# CENG2030 FUNDAMENTALS OF EMBEDDED SYSTEM DESIGN

# LECTURE 9: SENSOR AND ACTUATOR

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1

1

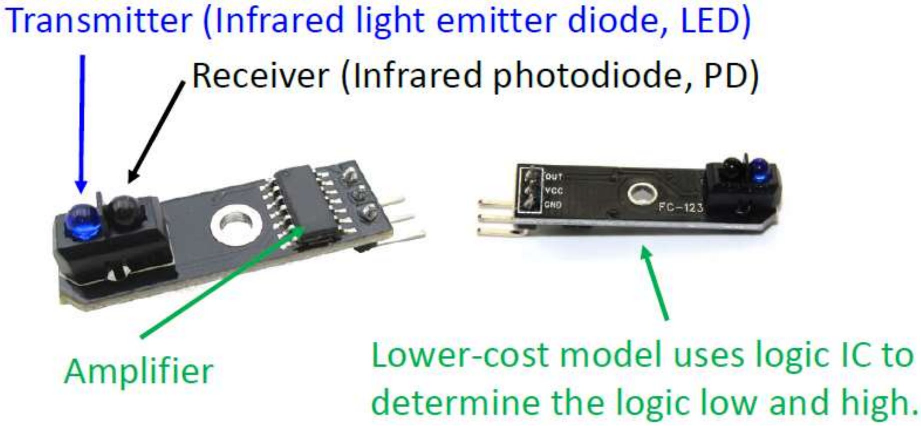
# CONTENTS

- Common Sensors
  - IR Sensor
  - Ultrasound Sensor
  - Photoresistor
  - LIDAR
  - IMU
- Common Actuators
  - D.C. Motor
  - Servo Motor

2

2

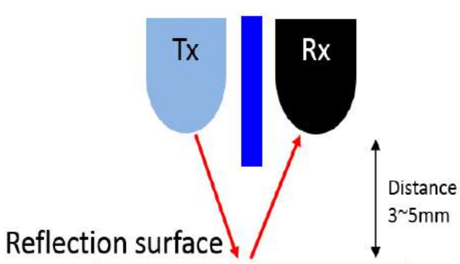
# IR SENSOR




3

3

# IR REFLECTIVE SENSOR

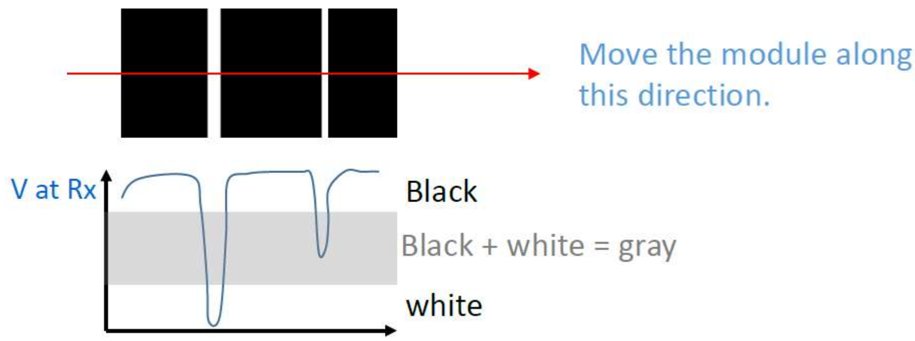



- The reflected light intensity depends on:
  - The reflectivity of the surface
  - The distance
- "White" surface reflects more light than "Black" or empty space

4

4

# IR SENSOR IN ACTION




5

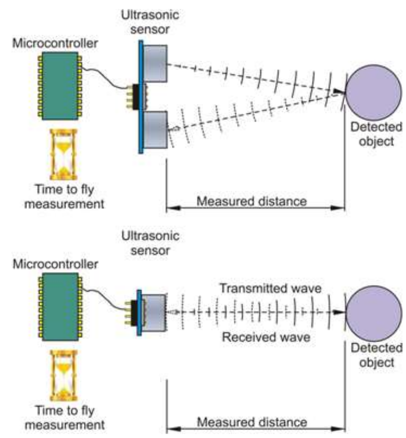
5

# LONG RANGE IR SENSOR

6

6

# ULTRASOUND SENSOR




7

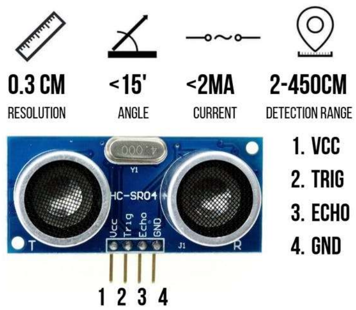
# ULTRASOUND SENSOR

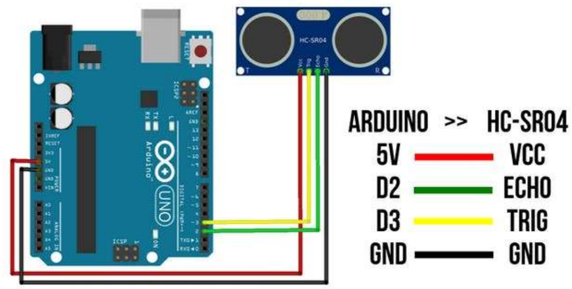
- An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves.
- An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity.
- High-frequency sound waves reflect from boundaries to produce distinct echo patterns.



8

# APPLICATION OF ULTRASOUND SENSOR

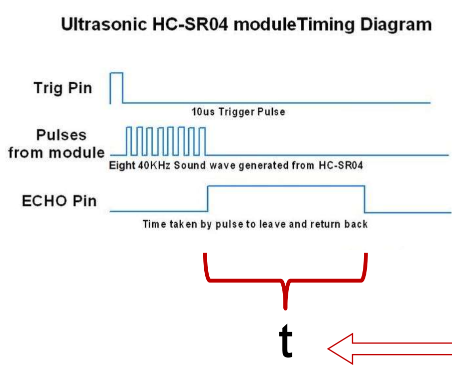


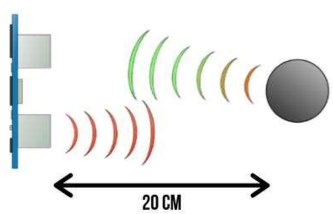








# APPLICATION OF ULTRASOUND SENSOR



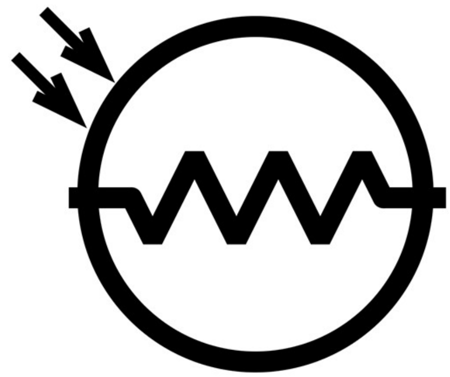




Speed of Sound:
v = 343 m/s
v = 34.3 cm/ms

Time = Distance/Speed:
t = s/v
t = 40/34.3 = 1.166ms

s = vt/2
s = 34.3(1.166ms)/2
s = 20cm

# PHOTORESISTOR



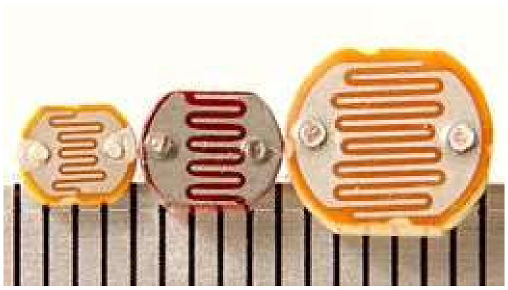
11

11

# PHOTORESISTOR

- Photoresistor is also called
  - Light Decreasing Resistance (LDR)
  - Light-dependent resistor
  - Photo-conductive cell

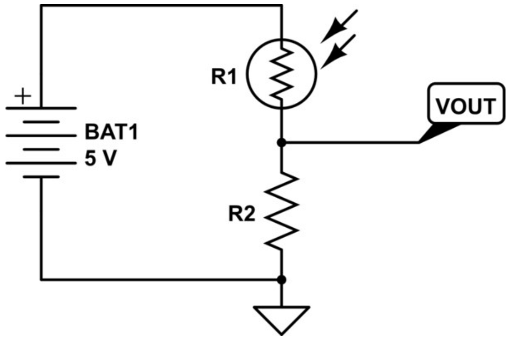
- Photoresistor is a passive component that decreases resistance with respect to receiving luminosity (light) on the component's sensitive surface.

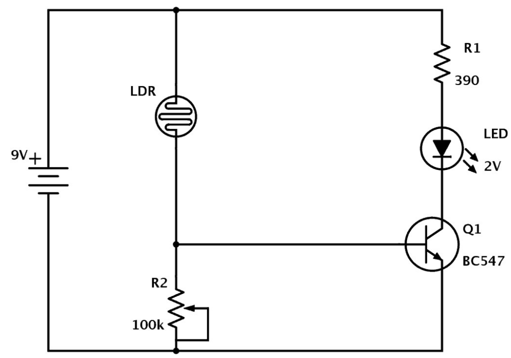


12

12

# SAMPLE CIRCUIT OF LDR



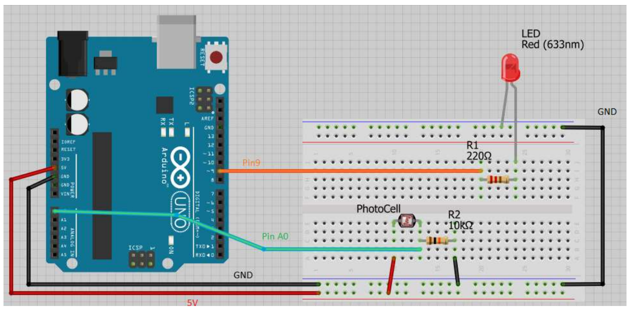




13

13

# ARDUINO WITH LDR

- The output pin of the LDR circuit is connected to the A0 of Arduino UNO board
- A0 is one of the analog input pin




14

14

# ARDUINO WITH LDR

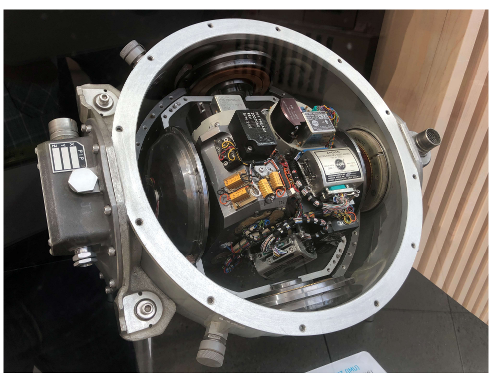
```
// IO Ports
const int pResistor = A0;
const int ledPin = 9;

//Photoresistor value from 0 to 1023
int value;

void setup(){
  pinMode(ledPin, OUTPUT);
  pinMode(pResistor, INPUT);
}
```

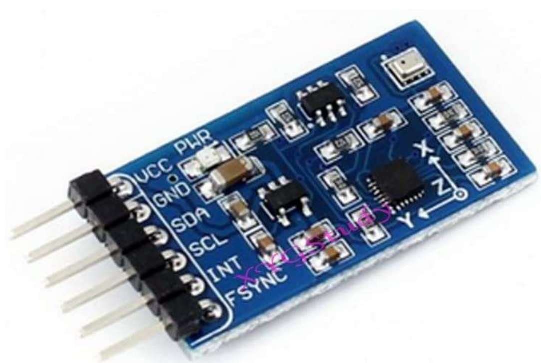
```
void loop(){
  value = analogRead(pResistor);

  //You can change value "25"
  if (value > 25){
    //Turn led off
    digitalWrite(ledPin, LOW); }
  else{
    //Turn led on
    digitalWrite(ledPin, HIGH); }

  delay(500);
}
```

15

15

# IMU



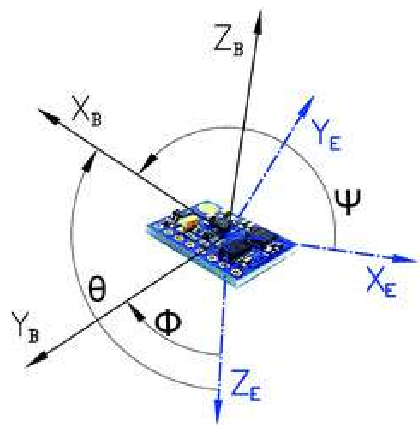



16

16

# IMU

- IMU stands for Inertial Measurement Unit
- IMU contains sensors such as accelerometers, gyroscopes, and magnetometers
  - Accelerometer measures velocity and acceleration
  - Gyroscope measures rotation and rotational rate
  - Magnetometer establishes cardinal direction (directional heading)




17

17

# APPLICATIONS OF IMU

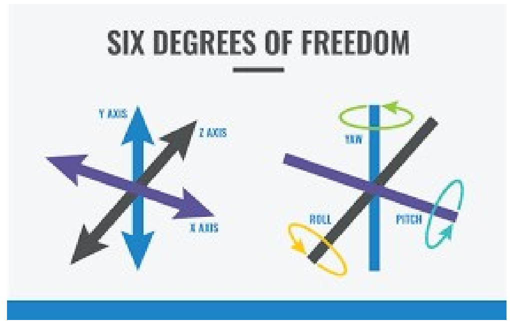
- Navigation
  - Manned and unmanned aircraft: IMU's measurements to calculate altitude and relative position to a reference frame, making them exceedingly useful in aircraft applications.
  - GPS positioning systems: IMUs serve as a supplement to GPS positioning systems, allowing the navigational device to continue with an estimated position and heading if it loses satellite connection.

18

18

# APPLICATIONS OF IMU

- Motion detection
  - Most smartphones, tablets and fitness tracking devices contain a low-cost IMU
  - IMUs are involved in sports training applications that need to measure, for example, the precise angle and force of a swing in golf or baseball.
  - IMUs drive the self-balancing systems of personal transportation devices like Segways and hoverboards.




19

19

# DISADVANTAGES OF IMU

- The principal disadvantage of an IMU is that they are prone to error that accumulates over time, also known as "drift."
  - Because the device is always measuring changes relative to itself, the IMU constantly rounds off small fractions in its calculations, which accumulate over time. Left uncorrected, these tiny imprecisions can add up to significant errors.

- Still, when coupled with a corrective technology or a human operator, IMUs can be a beneficial supplement to other sensors. In precision applications, you can suspend the sensors from shock absorbers to mitigate errors as well as protect the unit.

20

20

# ACTUATOR

21

21

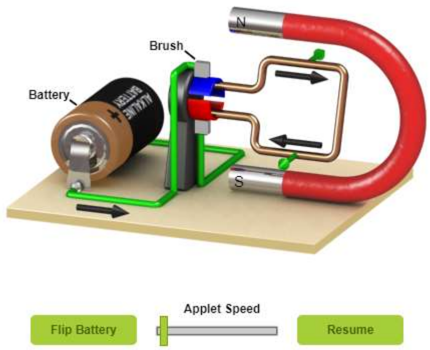
## DC MOTOR

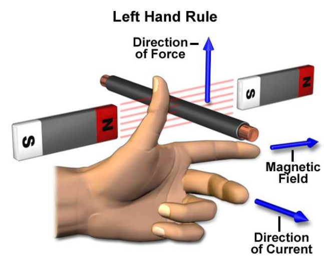
22

22

# DC MOTOR WORKING PRINCIPLE

- Online simulator of DC motor [Source: MagLab]
  - https://nationalmaglab.org/education/magnet-academy/watch-play/interactive/dc-motor




23

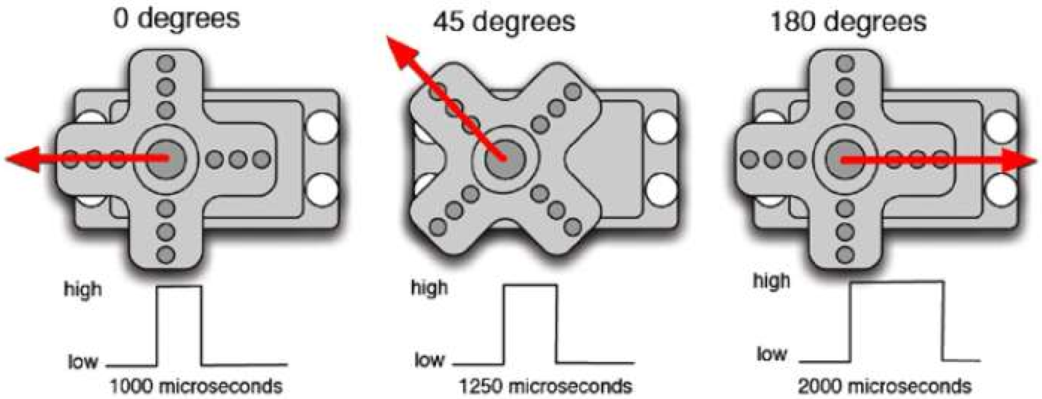
23

# SERVO MOTOR


24

24

# SERVO MOTOR BY PWM



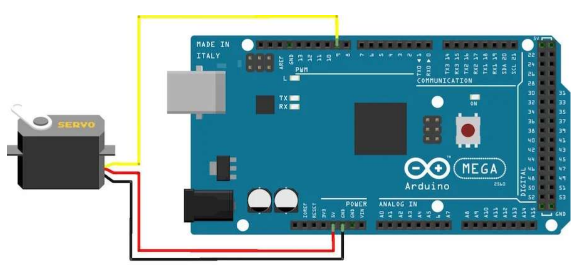

25

25

# ARDUINO WITH SERVO

- There are normally 3 pins on a servo motor
  - Vcc for 5V
  - GND for Ground
  - PWM for Pulse Width Modulated signal

- PWM pin is connected to one of the **digital output** pin of Arduino




26

26

# ARDUINO WITH SERVO

```
#include <Servo.h>

Servo myservo;

int angle=0;

void setup()
{
  // attach servo at pin 9
  myservo.attach(9);
}
```

```
void loop()
{
  for(angle=0; angle<180; angle+=1)
  {
    myservo.write(angle);
    delay(15);
  }

  delay(1000);

  for(angle=180; angle>0; angle-=5)
  {
    myservo.write(angle);
    delay(5);
  }

  delay(1000);

}
```

Note: For Arduino Uno, Nano, & Mini, only Pin 3, 5, 6, 9, 10, & 11 can be used for PWM output.

27

27

# ANY QUESTIONS ?

28

28