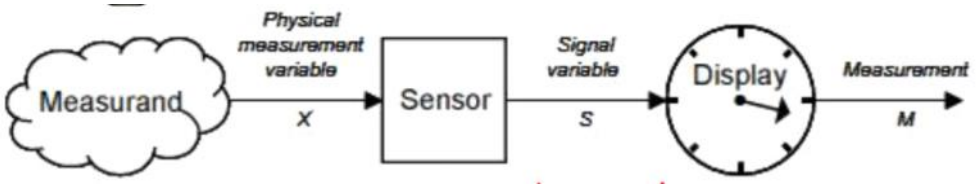
Lecture 1 - Sensors and Systems: Measurement

Monday, October 29, 2018 11:57 AM

Website: bme2210-wpi.github.io/course

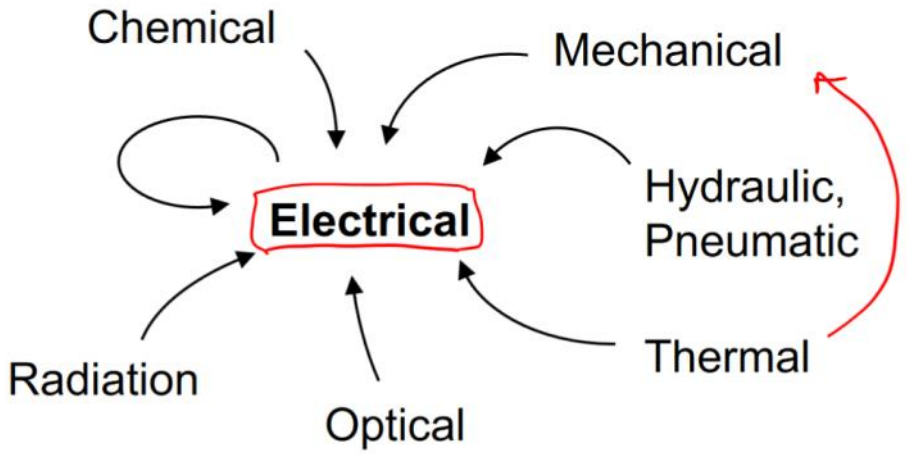
Measurand

- Physical Quantity, property or condition that the system measures
- Accessibility: can either be internal, external, or a combination
- Category (among others):
  - Biopotential
  - Pressure
  - Flow
  - Dimensions
  - Temperature
- Localized: specific organ or systemic

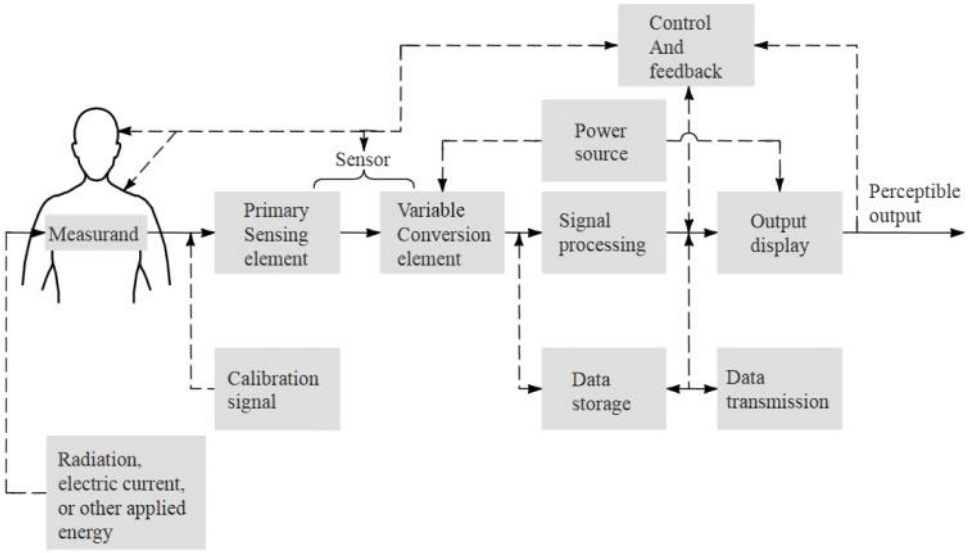


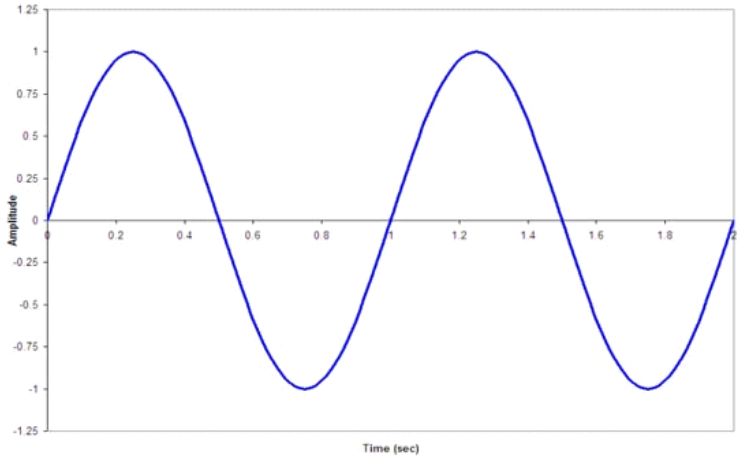
What is a sensor?

What is a transducer?



a sensor often has a transducer,
but a transducer may not be a sensor!



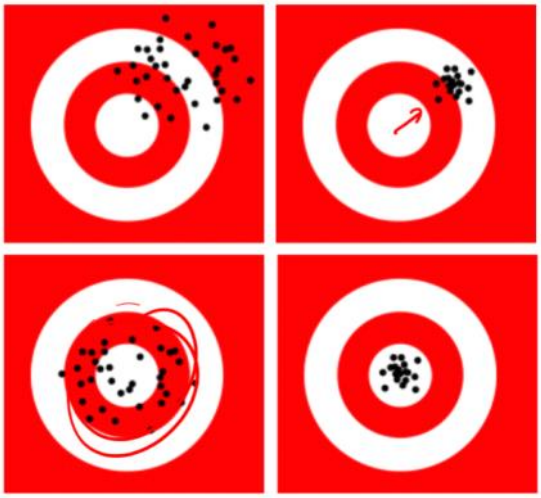


How would we measure the following:

- Heart Activity
- Blood Pressure
- Brain Activity
- Brain Activity
- Blood Glucose
- Heart Rate

Accuracy v. Precision v. Resolution:

- Accuracy:
  - How close your values are to the true value
- Precision:
  - How close your repeated points are to each other (when measured reliably)
- Resolution:
  - The smallest quantity change that your measurement system can differentiate



$$\text{Relative Accuracy}\,(\%) = \frac{\text{Measured value} - \text{True value}}{\text{True value}} \times 100$$

$48

$245

Temperature

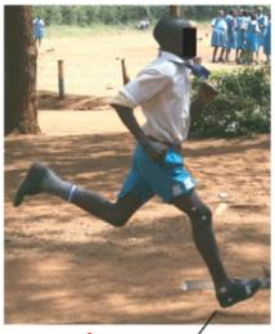
Resolution	0.1°C	0.01°C
Accuracy	±1°C	±1°C
Range	0.0 to 50.0°C	0.00 to 50.00°C

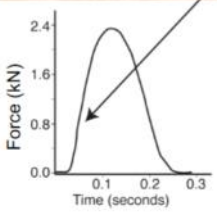
Relative Humidity

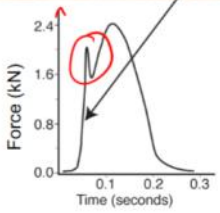
Resolution	1% RH	0.01% RH
Accuracy	±5% RH midrange, otherwise 8%	±3% RH
Range	20 to 90% RH	10.00 to 95.00% RH

Running barefoot

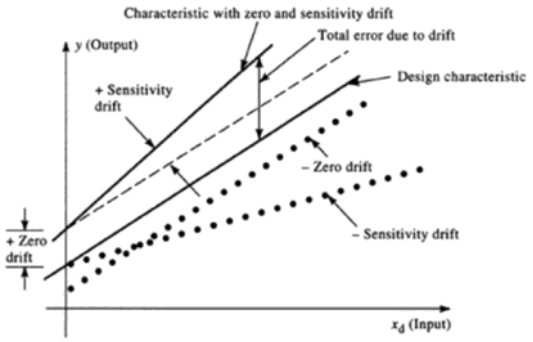
Running with shoes

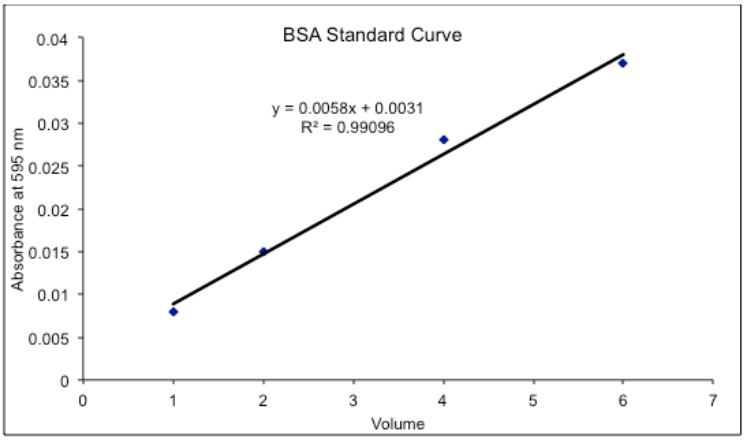


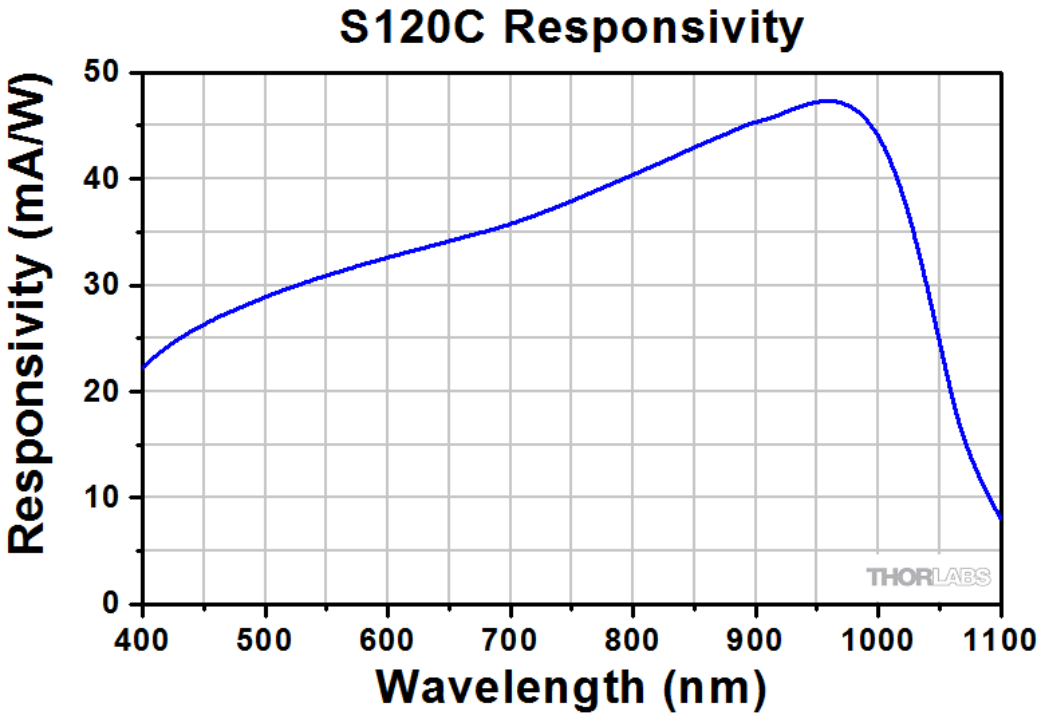




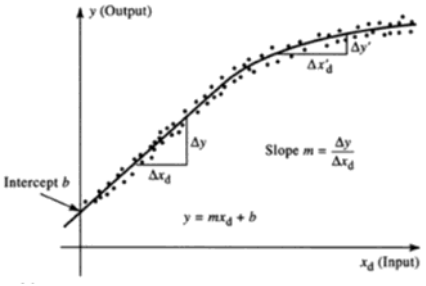
Calibration



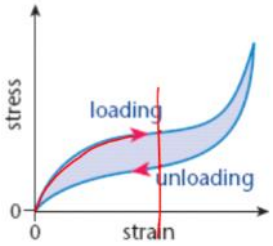




Sensitivity



Hysteresis

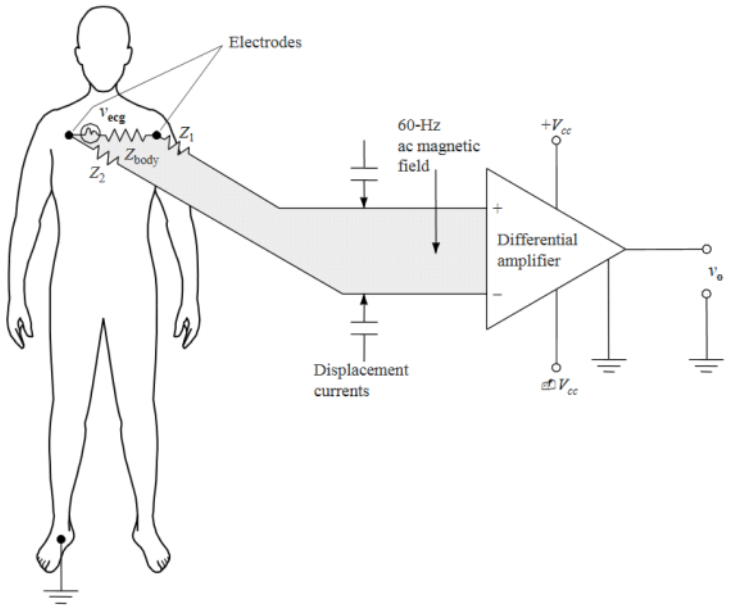


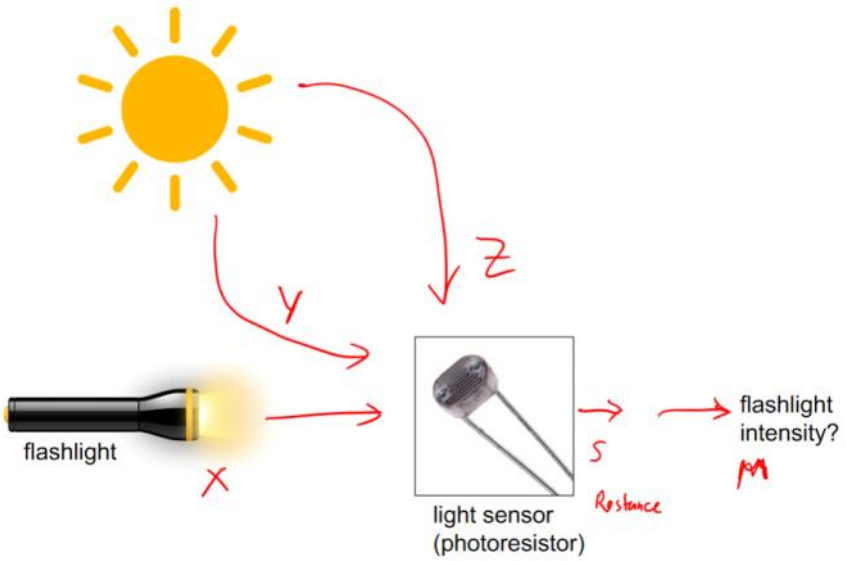
What is a modifying input?

- At sensor/on top of or within in measurand

What is an interfering input?

- Affects performance of sensor





How do systemic and random errors compare?

Statistics

Excel MATLAB

Assume symmetric (normally) distributed data

Mean
(*central tendency*)

$$\bar{X} = \frac{\sum X_i}{n} \quad (1.4)$$

AVERAGE(X)
= mean(X)

Standard Deviation
(*spread about the mean*)

$$s = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n-1}} \quad (1.6)$$

STDEV(X)
= std(X)

Standard Error of the Mean
(*standard deviation of sample means over the entire population*)

$$s_{\bar{X}} = s / \sqrt{n-1}$$

STDEV(X)/SQRT(n-1)
= std(X) / sqrt(n-1)

References

[1] Albrecht, D. (2018). "BME 2210 Lecture 2: Sensors and Systems" [Lecture for WPI BME 2210].
[2] Albrecht, D. (2018). "BME 2210 Lecture 3: Instrumentation Systems" [Lecture for WPI BME 2210].

[3] Wikimedia Commons: BSA Standard Curve
[4] Woo, E. (n.d.). "BME 302: Biomedical Instrumentation". [Lecture Notes]. Retrieved from: https://www.ejwoo.com/biomedical-instrumentation.html
[5] Wikimedia Commons: 10 Downing St. (credit: David Sharp)