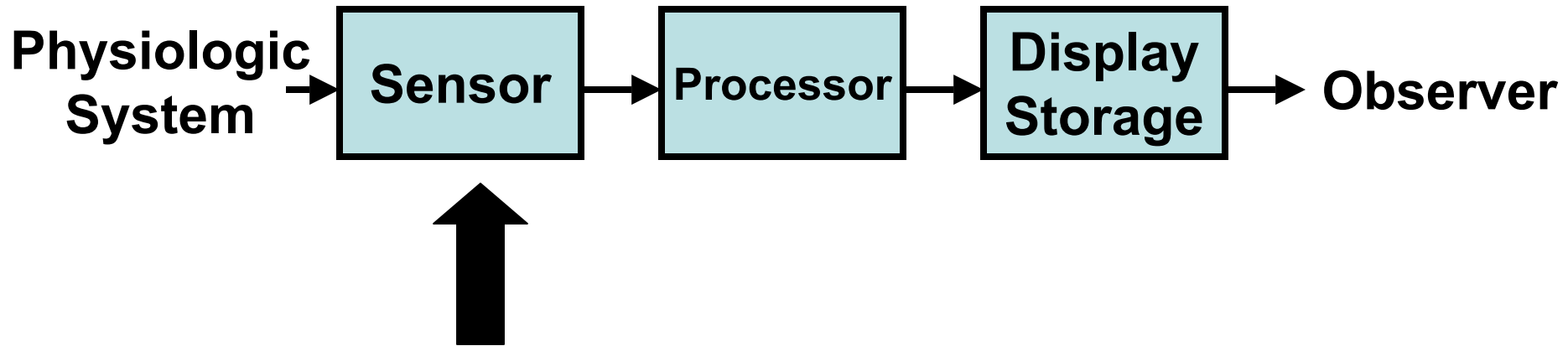
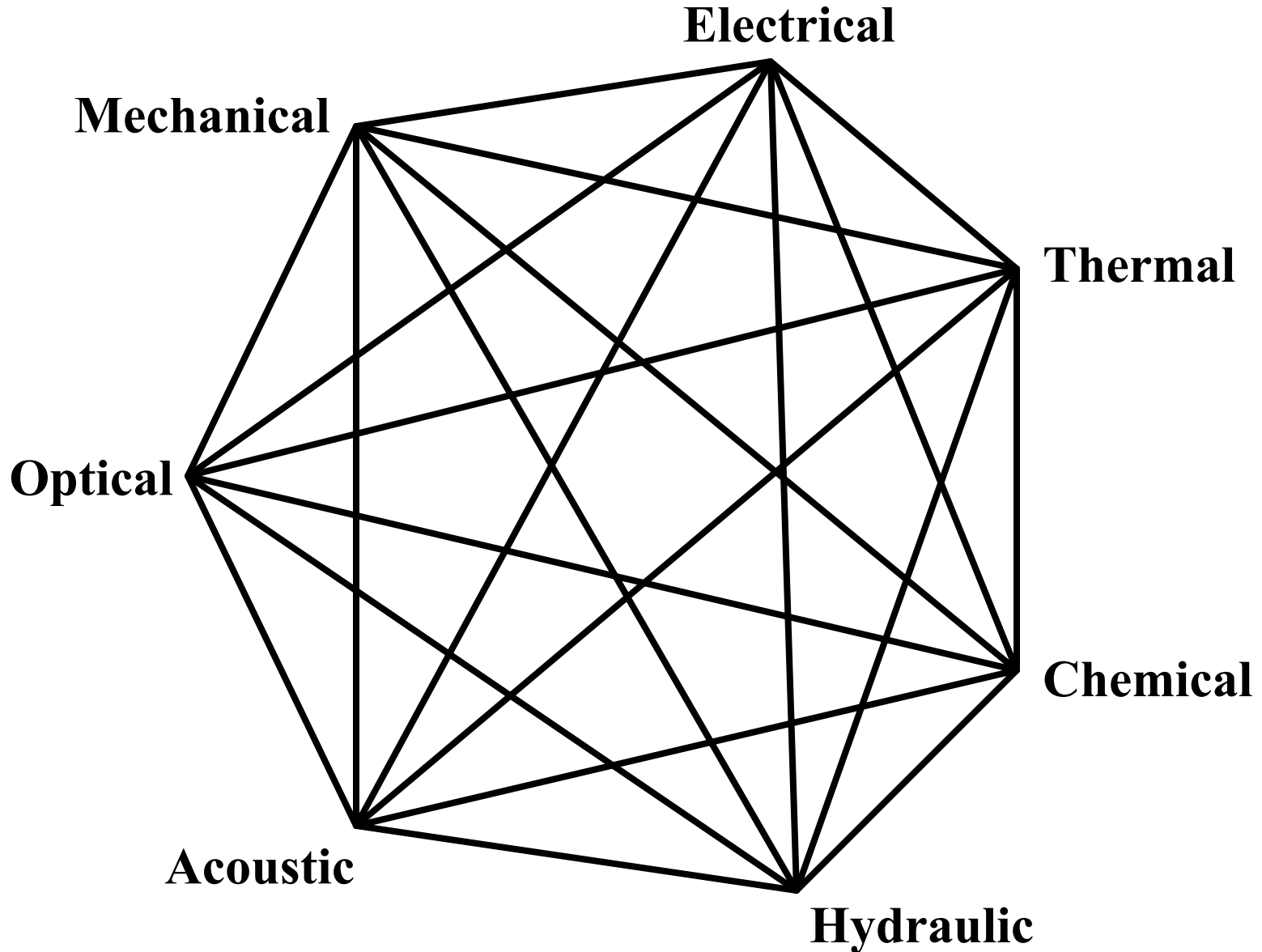


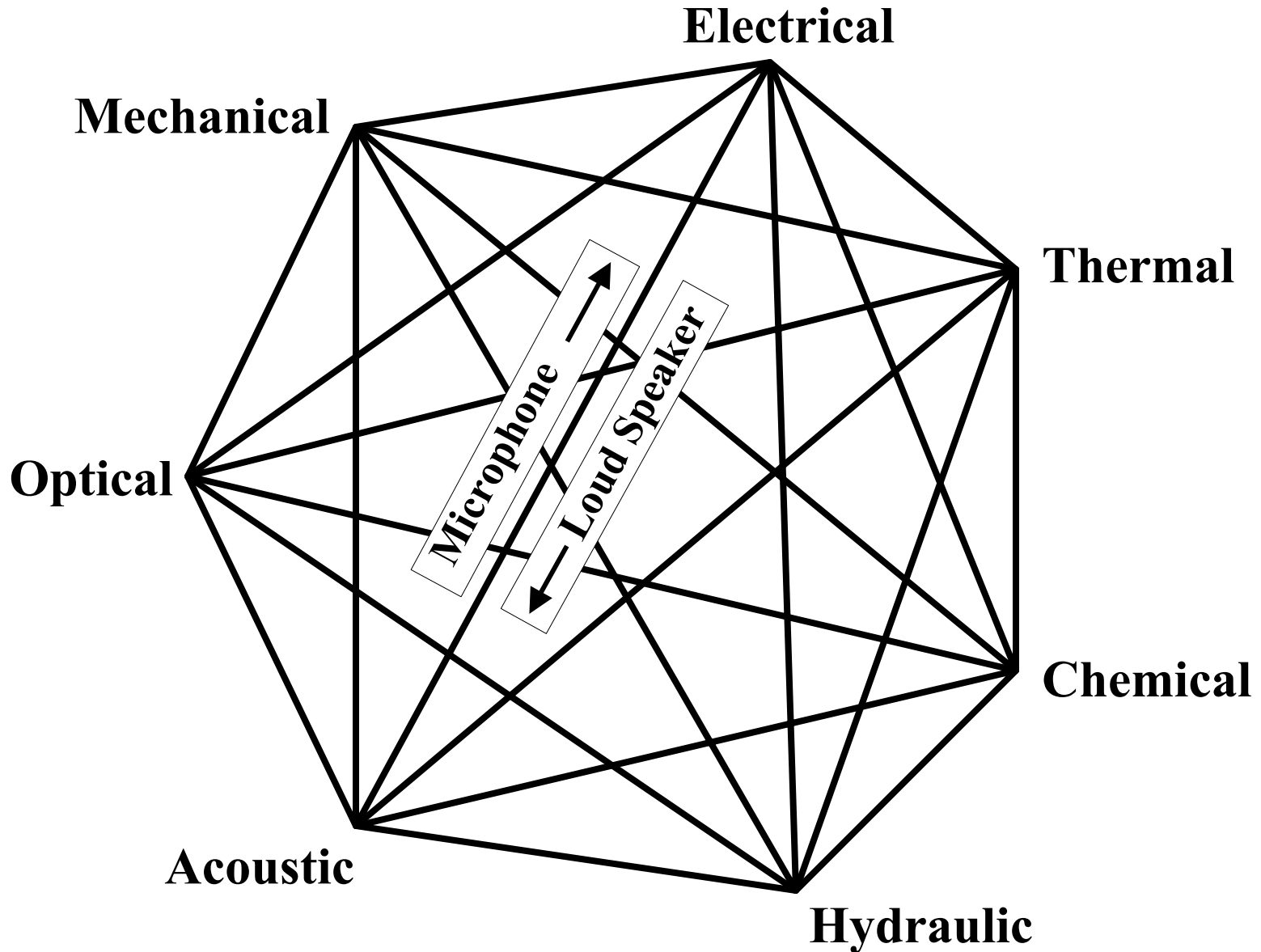
# Basic Biomedical Instrument



# Possible Types of Transducers



# Possible Types of Transducers



# Types of Sensors

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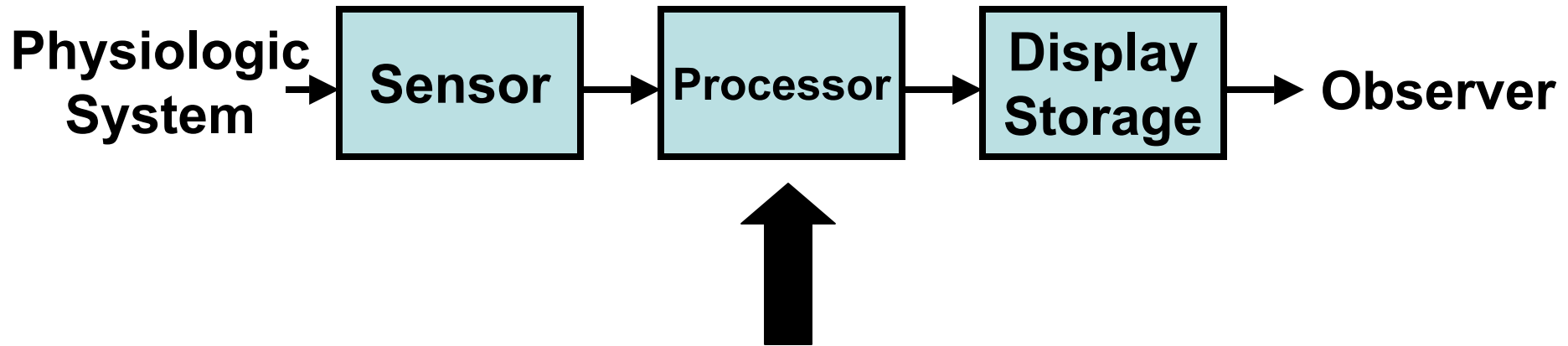
- **Physical**
- **Chemical**
- **Bioanalytical**

# Types of Sensors

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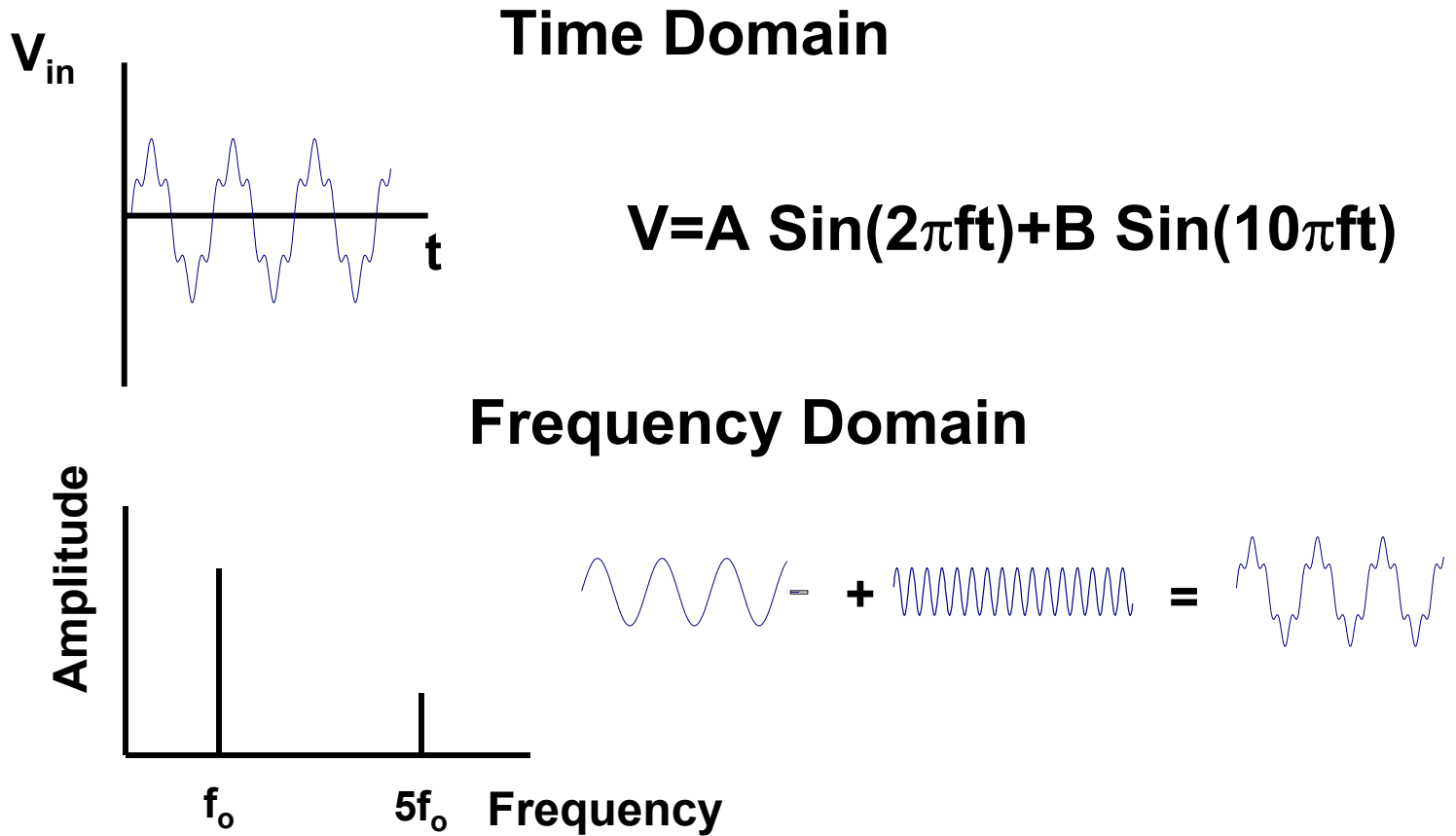
- **Physical**
    - Strain gauge
    - Accelerometer
    - Load cell (force)
    - Pressure sensor
    - Velocimeter
    - Thermistor
    - Metal resistance thermometer
    - Flow sensor
  - **Chemical**
    - Oxygen electrode
    - Glass electrode (pH)
    - Ion-selective electrode
    - CO<sub>2</sub> sensor
  - **Bioanalytical**
    - Glucose sensor
    - Lactate sensor
- And so on .....

# Basic Biomedical Instrument

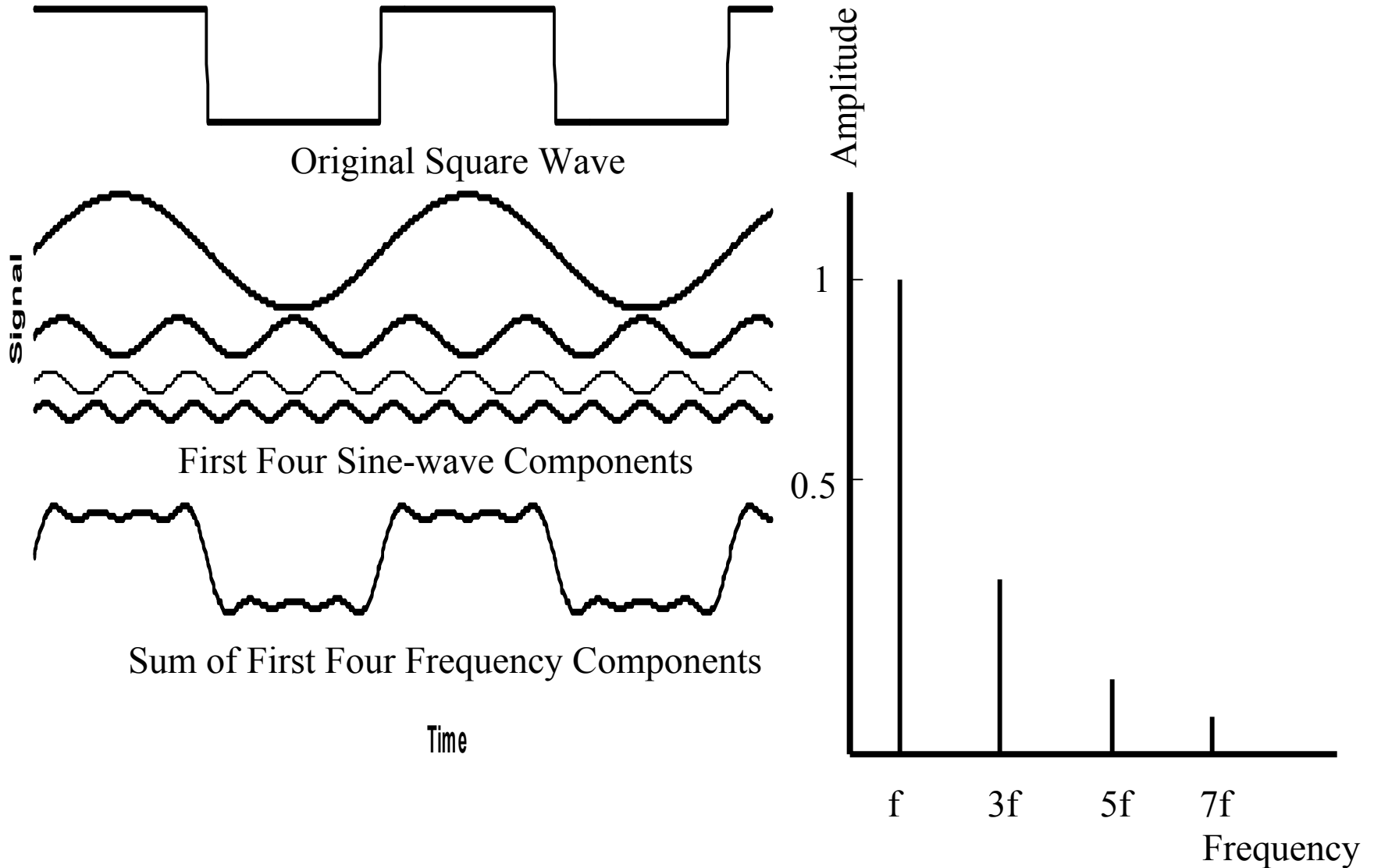


# Two Ways to Look at a Signal

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# Representation of a Square Wave





# Transfer Characteristic

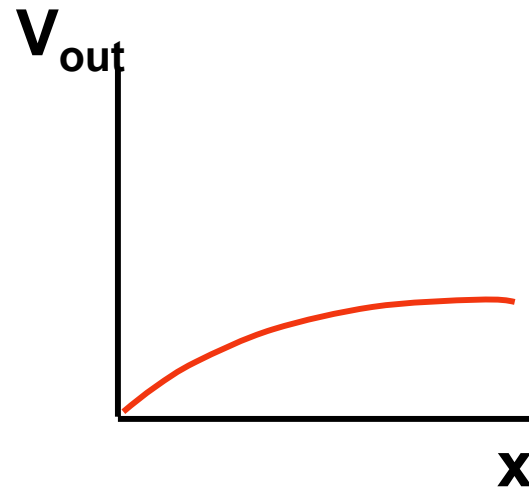
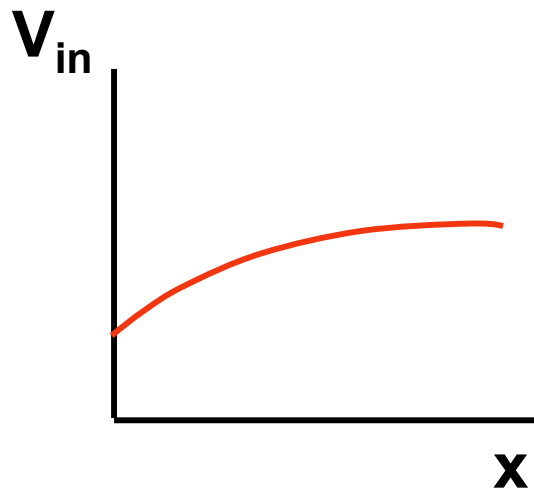
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$$U_o(t) = f(U_i(t))$$

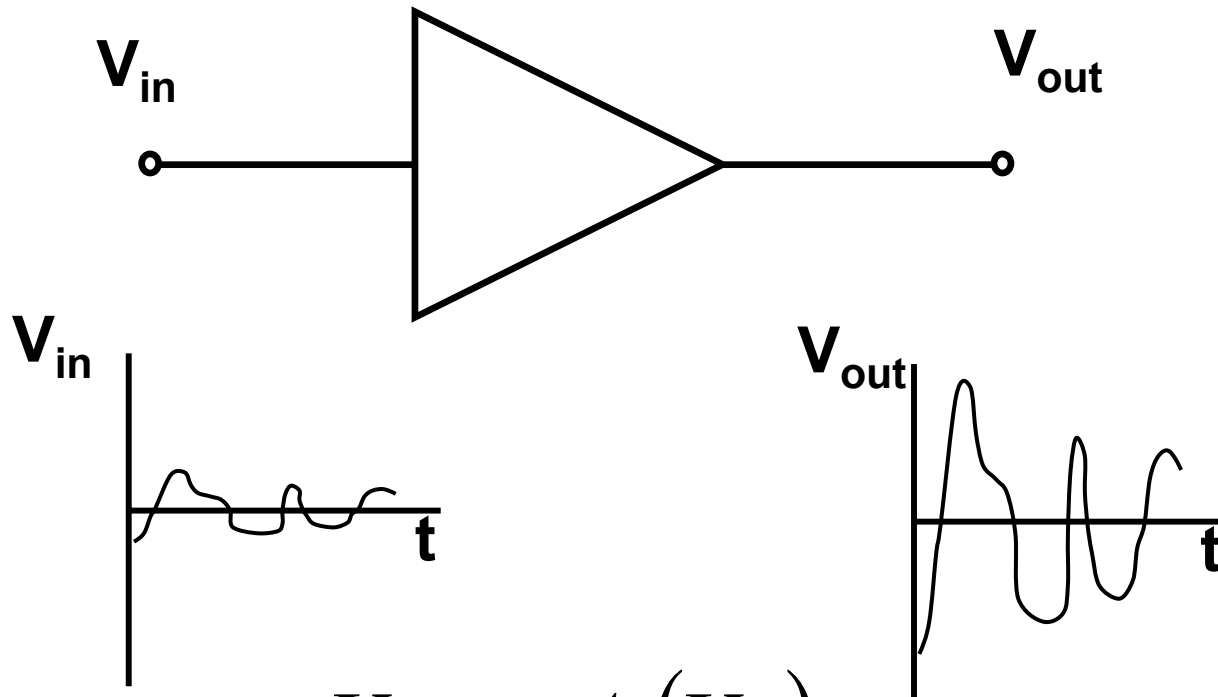
# Offset

---



# Amplification

---

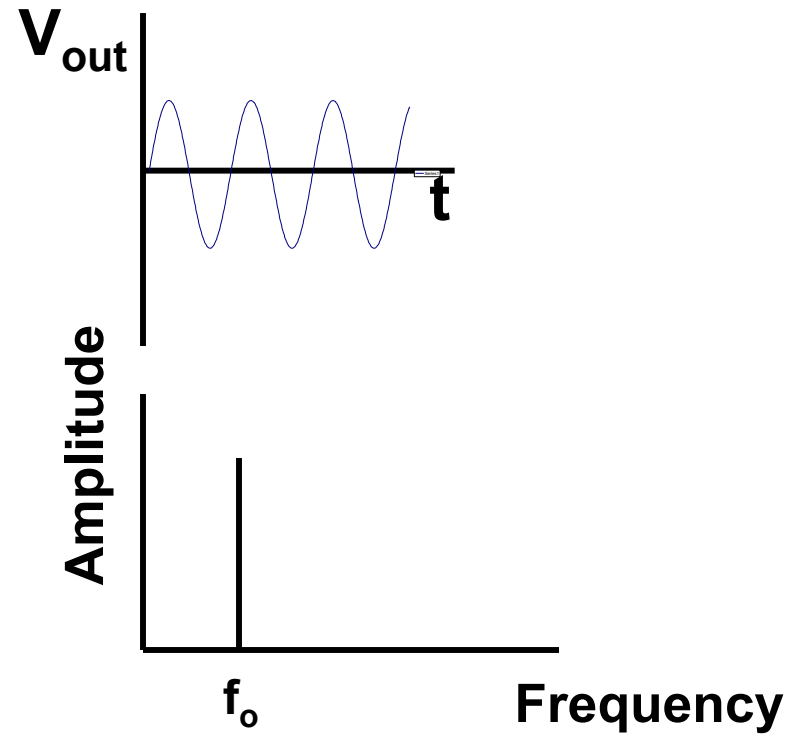
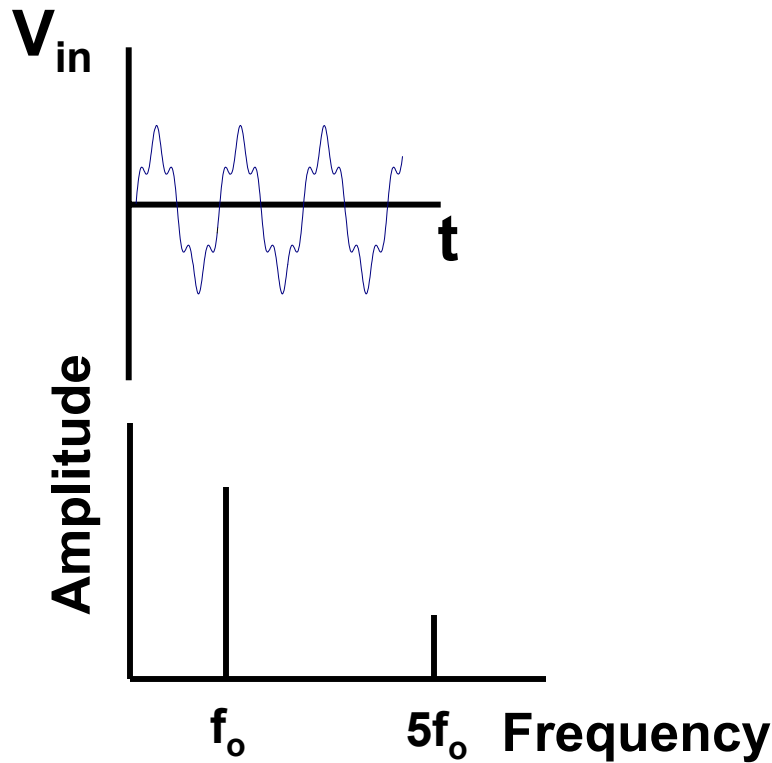


$$V_{out} = A_v(V_{in})$$

$A_v$  is the voltage gain

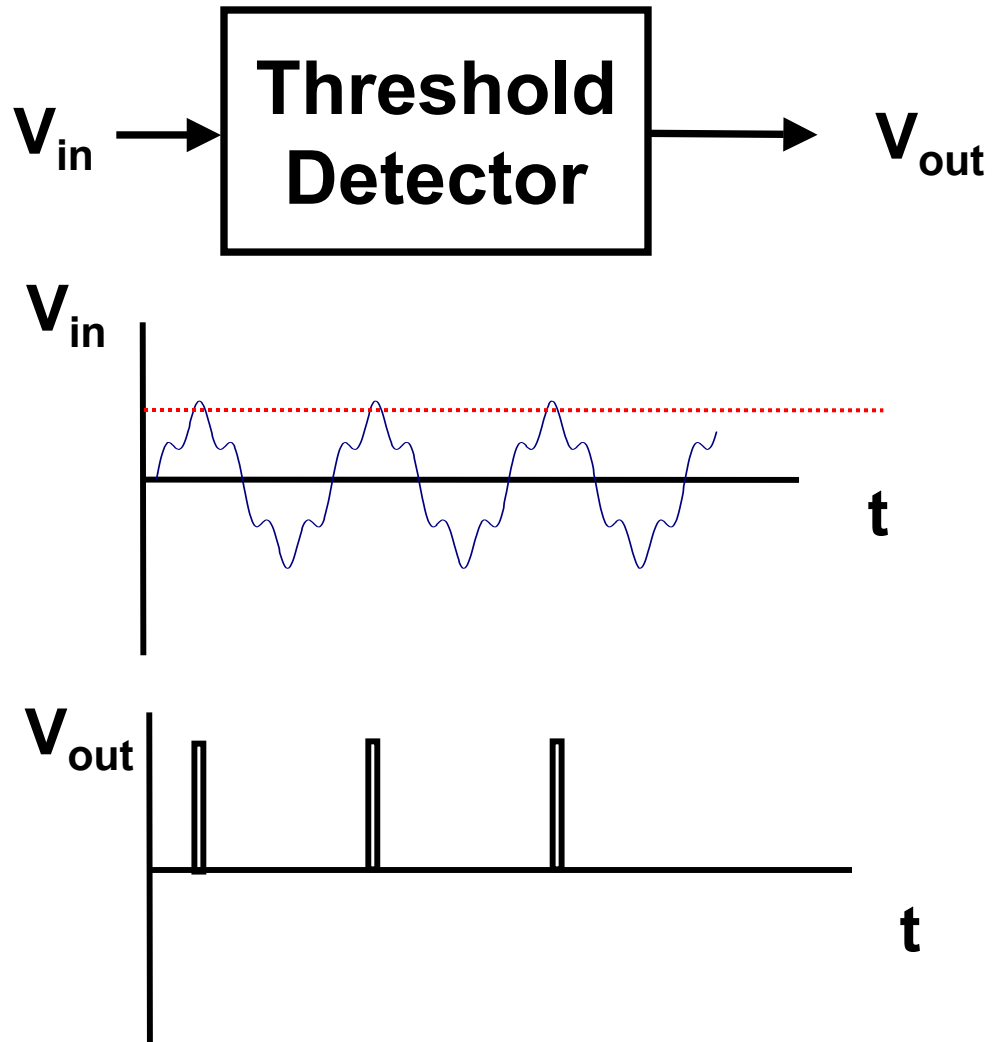
# Filtration (filtering)

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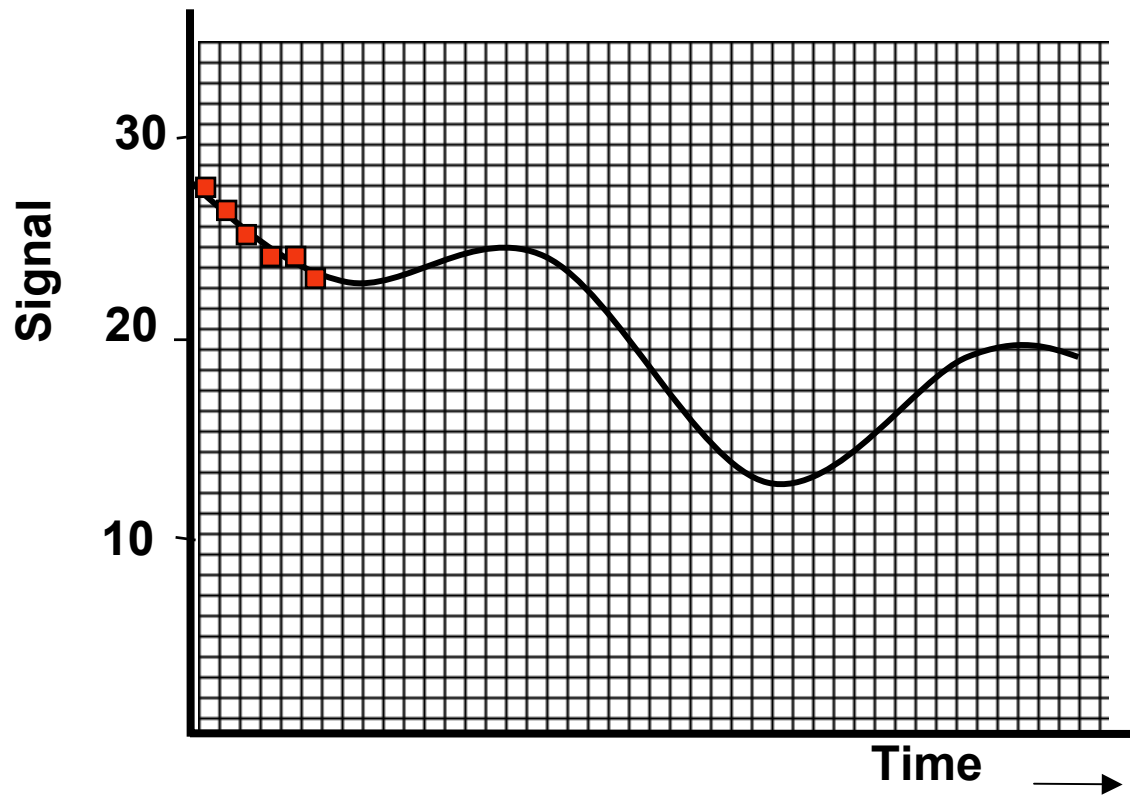
# Decision Making (Logic)

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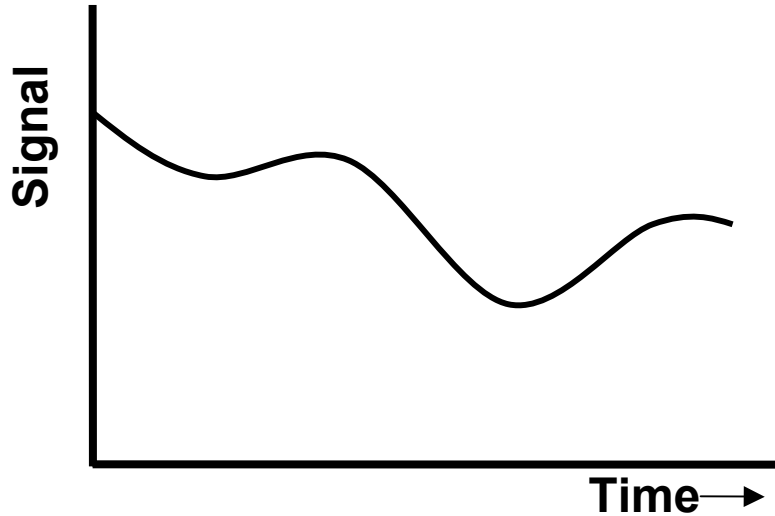
# Another two ways to represent a signal

---

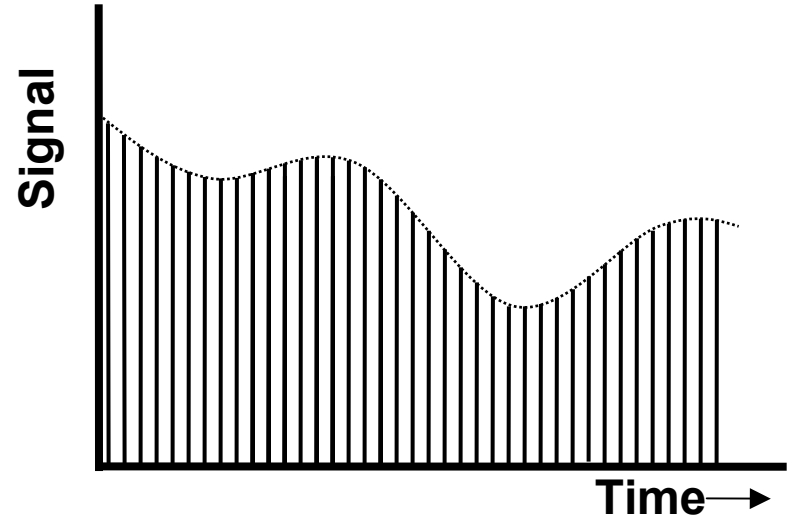


27  
26  
25  
24  
24  
23

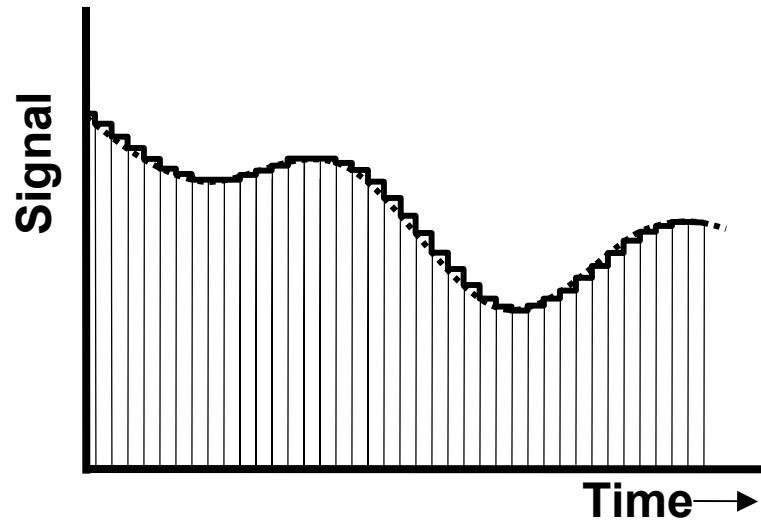
# Analog and Digital



Analog

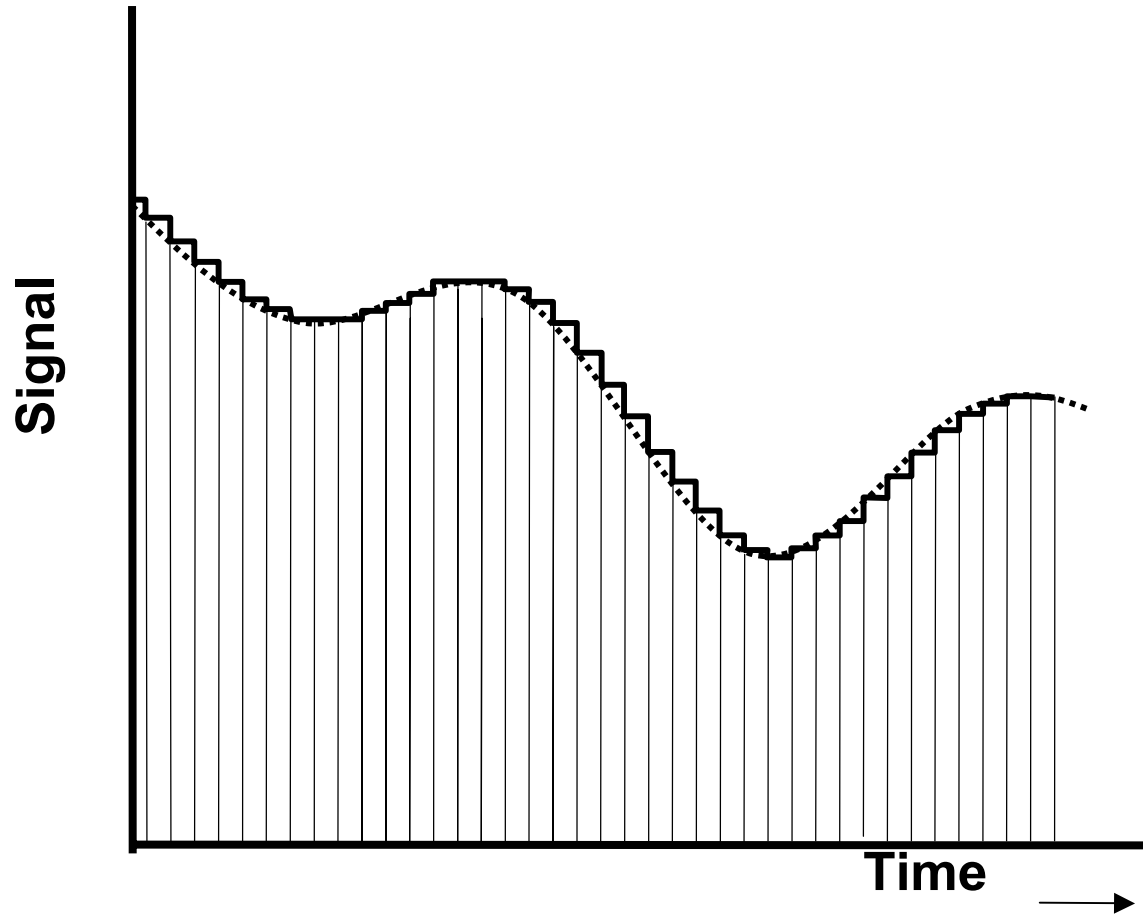


Digitized



Converted back to analog

# Digital to Analog Conversion



Converted back to analog



# Sampling Theorem

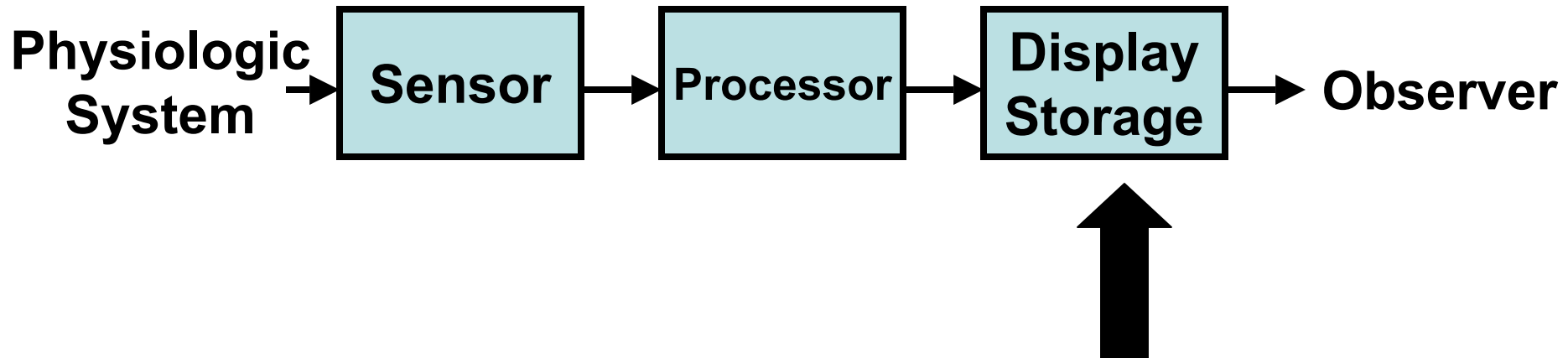
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**Must sample signal at least at two times the highest frequency component**



**Rule of thumb: sample at five times the highest frequency component**

# Basic Biomedical Instrument



# Display/Storage Devices

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## Display Devices

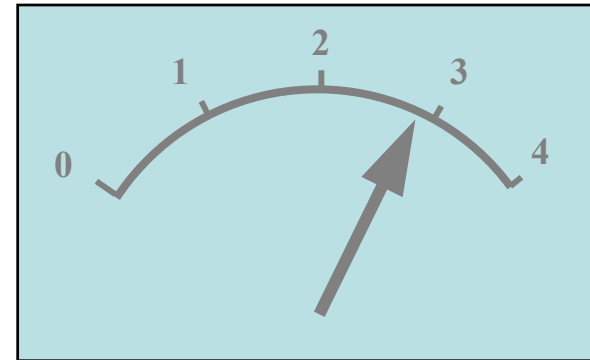
- **Flashing light or sound**
- **Analog meter**
- **Digital Meter**
- **Computer monitor**

## Storage Media

- **Paper chart**
- **Magnetic tape**
- **Electronic Memory**
- **Computer hard disk**
- **Other computer memory media**

**25.81 units**

**Digital Meter**

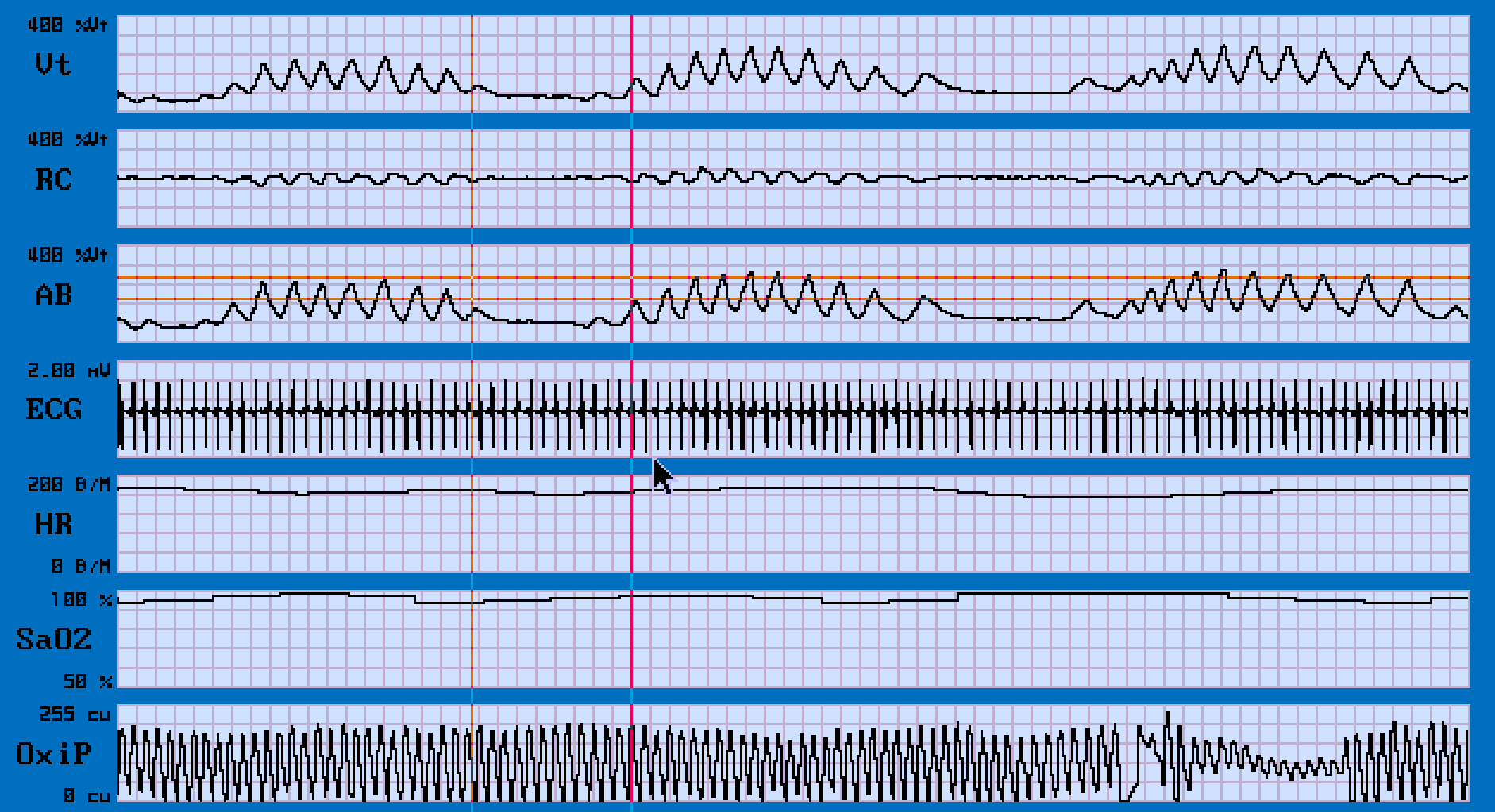


**Analog Meter**

**Are there situations where one type of meter would be better than the other?**

**Give some examples of these situations.**

Value	dV 87 %Ut	Scale	5.0mm/s	Time/Date	4.71sec	28-JUN-95	Edit						
Scale	Zoom	Gain	Base	Mtg	RT	Loop	Report	Info	Score	Cut	Print	Next	xOut1



No Active Markers

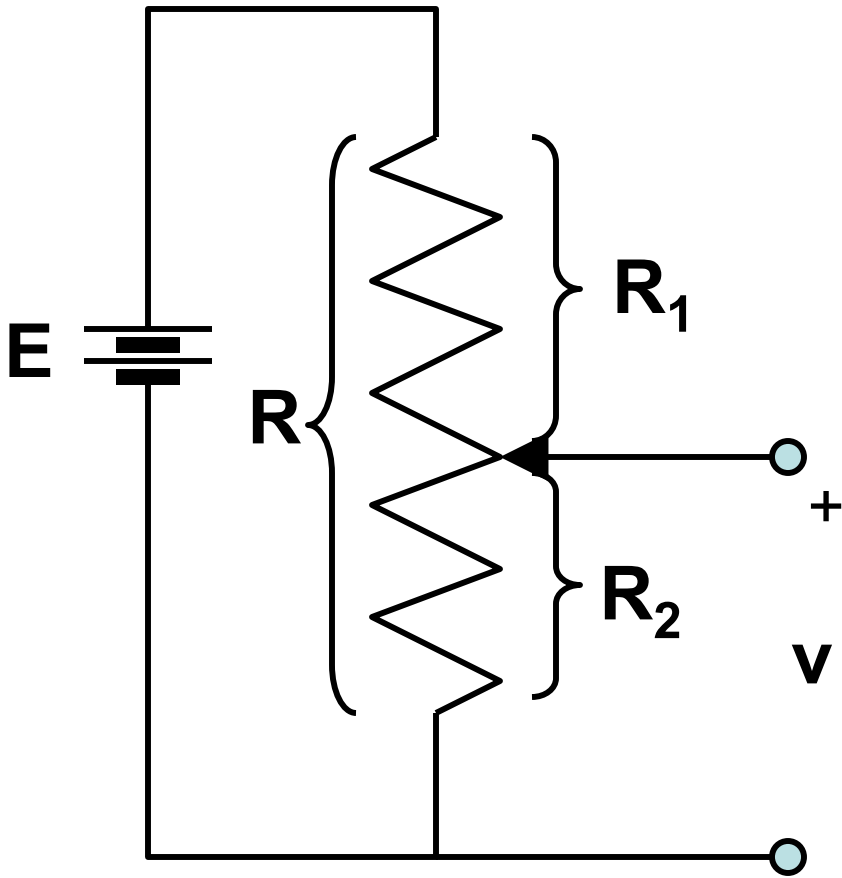
# Displacement Measurement

- **Linear displacement (distance between two points)**
- **Angular displacement**
- **Volume displacement**

- **Velocity**       $v = \frac{d}{dt}(\textit{displacement})$

- **Acceleration**       $a = \frac{d}{dt}(\textit{velocity}) = \frac{d^2}{dt^2}(\textit{displacement})$

# Variable Resistance



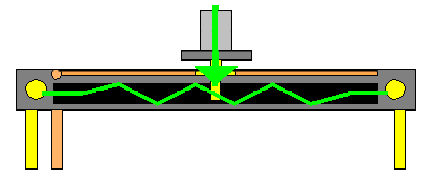
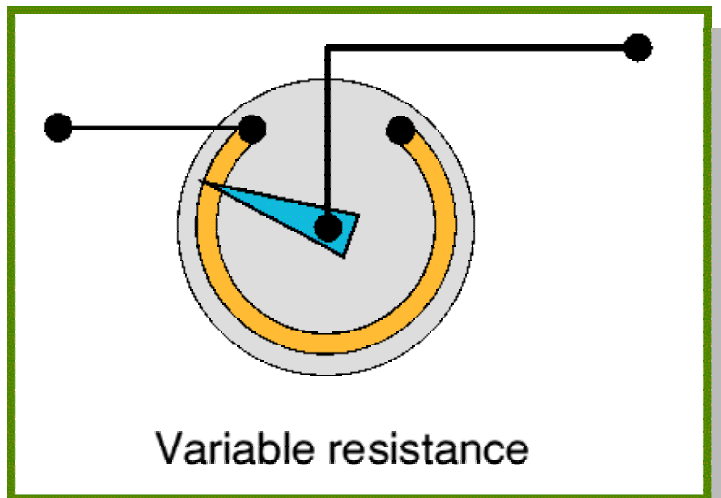
Linear or angular displacement =  $x$

$$R_2 \propto x$$

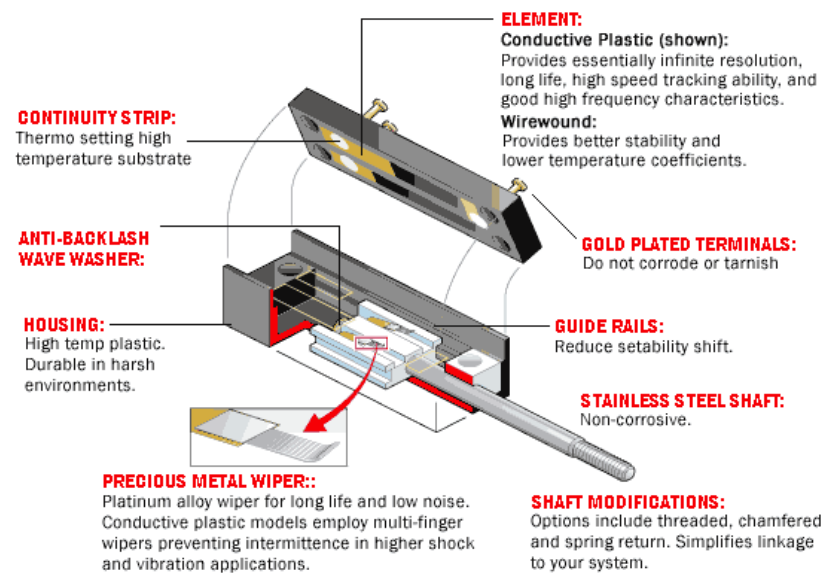
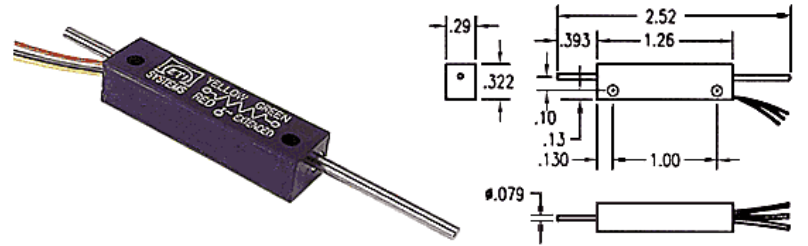
$$v = \frac{R_2}{R_1 + R_2} E = \frac{R_2}{R} E$$

$$\therefore v = \frac{E}{R} x$$

# Resistance Sensors



Overlay of schematic symbol on drawing of potentiometer





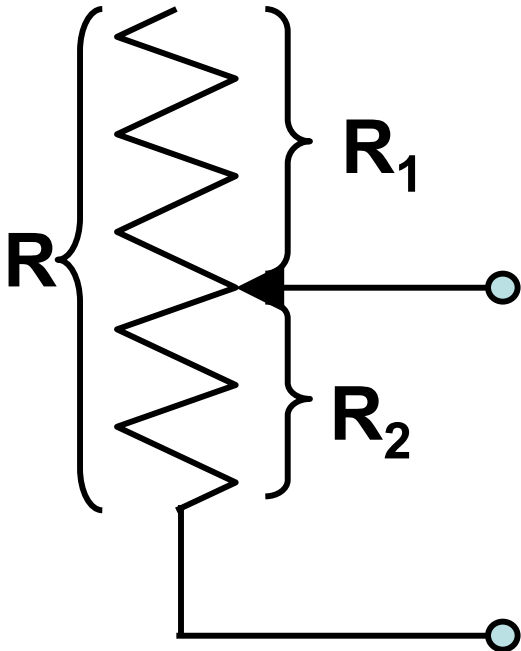
# Sample Problem



**Problem: Find resolution of variable resistance**

**$R_{\text{total}} = 1,000 \text{ Ohms}$**

**Number of turns = 100**



Resistance change between turns

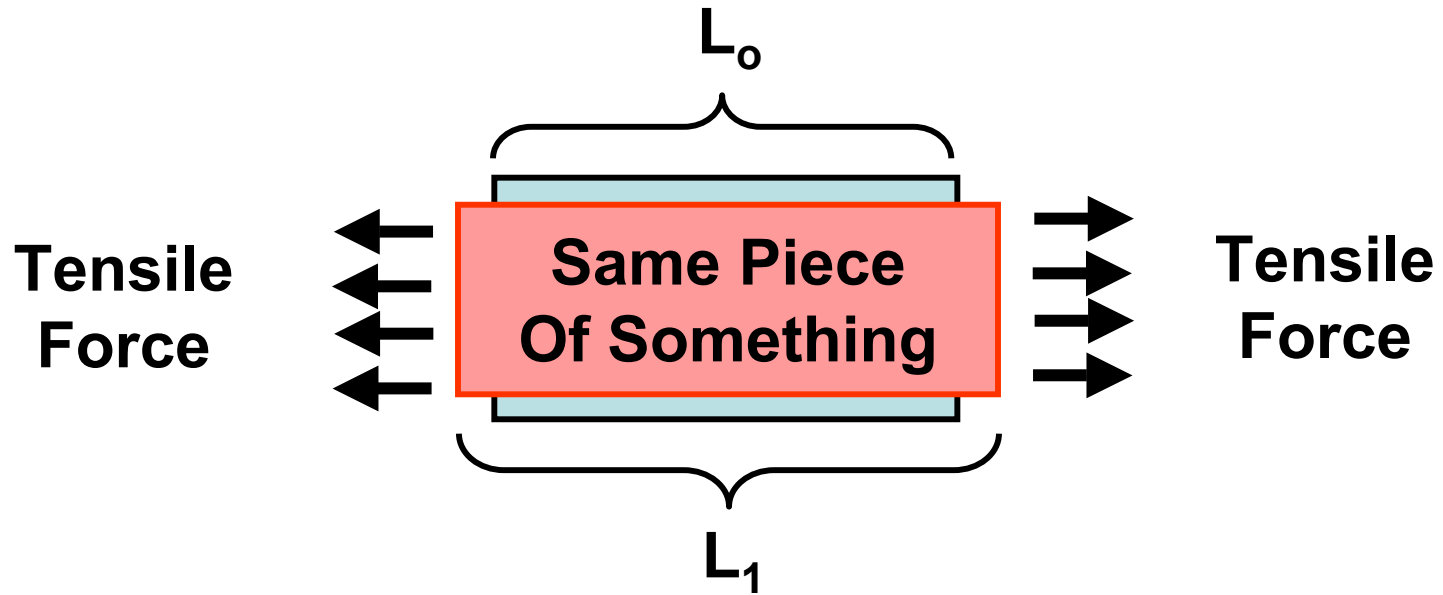
$1,000 \text{ } \Omega / 100 \text{ turns} = 10 \text{ } \Omega / \text{turn}$

Not possible to see resistance change of less than  $10 \text{ } \Omega$

# Resistance Strain Gauge

**Piece of  
Something**

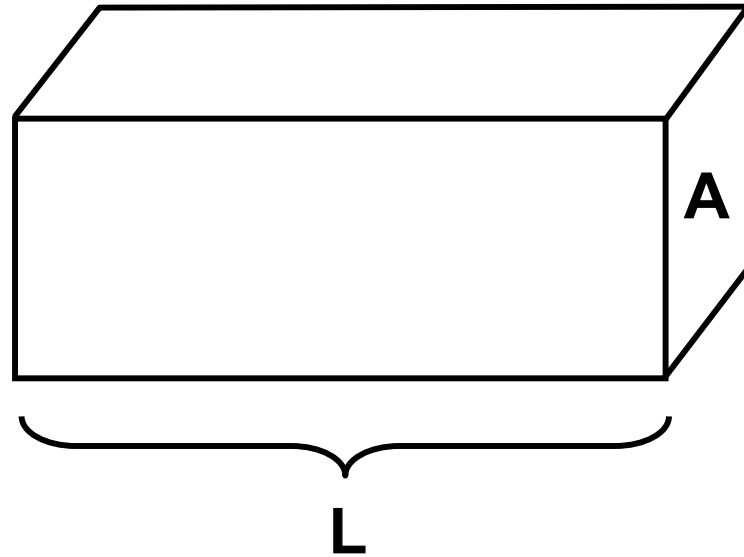
# Resistance Strain Gauge



$$\textit{Strain} = \Delta L = L_1 - L_0$$

$$\textit{Gauge Factor } \gamma = \frac{\Delta R / R}{\Delta L / L}$$

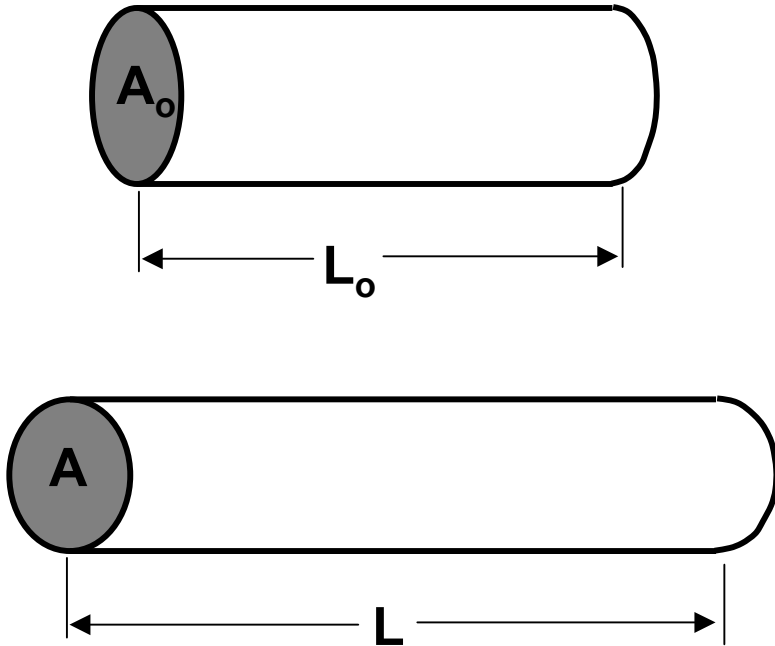
# Electrical Resistance of a Material



$$R = \rho \frac{L}{A}$$

*$\rho$  is a physical property (constant) for a material*

# Liquid Metal Strain Gauge



$$V = AL = A_0L_0 = \text{const.}$$

$$R = \rho \frac{L}{A} = \rho \frac{L^2}{AL} = \rho \frac{L^2}{V}$$

$$dR = 2\rho \frac{LdL}{V}$$

$$\frac{dR}{R} = \frac{2\rho \frac{LdL}{V}}{\rho \frac{L^2}{V}} = 2 \frac{dL}{L}$$

$$\gamma \equiv \frac{dR/R}{dL/L} = 2$$