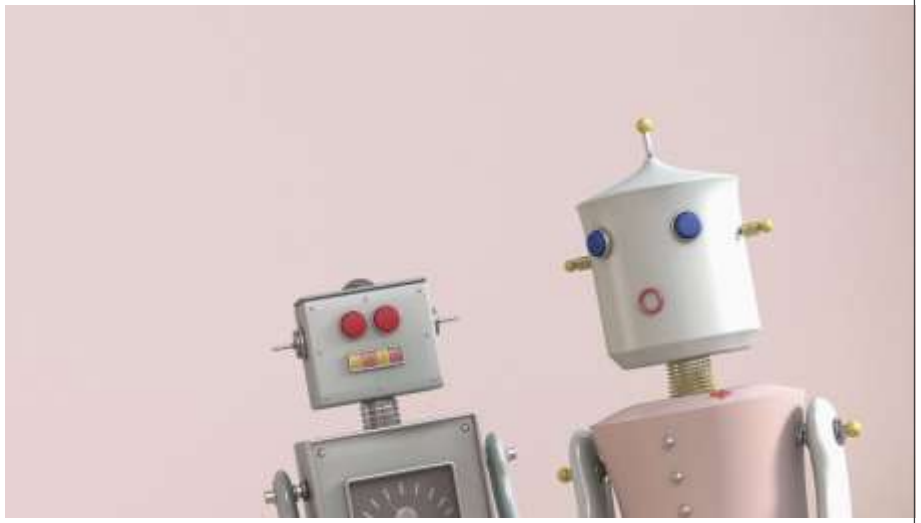
SENSORS

Seneca

Saeid Khosravani

Fall 2021



Safety First

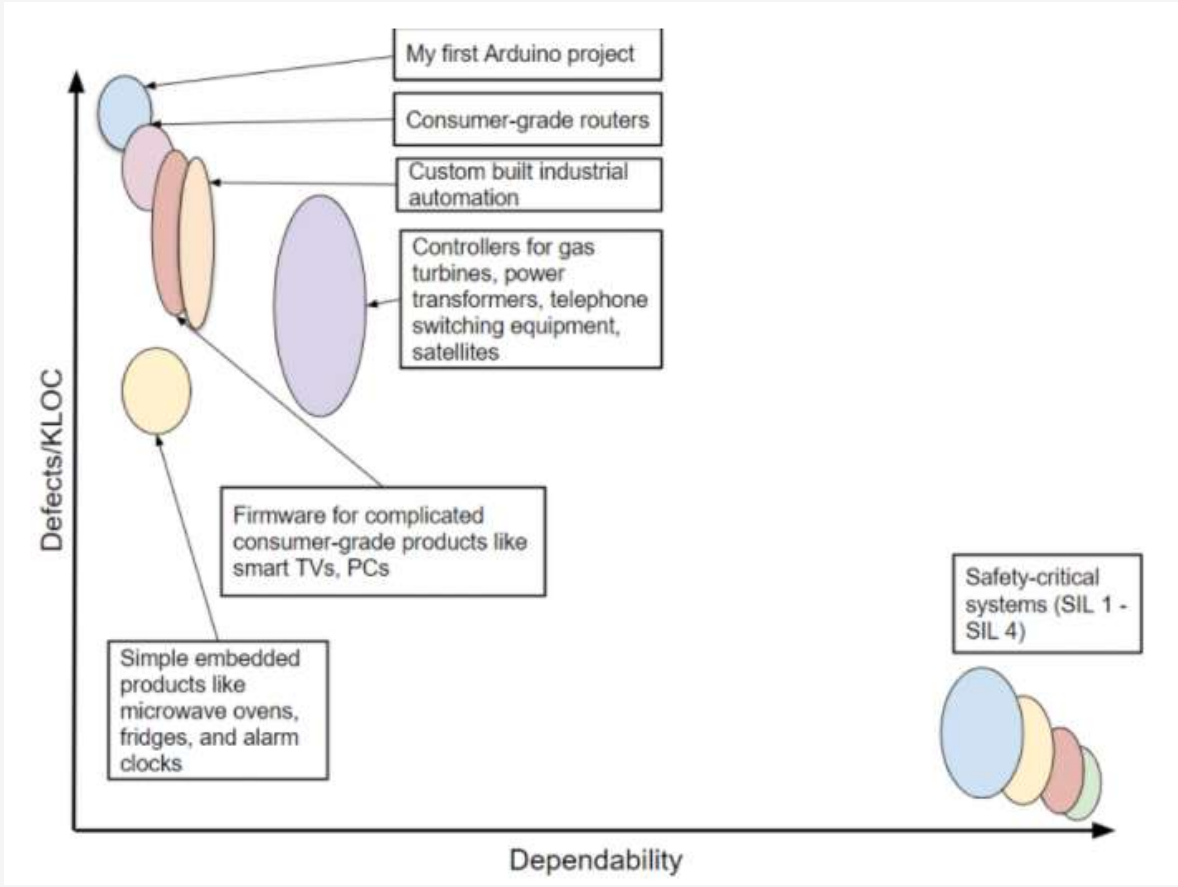
Safety-critical systems are those systems whose failure could result in loss of life, significant property damage, or damage to the environment. Aircraft, cars, weapons systems, medical devices, and nuclear power plants are the traditional examples of safety-critical software systems.

- The allowable failure rate for the most critical systems is absurdly low.

IEC 61508 SILs

Safety Integrity Level	Probability of dangerous failure per hour (Continuous mode of operation)
SIL 4	$>=10^{-9}$ to $<10^{-8}$
SIL 3	$>=10^{-8}$ to $<10^{-7}$
SIL 2	$>=10^{-7}$ to $<10^{-6}$
SIL 1	$>=10^{-6}$ to $<10^{-5}$

safety-critical system



https://dev.to/bosepchuk/safety-critical-software-15-things-every-developer-should-know-1kdh

Sensors

Important questions to consider when choosing sensors for your robot:

- What do you need the robot to sense?

You do not need a specialized sensor if your robot has no application for it

- Where will your robot be operating?

Some sensors are more suitable for indoors vs outdoors or harsh / industrial vs domestic environments

- What is your budget?

Sensors can largely be expensive, the more sensors your robot requires the more it will cost. Take into consideration the caliber of sensor you really require vs what you can afford

What will your robot need to sense?

Contact Sensors

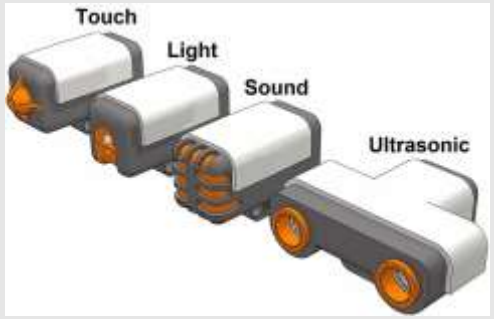
- Potentiometer
- Limit switch
- Piezoelectric switch

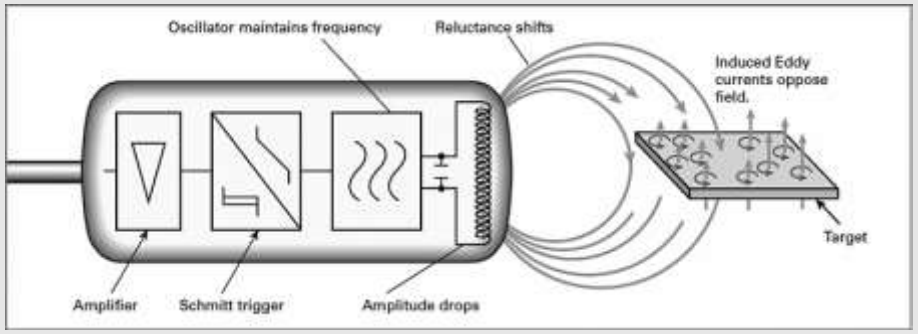
Non-Contact Sensors

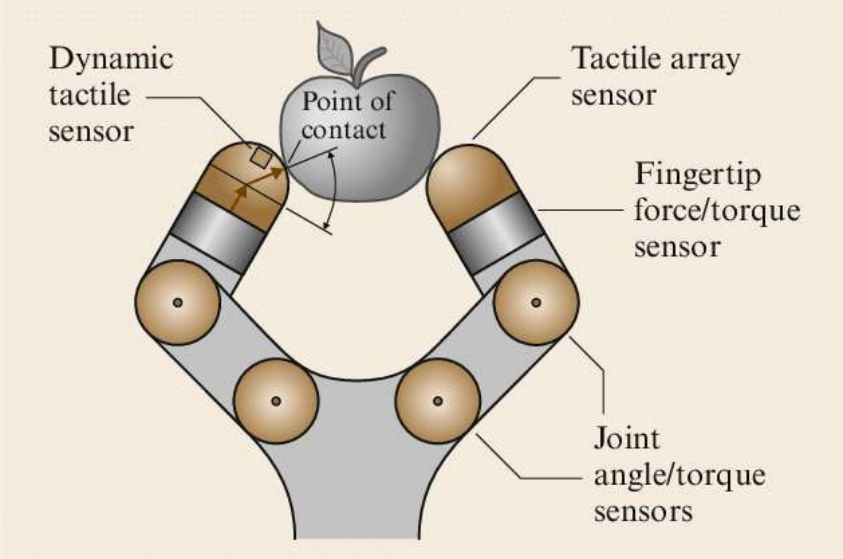
- Optical sensors
- Magnetic or Proximity sensors
- Inductive sensors
- Capacitive sensors

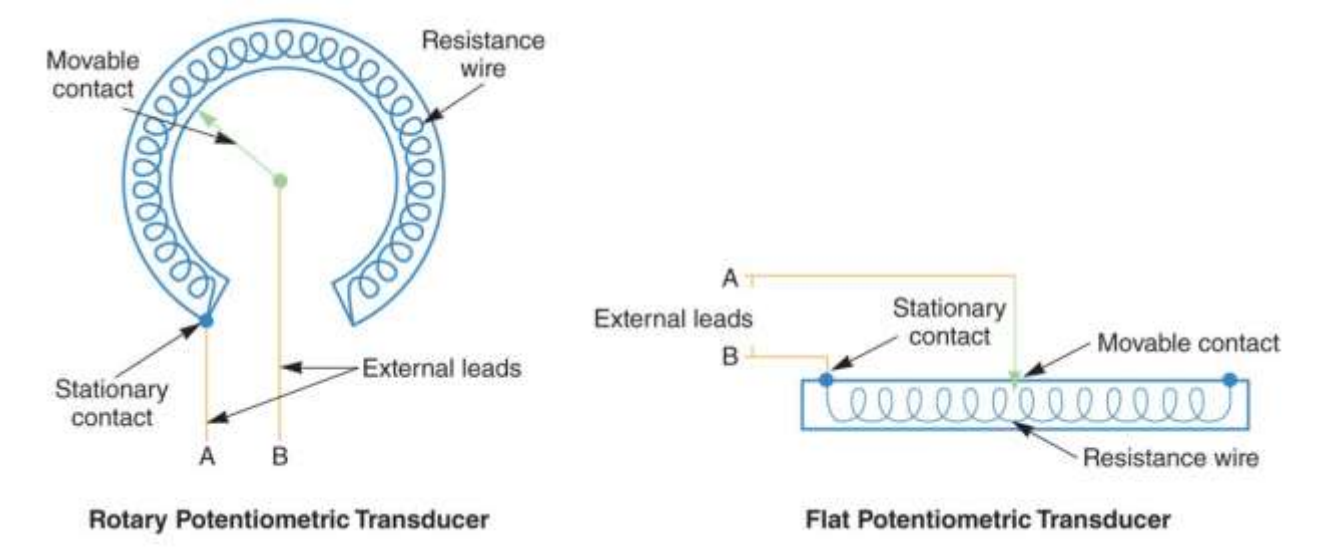
Position and Velocity Sensors

- Absolute Encoders
- Incremental Encoders
- Electronic tachometer
- Linear Velocity Transducers









Contact Sensors

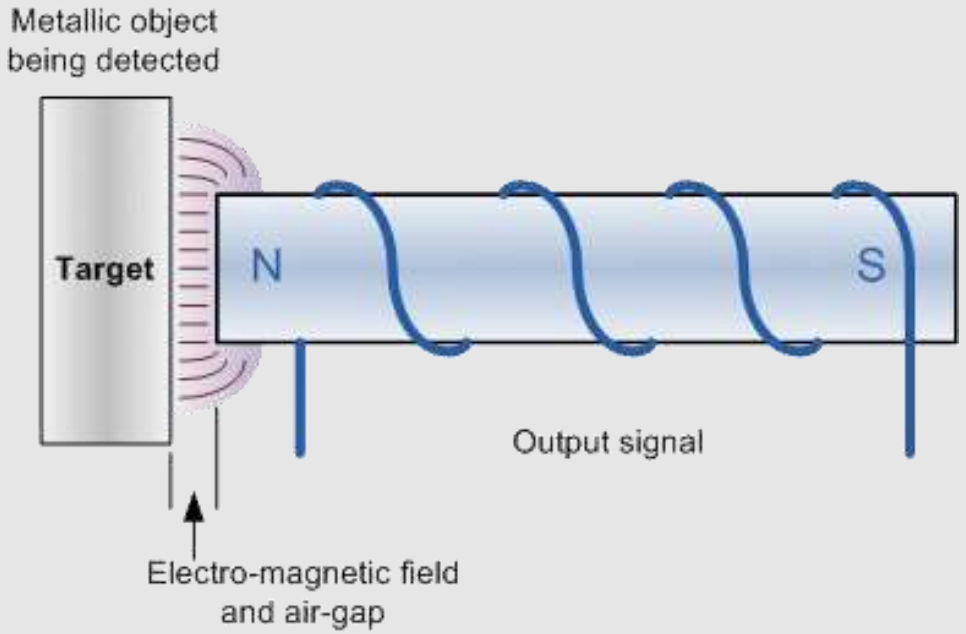
Sensors meant to trigger and gather data based on physical contact. The most common kind of sensor in basic robotics applications.

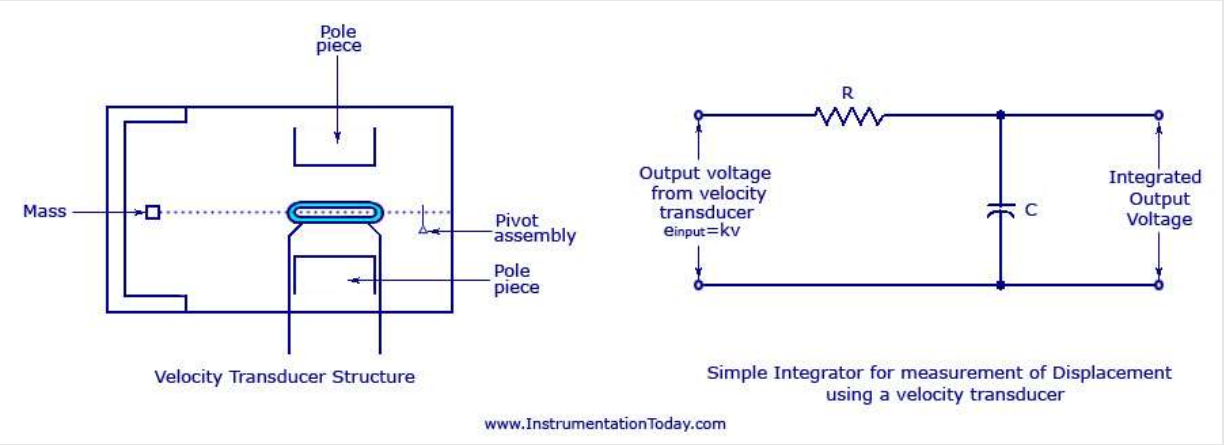
If your robot is meant to make any meaningful contact with objects and surfaces within the environment, these will be necessary.

Non-Contact Sensors

Sensors that are meant to trigger and collect data indirectly, and without physical contact.

These kinds of sensors are integral for path-planning algorithms, line-followers, mapping applications, etc. Any robot that requires a constant feed of information from their surroundings to assist in positioning, movement, and terrain data collection will utilize many non-contact sensors.





Position and Velocity Sensors

Position sensors trigger and collect data based on movement, measuring distance traveled from a fixed location, or based on rotation. Velocity sensors trigger and collect data based on velocity and speed rather than absolute distance traveled.

Both types of sensor are important for precise movement in robots, as well as keeping track of a robot's position accurately. Any robot dealing with linear movement will make great use of these sensors.

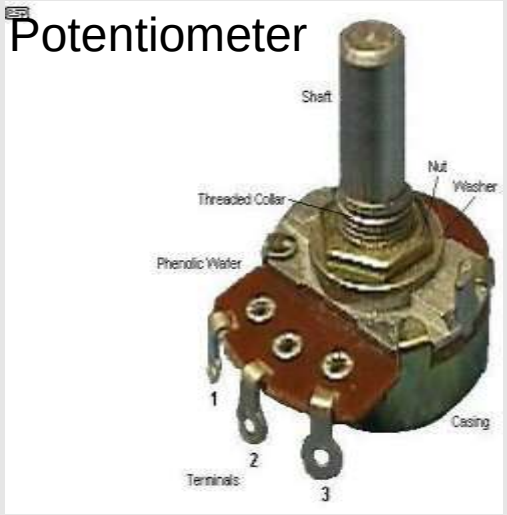
How to choose sensors?

- Application: what does the robot need to sense?
- Cost: sensors can be expensive, especially when you need several sensors on a single robot.
- Environment: there are many sensors that work well indoors, but not as well outdoors.
- Range: most sensors work best over a certain range of distances. If something comes too close, they bottom out, and if something is too far, they cannot detect it.
- Field of View: depending upon what you are doing, you may want sensors that have a wider cone of detection.

Contact, tactile sensors

- Potentiometer
- Limit switch (Mechanical Switch)
- Piezoelectric switch

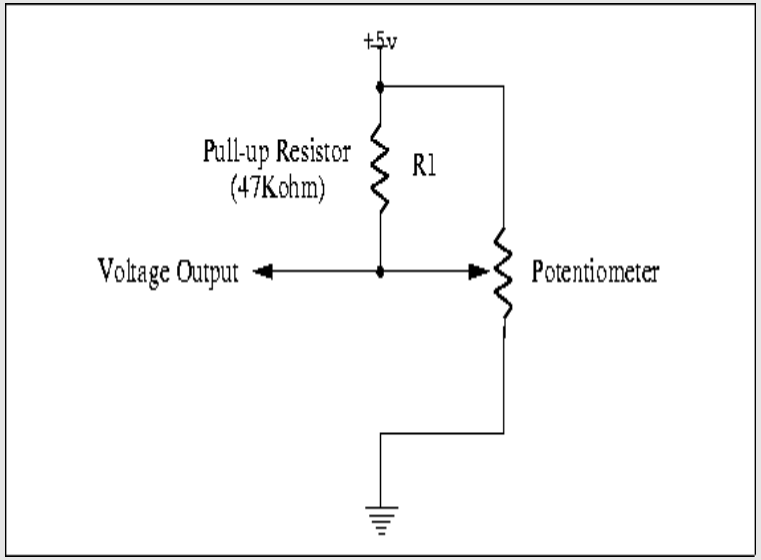
Limit Switch



Potentiometer

$$V_0 = V_{in}\left(\frac{R_1}{R_1 + R_{(variable)}}\right)$$

Think, where can you use this sensor in robotics ?



$$R_{variable} \propto Length of resistive wire$$

$$R_{variable} = (cons)\, L$$

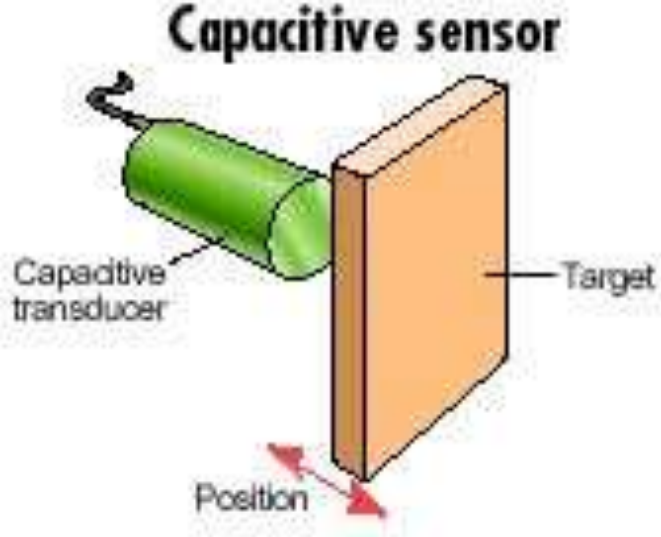
$$R_{variable} = L$$

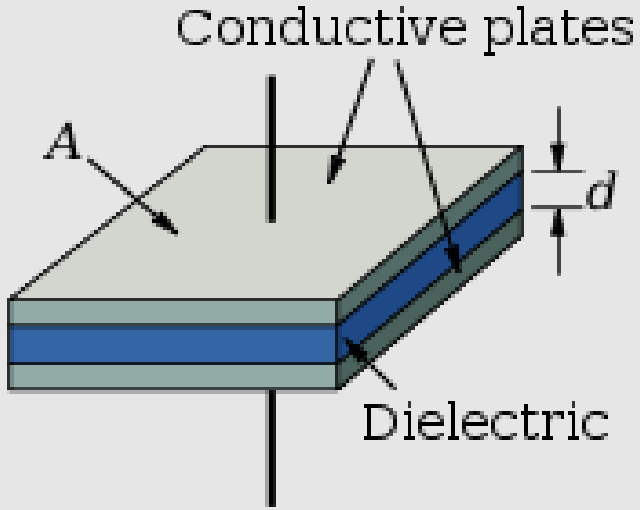
Non Contact Sensors

- Optical sensors
- Magnetic or Proximity sensors
- Inductive sensors
- Capacitive sensors

Proximity Sensor

Capacitive Sensors





Capacitance exists when two conductive materials (plates) are separated by insulating material

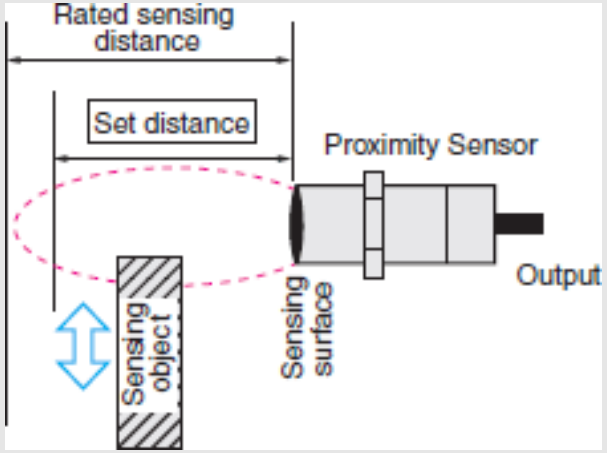
$$C = \varepsilon_0 \varepsilon_r \frac{A}{d}$$

Think, where can you use this sensor in robotics ?

Proximity Sensors

A **proximity sensor** often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal.

Think, where can you use this sensor in robotics ?



Detect absence or presence of an object

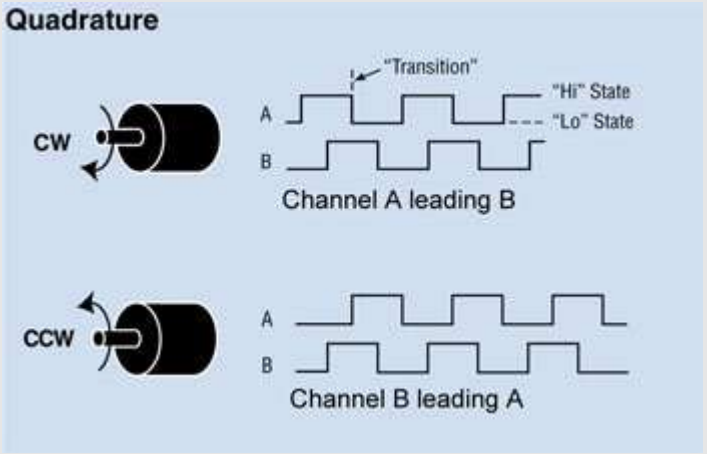
Optical proximity sensors

Measure light reflected from an object

Use incandescent lights or *light-emitting diodes (LEDs)*

Angular Position and Velocity Sensors

- Encoders
  - Incremental Encoders
  - Absolute Encoders



https://www.automationdirect.com/adc/shopping/catalog/sensors_-z-_encoders/rotary_encoders/heavy_duty_incremental_encoders_(quadrature)/trd-gk800-rzd

Other Speed Sensors

- Electronic tachometer

A reflective material is placed on the surface of the rotation portion of the equipment. Light emitted from the tachometer is reflected back when it encounters the reflected material. The photocell on the tachometer converts reflected light energy into electrical signals to measure the speed

Source: Oriental (otdl.com)

Infrared Sensors

- Infrared sensors respond to radiation in the infrared region of the electromagnetic wave. It detect this radiation in darkness and also work for heat control system

Infrared sensors respond to radiation in infrared region spectrum

Flying Robots – Gyroscope

- A **gyroscope** is a device used for measuring or maintaining orientation and angular velocity.
- Gyroscope is used to detect the rotational velocity in all three axes