Welcome

TO

NIU's

College of Engineering

and Eng. Technology

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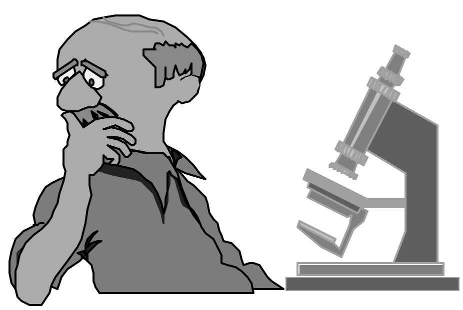
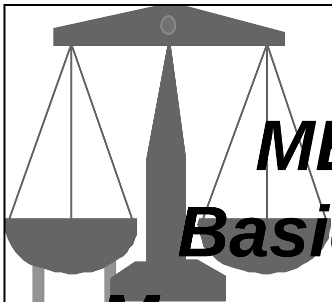
Experimentation and computation

Are often, unfortunately

- Two separate worlds





MEE 390&490 Basic Concepts of Measurement Methods

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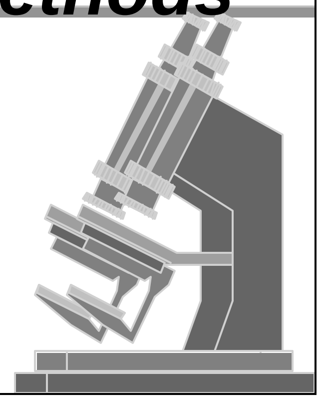
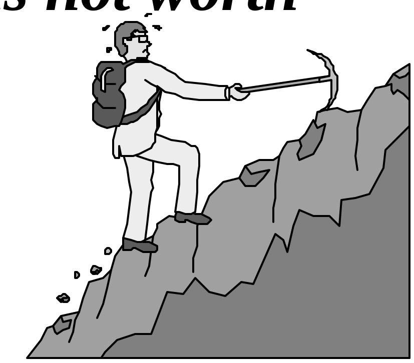
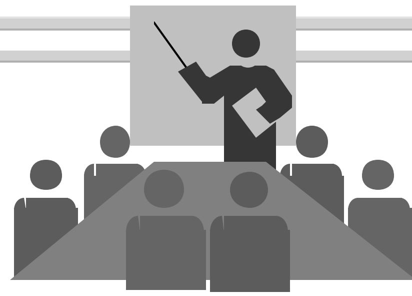


"If a road is without obstacles, it is not worth pursuing!"





Be Aware of Complexity but Make It Simple !

Measurements Are Very Common/important

- Process information
- Quality assurance
- Process control

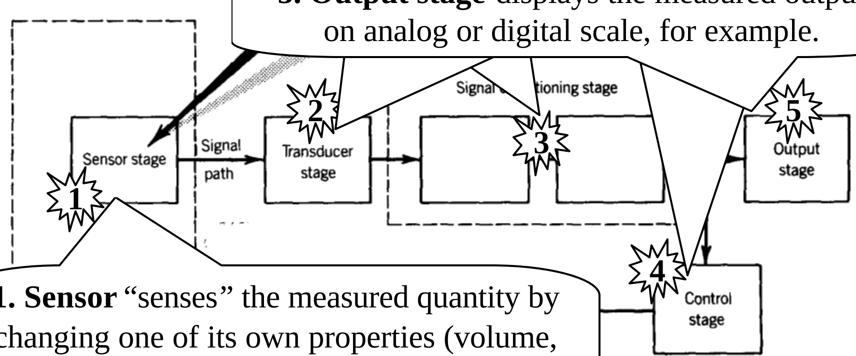
Components of a General Measurements System

3. Conditioning …
variable to fur…
amplifica…

4. Control stage (if available) uses the output signal to modify/control the process according to

2. Transducer stage changes the sensor's

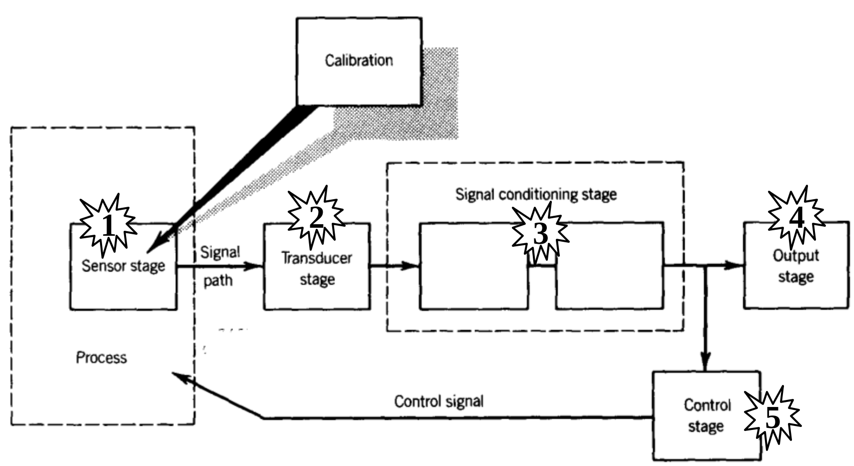
5. Output stage displays the measured output on analog or digital scale, for example.



1. Sensor "senses" the measured quantity by changing one of its own properties (volume, resistance, etc.) which is related to the measured quantity.

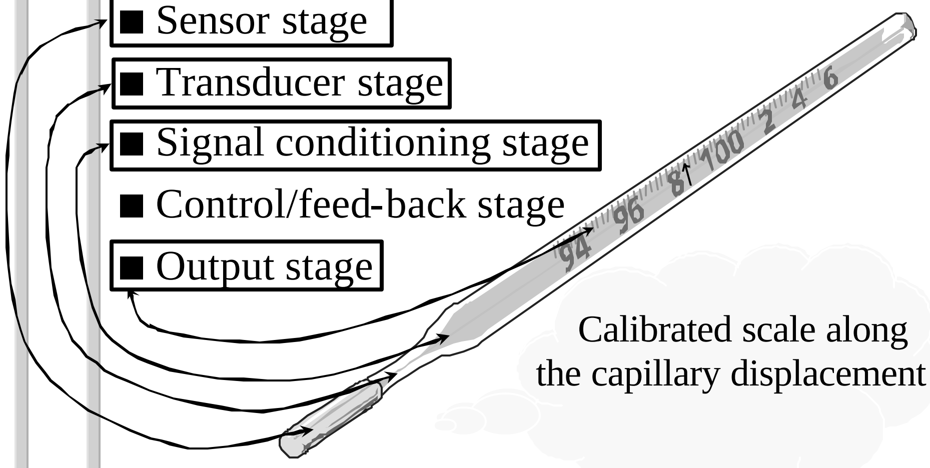
Components of a General Measurements System

FIGURE 1.1 Components of a general measurement system.



General Measurement System: Example

- Sensor stage
- Transducer stage
- Signal conditioning stage
- Control/feed-back stage
- Output stage



Experimental Test Plan

- Identify pertinent process variables/parameters
- Well-thought-out meas. Pattern for performing the tests
- Selection of meas. Technique/method
- Selection of instrumentation
- Data analysis plan

Data Analysis Plan

- Independent and dependent variables
- Controlled variables (held as per wish)
- Extraneous variables (noise & interference)

Random Test

- Replication
  – Avoid interference
- Repetition
  – Show trend in sequence

Concomitant Methods

- Quite independent ways of performing exps
- Example:
  - Measure volume through dimensions
  - Measure volume through specific weight

Calibration

Measuring a known input (standard) to check the instrument output (reading)

- Static calibration (constant signal)
  - Static sensitivity and range
- Dynamic calibration (harmonic or step-change dynamic signal)
  - Time constant
  - Amplitude ratio
  - Phase shift

Accuracy

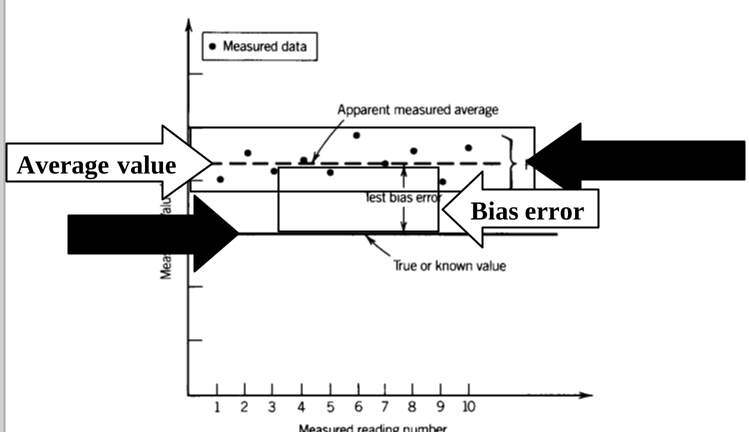
- Absolute error

  e=true value - indicates value
- Relative accuracy

  a=[1-(|e|/true_value)]100%
- Precision and bias errors
  - Precision errors: random variation
  - Bias errors: inherited deviation tendency

Bias and Precision Errors/Uncertainties

FIGURE 1.9 Effects of precision and bias errors on calibration readings.



Sequence Calibration

- Sequential variation of input to determine hysteresis

$E_h = y_{upscale} - y_{downscale}$

$(\%E_h)_{max} = e_{h,max}/r_o$, where r_o = full range

Random Calibration (1 of 2)

Each input is independent from previous one

- Minimizes impact of interference
- Break up hysteresis and observation effects
- Determines several important instrument performance characteristics - see next

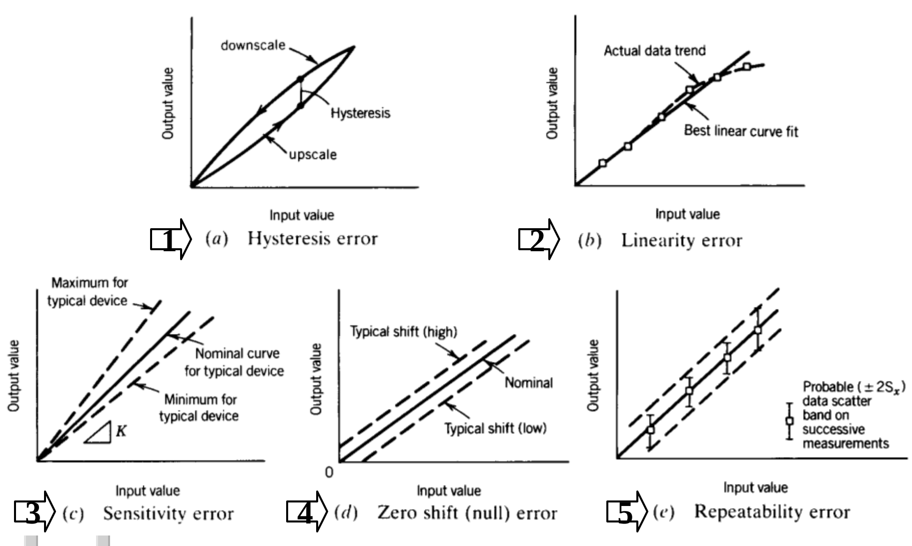
Random Calibration (2 of 2)

Determines several important instrument performance characteristics

- Linearity error
- Sensitivity and zero error
- Instrument repeatability
- Reproducibility
- Instrument precision

Different Instrument Errors

FIGURE 1.10 Examples of elements of instrument error.
(a) Hysteresis error. (b) Linearity error. (c) Sensitivity error.
(d) Zero shift (null) error. (e) Repeatability error.



Over-all Instrument Error

- $E_i = [e_1^2 + e_2^2 + e_3^2 + \ldots + e_m^2]^{1/2}$

  For M known errors

- $E_i = [e_h^2 + e_l^2 + e_k^2 + e_r^2]^{1/2}$

  For hysteresis, linearity, sensitivity, and repeatability errors

Standards

…Are known values and bases for calibration

- Dimension defines a physical variable
- Unit defines a measure of a dimension
- Primary standard defines the unique value of a unit (e.G.: M, kg, s, K, etc.)

Standard Important Features

- Continued reliability
- Global reproducibility/availability
- Stability

Dimensions and Units

- Length [m]
- Mass [kg]
- Time [s]
- Temperature [K]
- Electrical current [A]
- Substance amount [kmol]
- Luminous intensity [cd]

Derived Demensios/Units

- Force
- Velocity
- Energy/work
- Etc

Hierarchy of Standards

- Primary standards (SI, SI-Units, Int. Thermo scale)
- Secondary/national standards (NIST, ANSI)
- Inter-laboratory/transfer standards (platinum resistance thermometer)
- Local standards (platinum resistance thermometer)
- Working standards (glass bulb thermometer)

Test Standards

- ASME (power test code 19.5)
- ASTM (test standard F558-88 for vacuum cleaners effectiveness)
- And many others

Measurement Overview - Experimental Design Summary:

- Objective of experimental design
- Plan of experimental design
- Methodology assessment
- Uncertainty analysis
- Cost analysis
- Calibration
- Data acquisition
- Data reduction

…We are as powerful as the tools we use

… Our eng grad will be more competitive if trained to wisely use new tech tools

Thank You

For Staying Till The End !