Instrumentation Terms

The following is a list of terms that will be used widely throughout the course.

Accelerometer: A device that contains an internal mass whose deflection can be easily measured. This deflection is the result of an applied acceleration.

Accumulated Error: The square root of the sum of the squares for all of the errors.
$E_A=(E_1^2+E_2^2+E_3^2)^{1/2}$

Accuracy: The accuracy of the instrument is a measure of the expected error of the reading displayed. Accuracy is expressed in terms of the true value, error in terms of the deviation. The error is the additive inverse of the accuracy. I.E. *Accuracy = 1 – Error* for normalized ranges. See also *Experimental Error*. Accuracy is determined by a number of contributory error sources. Frequently an instrument will be listed as having an error of X%. We need to note carefully whether this is % of reading or % full-scale (%FS). This is one reason why we must carefully choose the range (or span) and resolution of instruments. Digital instruments will also usually have an additional error of 1 count in the least significant position. Errors can be expressed as average error or worst-case error. Note that for average error the absolute value must be used.

Active Sensors: Sensors which require a power supply to provide energy for the measurement being made. (Hall-effect sensors)

Bandwidth: The range of frequencies over which the device can operate with at least half-power output.

Calibration: The checking, adjusting, or systematically standardizing the graduations of a quantitative measuring instrument to make it meet a known standard of accuracy. Simple calibration of linear instruments requires adjusting the gain (slope) and offset (zero) of the instrument. Calibration is usually based upon laboratory standards. A good calibrator will always include a statement of traceability back to an absolute or laboratory standard. There is a significant effort to make standards based on freely available quantities. For example the standard of length used to be based on two marks on a bar in Paris. Now it is based on a particular wavelength of light.

Capacitive Sensing: To utilize the changing capacitance between a target plate and sensor head when the difference between them changes.

Contact Measurement: A measurement when the sensing element is in direct contact with the physical effect being measured. Opposite of *Non-Contact Measurement*.

Dead-Band: The insensitivity of the instrument over a certain range or span of input signals. The output does not change while the signals are changing within the dead band. Dead-band could be a natural part of the instrument, such as mechanical hysteresis or it could be designed into the system. Some instruments are designed to have a dead band over a range of signals to prevent the system from responding to small changes around a set point. (EG. home heating and cooling systems)

Detector: A sensing element that measures the presence or absence of a physical phenomenon and coverts it into an on/off signal.

Direct Measurement: A measurement where the parameter of interest or primary measurand is measured directly. An example is temperature measured with a thermocouple. The thermocouple directly converts the temperature to an electrical instrumentation signal. See *Indirect measurement*.

Doppler Shift: A phenomenon that takes place when dealing with a moving sound source or with a moving listening instrument. The relative velocity existing between the sound source and an observer can either add or subtract from the velocity of sound, depending on the direction of travel relative to the observer. This velocity alteration of the sound source's frequency can be observed and measured precisely.

Drift Error: An error which changes with time or drifts.

Dual Sensitivity or Multiple Sensitivity: The ability of a transducer to measure more than one single quantity. This can be used as a feature or (more often) it is a source of error to guarded against. If a transducer is used to measure force and it is also sensitive to temperature an error will result in the output if the temperature changes. (EG piezo crystals)

Dynamic Error: Error because of change in motion.

Electromagnetic Sensing Method: To utilize the changing electromagnetic field of devices for measurement purposes. To measure electromagnetic radiation.

Electromagnetic Radiation (other than heat and light): Radiation from a source operating in the electromagnetic spectrum.

Error: See Accuracy.

Experimental Error: The difference between the true value and the measured value of a quantity. The error can be expressed as a fraction, E=(true-measured)/true or as a percentage. Error is related to accuracy. EG if an instrument is 98% accurate then it has a 100-98=2% error. Errors result from:

1. Accumulation of accepted error in each element of the system.
2. Improper functioning of any element in the system.
3. Effect of the transducer on the process.
4. Dual sensitivity of the transducer.
5. Other less obvious sources.

Extrapolation: To estimate for values of the argument not used in the process of estimation; infer from known values.

Flow: A quantity of solid, liquid, or gas flowing past a fixed point in a given time. Flow can be measured as mass flow (Kg/sec) or as volume flow (Liter/sec)

Force (pressure): The weight of an object characterized by it's mass and the acceleration applied to it. Force = mass x acceleration (Newton II); Pressure = Force/area.

Frequency Response: The ability of a device to respond adequately to a given sinusoidal input signal.

Hysteresis: The characteristic that a transducer has in being unable to repeat faithfully, in the opposite direction of operation, the data that have been recorded in one direction. (also called memory effect, or lag)

Indirect Measurement: Where some parameter other than the parameter of interest or secondary measurand is measured and there is a relationship between what is measured and what is desired. For example we can measure the weight of a tank of liquid and by knowing the cross-sectional area and the density we can relate this to the level of liquid in the tank. Opposite of *Direct Measurement*.

Inductive Sensing Method: A method of measurement that involves altering the self inductance of the inductive sensor's coil to produce either a change in current through the coil or a change in voltage across the coil. One of the most common ways of producing this situation is to design s movable core that moves back and forth inside a coil so that as the core is displaced, a variable permeability is created within the coil. The core is usually made of a fairly highly permeable material such as ferrite or iron.

Inertia: A quantity having to do with that body's rotation about an axis, and its mass.

Inferential Measurement: An indirect measurement where the relationship between the parameter measured and the parameter of interest is inferred from statistical or other relationships. For example cardiac output cannot be measured directly, so a thermistor is placed in the pulmonary artery and a cold saline solution is injected into the vena cava. By measuring the temperature profile of the thermistor the cardiac output can be calculated.

Input/Output Relationship: The input to any sensor is the (change in) physical quantity being measured. The output is some (relatively) convenient response such as a voltage, current, resistance or frequency change. A simple thermometer has a volume change with temperature which we convert into a distance change in a thin tube.

Interpolation: To determine a value between two or more measured points in a range using a statistical prediction technique.

Light: An electromagnetic occurrence in nature caused by energy-carrying particles.

Linearization: To predict a linear relationship from data using linear regression or the least-means-fit method. The linearization with also have an error associated with it indicating how closely the system producing the data is in fact linear.

Linearity Error or Deviation From Linearity: Deviation from an assumed linear relationship between input and output. Can be expressed as worst-case deviation from a fitted straight line.