SENSORS

- Sensor : Reads variables in robot motion for use in control.
- Analogous to human sensory organs
  - Eyes, ears, nose, tongue, skin
- Sensors help the robot knowing its surroundings better
- Improves its actions and decision making ability
- Provides feedback control

Sensors - What Can Be Sensed?

- Light
  - Presence, color, intensity, content (mod), direction
- Sound
  - Presence, frequency, intensity, content (mod), direction
- Heat
  - Temperature, wavelength, magnitude, direction
- Chemicals
  - Presence, concentration, identity, etc.
- Object Proximity
  - Presence/absence, distance, bearing, color, etc.
- Physical orientation/attitude/position
  - Magnitude, pitch, roll, yaw, coordinates, etc.

Sensors - What Can Be Sensed?

- Magnetic & Electric Fields
  - Presence, magnitude, orientation, content (mod)
- Resistance (electrical, indirectly via V/I)
  - Presence, magnitude, etc.
- Capacitance (via excitation/oscillation)
  - Presence, magnitude, etc.
- Inductance (via excitation/oscillation)
  - Presence, magnitude, etc.
- Other Things?

SENSORS CHARACTERISTIS

- Resolution – Minimum step size
  = ‘Full range / 2^n’
- Sensitivity = Change in output Response/ Change in input Response
- Linearity = relationship between input and output variations
- Range = Diff. between smallest and the largest outputs

SENSORS CHARACTERISTIS

- Reliability = No of times a system operates properly / No of times a system tried
- Accuracy = How close to the output
- Reliability = How varied diff. outputs are relative to each other
- Interfacing = Micro controller or Micro processor
- Size, Weight and Volume

Types of Sensors

- Contact Sensors
  - - Physical contact – touch, slip, force and torque
  - Binary or Touch and Analog or Force
- Non Contact Sensors
  - Acoustic and Electro magnetic
  - Range , Proximity and vision system

Classification of Sensors

- **Power Requirement –**
  - Passive - Output provided by sensed physical phenomenon . Eg . Thermocouple, Thermometer.
  - Active – External power source .Eg. Strain Gauge
- **Output Signal** – Analog and Digital
- **Measurement** - Primary and Secondary
- **Types based on various types of measurements.**

Quantity to be measured and Types of Sensors

- 1. Linear / Rotational Displacement
  - Linear / displacement variable differential transformer (LVDT/ RVDT)
  - Optical Encoder
  - Electrical Tachometer
  - Hall effect sensor
  - Capacitive transducer
  - Strain gauge elements
  - Interferometer
  - Gyroscope
- 2. Proximity
  - Inductance
  - Eddy Current
  - Hall effective
  - Photo Electric

Quantity to be measured and Types of Sensors

- 3 . Force , Torque and Pressure
  - Strain gauge
  - Dynamometer/ load cell
  - Piezoelectric load cells
  - Tactile sensors
  - Ultrasonic stress sensors

- 4 . Velocity and Acceleration
  - Electromagnetic
  - Ultrasonic
  - Tacho generators
  - Resistive sensors
  - Capacitance
  - Piezoelectric
  - Photo electric

Quantity to be measured and Types of Sensors

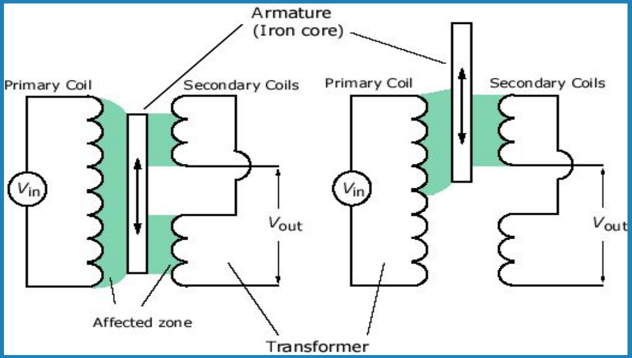
- 5 . Flow
  - Pitot tube
  - Orifice plate
  - Flow nozzle
  - Venturi Tubes
  - Rotameter
  - Ultrasonic flow meter
  - Turbine Flow meter
  - Electromagnetic flow meter
- 6 . Level
  - Float level sensor
  - Variable capacitance sensor
  - Piezo electric sensor
  - Photoelectric sensors

Quantity to be measured and Types of Sensors

- 7 . Temperature
  - Thermo couple
  - Thermostors
  - Thermodynamic
  - Resistance temperature detector
  - Infrared thermography
- 8 . Light
  - Photoresistors
  - Photodiodes
  - Photo transistors
  - Photo conductors
  - Charge couple diode

1. Linear / Rotational Displacement

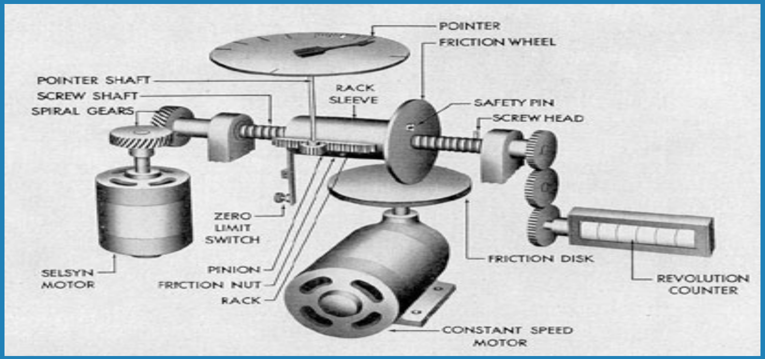
- Linear / displacement variable differential transformer (LVDT/ RVDT)



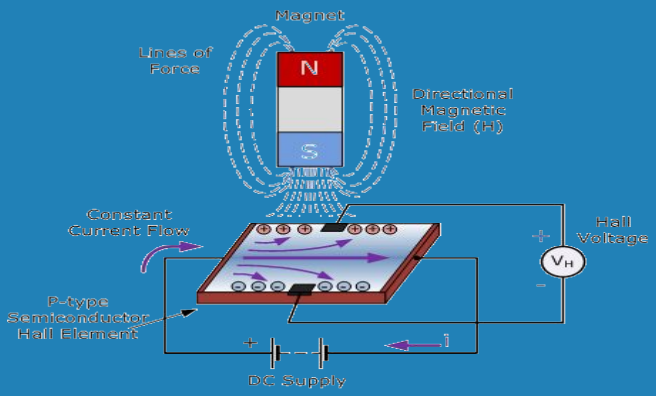
- Optical Encoder

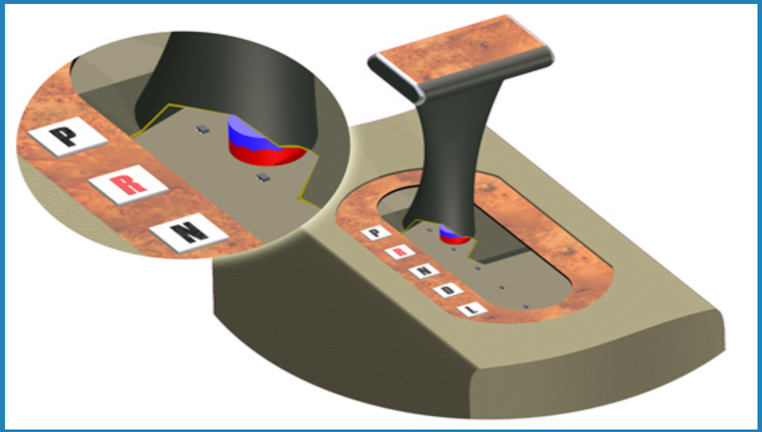
1. Linear / Rotational Displacement

- **Electrical Tachometer**



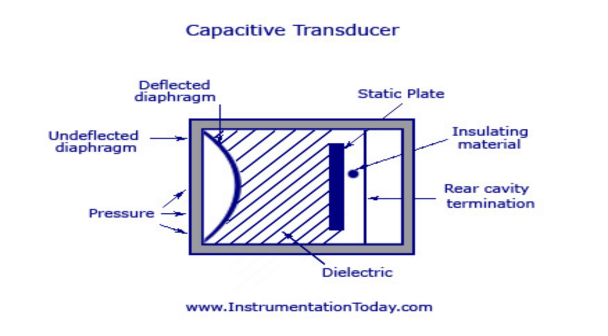
- **Hall effect sensor**



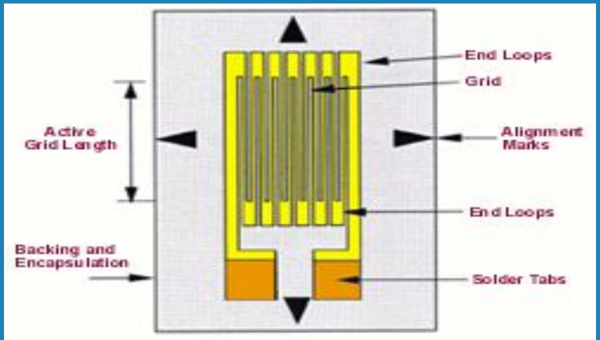


1. Linear / Rotational Displacement

- **Capacitive transducer**

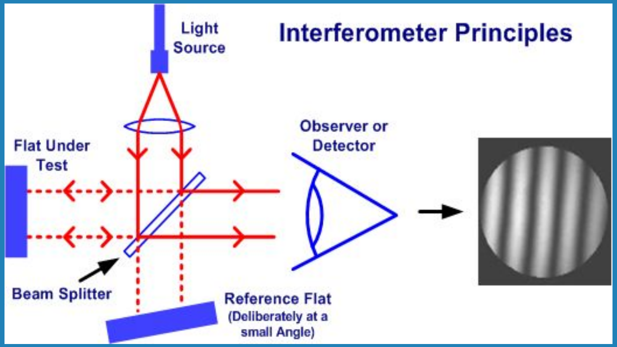


- **Strain gauge elements**

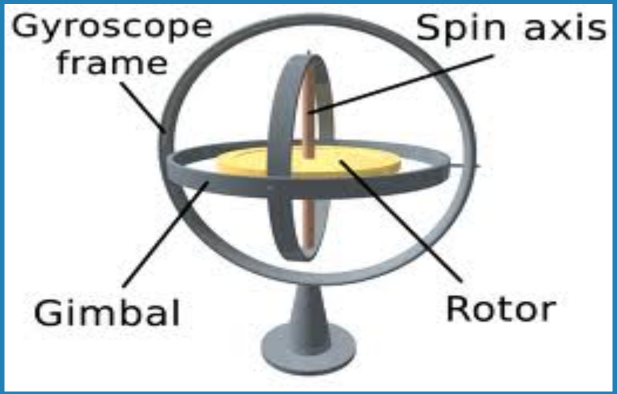


1. Linear / Rotational Displacement

- Interferometer

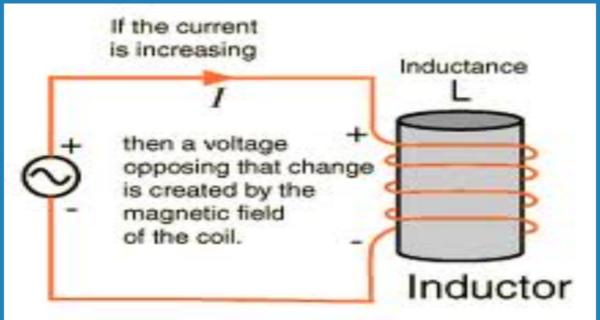


- Gyroscope

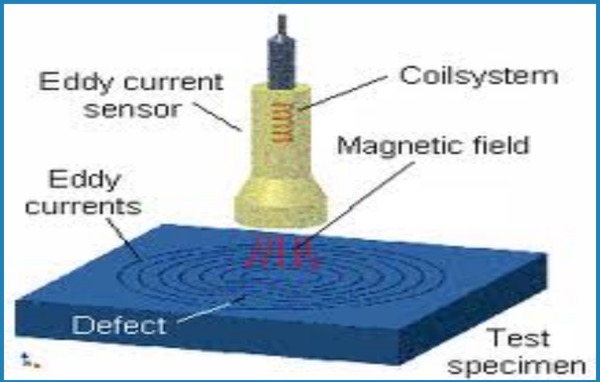


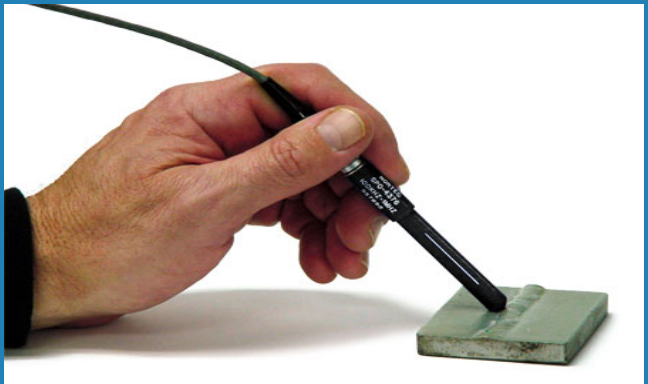
2 . Proximity

- Inductance



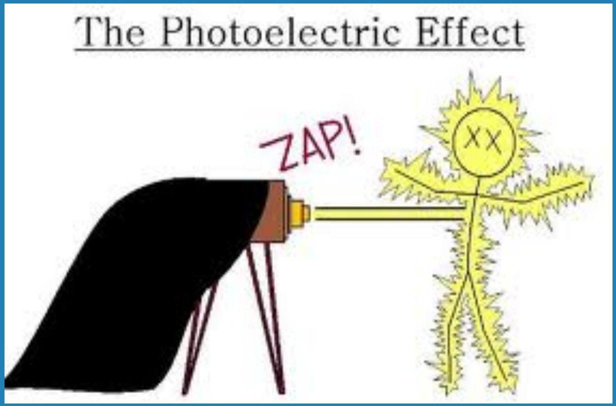
- Eddy current





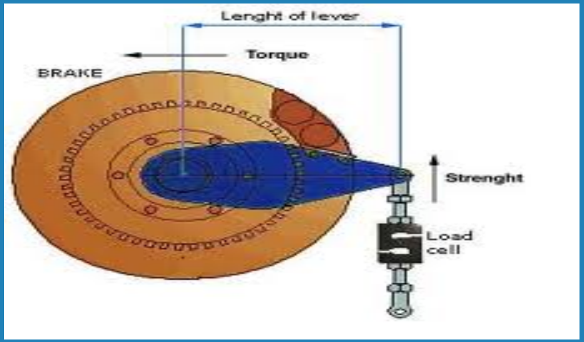
2 . Proximity

- Photo electric

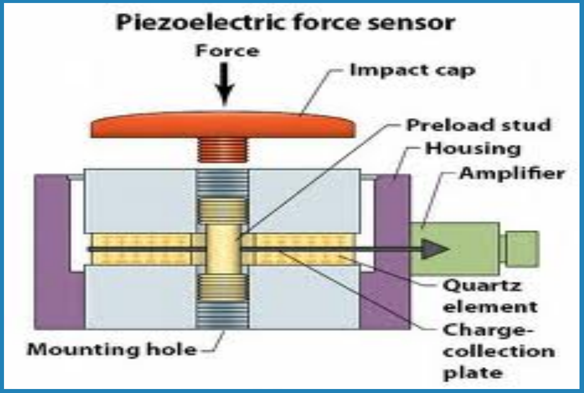


3. Force, Torque and Pressure

- **Dynamometer/ load cell**

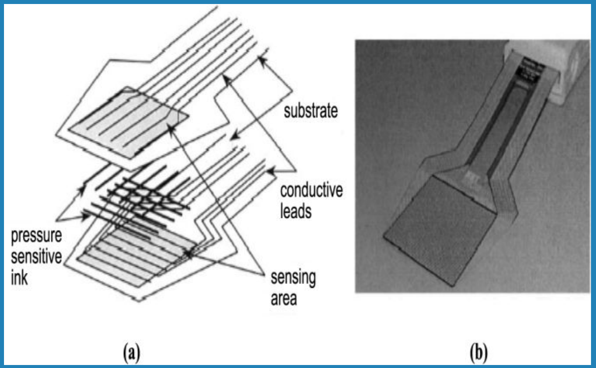


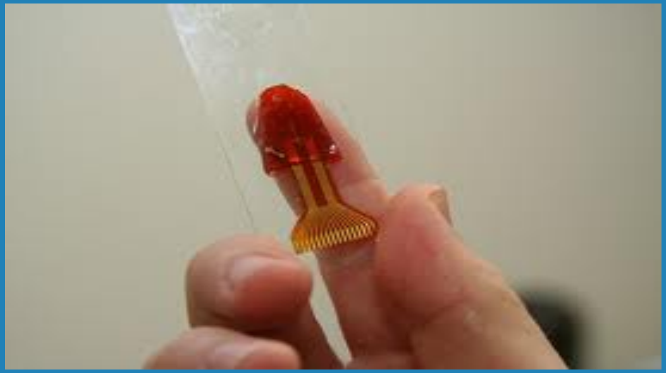
- **Eddy current**



3. Force, Torque and Pressure

- **Tactile sensors**

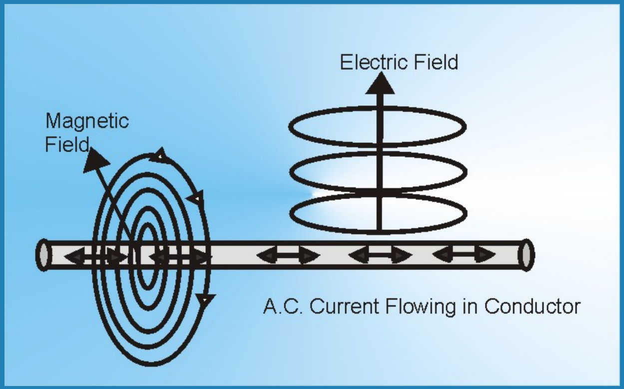


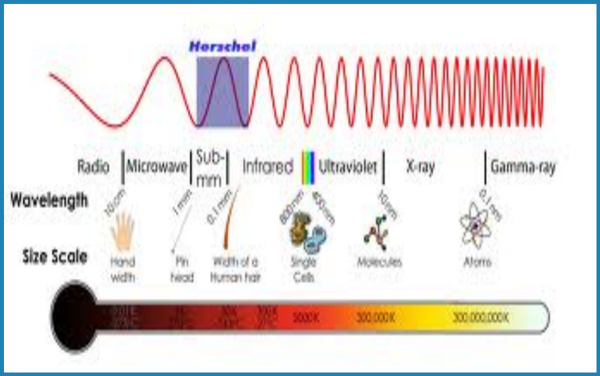


- **Ultrasonic stress sensors**

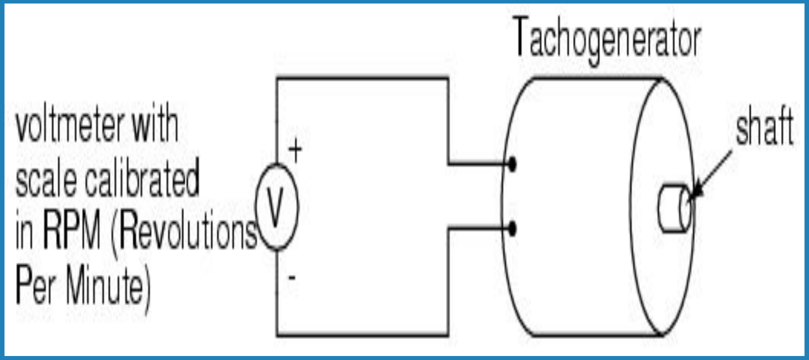
4 . Velocity and Acceleration

- **Electromagnetic**



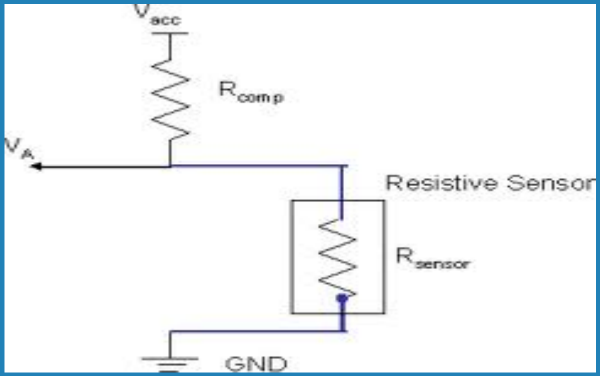


- **Tacho generators**



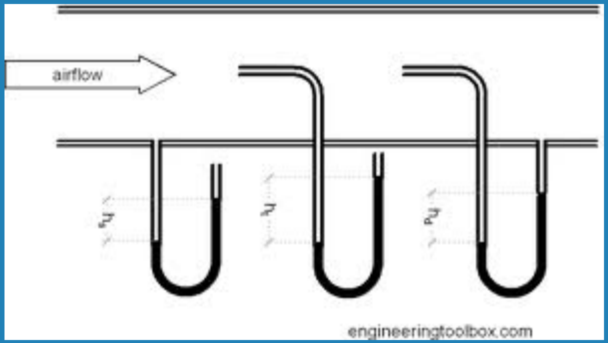
4 . Velocity and Acceleration

- Resistive sensors

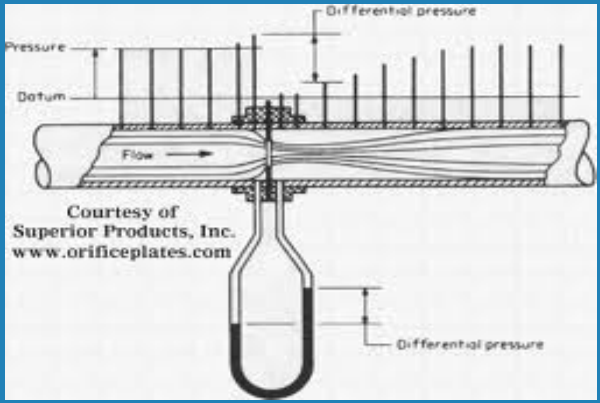


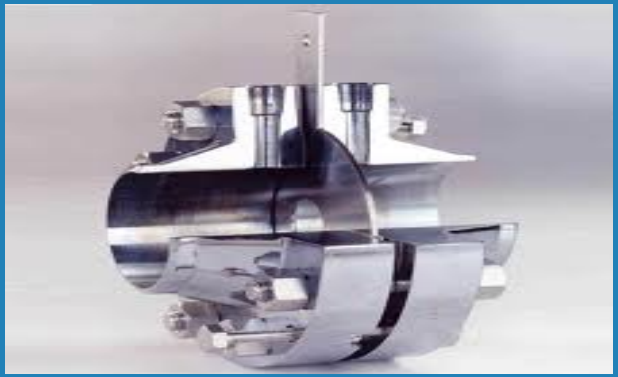
5 . Flow

- Pitot tube



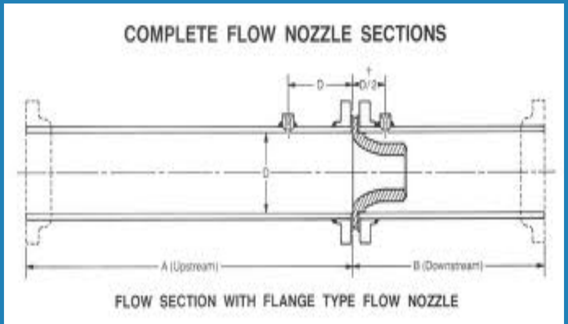
- Orifice plate



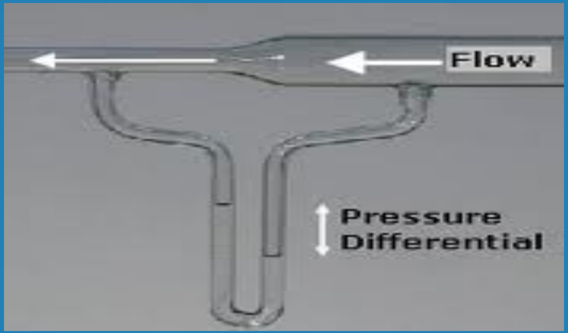


5 . Flow

- **Flow nozzle**

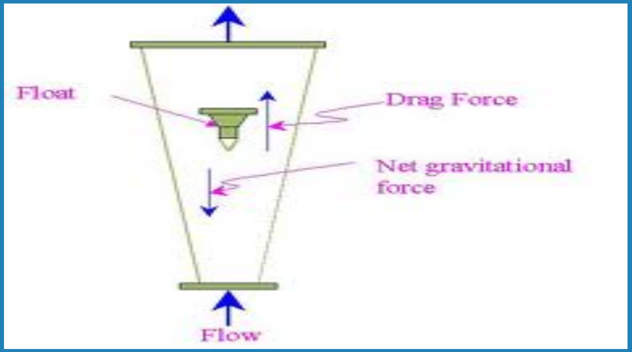


- **Venturi Tubes**

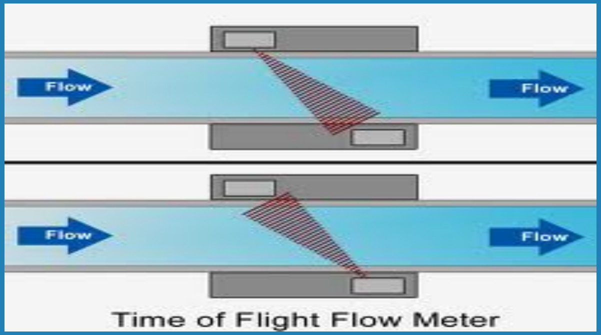


5 . Flow

- **Rotameter**

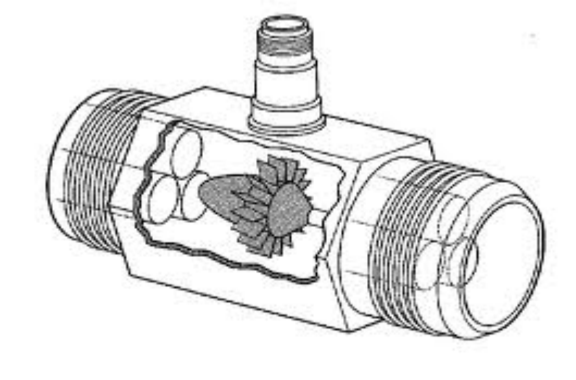


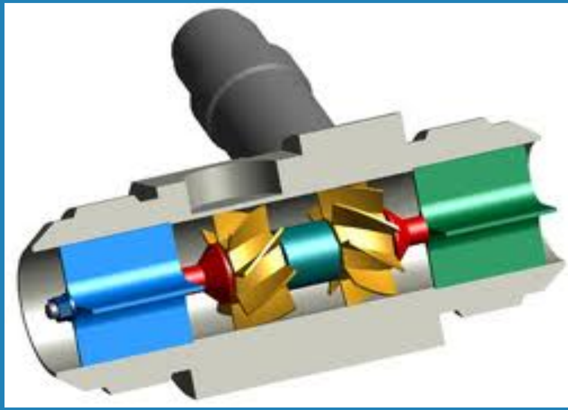
- **Ultrasonic flow meter**



5 . Flow

- **Turbine Flow meter**





- **Electromagnetic flow meter**

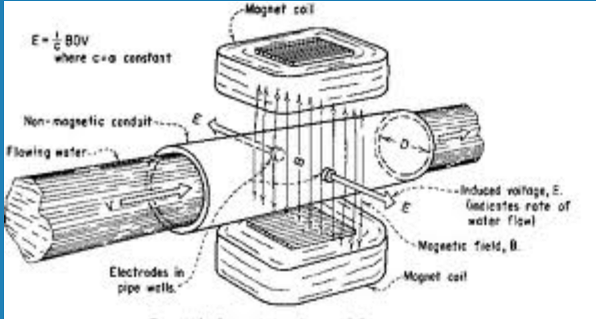
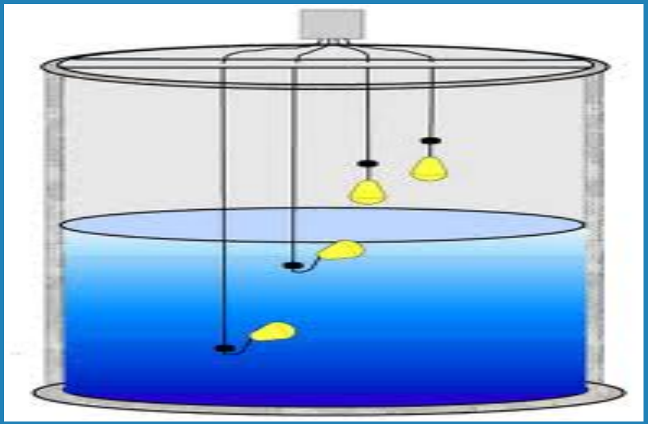


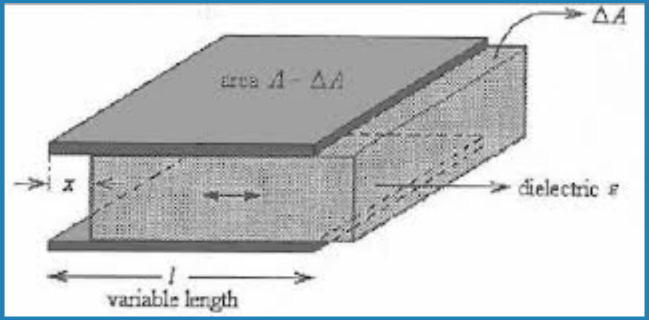
Figure 14-8.—Schematic view of a magnetic flowmeter.

6 . Level

- Float level sensor

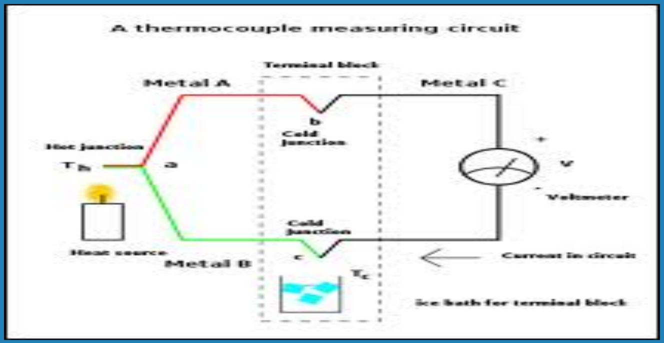


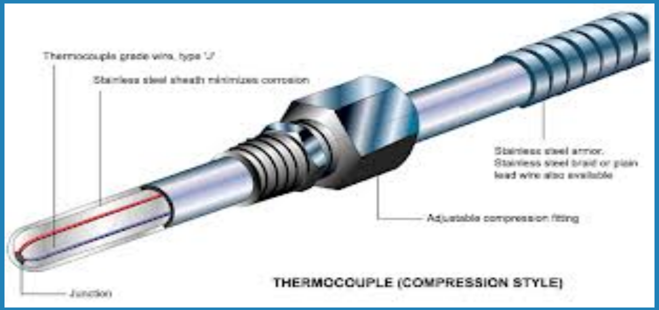
- Variable capacitance sensor



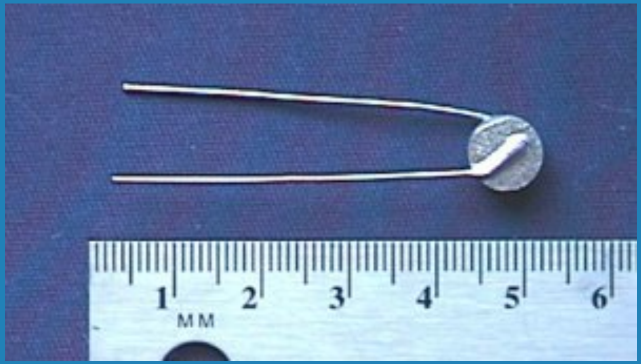
7. Temperature

- Thermo couple





- Thermostors



7. Temperature

- Resistance temperature detector

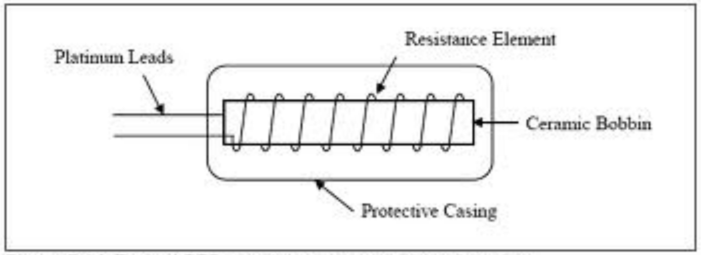
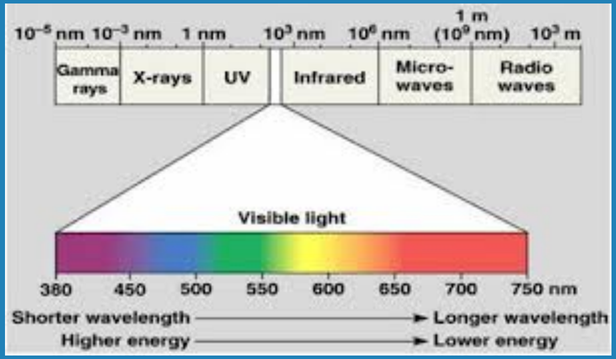


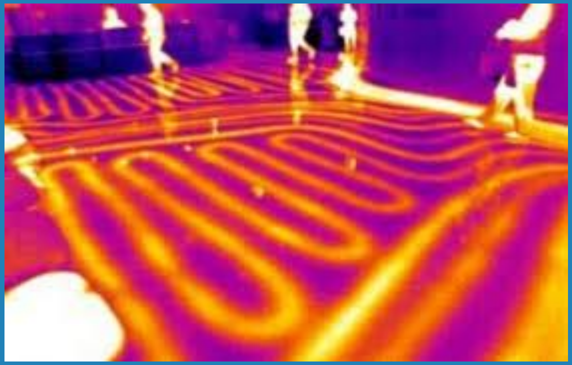
Figure 7-14. Typical RTD – resistance temperature detectors

RTD (Resistance Temperature Detector)

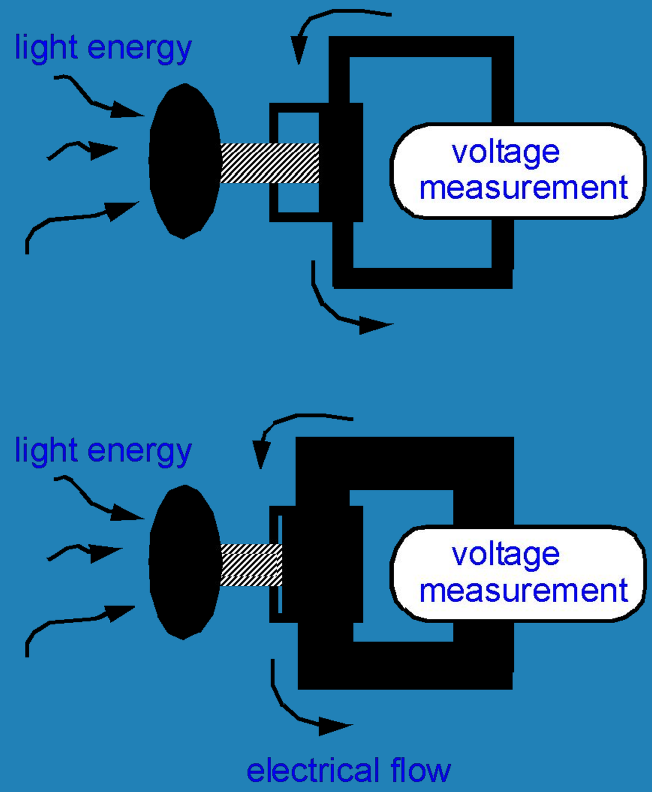
7. Temperature

- Infrared thermography



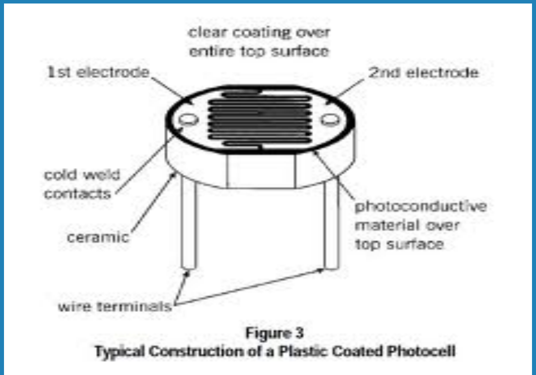


8 . Light

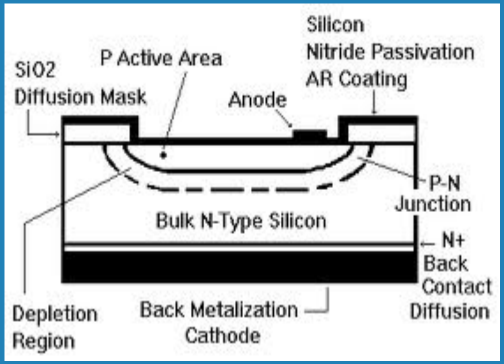

light energy
voltage
measurement
light energy
voltage
measurement
electrical flow

8 . Light

- **Photoresistors**

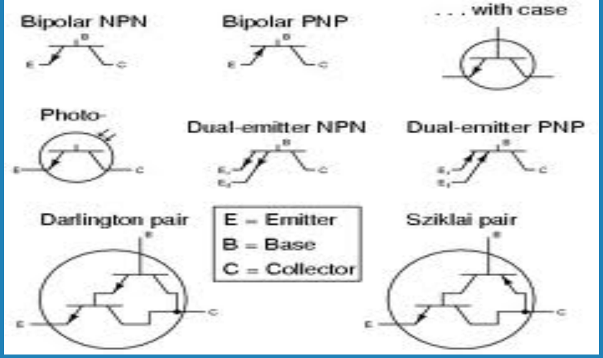


- **Photodiodes**

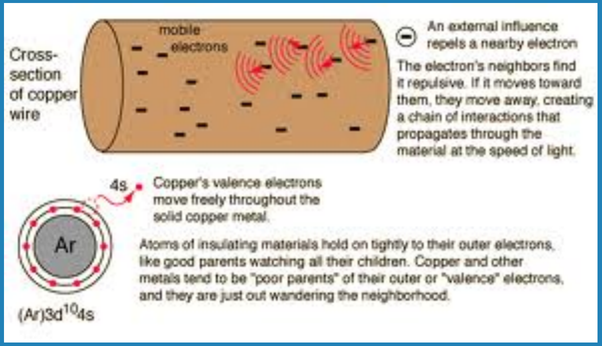


8 . Light

- Photo transistors

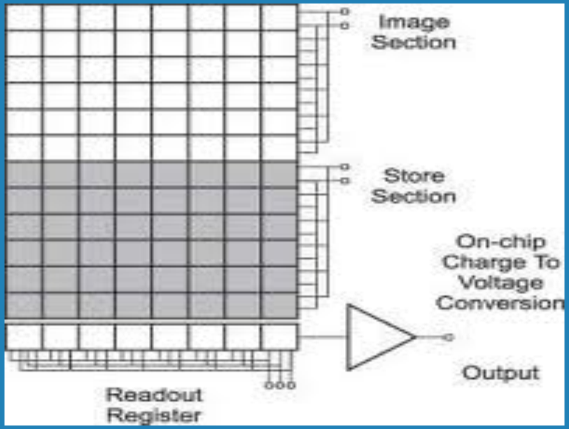


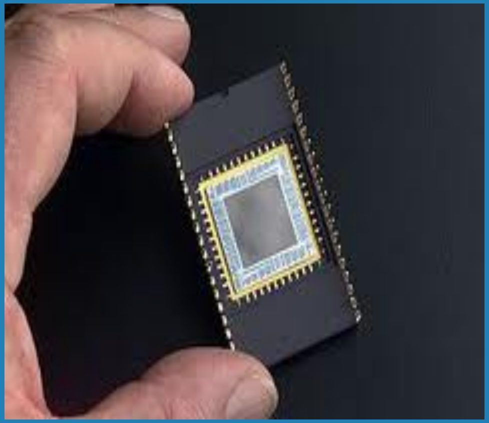
- Photo conductors



8 . Light

- Charge couple diode

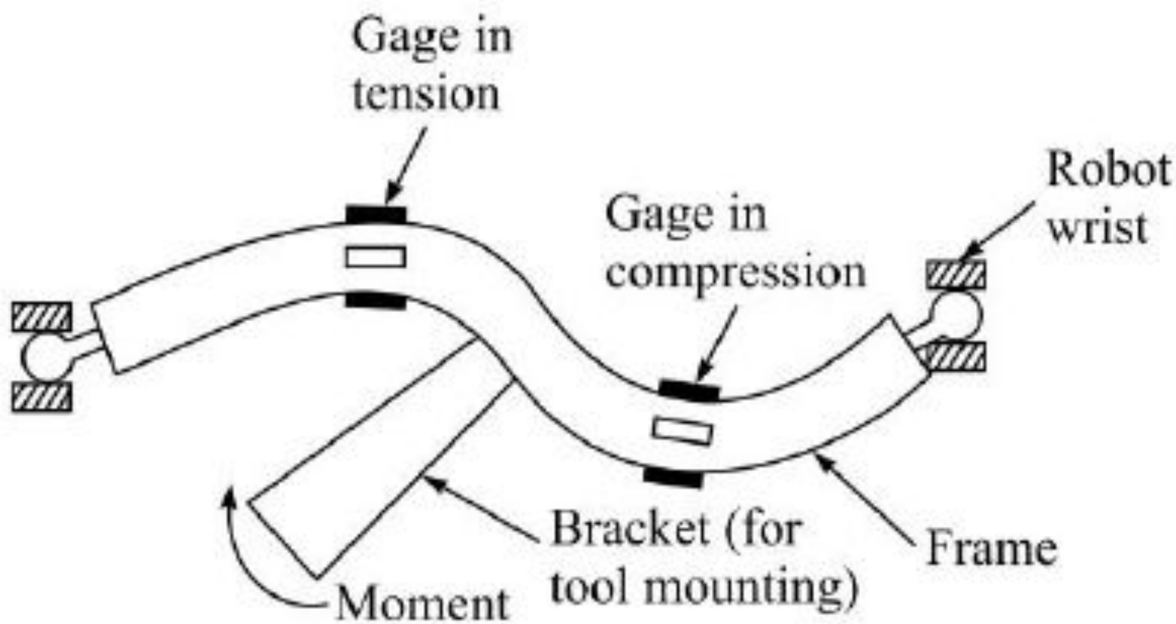




Types of Force sensors

- Special load cell mounted between gripper and wrist (Force sensing Wrist)
- Joint sensing
- Array of Force sensing element
- Ex. Peg in hole(no side force reqd)
- Following edge /contour(force accommodation)

Force-sensing wrist



Possible configuration of sensing device used for a force sensing wrist, showing deflection (exaggerated) due to a moment about one of the axes.

Force Accommodation

1. Measure the forces at the wrist in each axis direction.
2. Calculate the force offsets required. The force offset in each direction is determined by subtracting the desired force from the measured force.
3. Calculate the torques to be applied by each axis to generate the desired force offsets at the wrist. These are moment calculations which take into account the combined effects of the various joints and links of the robot.
4. Then the robot must provide the torques calculated in step 3 so that the desired forces are applied in each direction.

Force Accommodation

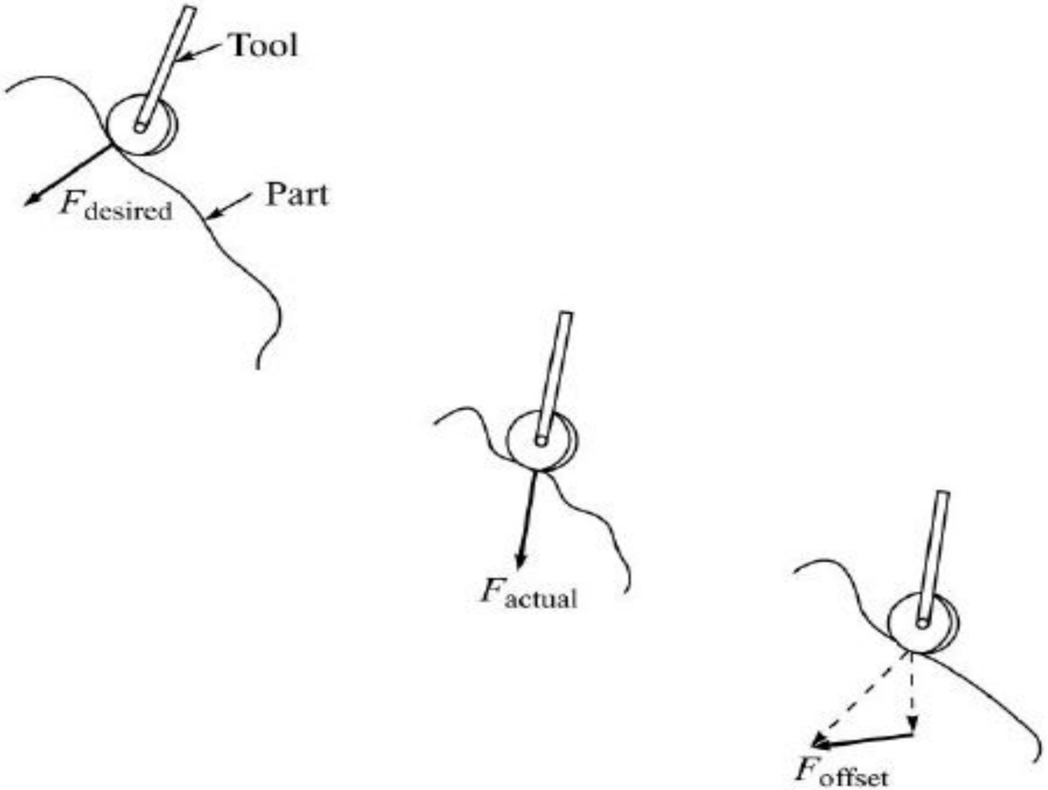
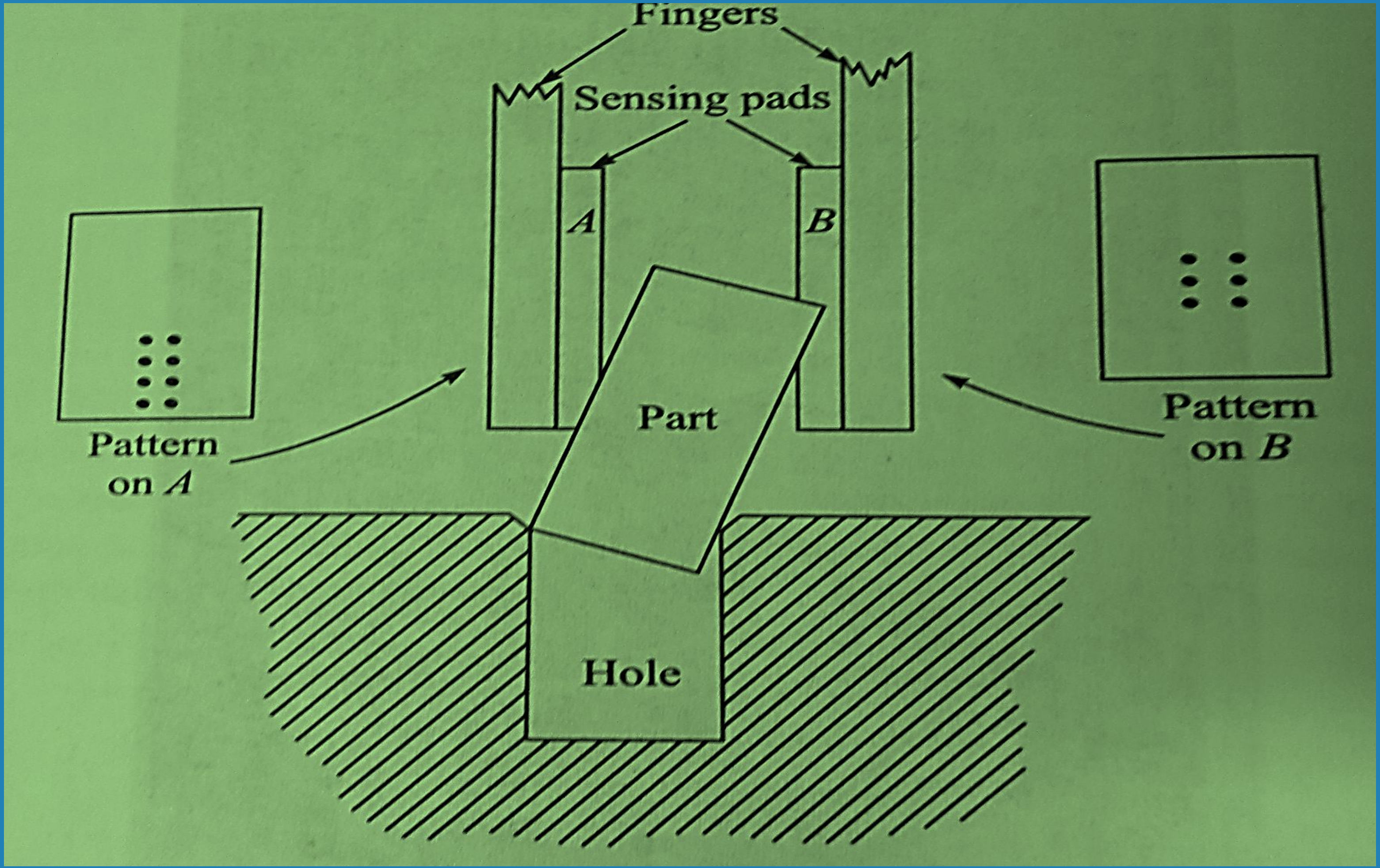


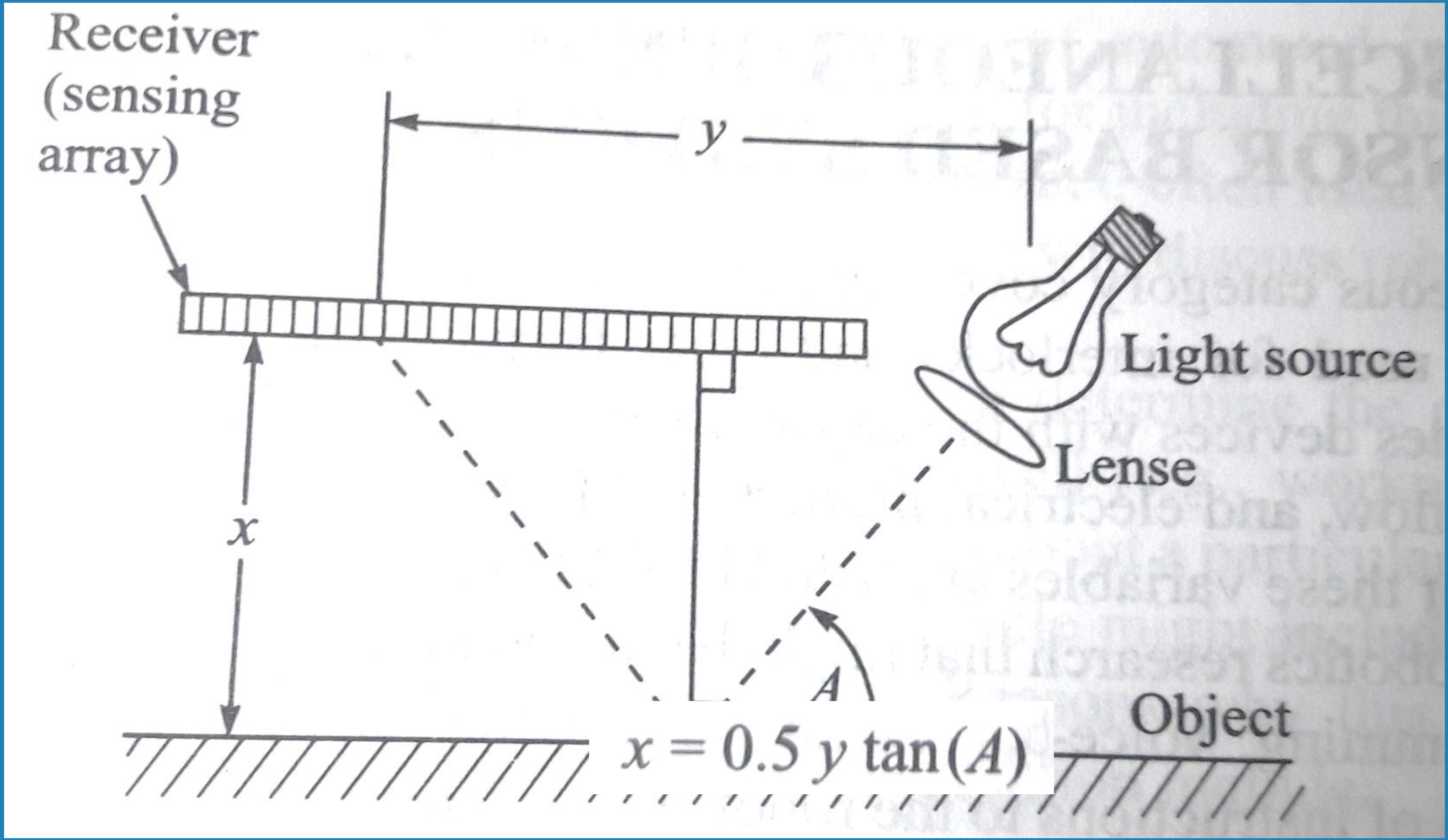
Fig. 6.2 *Force accommodation, showing how the required offset force would compensate for the difference between actual force and desired force.*

Tactile Array sensors



Proximity sensors are devices that indicate when one object is dose to another object. How close the object must be in order to activate the sensor is dependent on the particular device. The distances can be anywhere between several millimeters and several feet. Some of these sensors can also be used to measure the distance between the object and the sensor, and these devices are called range sensors. Proximity and range sensors would typically be located on the wrist or end effector since these are the moving parts of the robot. One practical use of a proximity sensor in robotics would be to detect the presence or absence of a workpart or other object. Another important application is for sensing human beings in the robot workcell. Range sensors would be useful for determining the location of an object (e.g., the workpart) in relation to the robot.

Optical Proximity sensor(Active)



Another optical approach for proximity sensing involves the use of a collimated light beam and a linear array of light sensors. By reflecting the light beam off the surface of the object, the location of the object can be determined from the position of its reflected beam on the sensor array. This scheme is illustrated in Fig. 6.10. The formula for the distance between the object and the sensor is given as follows:

$$x = 0.5\, y \tan(A)$$

where x = the distance of the object from the sensor

y = the lateral distance between the light source and the reflected light beam against the linear array. This distance corresponds to the number of elements contained within the reflected beam in the sensor array

A = the angle between the object and the sensor array as illustrated in Fig. 6.10.

Use of this device in the configuration shown relies on the fact that the surface of the object must be parallel to the sensing array.