**Ohmmeters**

**μA Meter**

\[ I = \frac{E}{R_s + R_p} \]

**Series**

\[ I = \frac{E}{R_s + \frac{R_p R_x}{R_p + R_x}} \]

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

**Shunt**

**Digital**

\[ V = IR_x \]
For the meter to read zero

\[ V_1 = V_2 \]

\[ \frac{R_2}{R_1 + R_2} E = \frac{R_4}{R_3 + R_4} E \]

\[ R_2 (R_3 + R_4) = R_4 (R_1 + R_2) \]

\[ R_2 R_3 = R_1 R_4 \]

or \[ \frac{R_1}{R_2} = \frac{R_3}{R_4} \]
Wheatstone Bridge

![Wheatstone Bridge Circuit Diagram]

\[ R_x = \frac{R_3}{R_1} R_2 \]
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

\[ C = \varepsilon_0 \frac{A}{d} \]

Solid Dielectric

\[ C = k\varepsilon_0 \frac{A}{d} \]
Linear Variable Differential Transformer (LVDT)
Other Displacement Sensors

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