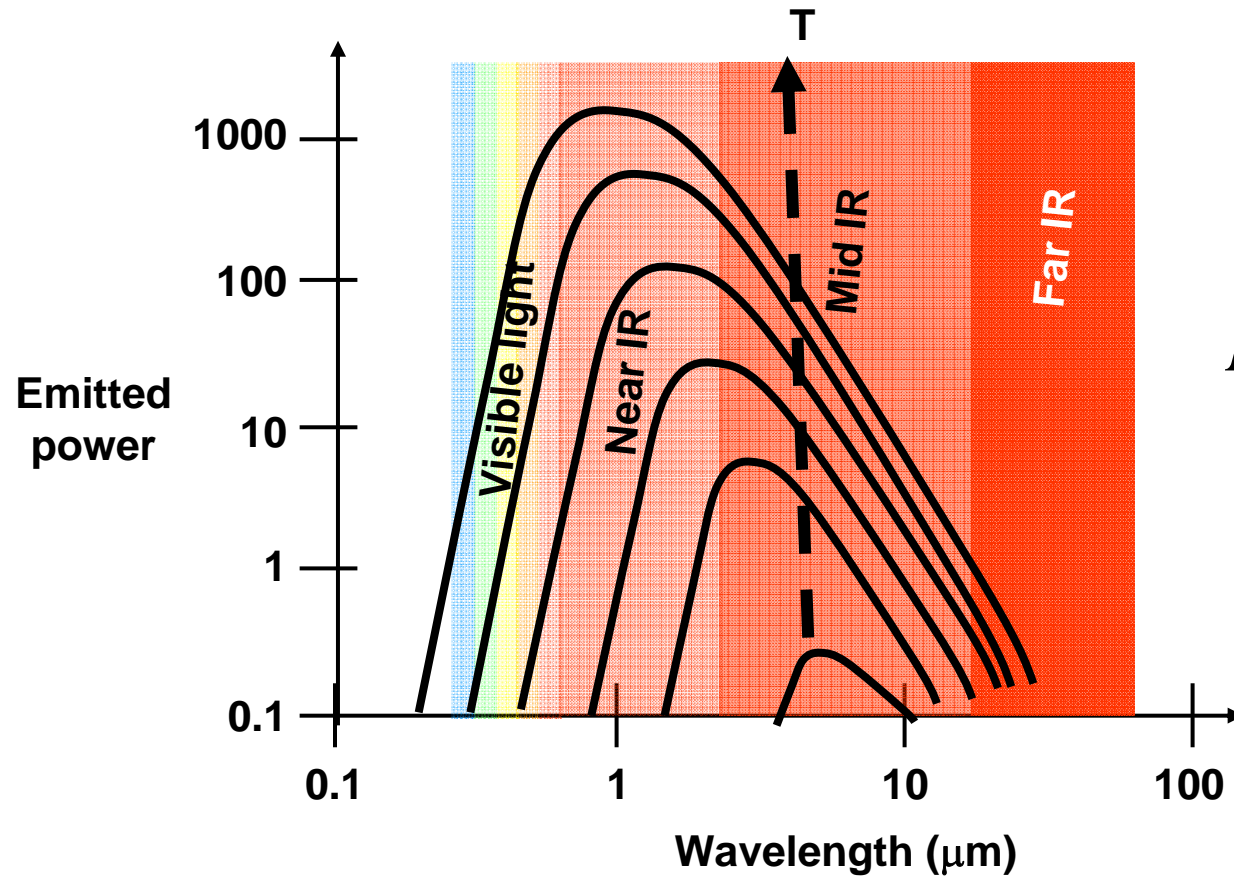
- Blackbody radiation



$$E_{b\lambda} = \frac{C_1 \lambda^{-5}}{e^{\frac{C_2}{\lambda T}} - 1}$$

Non-contact Temperature Measurement

- Blackbody radiation



$$E_{b\lambda} = \frac{C_1 \lambda^{-5}}{e^{\frac{C_2}{\lambda T}} - 1}$$

Next time

- More measurement sensors