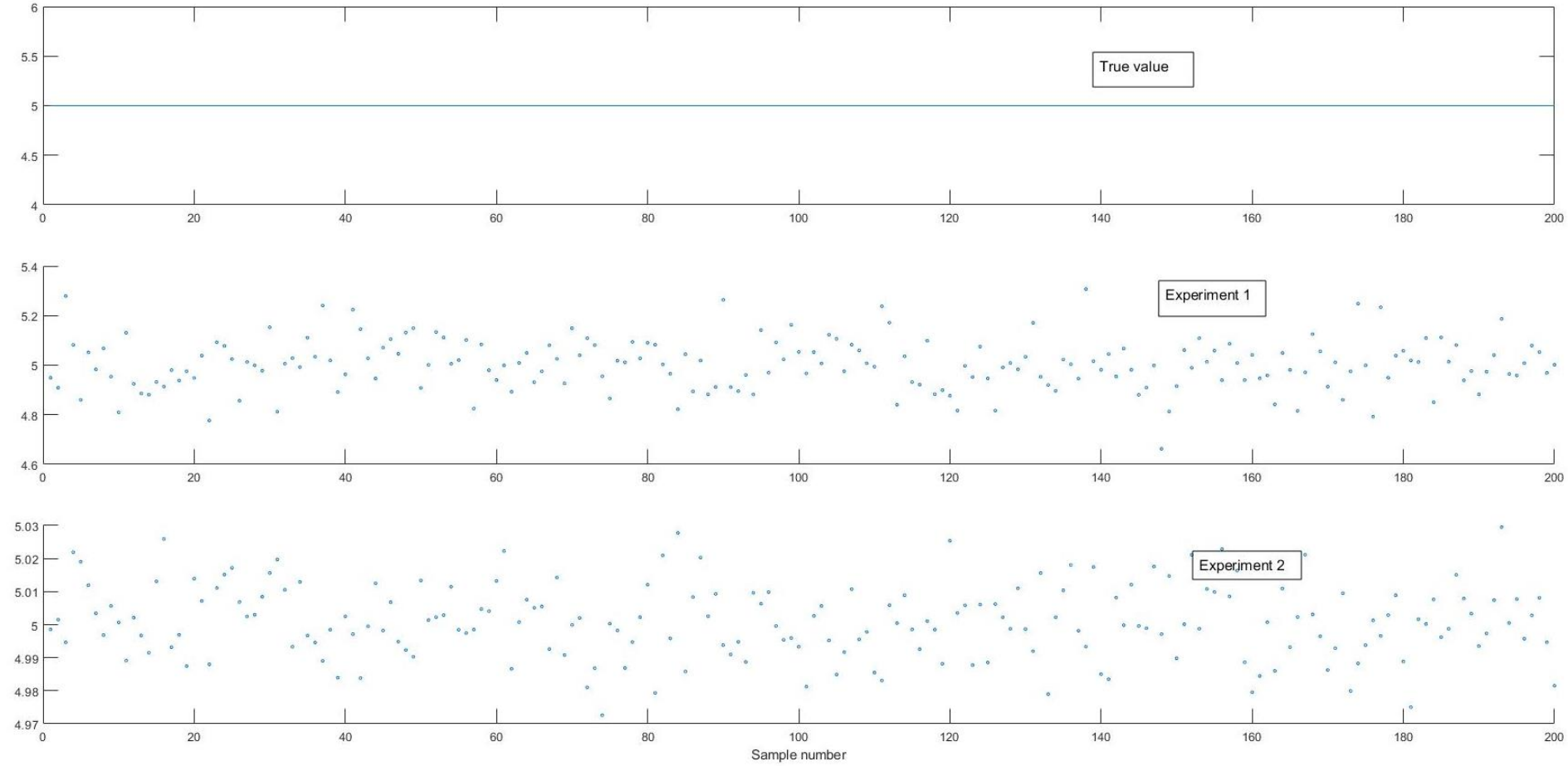
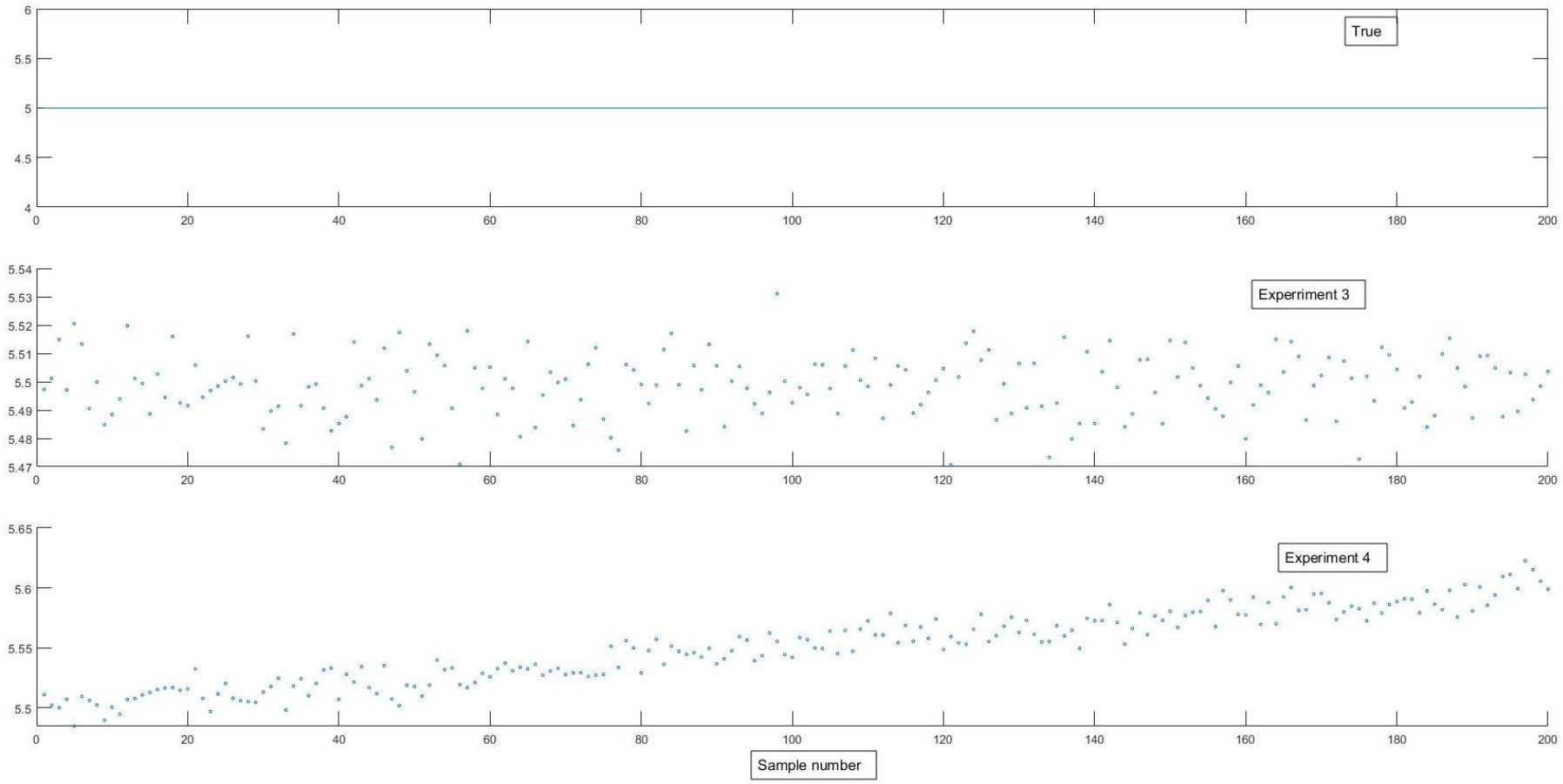
AE 242
Aerospace Measurements Laboratory



Two thermometers are used for measuring temperature. 200 samples are recorded when temperature input is 5 units. From the above two observations, what can be deduced about thermometers?



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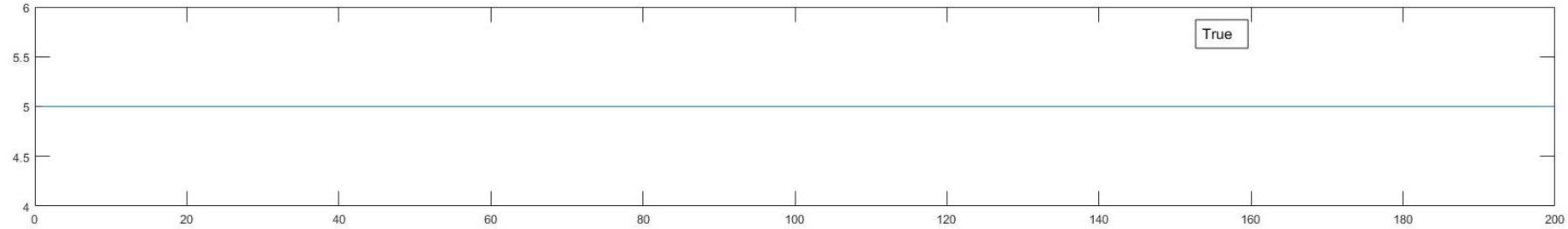
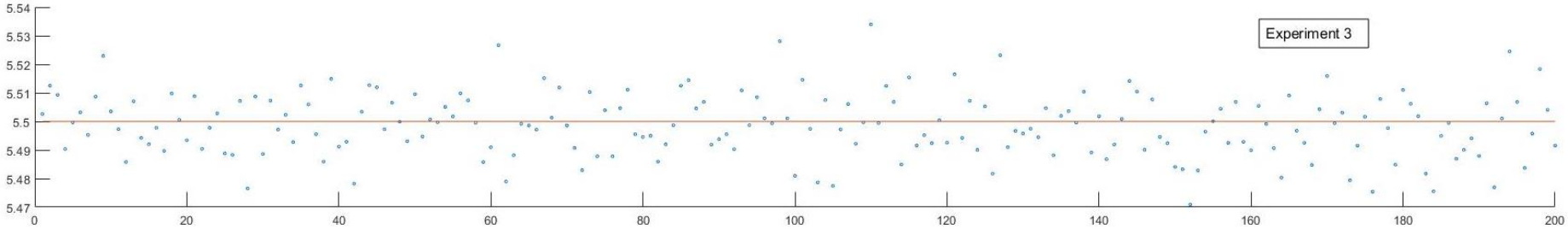
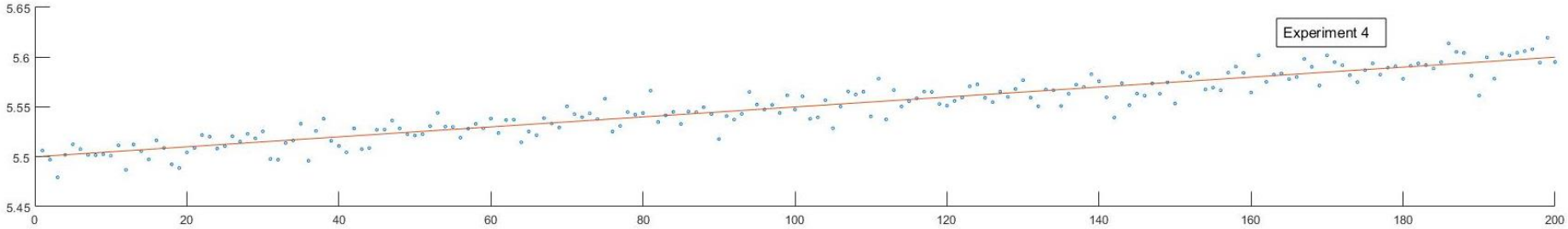
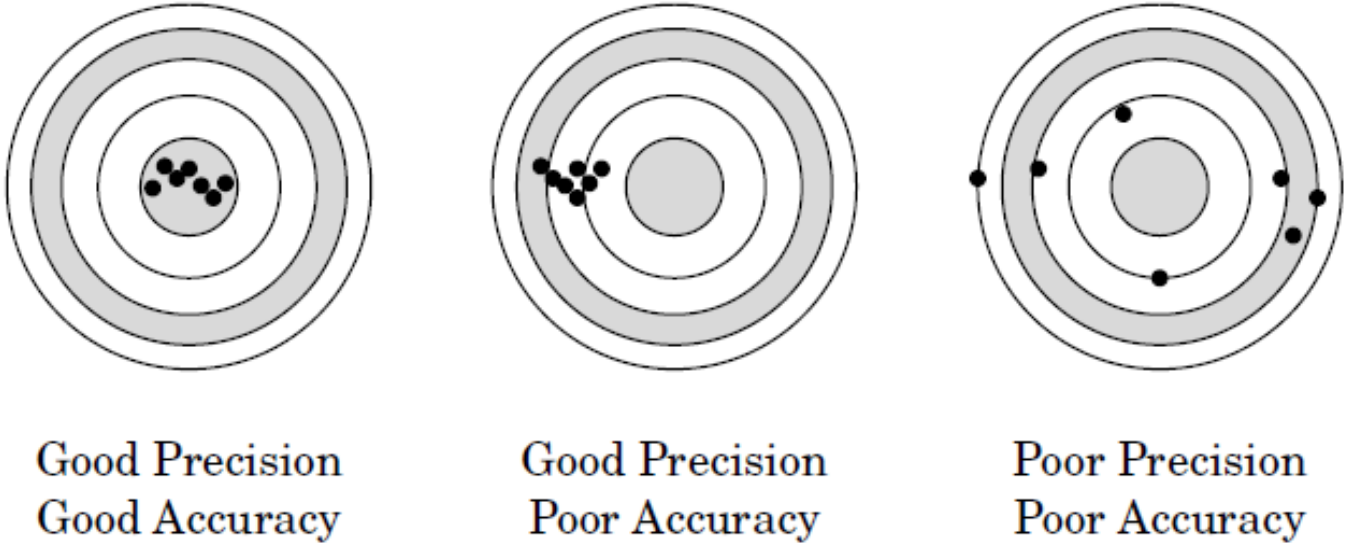






Bias and drift can be estimated by suitable curve fitting (static case).

Accuracy and Precision?



Good Precision
Good Accuracy

Good Precision
Poor Accuracy

Poor Precision
Poor Accuracy

Accuracy: How close observations are with truth.

Precision: How close observations are with respect to each other under same conditions.

Absolute accuracy: When results are compared with truth.

Relative accuracy: When results are compared with observed data.

What is standard?

Standard forms the basis for consistency. Various measurements can be compared easily using standard. Standard unit of length, weight & time.

International standard: Units of measurement of physical quantities to the highest possible accuracy. Not used for day to day use. Not freely available. Not referenced to other standard.

The meter is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second.

1 sec is defined as 9,192,631,770 cycles of the atomic resonant frequency of cesium-133.

Bureau International des Poits et Mesures standard http://www.bipm.org/en/about-us/
National Physical Laboratory http://nplindia.org/

What is standard?

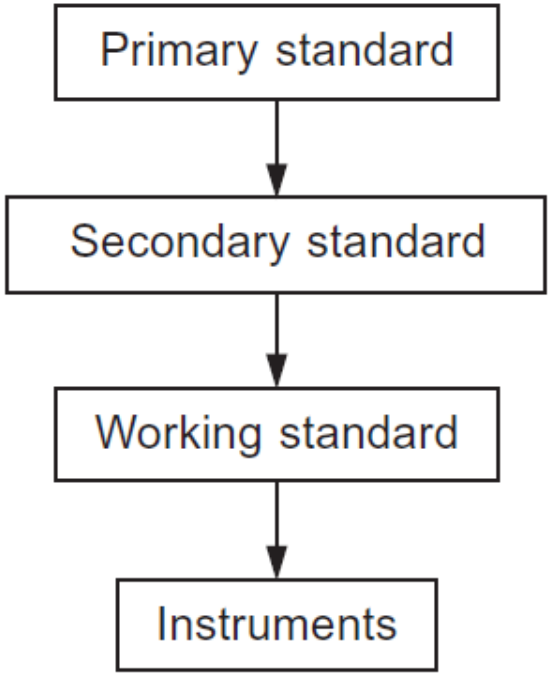
Primary standard: These standards are kept at national laboratories. These are calibrated against international standard. Not used frequently. Not freely available.

Secondary standard: These maintained by industrial measurement laboratory for their own calibration of working standard. These are freely available.

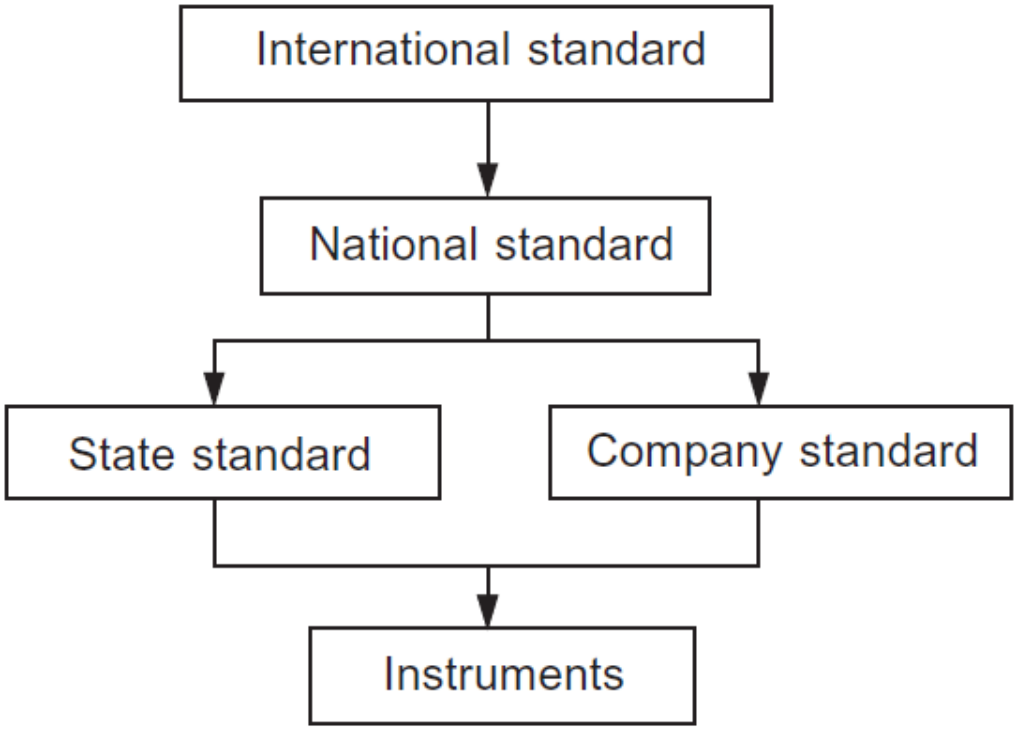
Working standard: These are high accuracy devices commercially available and calibrated against secondary or primary standard. These are used for calibrating laboratory equipment or for checking the quality of products etc.

Standard Hierarchy

Hierarchy by metrological level



Hierarchy by geographical location



G.M.S. de Silva, Basic Metrology for ISO 9000 Certification, Butterworth-Heinemann, 2002

What is calibration?

It is a act or result of quantitative comparison between known standard and the output of measuring instrument measuring the same quantity.

Comparing the standard and test instrument simultaneously.

Quantity is varied in ascending and descending order and results are compared.

Standard should be ten times more accurate compared to expected accuracy of the instruments.

Calibration can be done for various environmental conditions.

Types of calibration

Primary Calibration : Device / system calibrated against primary standards. Primary standards are available with national physical laboratories. After primary calibration device is employed as secondary calibration device.

Secondary Calibration : When secondary device is used for calibration then it is called as secondary calibration.

Types of calibration

Direct Calibration : Calibration using a known input source. It is as good as primary calibration. Direct calibrated devices can be used for secondary calibration. E.g. Flow meter is calibrated by accurately measuring the mass of fluid for a given time. In this another accurate flow meter is not required for calibration.

Routine Calibration : Periodically checking the accuracy and proper functioning of an instrument with standard. Very important for reliable functioning of a system.

Types of measurement

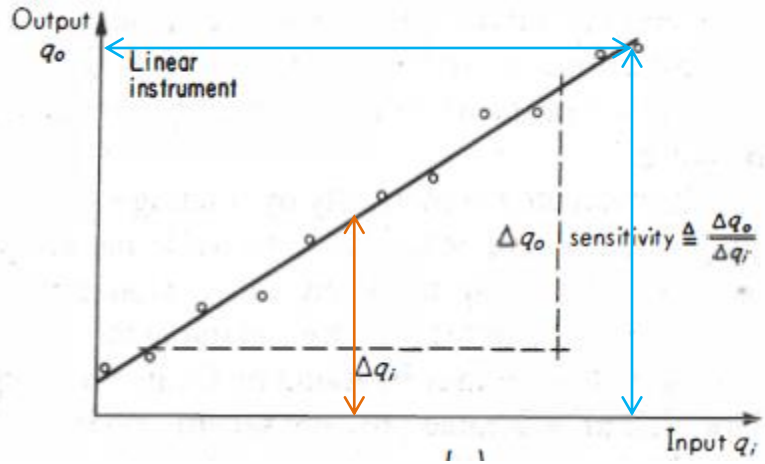
Static measurement : Quantities do not change with time or variation is very slow. Input and output can be related using algebraic expressions

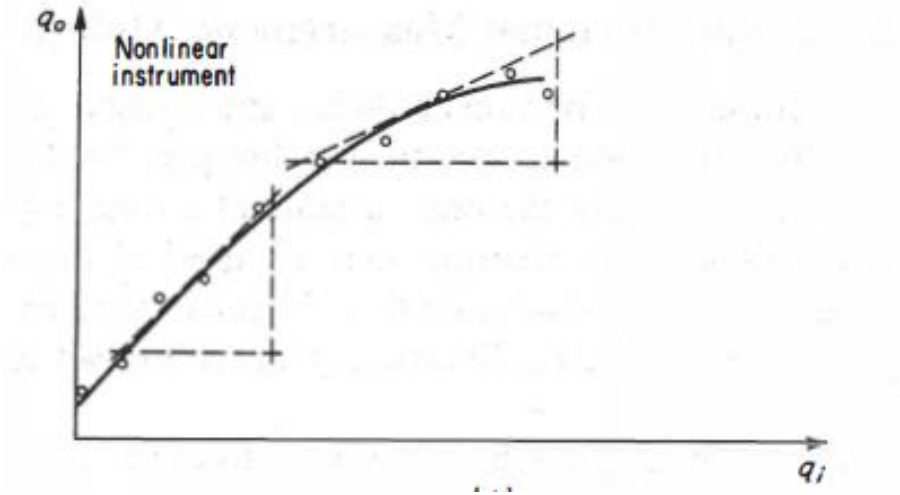
Dynamic measurement : When the signal is varying with time. Input and output related by differential equations. More complex relationship as compared to static measurement.

Measurement Errors

Errors in measurement are introduced due to construction of the sensor, due to specific transducer, due to threshold, due to dead space, due to random behavior etc. Error characteristics may remain constant over time or may change with time. Some errors are introduced only during switching.

Measurement Errors





Static sensitivity – slope of input-output calibration curve. It could be linear or nonlinear.

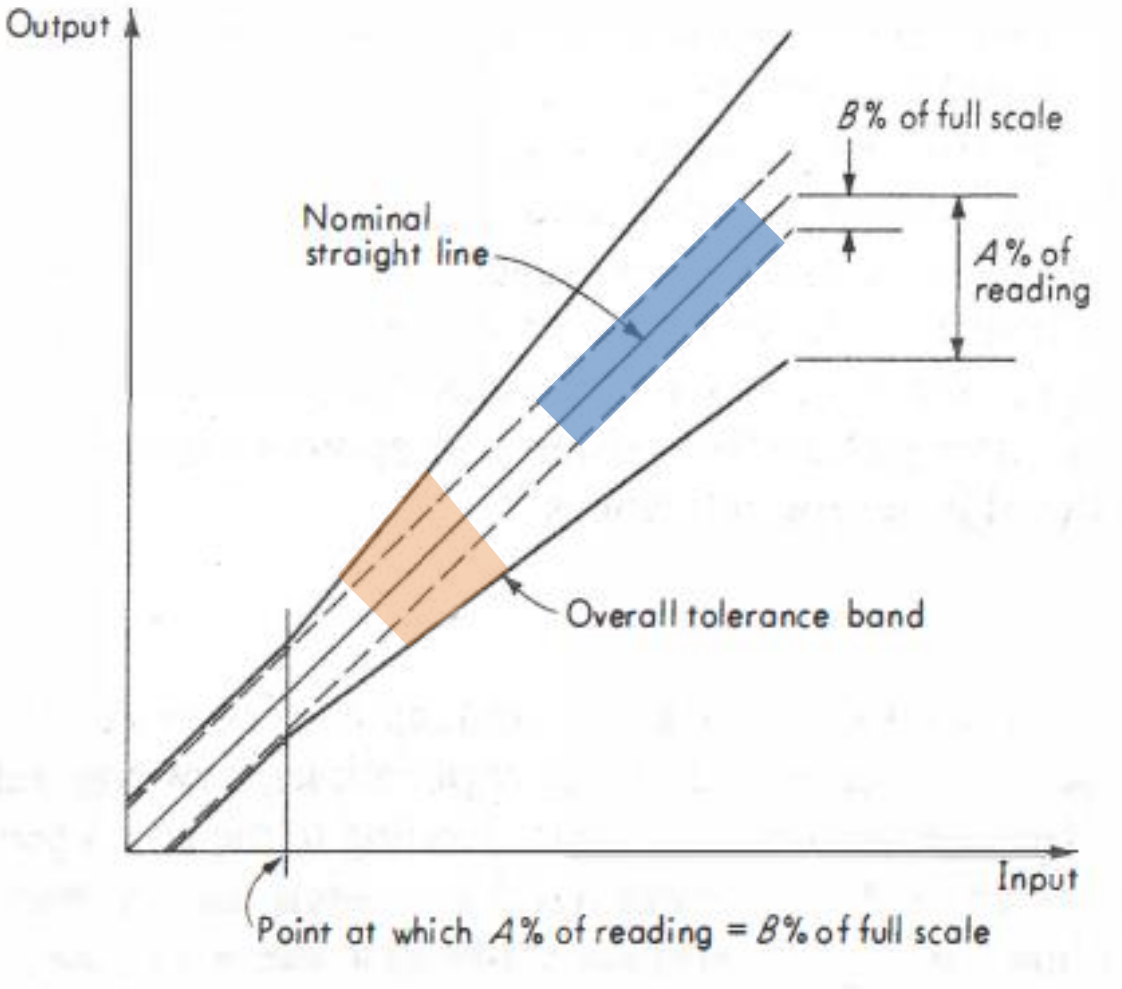
Calibration curve also effected by interfering or modifying inputs.

Accuracy is specified as

± A percent of reading

or ± B percent of full scale

Measurement Errors



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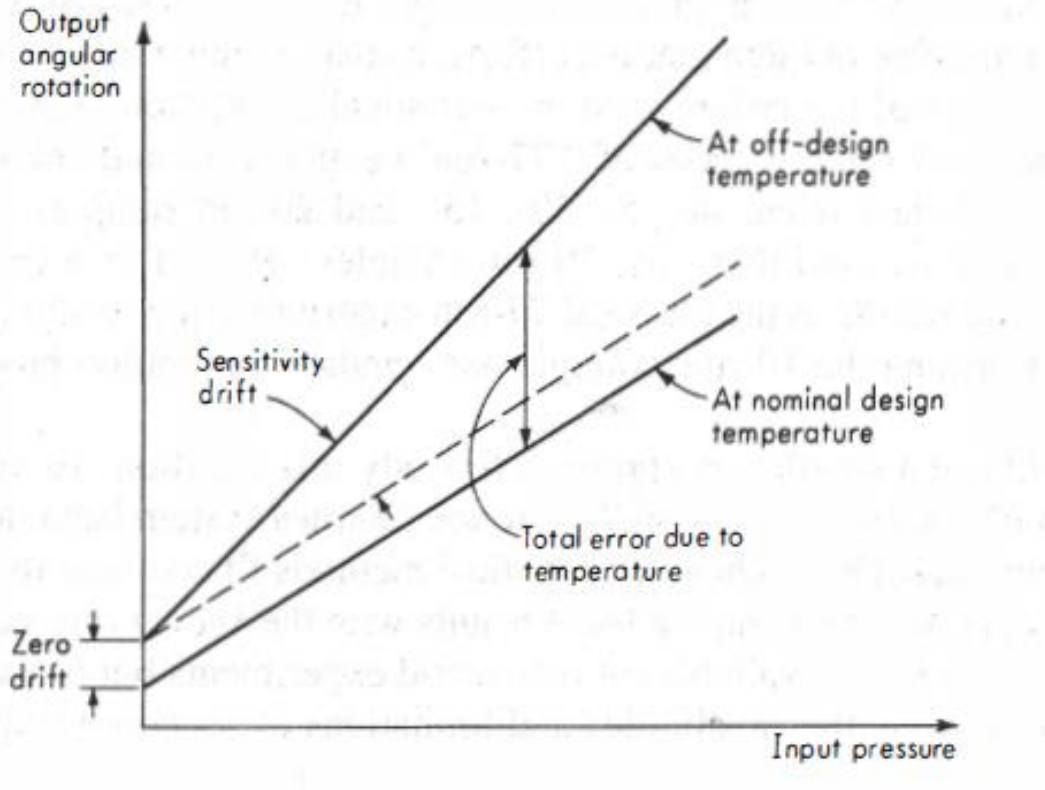
For the first case error is zero when input is zero and it is also small for small input, this is not a practical case. There will be always finite error.

Measurement Errors



Calibration curve also effected by interfering or modifying inputs.

When the instrument is switched on, it may different bias. This bias may have dependency on interfering or modifying inputs.

Example

Fluid pressure exerted on piston results into force. Piston surface is sliding on cylinder surface (friction). Spring is deformed due to application of piston force (could be non-linear). Linear motion of piston is converted to rotary by needle mechanism (mechanical play).

Many of the above factors introduces error.