What is it?

• Characterize the static performance of a sensor
  – Performance of sensor when input is constant or slowly varying.
  – Varying one input, usually in a stepwise fashion, over a range of values while holding other inputs constant.

• Output is observed in steady-state conditions.
  – Input is held constant long enough for output to stabilize.

• Objective 1: Define instrument accuracy

• Objective 2: Develop input-output, or transfer equation.

• Example: calibration of thermocouples in a water bath.

• Dynamic Performance: The performance of a sensor when the input is rapidly varying.
Definitions

• Static Sensitivity: slope of the transfer curve
  – $S_s \equiv \frac{d(\text{raw output})}{d(\text{input})}$
    • Straight line: $S_s = \text{constant}$, linear sensor
    • Otherwise: non-linear sensor

• Range: Measured interval over which a sensor is designed to respond.

• What would you want out of an ideal instrument in terms of $S_s$ and range?
  – Large, constant static sensitivity over the whole range

• A sensor with $S_s = 0$ is a useless sensor.
  – Using a brick for a pressure sensor, for example.
Definitions cont.

• Resolution: Smallest change in the input that produces a detectable change in the output.
  – Higher the sensitivity, the higher the resolution.
  – Resolution is not a function of sensitivity only.
    • Friction and noise can also reduce resolution.

• Hysteresis: Present when the sensor output for a given input depends upon whether the input was increasing or decreasing.

• Stability: An instrument is said to be stable and free from drift if repeated calculations over some period of time produce the same transfer curve.
  – Period can vary from days to years.
Hysteresis Graph
Calibration Procedure

Objective: Develop a transfer equation that can be used to convert the observed output $Y_i$ to an estimate of the known input $X_i$.

1. Development of transfer plot.
   - Accurate measurement of $X_i$, the primary input, and $Y_i$, the primary output, at $N$ points over the design range of the sensor.

2. Development of a transfer equation.
   - Fit a straight line, or curve if necessary, to the data, using the least-squares procedure.
   - Objective: equation that can be used to convert output $Y_i$ to an ESTIMATE of the observed input, $X_i$.

   - Objective: equation that allows us to determine the observed quantity from the sensor output.
Calibration Equation

• Final result of the calibration procedure.

• Converts sensor readings into the measurable quantity we are interested in.
Bias and Imprecision

• Both can be used to measure the quality of our calibration.

• Bias
  – Systematic error that can be corrected by calibration.

• Imprecision: By convention, typically one or two $\sigma$.
  – Uncertainty in a single measurement.

• After calibration:
  – Bias should be zero.
  – Drift could change this.

• Inaccuracy $\equiv$ Bias $\pm$ imprecision