SENSOR:

A **sensor** is a device that **detects or measures a physical quantity** from the environment and converts it into a signal (usually electrical) that can be measured and used. **Sensing element** detects physical quantity (temperature, pressure, etc.). It **converts** that physical quantity into an electrical signal. The signal is **processed and displayed.**

SENSOR CHARACTERISTICS:

To choose an appropriate sensor for a particular need, we have to consider a number of different characteristics. These characteristics determine the performance, cost, ease of application, and utility of the sensor. In certain situations, different types of sensors may be available for the same purpose. Therefore, we may consider the following before a sensor is chosen:

- **Cost:** The cost of a sensor is an important consideration, especially when many sensors are needed for one machine. However, the cost must be balanced with other requirements of the design such as reliability, importance of the data they provide, accuracy, repeatability, life, and so on.
- **Size:** Depending on the application of the sensor, the size may be of primary importance. For example, the joint-displacement sensors have to be adapted into the design of the joints and move with the robot's body elements. The available space around the joint may be limited. Additionally, a large sensor may limit the joint's range.
- **Weight:** Since robots are dynamic machines, the weight of a sensor is very important. A heavy sensor adds to the inertia of the arm and reduces its overall payload, e.g. a heavy camera mounted on a robotic insect airplane severely limits its flying capabilities.
- **Type of output (digital or analog):** The output of a sensor may be digital or analog; and, depending on the application, this output may be used directly or it may have to be converted. For example, the output of a potentiometer is analog, whereas that of an encoder is digital. If an encoder is used in conjunction with a microprocessor, the output may be directly routed to the input port of the processor, while the output of a potentiometer has to be converted to a digital signal with an analog-to digital converter (ADC). The appropriateness of the type of output must be balanced with other requirements.

- **Interfacing:** Sensors must be interfaced with other devices such as microprocessors and controllers. The interfacing between the sensor and the device can become an important issue if they do not match or if other add-on components and circuits such as resistors, transistor switches, or a power source are needed. The length of wires involved is also an important consideration.
- **Sensitivity:** Sensitivity is the ratio of a change in output in response to a change in input. Highly sensitive sensors will show larger fluctuations in output as a result of fluctuations in input, including noise.
- **Linearity.** Linearity represents the relationship between input variations and output variations. This means that in a sensor with linear output, the same change in input at any level within the range will produce a similar change in output. Almost all devices in nature are somewhat nonlinear, with varying degrees of nonlinearity. Some devices may be assumed to be linear within a certain range of their operation. Others may be linearized through assumptions. A known nonlinearity in a system may be overcome by proper modeling, equations, or additional electronics. For example, suppose a displacement sensor has an output that varies as a second-order equation. Using the square root of the signal, either through programming or by a simple electronic circuit, will yield a linear output proportional to the displacement. Therefore, the output will be as if the sensor were linear.
- **Range.** Range is the difference between the smallest and the largest outputs the sensor can produce, or the difference between the smallest and largest inputs with which it can operate properly.
- **Response time.** Response time is the time that a sensor's output requires to reach a certain percentage of the total change. It is usually expressed in percentage of total change, such as 95%. It is also defined as the time required to observe the change in output as a result of a change in input. For example, the response time of a simple mercury thermometer is long, whereas a digital thermometer's response time, which measures temperature based on radiated heat, is short. A special response time of 63.2% is called the time constant τ. Similarly, rise time is the time required between 10% and 90% of the final value. Settling time is the time between 0% and 98% rise.
- **Accuracy:** Accuracy is defined as how close the output of the sensor is to the expected value. For example, a thermometer should read 100 C when placed in pure boiling water at sea level.

- **Repeatability:** The output of a sensor to a series of similar input values may vary. Repeatability is defined as the radius of a circle that encompasses all output values if a sufficient number of measurements are made. In general, repeatability is more important than accuracy. We can generally measure or predict systematic inaccuracies in the response and compensate for the error.