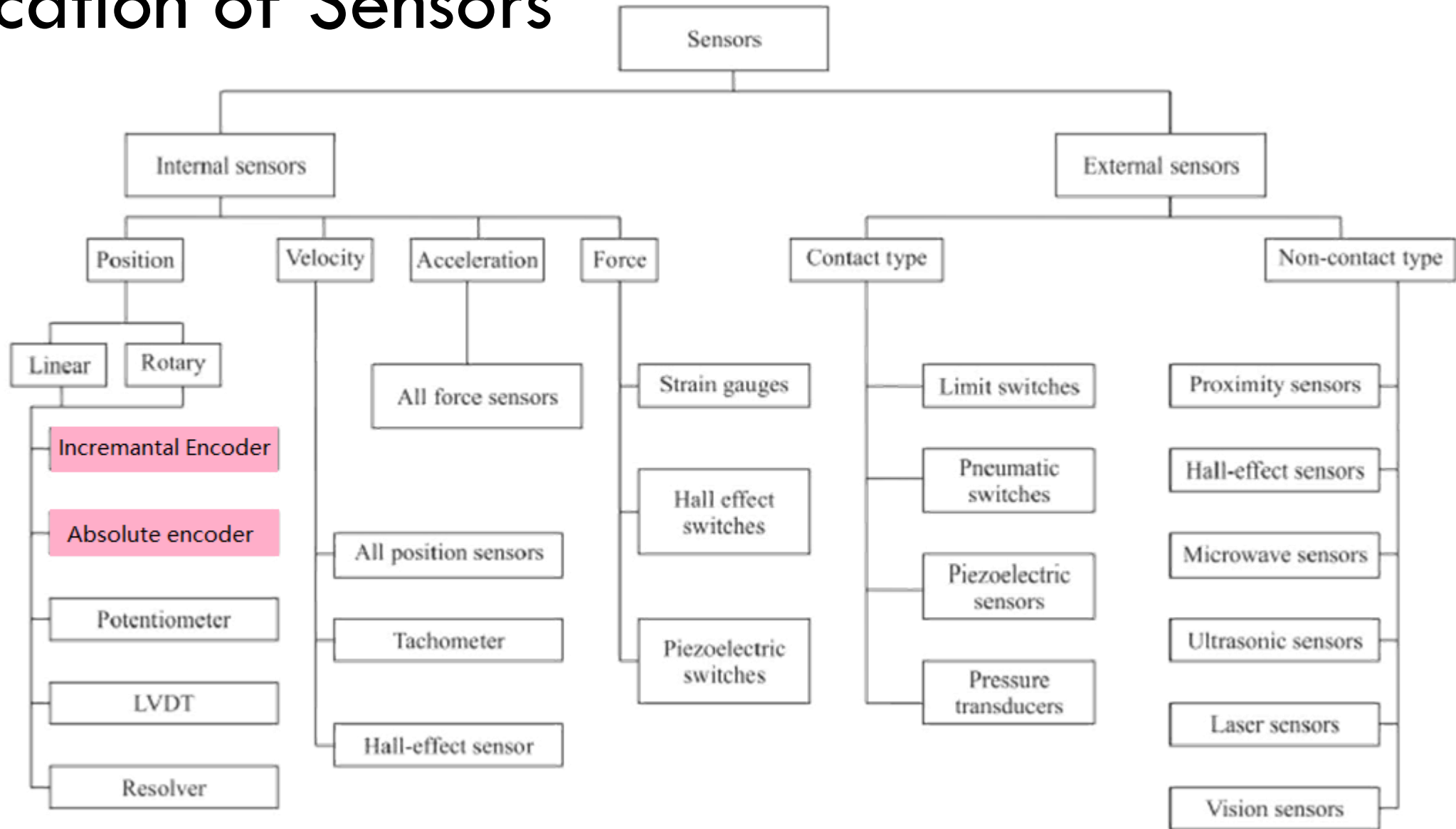




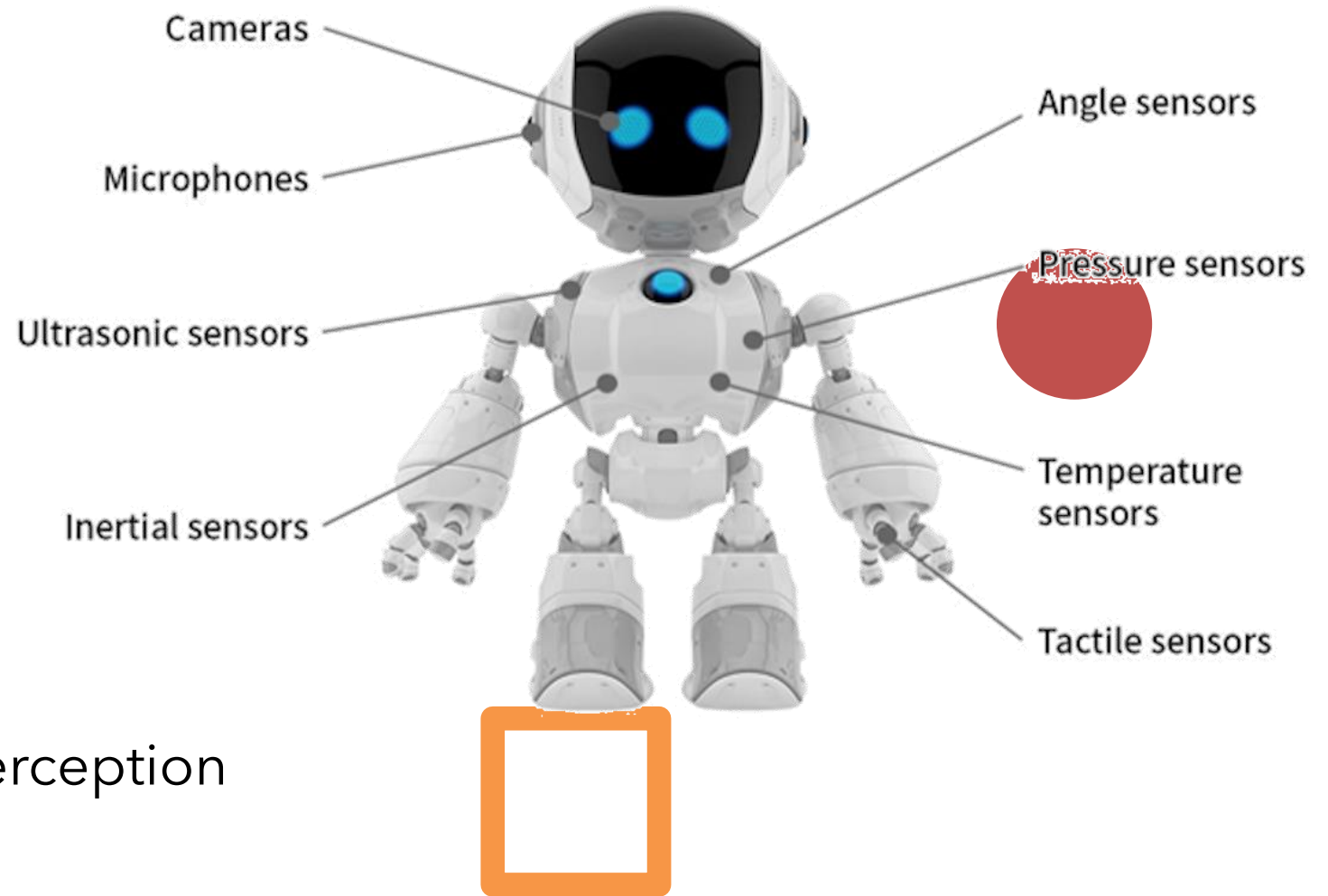
# Perceptions and Sensors

Mustafa Shiple

# Classification of Sensors

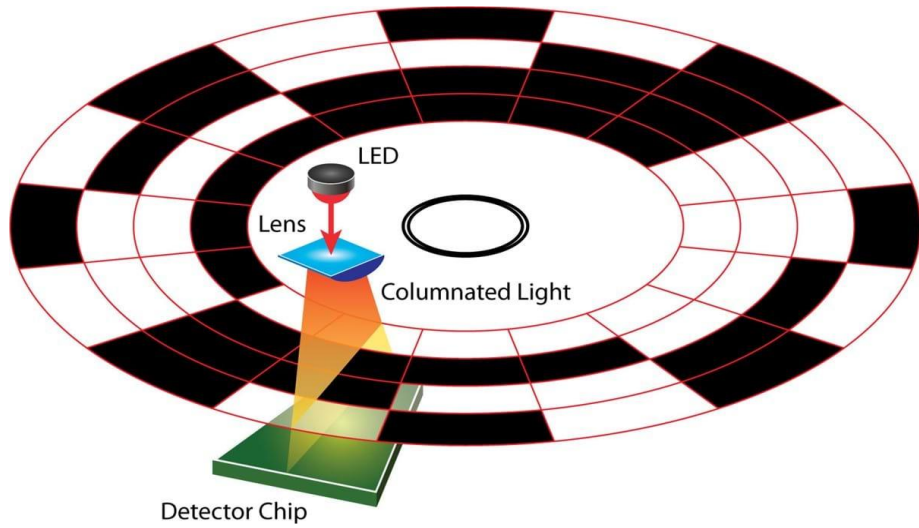


# Introduction



**Proprioception** refers to the perception of internal states of a robot.

**Exteroception**, which describes sensing of anything outside of the robot.



# Encoders

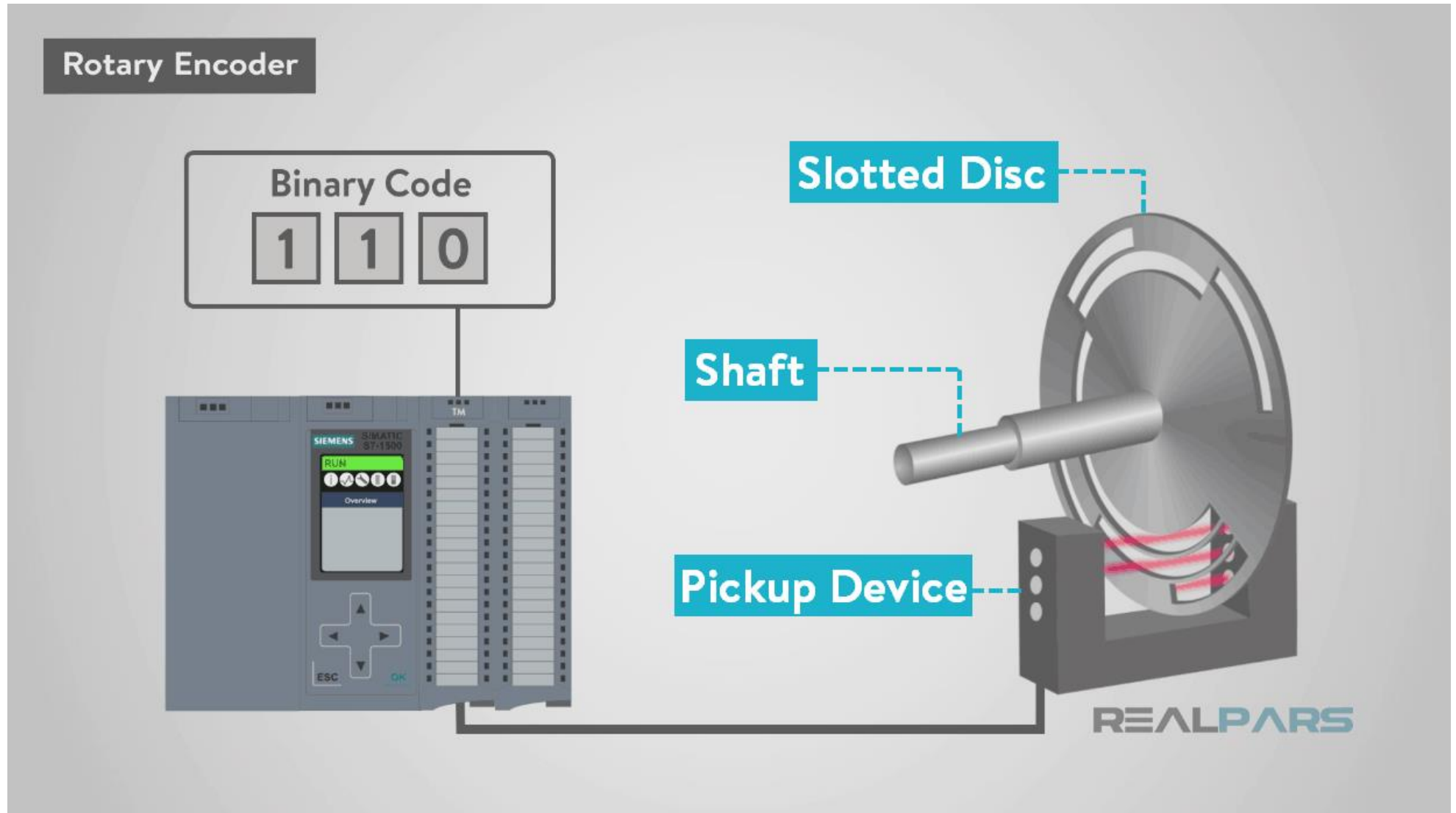
- Encoders can be used for sensing joint position and speed,

## •Type of movement:

- Linear
- Rotary

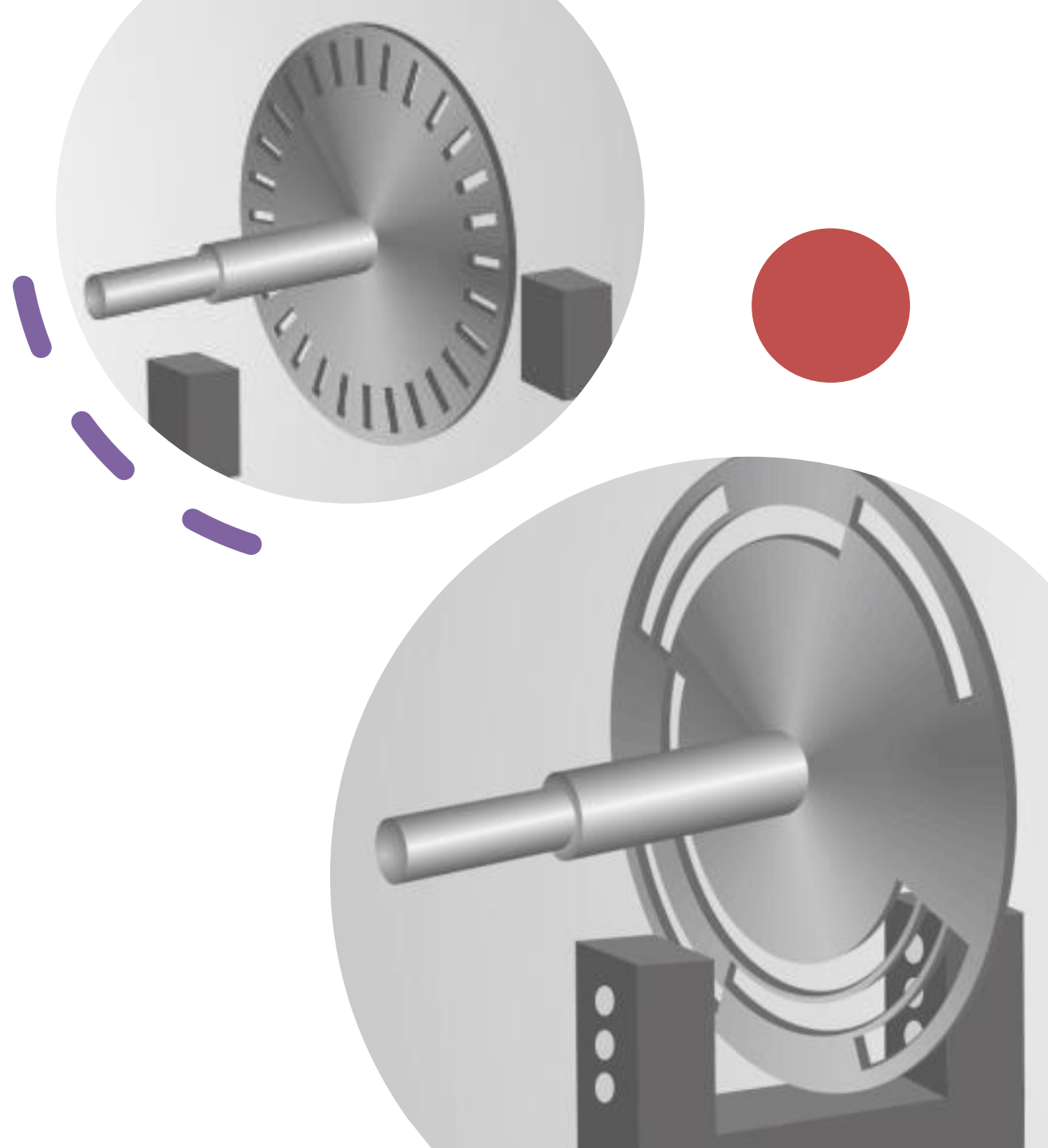


# Rotary encoder



# Encoding principle:

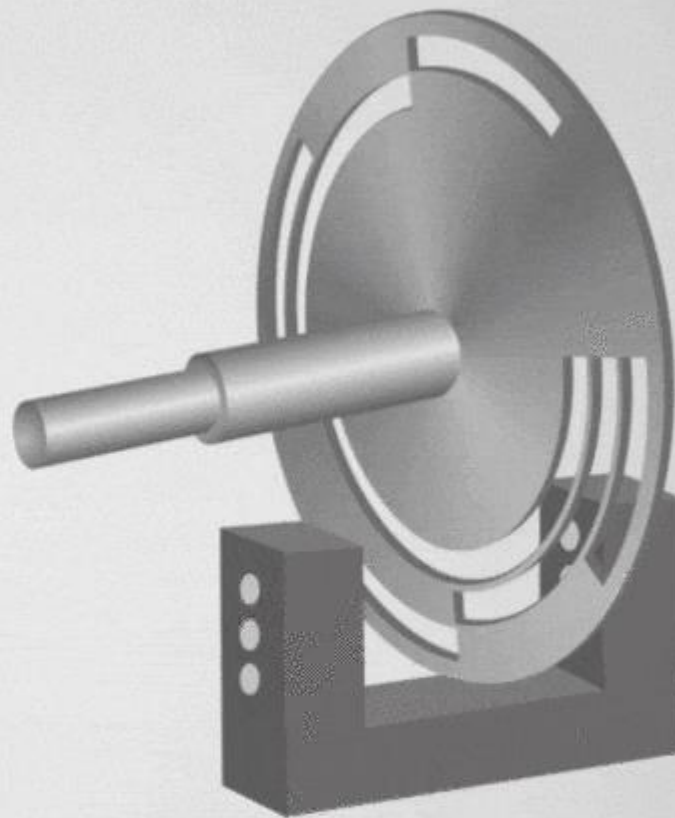
- Incremental
- Absolute



# Absolute Encoder

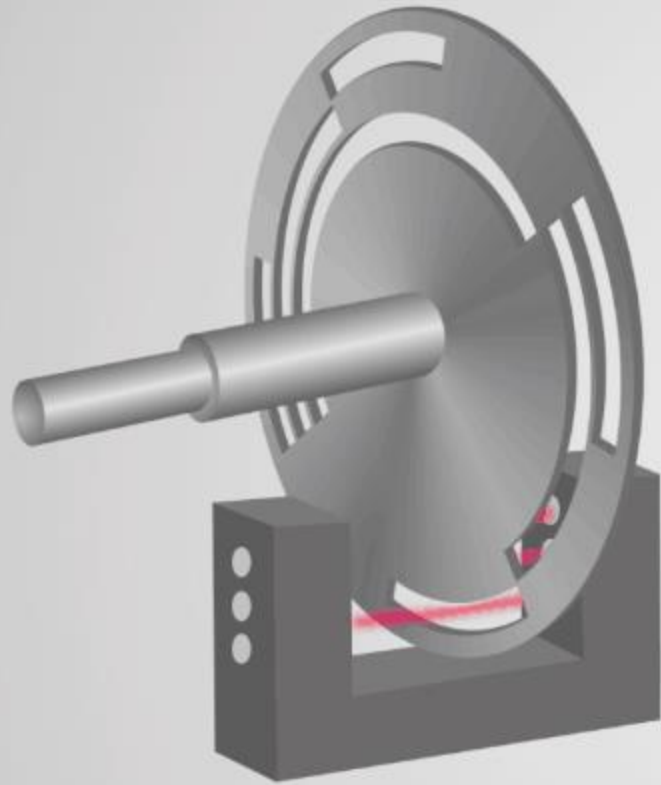
Binary Code  
0 0 0

252°

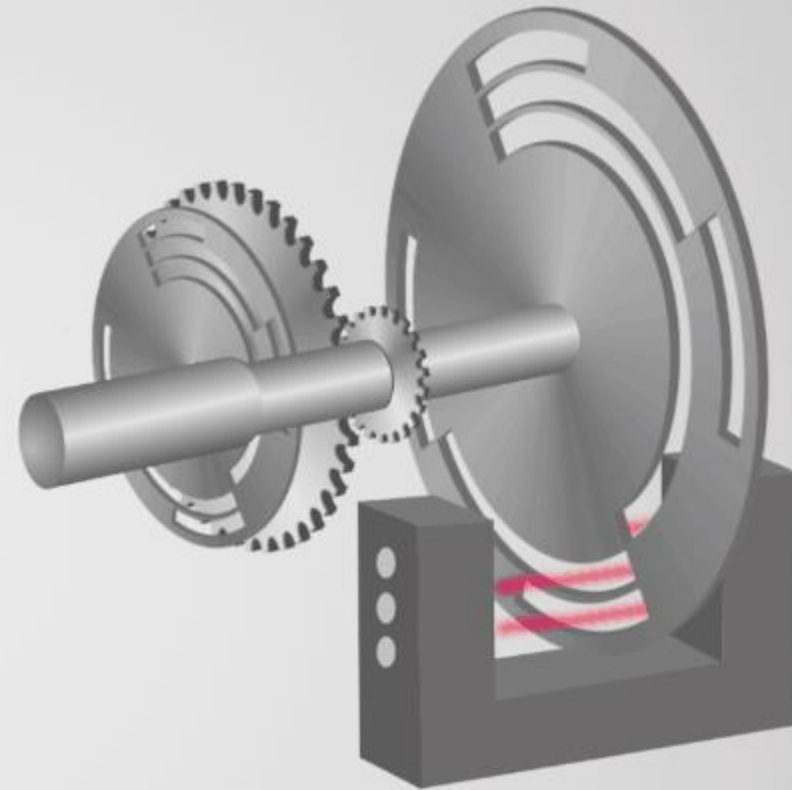


REALPARS

## Absolute Encoder



Single-turn Encoder



Multi-turn Encoder

REALPARS

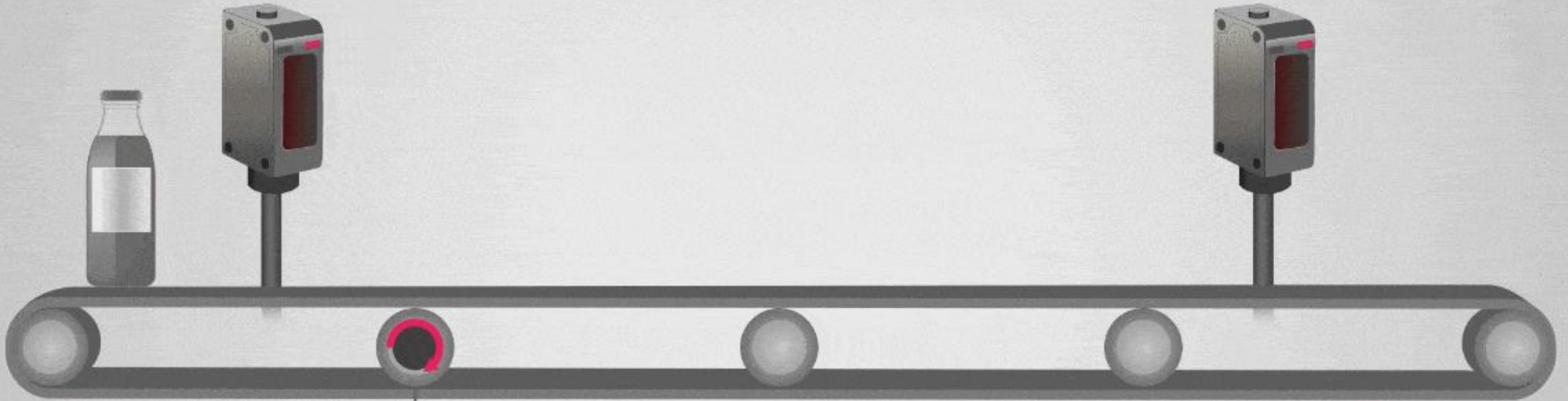


# Incremental Encoders

Standard



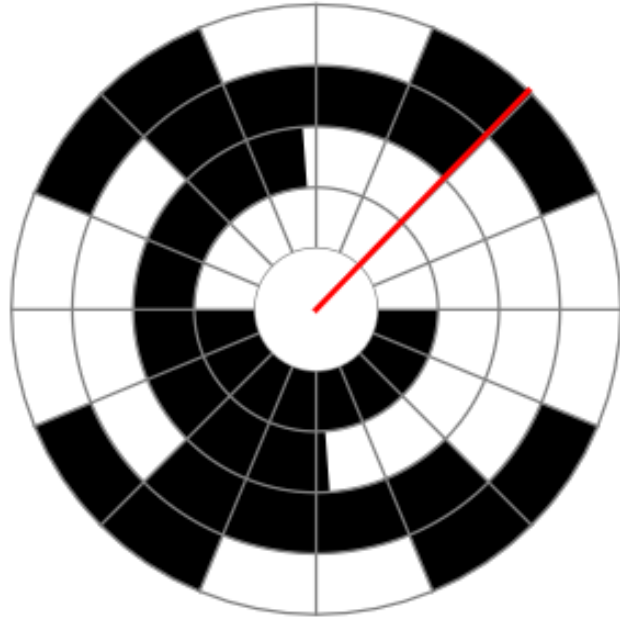
Antifreeze



149

PLC

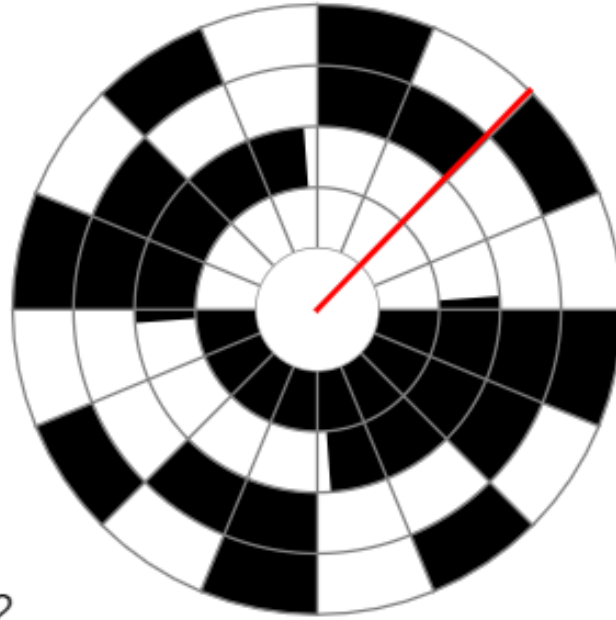
Gray



0011  
Step: 2

Real step: 2

Binary

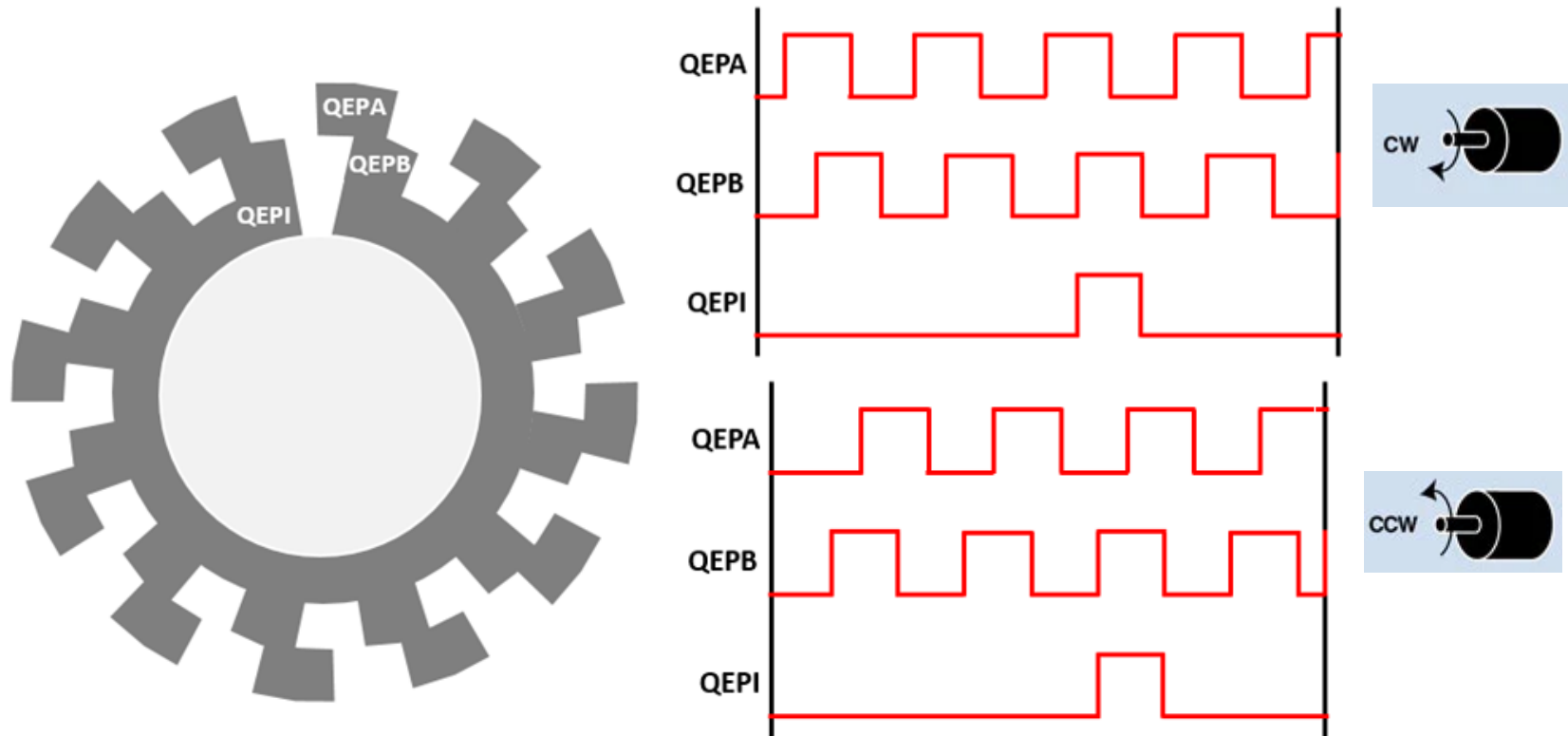


0010  
Step: 2

Decimal	Gray Code	Binary
0	0000	0000
1	0001	0001
2	0011	0010
3	0010	0011
4	0110	0100
5	0111	0101
6	0101	0110
7	0100	0111
8	1100	1000
9	1101	1001
10	1111	1010
11	1110	1011
12	1010	1100
13	1011	1101
14	1001	1110
15	1000	1111

# Quadrature Encoder (Direction Encoders)

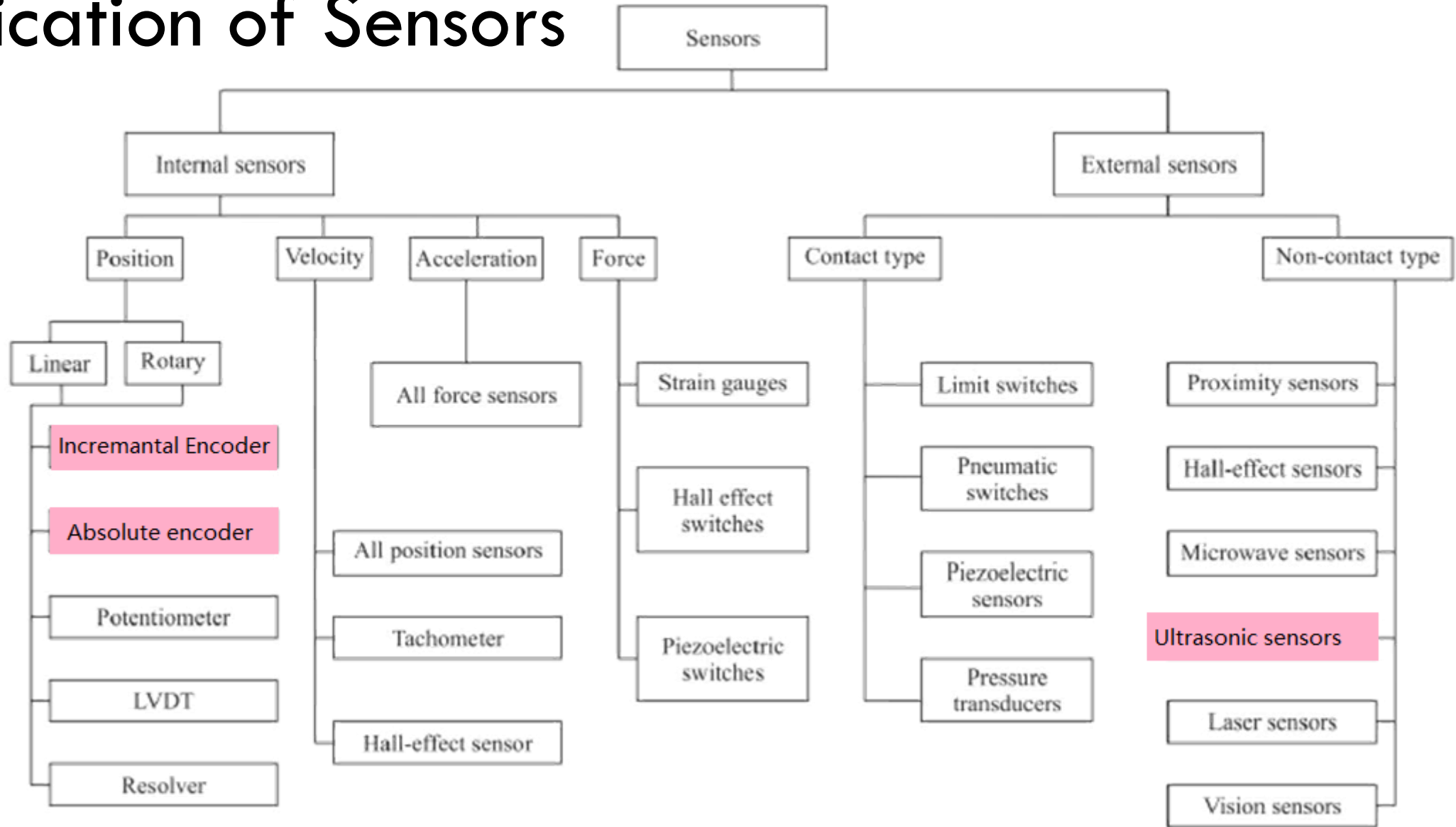
- Incremental Encoder with two out-of-phase output channels





# The Uses Ultrasonics

# Classification of Sensors



# What is sound?

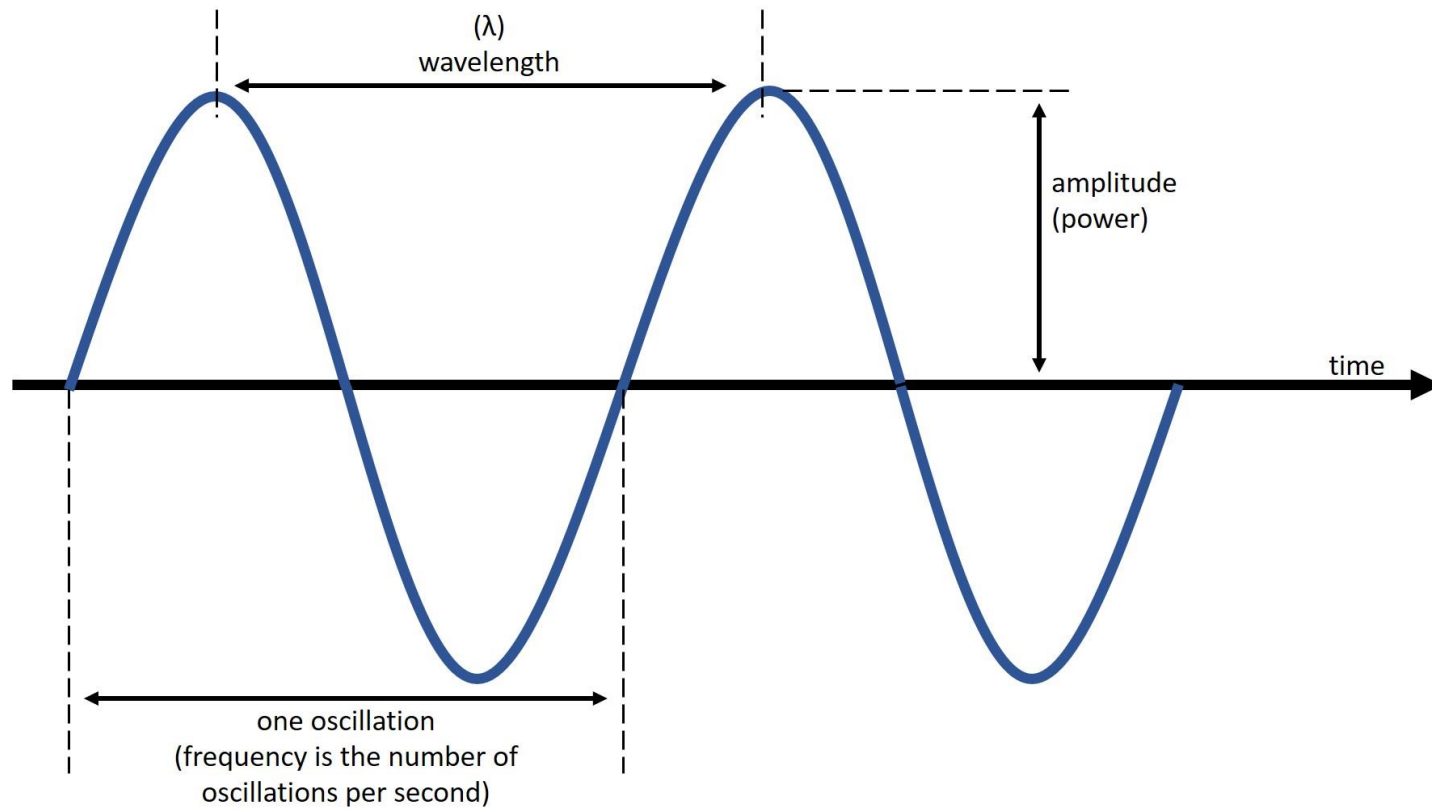
Sound is the movement of energy in vibrations that travel through the air/water as sound waves.

When the vibrations move through air they disturb it causing it to expand and contract.

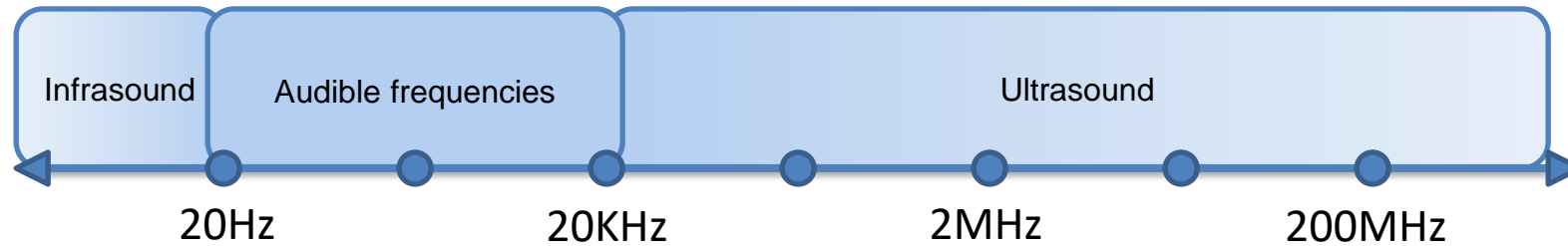
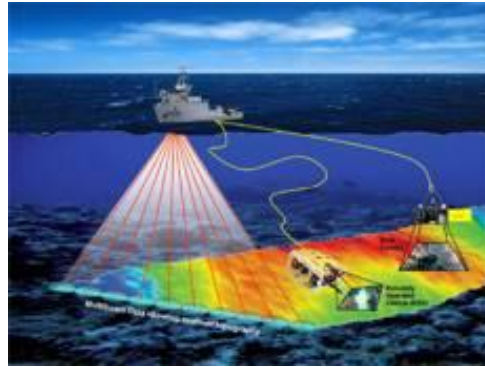
Sound also can bounce off objects, changing the direction and strength of the vibrations.



# Image of a sound wave



# Ultrasonic applications





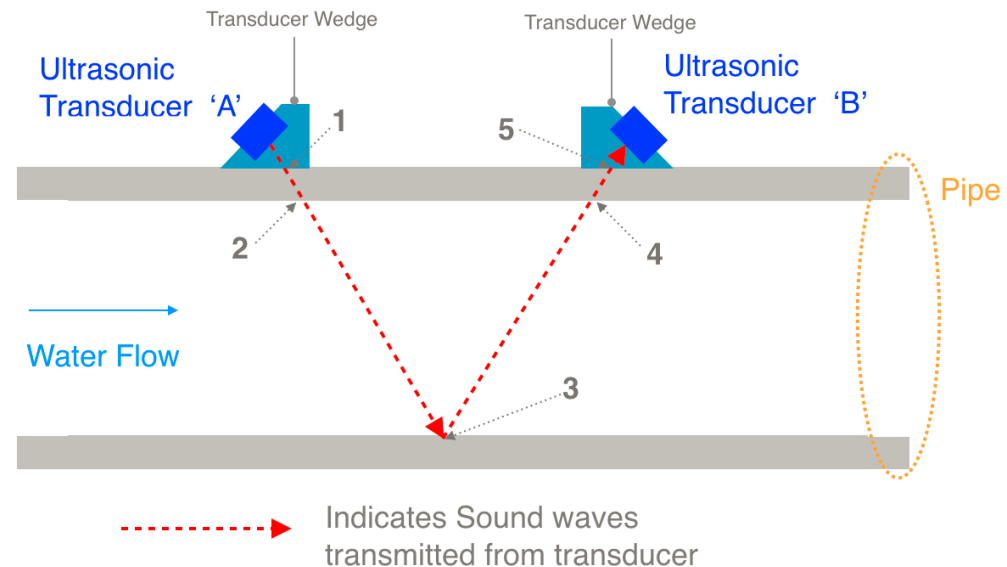
# When sound travels

- As sound travels it can be *reflected*, *refracted*, or *focused*.
- Reflection and refraction occur when the waves interact with a medium of differing properties. Focused sound may use a piece of technology to direct it.
- Sound travels at slower speeds in gases than liquids; it travels the fastest in solids.
  - Sound travels at 343 m/s in air; it travels at 1,484 m/s in water; and at 5,120 m/s in iron.

# Producing ultrasound waves

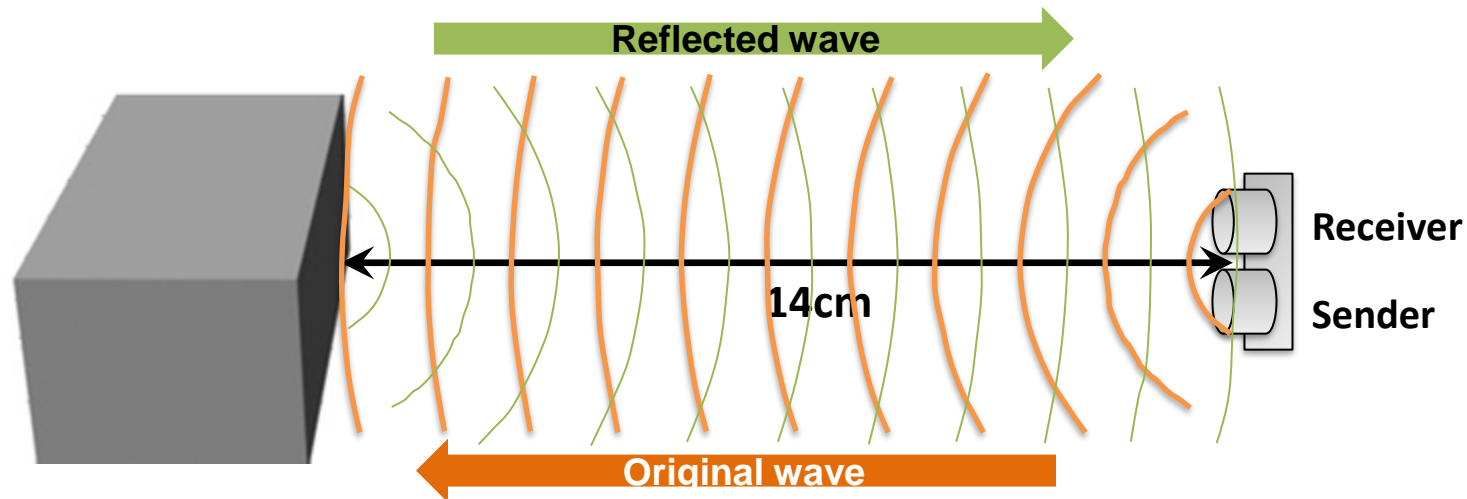
One way to replicate ultrasound wave frequencies is with a transducer.

Depending on the direction, the transducers may be positioned at an angle rather than perpendicular to the object being tested.



# Measuring distance with sound

Ultrasonic waves can be used to accurately measure distances with special sensors.



In air, sound travels at a constant speed, which means we can measure distance by seeing how long it takes for a sound to hit an object and bounce back to the sensor.

# Why use a sensor



Anti-reverse port(JST-XH) for HC-SR04 V2.0

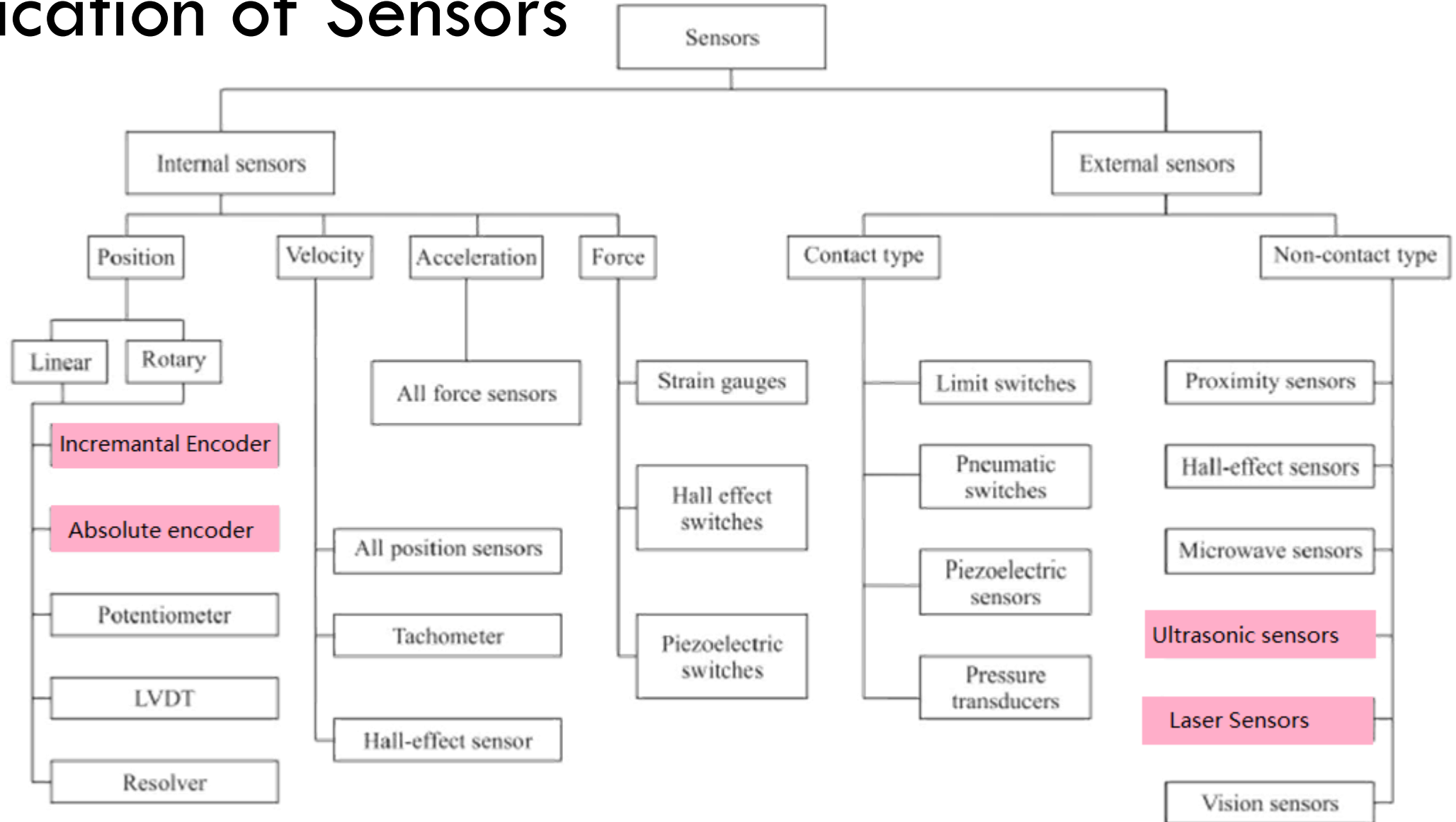


With the use of sensors like the ones above and the use of computer programming, many opportunities are available for humans to accurately measure distance at a faster more reliable pace than our use of a ruler or tape measure.

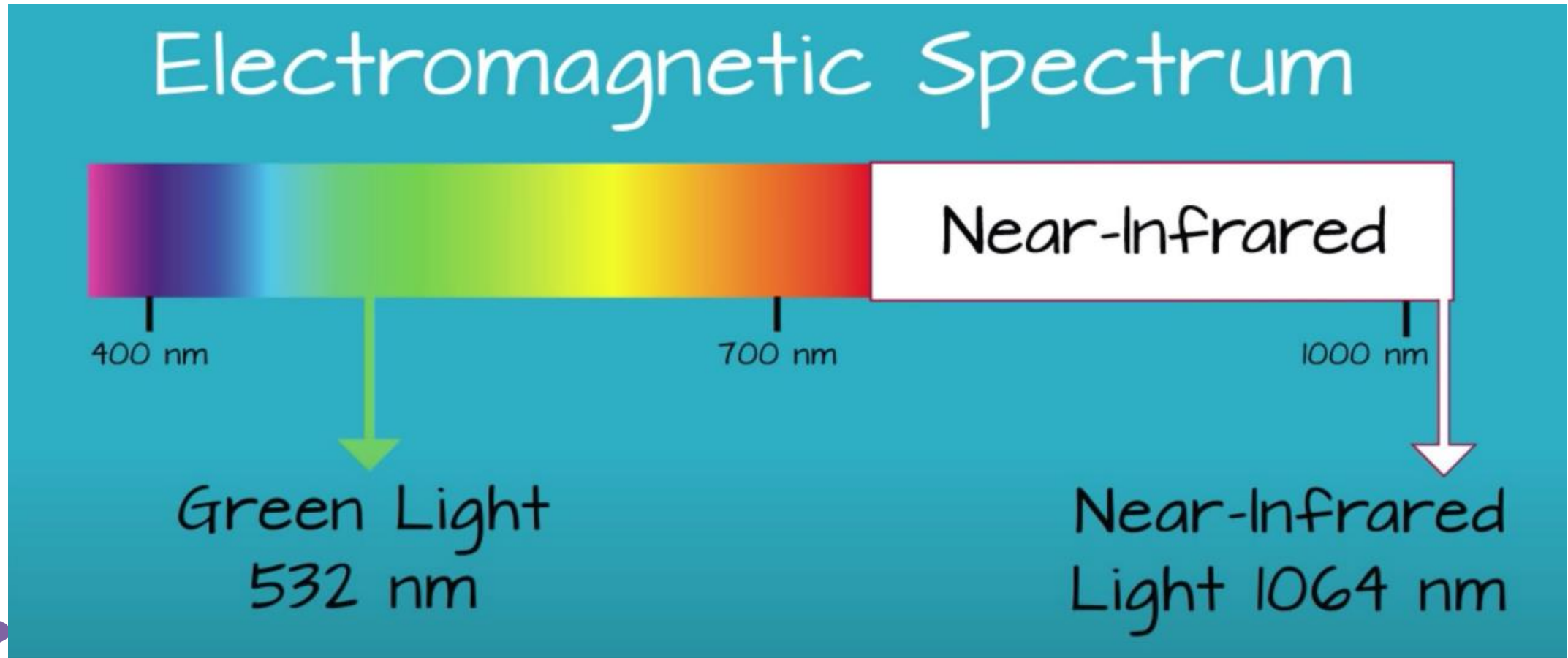


# Light Detection And Ranging (LiDAR)

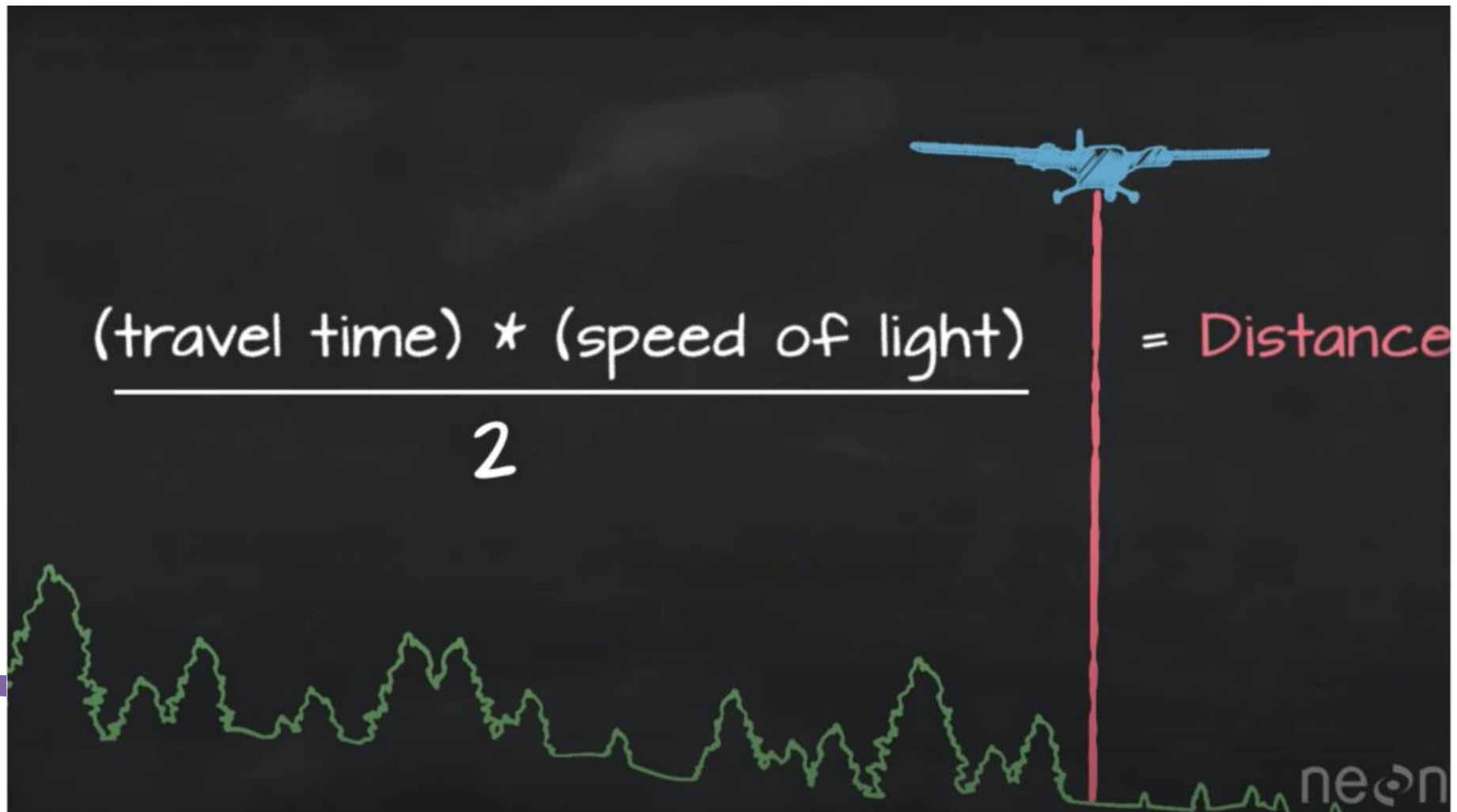
# Classification of Sensors



# LiDAR Wavelength

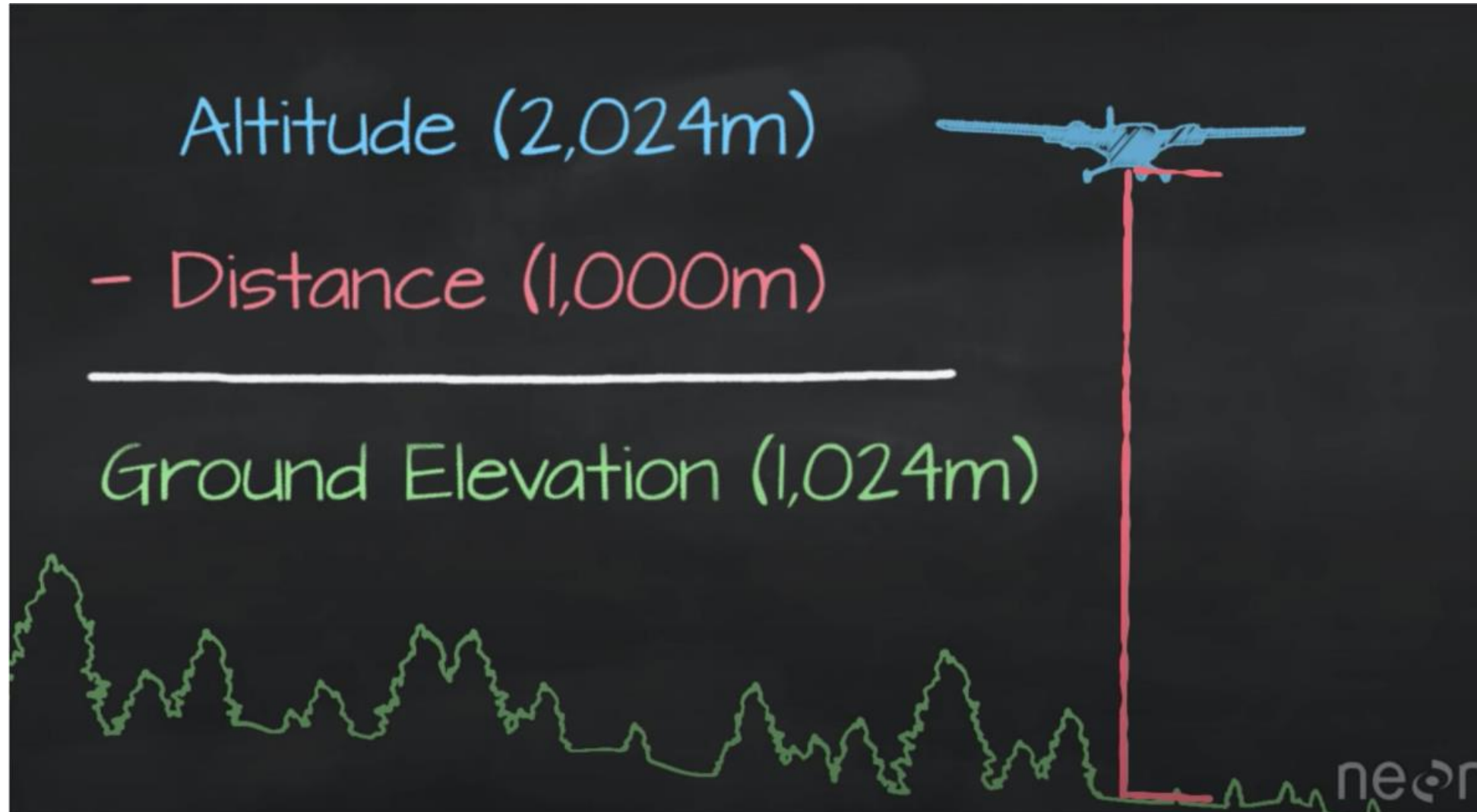


# Light Detection And Ranging(LiDAR)

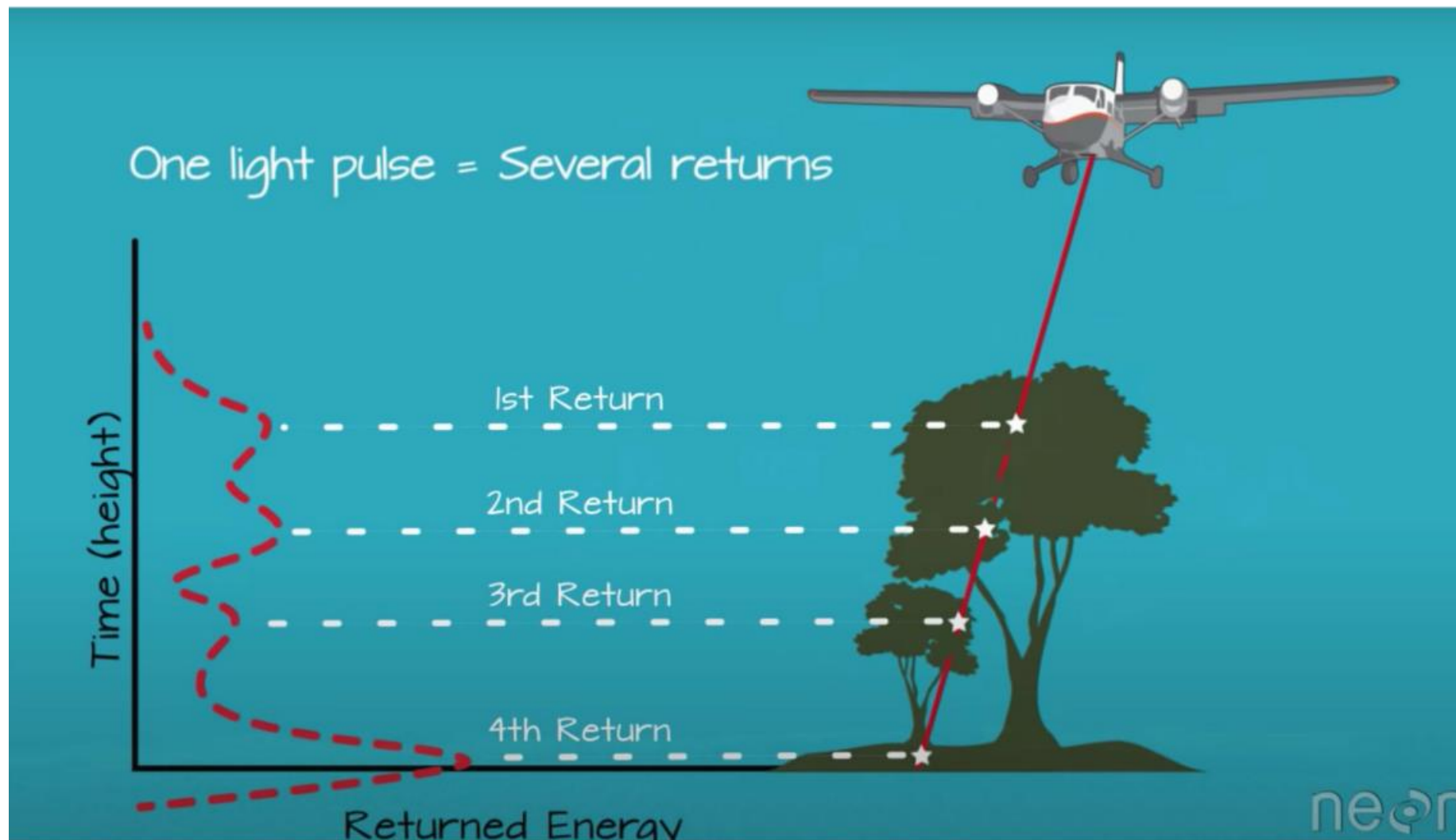




# Calculate distances

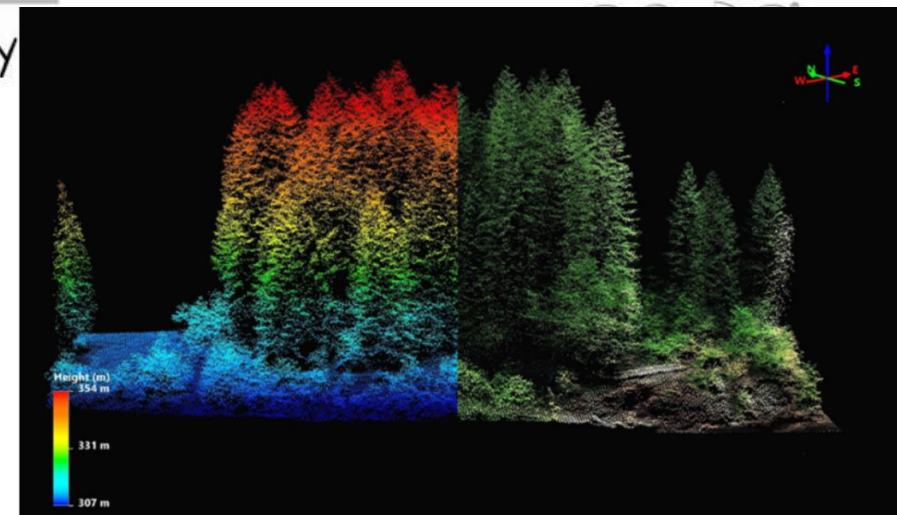
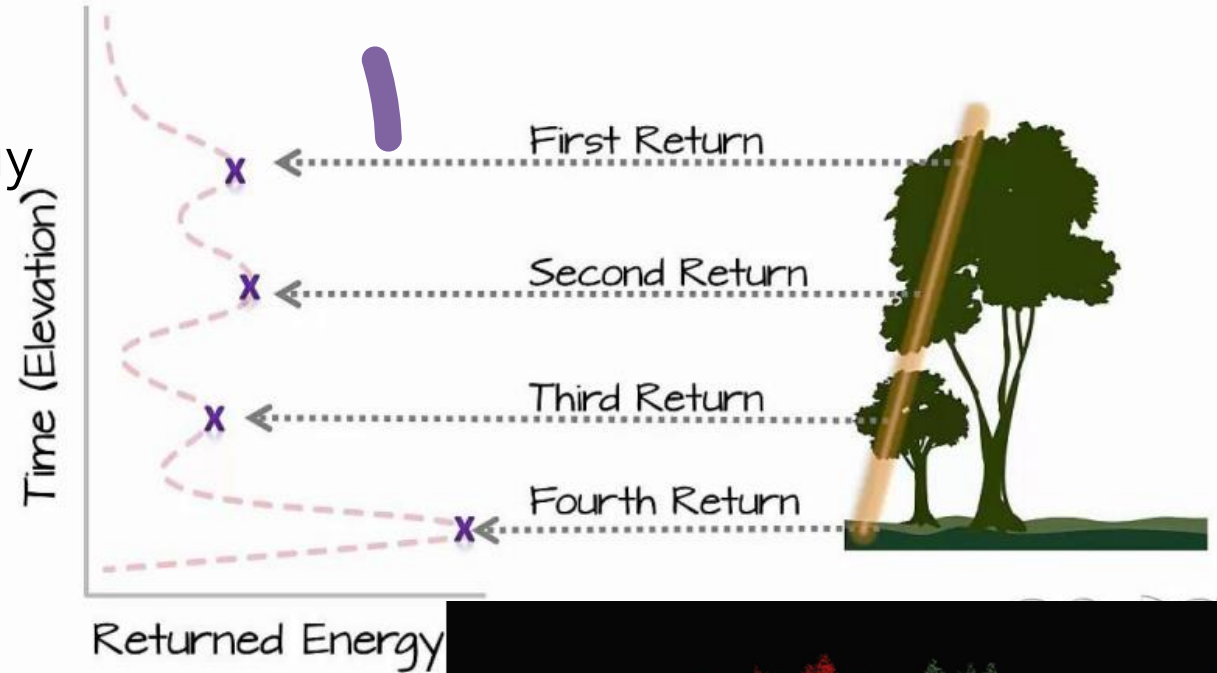


# Multiple echoes (time/GPS based)



# Multiple echoes (Discrete (PLUSES))

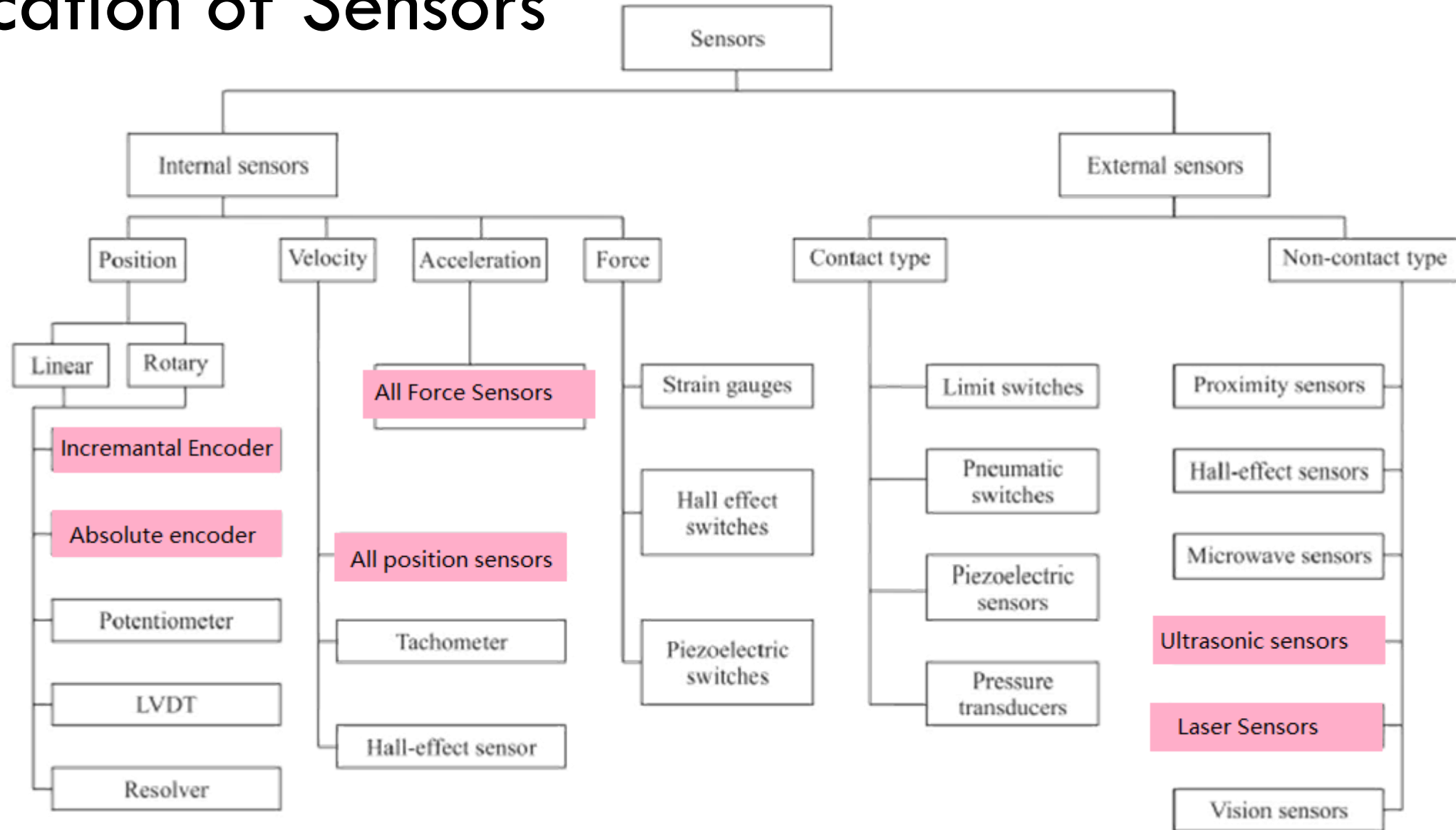
- The pulse represents peaks in energy
- The returned pulse is classified into one or more discrete returns:
  - X, Y, Z intensity
  - Returns are recorded when the intensity exceeds a predefined system threshold.
  - Multiple returns are recorded (usually 1-5). The last returns are especially important for detecting the ground.



The image features a large, solid red circle on the right side, which serves as a background for the text. To the left of this circle, there are several abstract geometric elements: a teal circle, a purple dashed line, an orange square outline, a purple dashed line, and a purple circle. The text "Inertia-based sensors" is written in white, sans-serif font within the red circle.

Inertia-based sensors

# Classification of Sensors



# Accelerometer (g- force)



Accelerometers are electromechanical devices that are able of measuring static and/or dynamic forces of acceleration.



Static forces include gravity, while dynamic forces can include vibrations and movement.



Accelerometers can measure acceleration on 1, 2 or 3 axes



$u = 0 \text{ m/sec}$

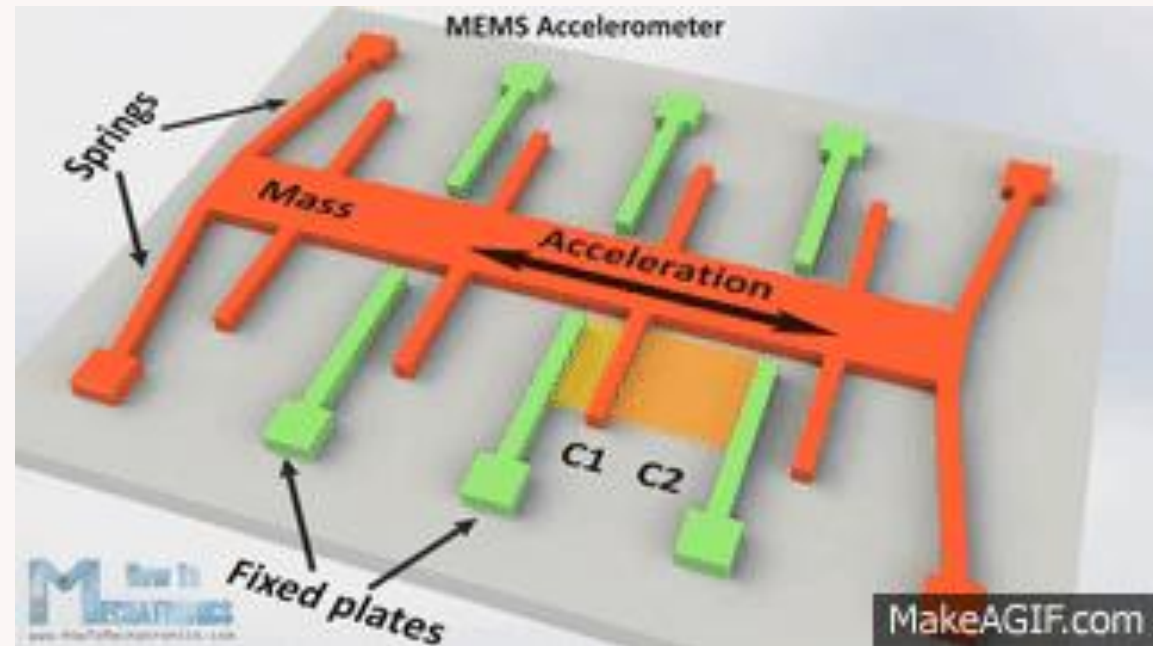
$g = 9.8 \text{ m/sec}^2 = 1 \text{ g}$

# Accelerometer (g- force)

Using mems capacitive type : **micro-electromechanical systems**)

**PROS:**  
+ PCB MOUNTING

**CONS:**  
- LOW ACCURACY



# Accelerometer (g- force)

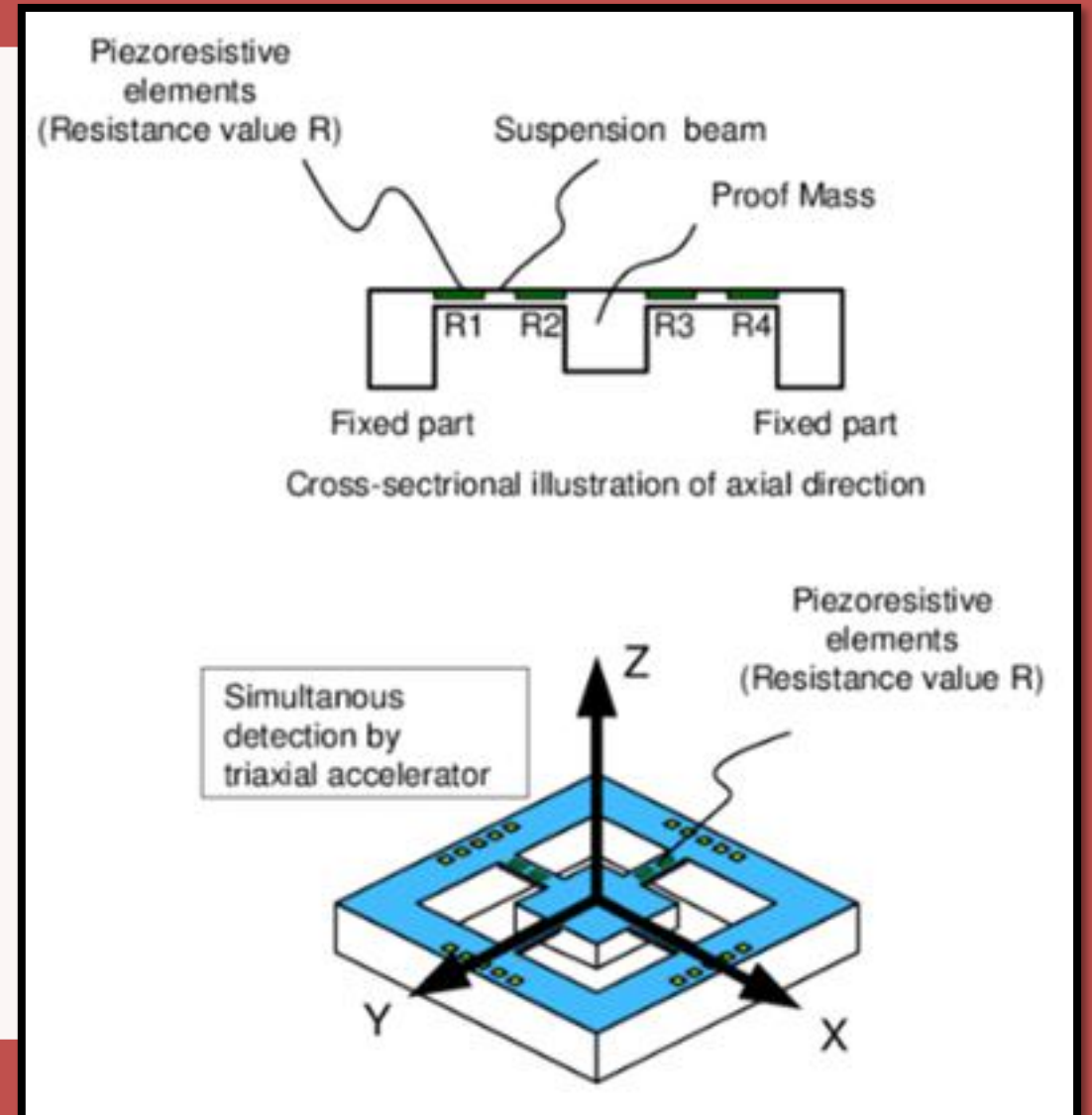
## Using Piezoresistive type :

### PROS

- Wide measurement range
- low frequencies with slow motions detections

### Cons :

- low sensitivity
- affected by environmental changes (temperature / humidity)





# Accelerometer (g- force)

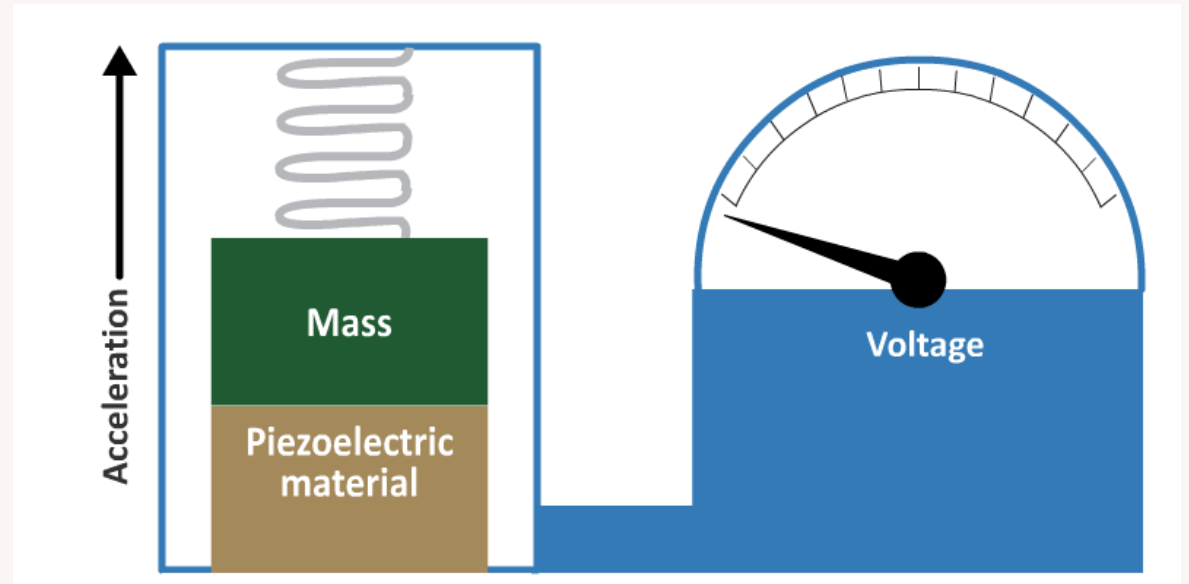
Using Piezoelectric type :

## PROS:

- + HIGH FREQUENCY
- + HIGH TRANSIENT RESPONSE
- + HIGH OUTPUT

## CONS:

- LOW OUTPUT
- HIGH IMPEDANCE
- HARDER TO PRODUCE



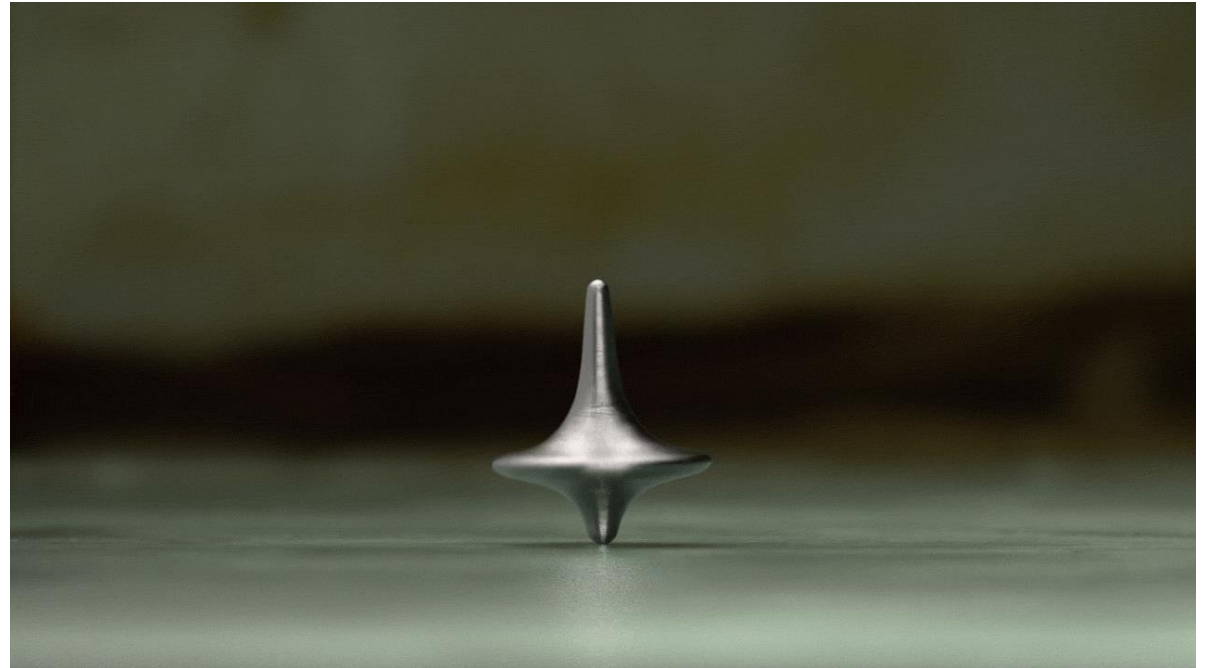


Gyroscope

# background

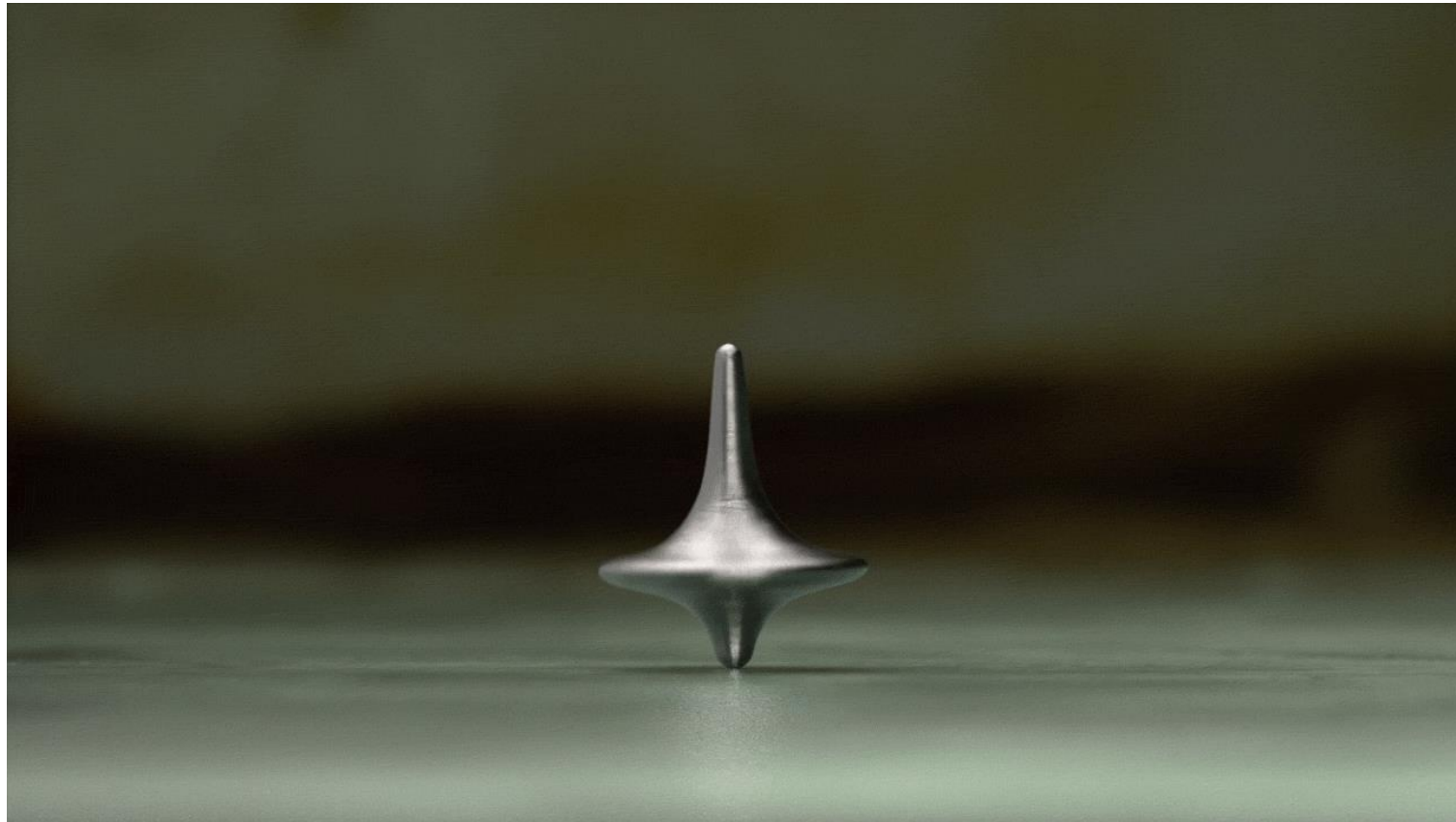
*Angular momentum is defined as:*

The property of any rotating object given by moment of inertia times angular velocity.

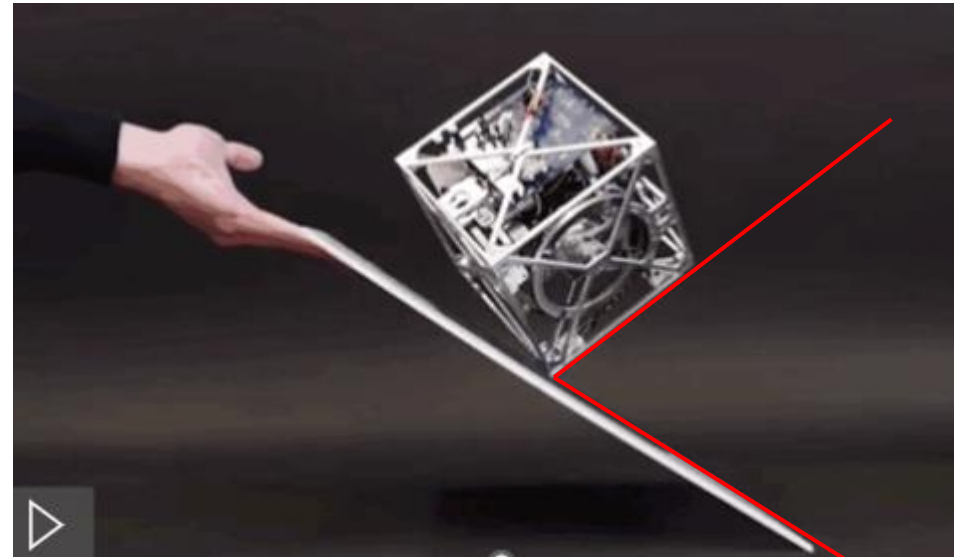
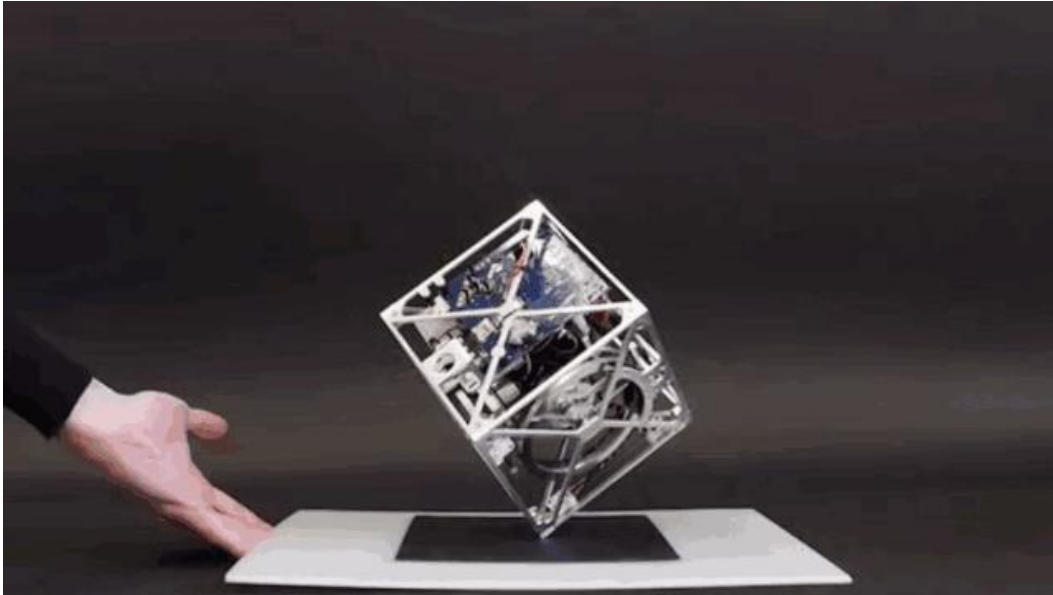


# What is the gyroscope

*The device has a spinning disc mounted on the base so that it can move freely in more than one direction so that the orientation is maintained irrespective of the movement in the base.*



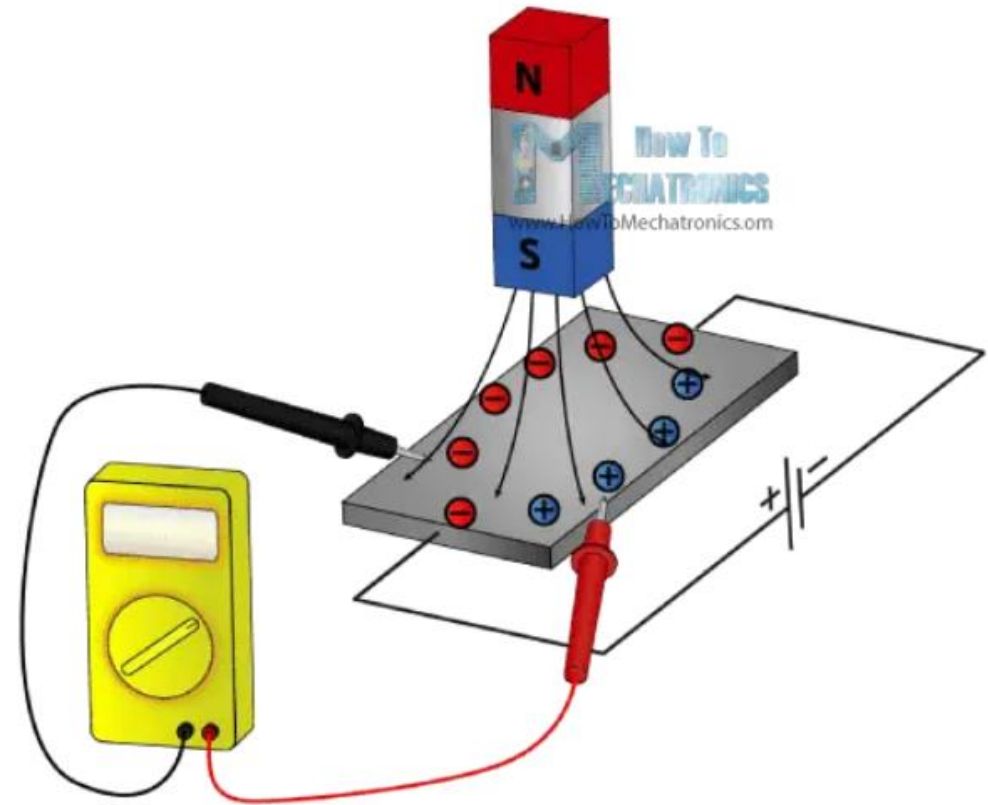
# 3D Gyroscope (types)



1. mechanical gyroscopes,
2. fiber-optic gyroscopes (FOGs),
3. ring laser gyroscopes (RLGs),
4. quartz/MEMS gyroscopes

# MAGNETOMETER

- A magnetometer is a type of sensor that measures the strength and direction of a magnetic field.



# WHAT IS AN INERTIAL MEASUREMENT UNIT?

- An Inertial Measurement Unit (IMU) is a device that can measure and report specific gravity and angular rate of an object to which it is attached.
  - ❑ Gyroscopes: providing a measure angular rate
  - ❑ Accelerometers: providing a measure specific force/acceleration
  - ❑ Magnetometers (optional): measurement of the magnetic field surrounding the system



Thank you