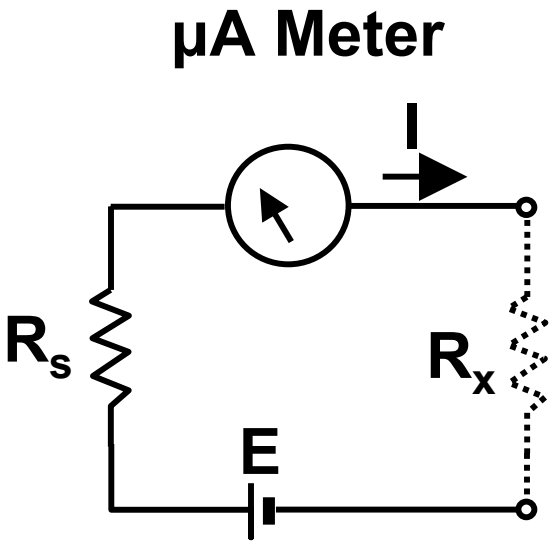
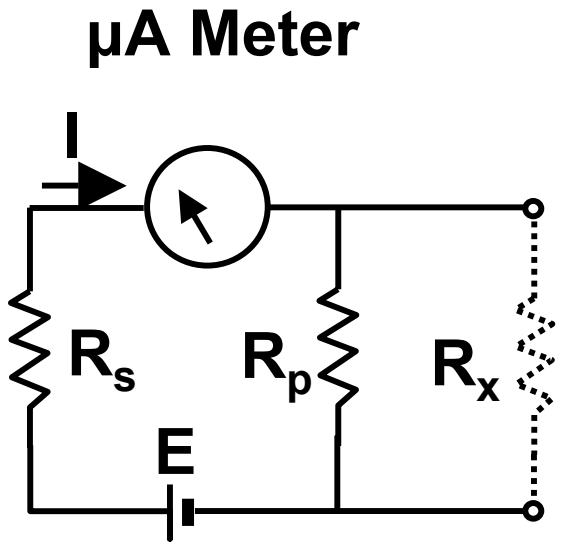
Ohmmeters



Series

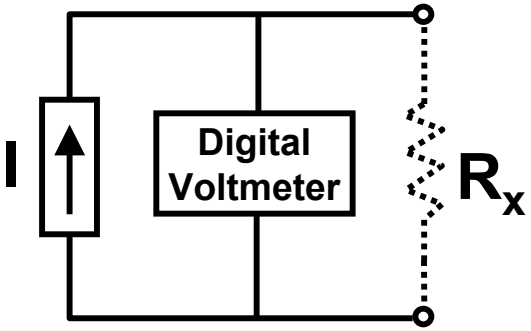
$$I = \frac{E}{R_s + R_p}$$



Shunt

$$I = \frac{E}{R_s + \frac{R_p R_x}{R_p + R_x}}$$

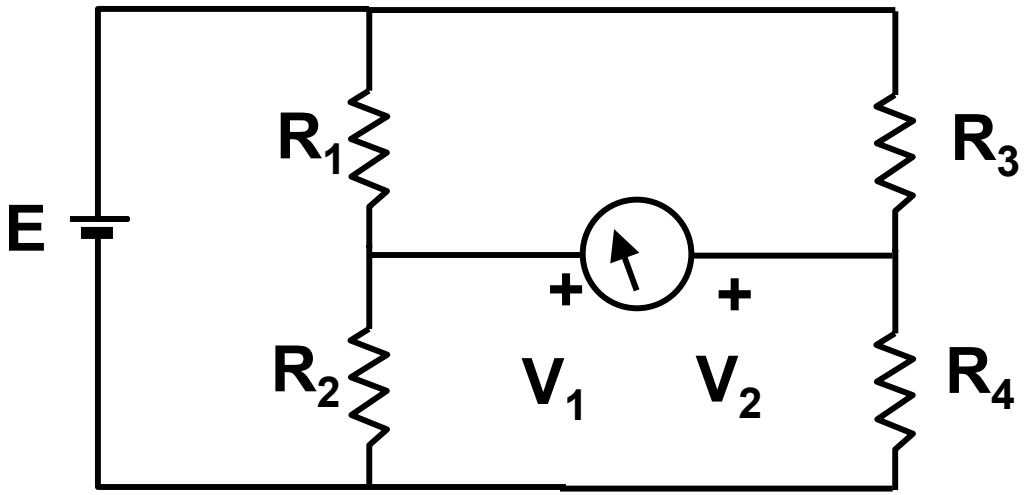
$$I = \frac{E(R_p + R_x)}{R_s(R_p + R_x) + R_p R_x}$$



Digital

$$V = IR_x$$

Wheatstone Bridge



$$V_1 = \frac{R_2}{R_1 + R_2} E$$

$$V_2 = \frac{R_4}{R_3 + R_4} E$$

For the meter to read zero

$$V_1 = V_2$$

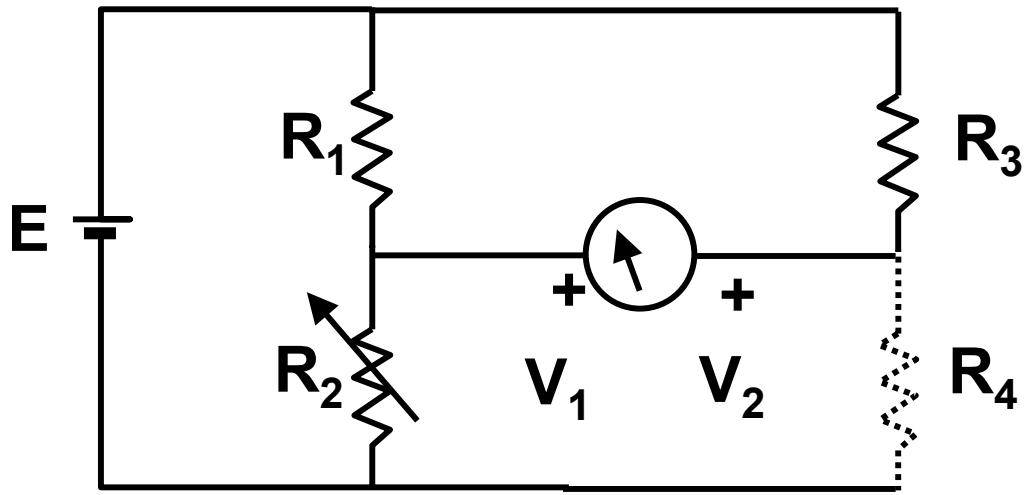
$$\frac{R_2}{R_1 + R_2} E = \frac{R_4}{R_3 + R_4} E$$

$$R_2(R_3 + R_4) = R_4(R_1 + R_2)$$

$$R_2 R_3 = R_1 R_4$$

$$\text{or} \quad \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

Wheatstone Bridge

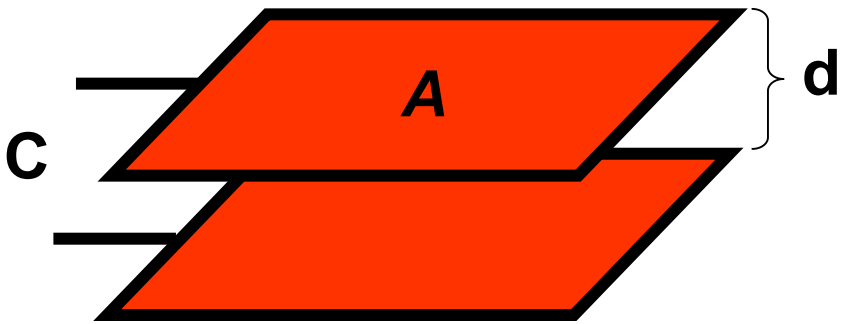


$$R_x = \frac{R_3}{R_1} R_2$$

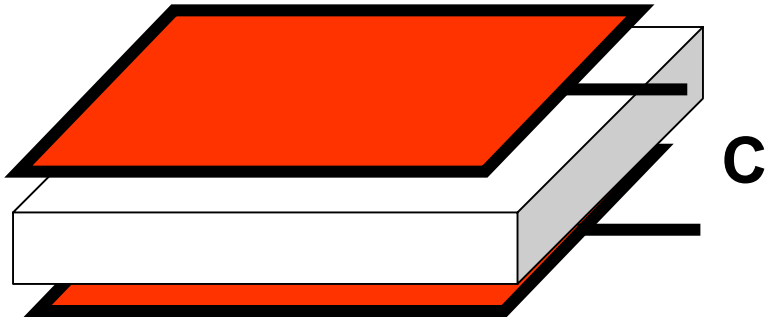
Fundamental Principles of Instrumentation

- **Minimum Disturbance to Physiological Systems**
- **Sensor must be at value of measured variable**
- **Null Measurements (Measurement by Comparison)**

Variable Capacitance Displacement Sensor



Air Dielectric

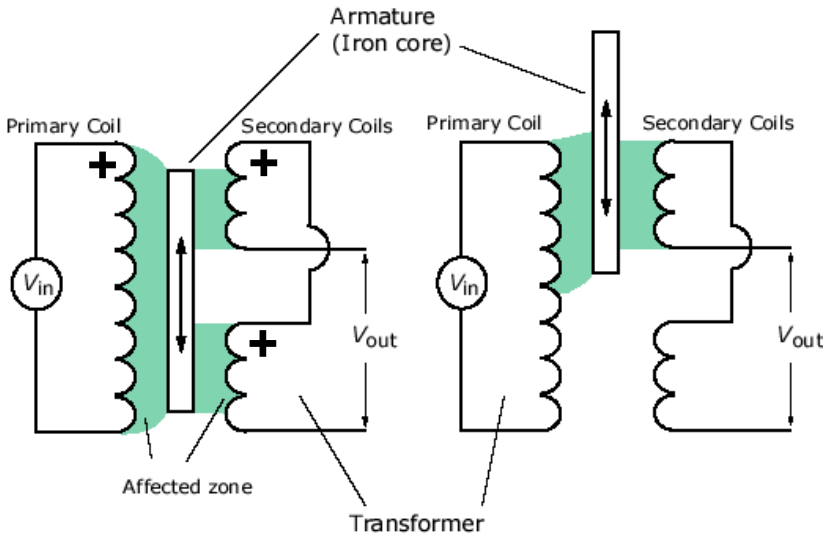


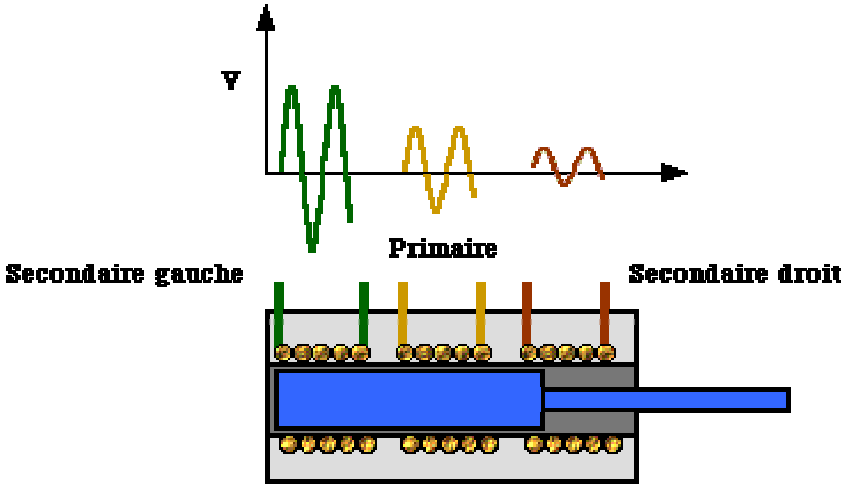
Solid Dielectric

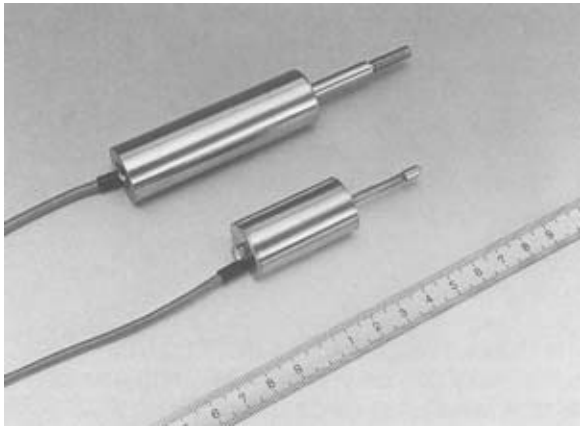
$$C = \varepsilon_0 \frac{A}{d}$$

$$C = k\varepsilon_0 \frac{A}{d}$$

Linear Variable Differential Transformer (LVDT)







Other Displacement Sensors

- Variable capacitance
- Linear variable differential transformer (LVDT)
- Variable inductance
- Mutual inductance
- Ultrasound transit time