## Purpose and outline of the Course

- To combine the principles of EE and Physics to gain an understanding of the fundamentals and applications of sensors for the measurement of physical properties such as, for example, temperature, pressure, light, stress, chemical composition, fatigue etc, etc
- At the end of the course, students should be able to design a solution to a particular sensing problem.
- Some of the sensors to be covered:
  - Electrical
  - Mechanical
  - Chemical
  - Optical

## Assessment

- End of Semester Examination: 50%
- Tutorial Assignment: 30%
- Laboratory Reports 20%

## What is a sensor?

- A sensor is a device that
  - responds to an applied stimulus
  - in response to that stimulus produces an electrical signal
  - the electrical signal must correspond in a predictable way to the stimulus

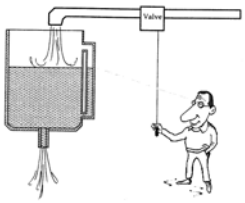


Fig. 1-1 Level Control System
A sight tube and operator's eye form a sensor: a device which converts information into electrical signal.

A biologically based sensor system

## Transducers versus Sensors

- Transducers convert energy from one form to another.
- Are the following transducers or sensors or both?
  - Microphone
  - An electrocardiograph
  - A loudspeaker

## Sensors are usually part of larger control systems

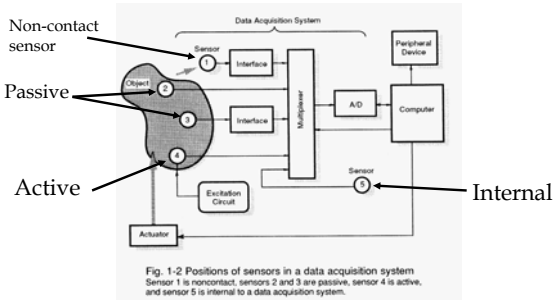


Fig. 1-2 Positions of sensors in a data acquisition system
Sensor 1 is noncontact, sensors 2 and 3 are passive, sensor 4 is active, and sensor 5 is internal to a data acquisition system.

## Passive versus Active Sensors

- Active Sensors
  - Require an external power supply and driving circuit
  - Eg: infrared or ultrasonic motion sensor
- Passive Sensors
  - generate own electrical signal based on the stimulus.
  - Eg: Thermocouple.

# Direct, Indirect and Inferential Measurements

- Direct
  - Measurement made directly on a parameter, eg measuring mass with an electronic balance
- Indirect
  - Requires interpretation, calculation or interpolation, eg rotor speed to measure fluid flow
- Inferential
  - measurement cant be made directly or indirectly on a parameter, so requires a chain of interpolation and/or interpretation eg measuring blood flow through the heart by use of a thermistor.

# Sensor Classification

- What does it measure (ie what is the stimulus)
  - Eg acoustic, biological, chemical, electric, magnetic, optical, mechnanical, radiation, thermal.
- Specifications
  - Eg, sensitivity, stability, linearity (more on this later).
- Means of detection
  - Eg, biological, chemical, electrical, heat, temperature, radioactivity
- Conversion phenomena
  - eg thermolectric, piezoelectric, electrochemical
- Material from which it is constructed.
- Field of applications.

# Sensor Selection

- There is often a wide choice of sensors to monitor a particular stimulus.
- The choice of the 'right' sensor must take into account
  - availability
  - cost
  - power consumption
  - environmental conditions
  - Reliability and lifetime.
- Therefore the choice is often not black and white and it is prudent to retain a few alternatives.

# Sensor Characteristics: The Transfer function

- The transfer function converts from the stimulus, s, to the electrical output signal, S, ie. $S = fn(s)$
- Many functions are possible
  - Linear: $S = a + bs$ (b = slope or sensitivity)
  - Logarithmic: $S = a + b\ln(s)$
  - Power $S = a + bs^k$
- For nonlinear transfer functions $b = dS/ds$
- Sensitivity can also be defined as the minimum input (or change) in the physical stimulus parameter which will create a detectable output change

# Transfer function

- Span
- Full Scale Output
- Accuracy
  - May be specified as a % of full scale or in absolute terms
  - Eg a pressure sensor has 100kPa input full scale and 10 ohms FSO. We can specify the inaccuracy as 0.5% or 500 Pa or 0.05ohms