Robotic and Intelligent System Lab

Jacobs University Bremen
Instructor: Fangning Hu

Smart System

Sensors

- Examples of sensors from biology: the human body
  - eyes: capture optical information (light)
  - ears: capture acoustic information (sound)
  - nose: captures olfactory information (smell)
  - skin: captures tactile information (temperature, texture)

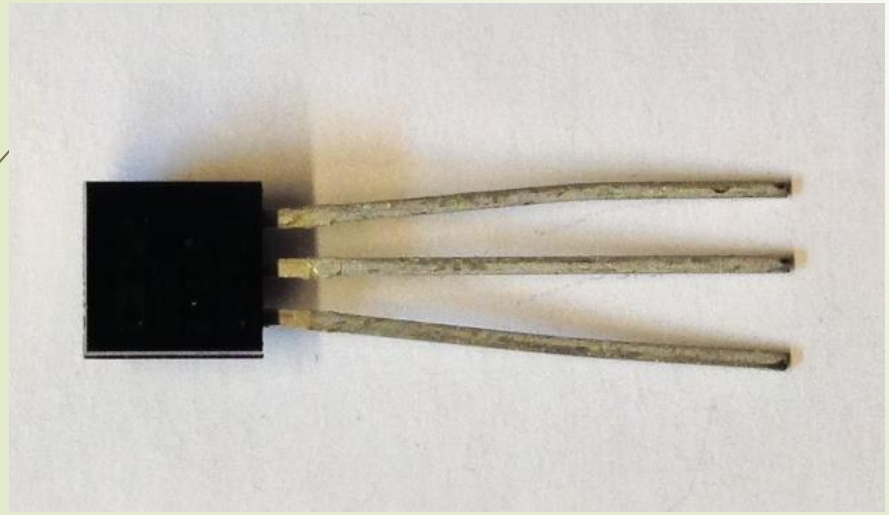
Then convert gathered information into electro-chemical impulses in neurons.

Functions of the Brain

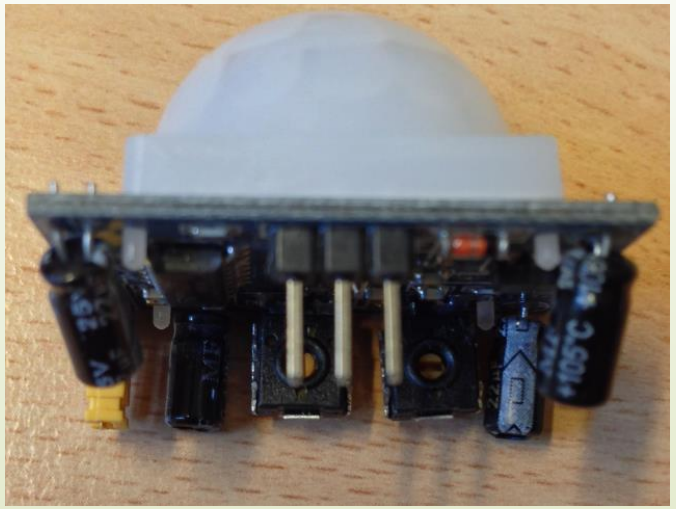
- Read in sensor data
- Memory to store data
- Logic operation and computation
- Control the body (arms, legs, etc.)

Sensors in electronic world

- object converting one form of energy in the physical world into electrical energy



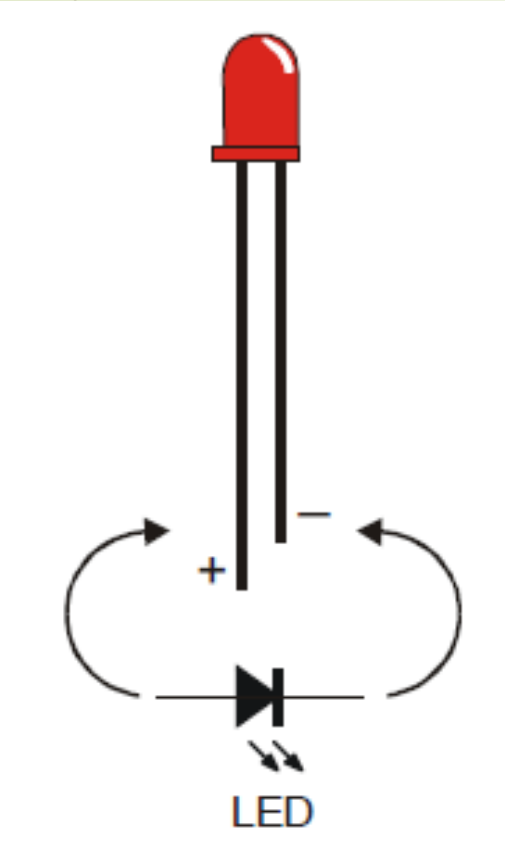
Temperature Sensor



Infra-Red Sensor

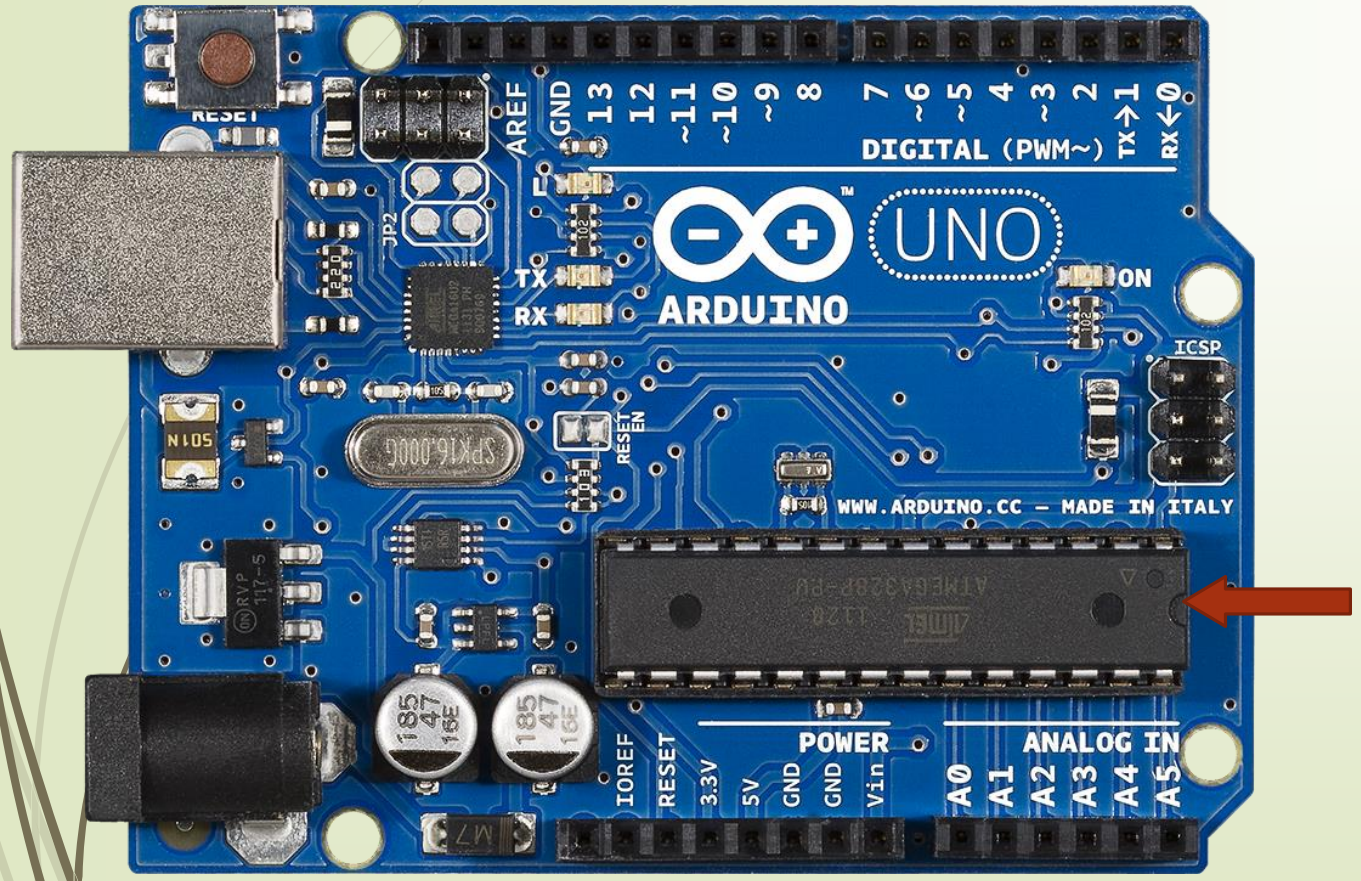
Convert temperature and Infra-Red light to voltages: 1.5V, 5V, …

Actuators (arms, legs, etc.)



Servo Motor

Microcontroller



Functions:

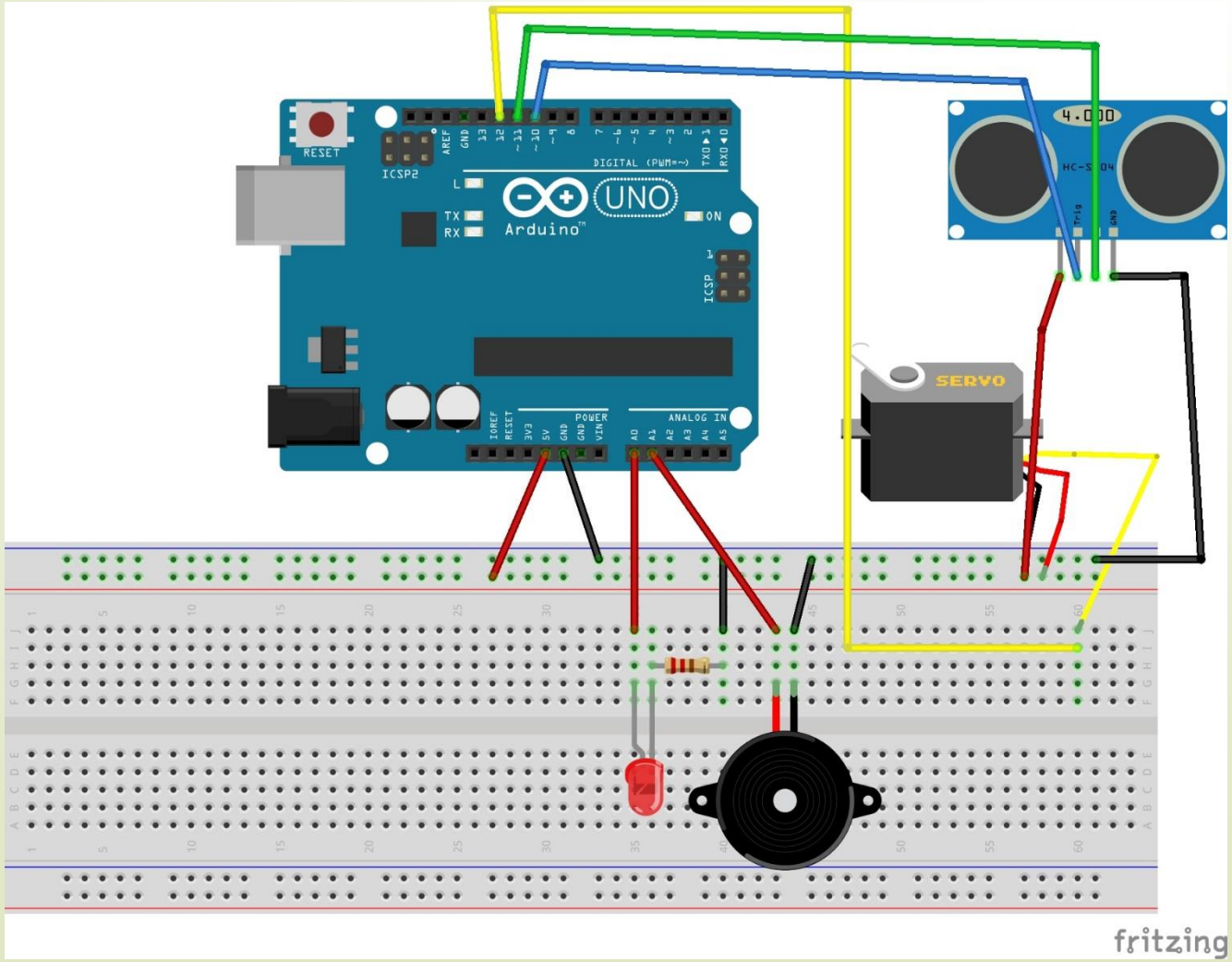
- Read in sensor data
- Logic operation and computation
- Control actuators
- Communicate with computer

A small computer on a single integrated circuit:

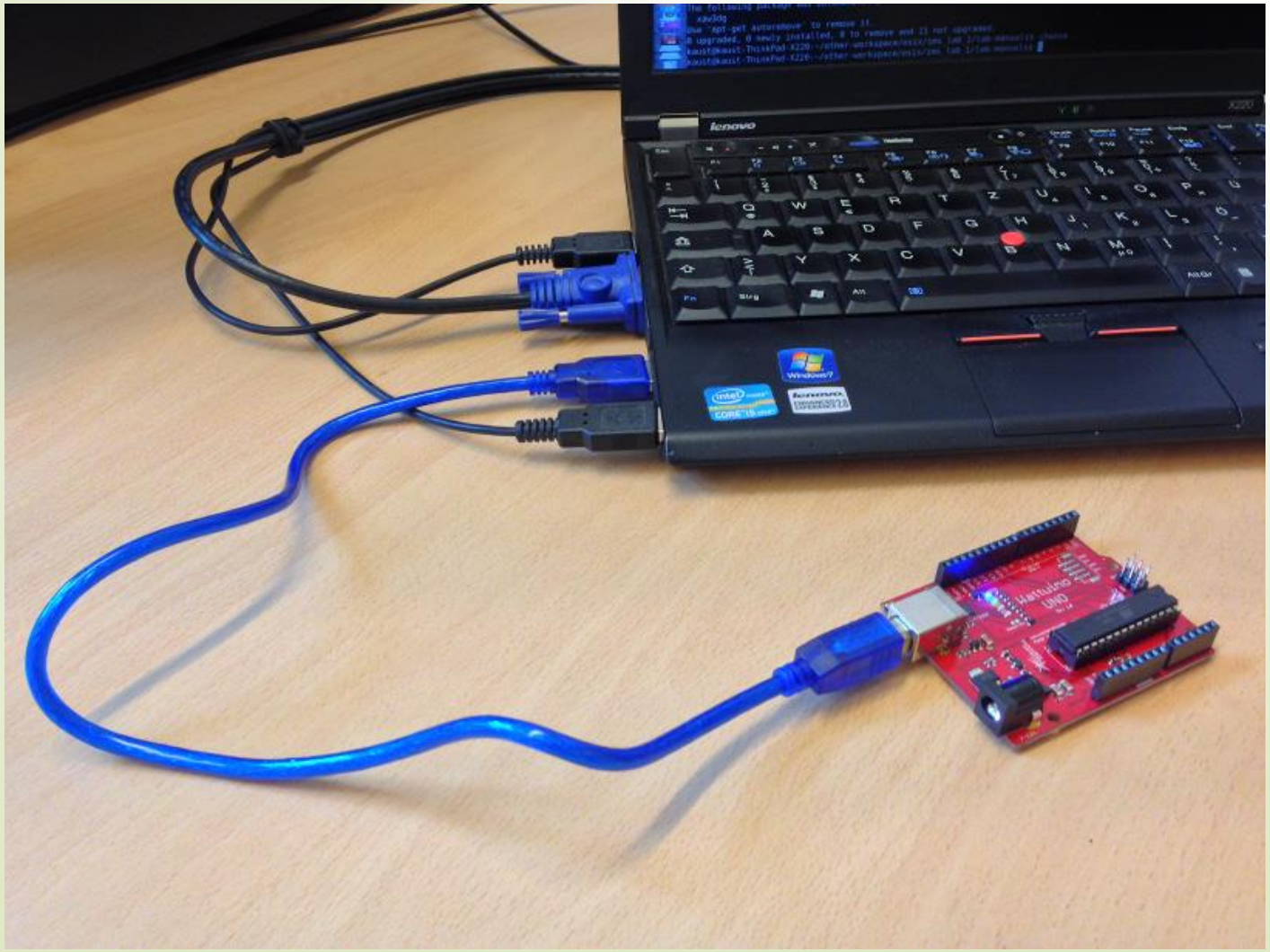
- Input Output pins
- Memory
- Processor

The Arduino UNO is based on the ATmega328P microcontroller

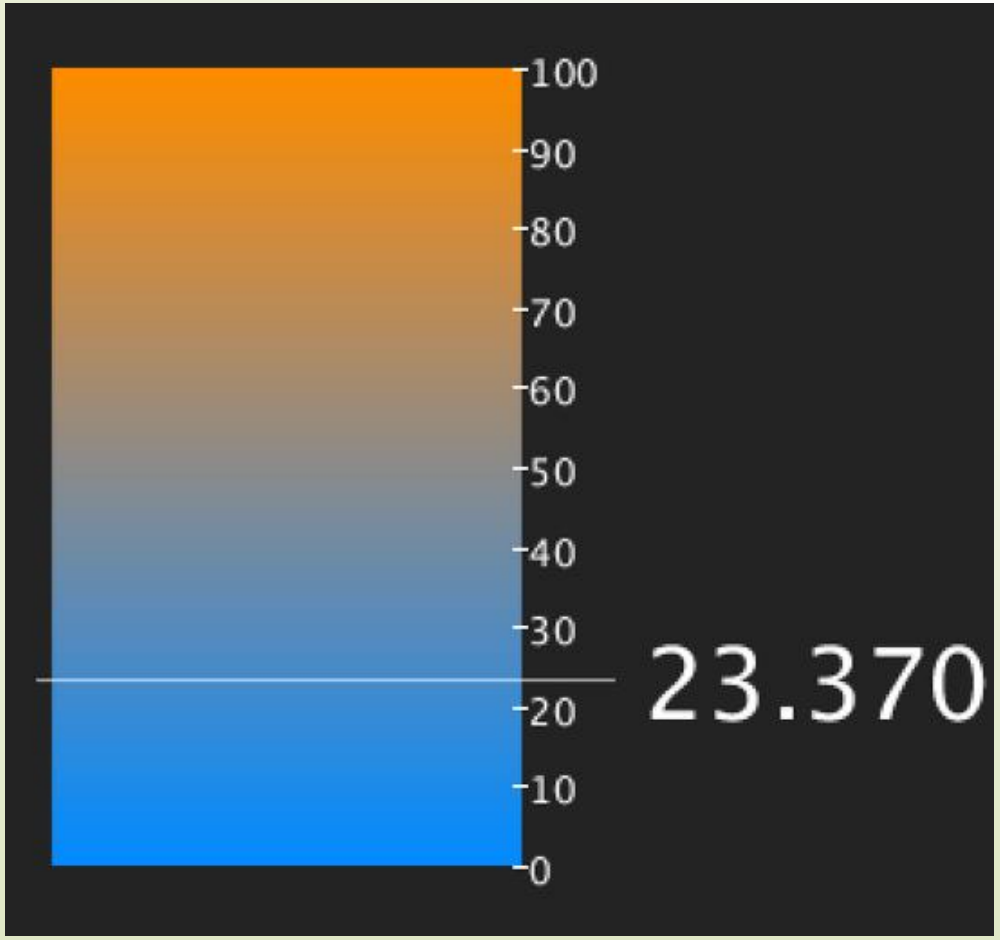
Program Arduino to achieve tasks



Communicate to computer



Display Data on the Computer



Remote Control

Download Material

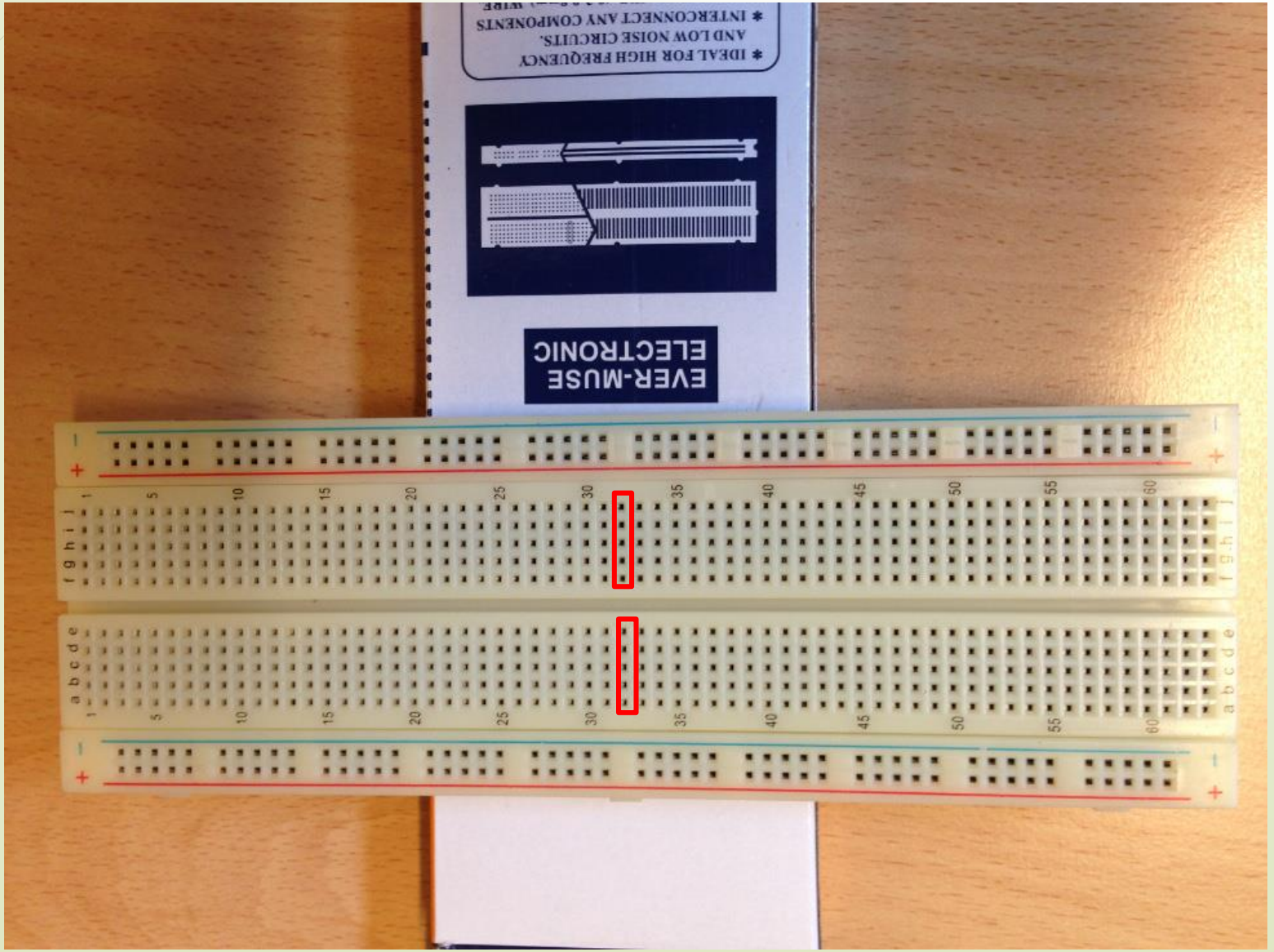
Moodle

Lab Manual

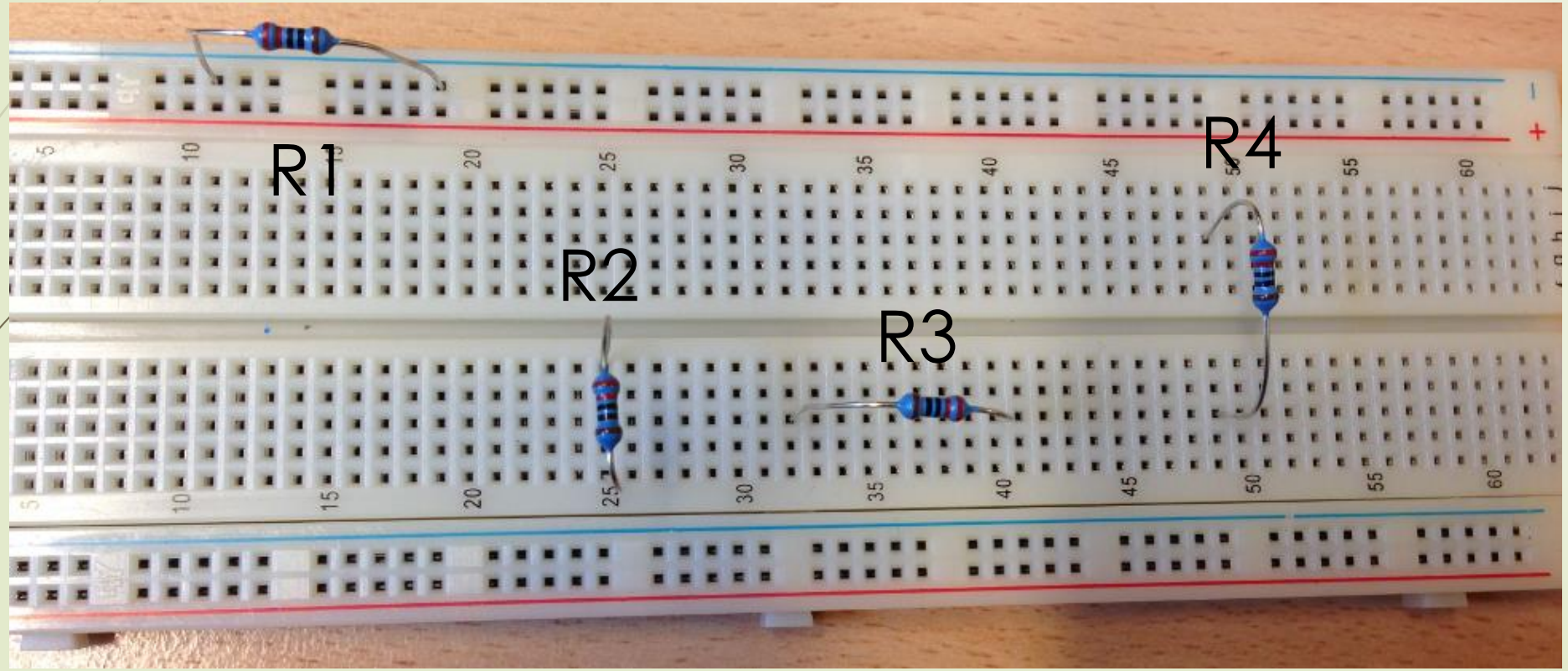
Basic electronic you need in the lab

- Using a breadboard
- Ohm's law: V=IR
- Voltage-Divider
- Safety issues
- Using a multimeter

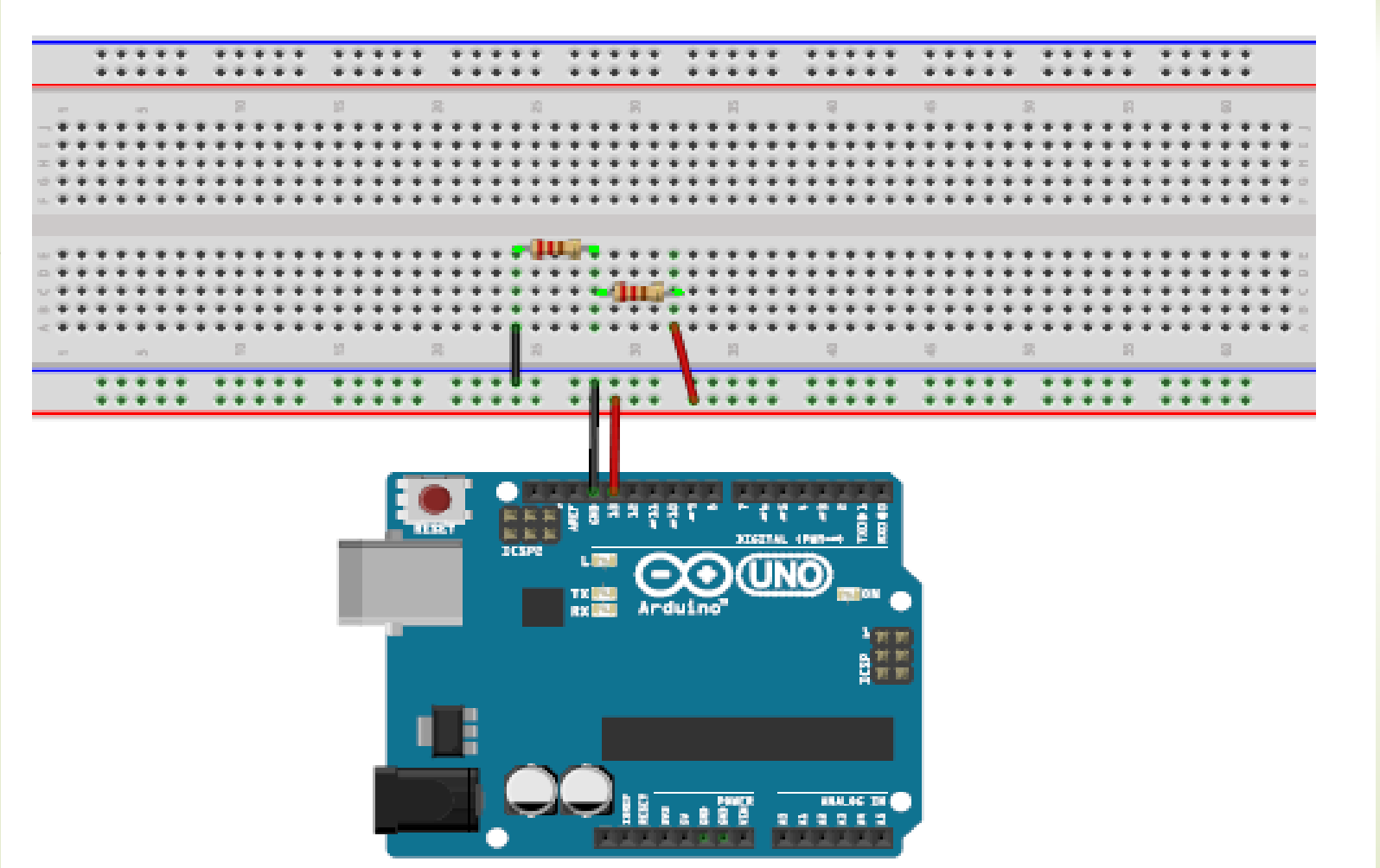
Breadboard



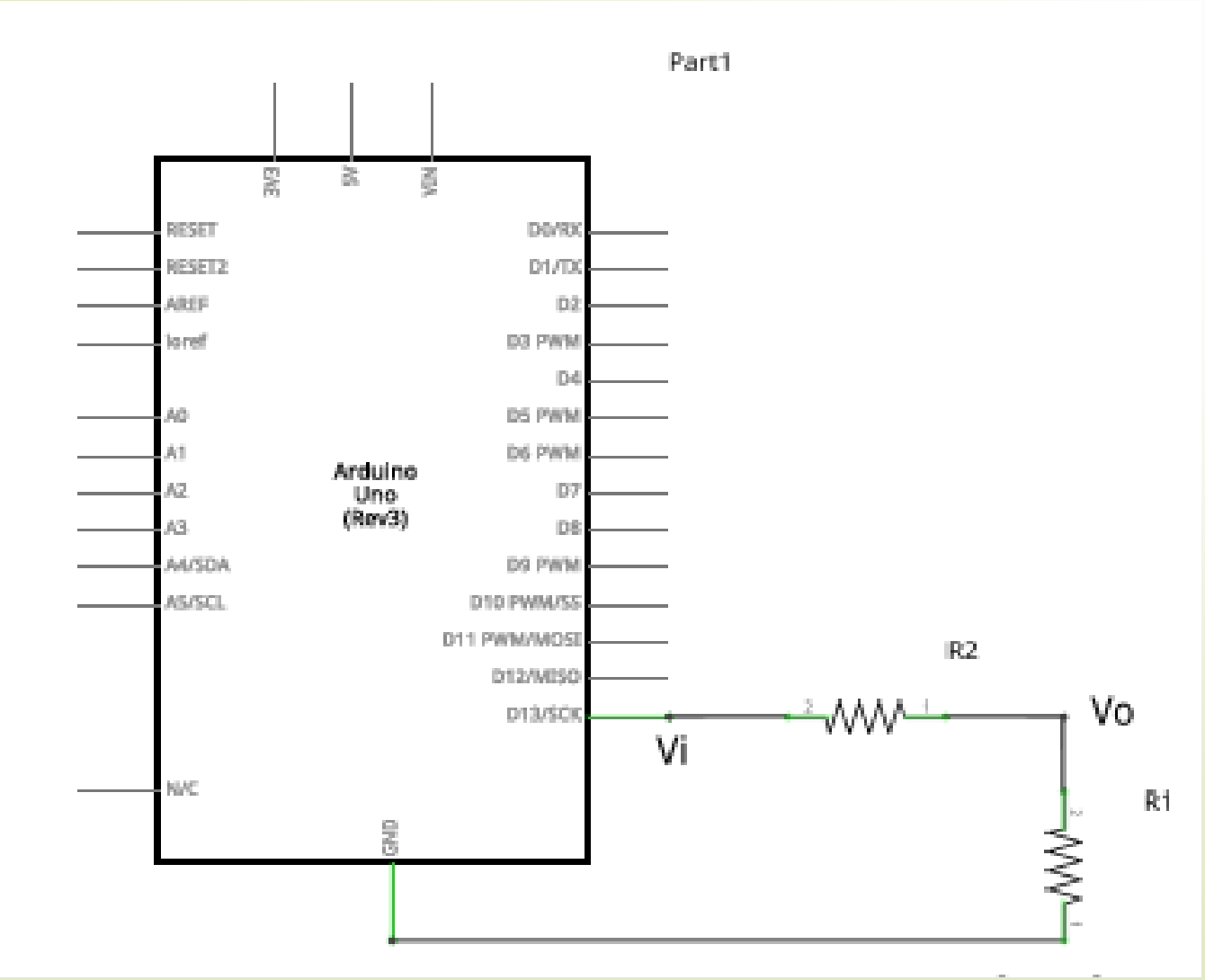
Which resistors are correctly connected



R3 and R4 are correctly placed.
The ends of R1 and R2 are shorted, which could be dangerous.

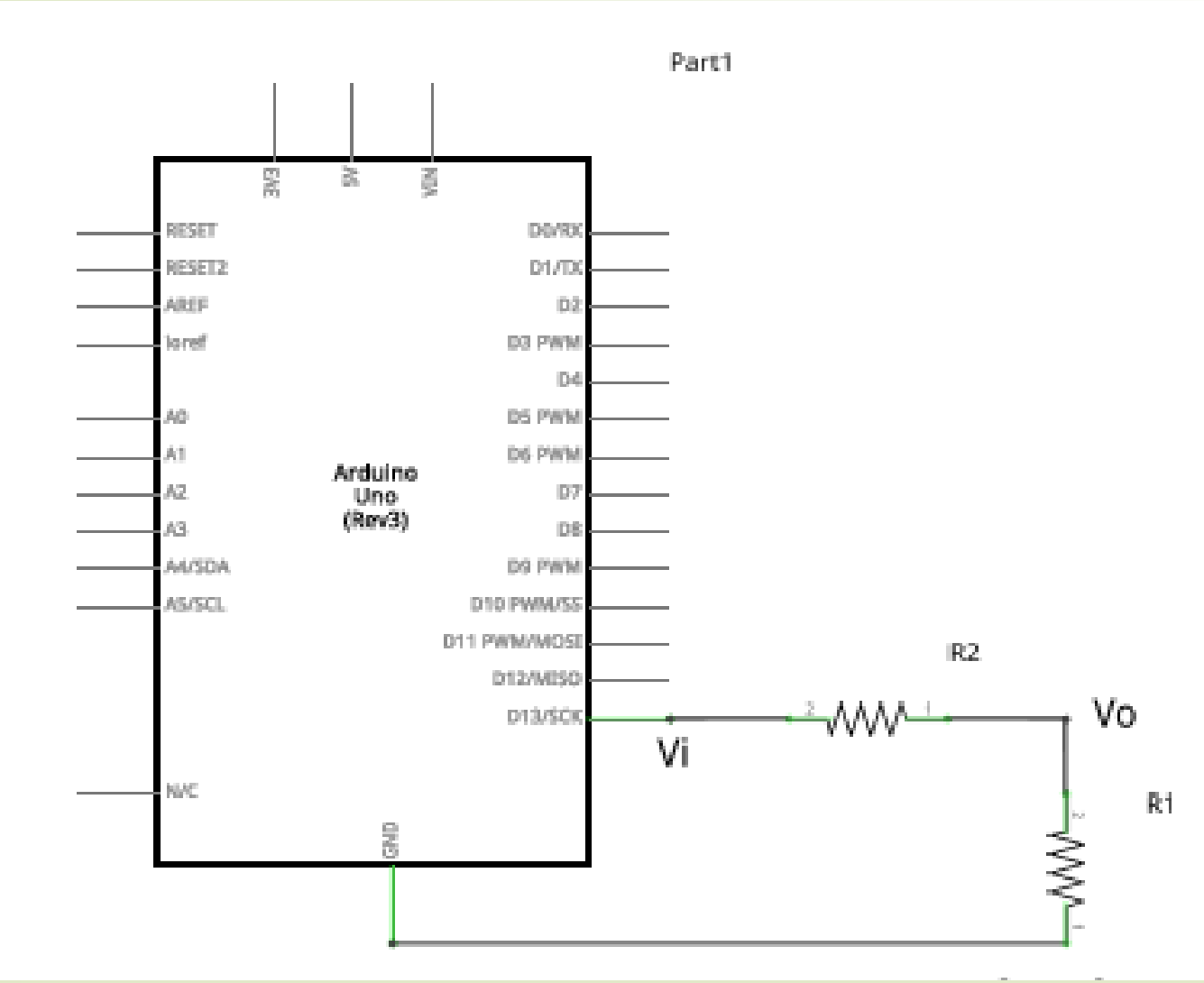


The Arduino provide 5V voltage supply. The safety current is 20mA, what is the requirement for the resistors in between? How large should they be?



$$R1 + R2 \geq \frac{V}{I} = \frac{5}{20 \times 10^{-3}} = 250\Omega$$

The voltage supplied by an Arduino digital OUTPUT pin is 5V. The safety current is 20mA, there should be a 250Ω between an OUTPUT pin and the ground.



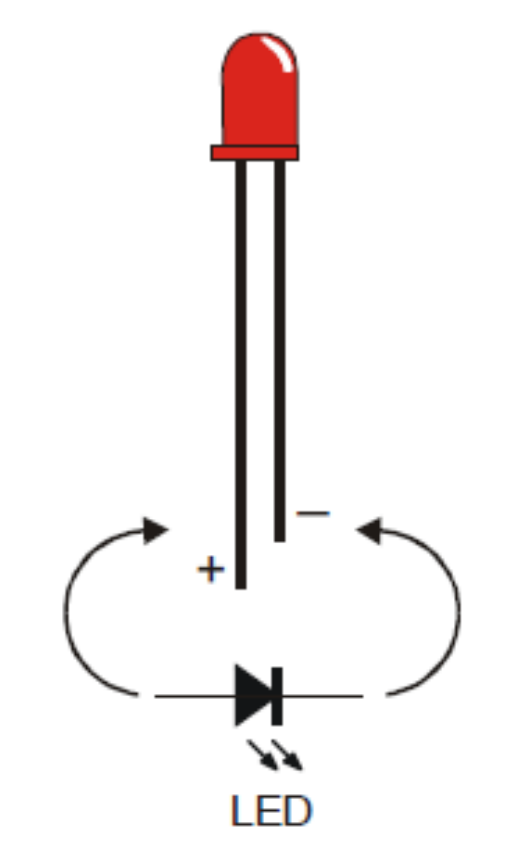
The Voltage-Divider Circuit

$$I = \frac{V}{R_1 + R_2}$$

$$V_0 = I \bullet R_1 = V \bullet \frac{R_1}{R_1 + R_2}$$

We can divide Vi in the proportion of resistance.

A Light Emitting Diode (LED)

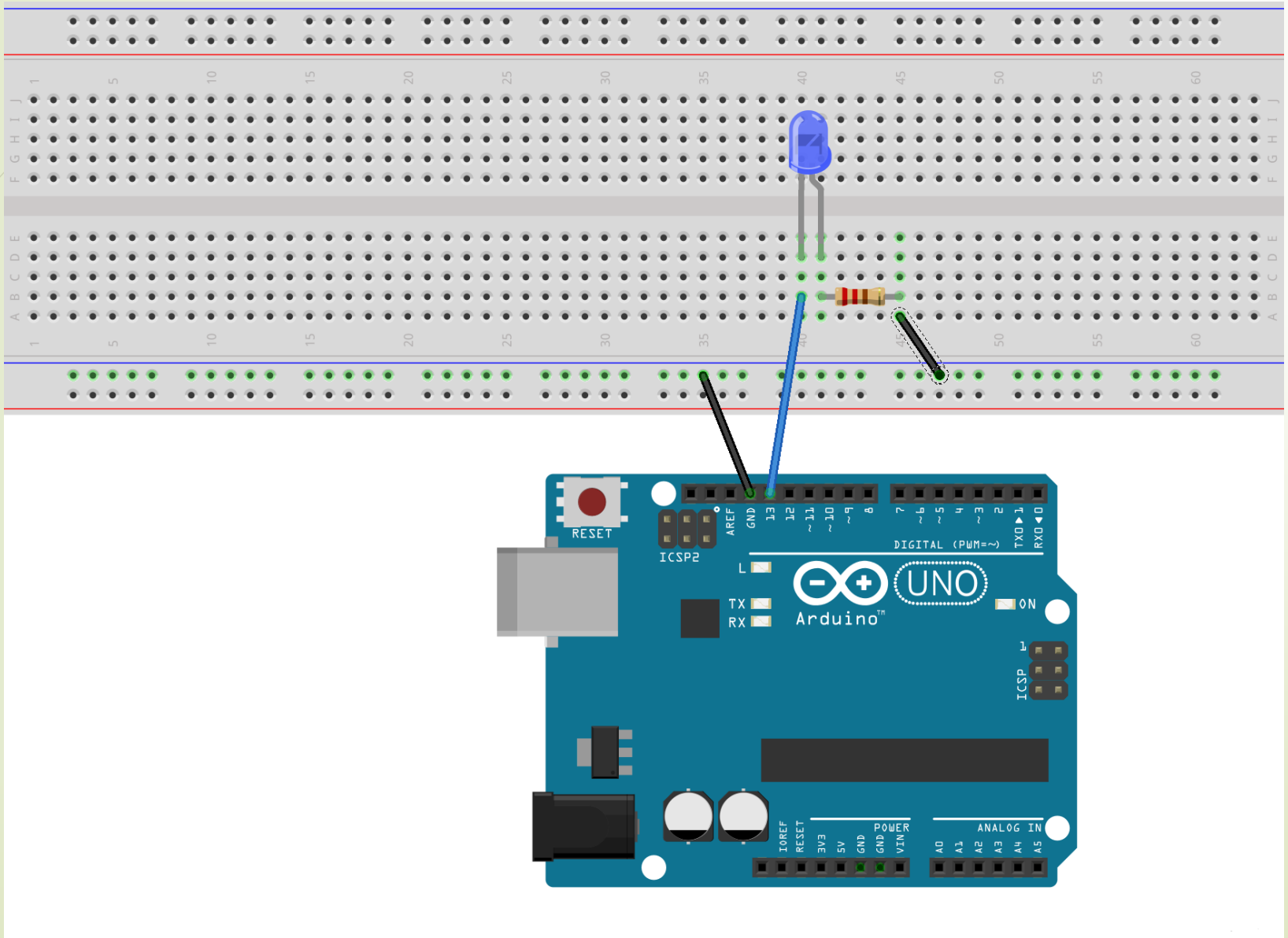


The longer lead is the anode (+) and the shorter is the cathode (-). The anode should be connected to the more positive voltage.

Recommended Resistor Values

To avoid burning out the LED due to excessive current, a resistor is always needed.

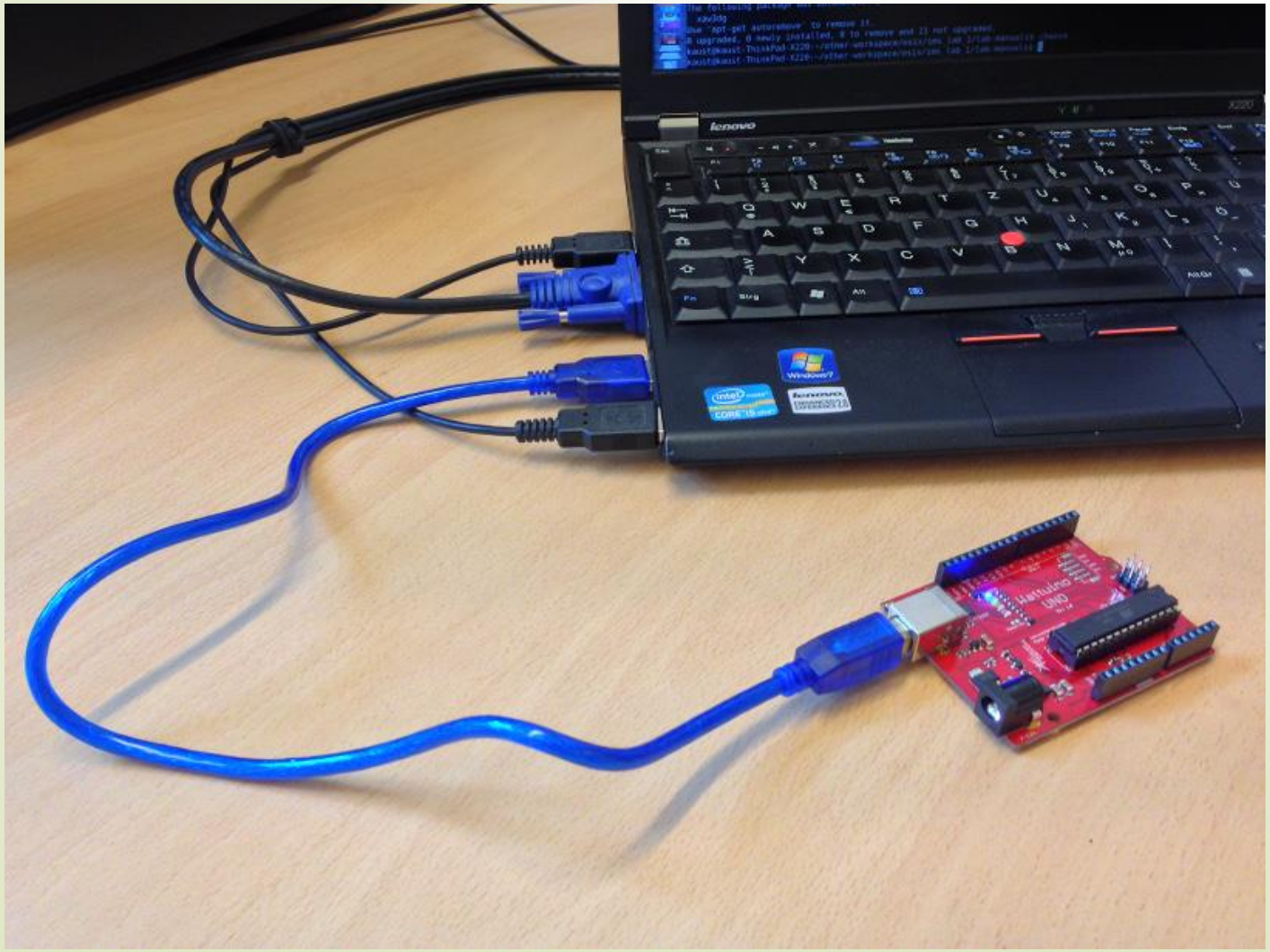
LED	White	Red	Yellow	Green	Blue
$V_{Forward}$	3.3V	2.1V	2.2V	3.7V	3.1V
Resistance	100Ω	200Ω	200Ω	100Ω	100Ω


RESET
ICSP2
AREF
GND
13
12
~11
~10
~9
8
7
~6
~5
4
~3
2
TX→1
RX←0
DIGITAL (PWM=~)
L
TX
RX
UNO
Arduino™
ON
ICSP
POWER
ANALOG IN
IOREF
RESET
3V3
5V
GND
GND
VIN
A0
A1
A2
A3
A4
A5

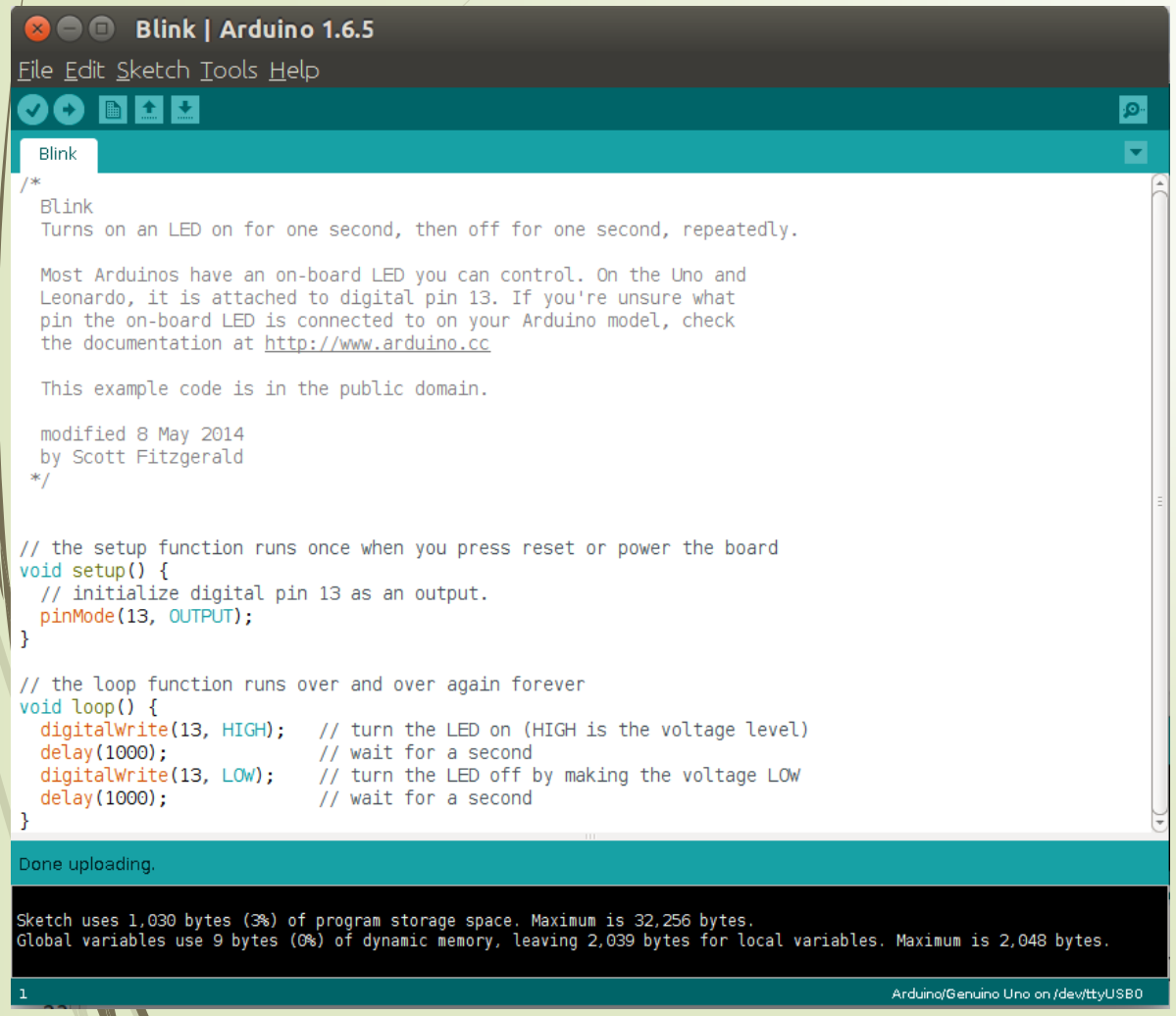
The Blink.ino

```
void setup() { // Called once to initialize
  pinMode(13, OUTPUT);     // Initialize pin 13 for
                                    // digital-write
}
void loop() { // Called repeatedly
  digitalWrite(13, HIGH);   // Set pin 13 to 5V
  delay(1000);                  // Wait 1 sec = 1000 millisec.
  digitalWrite(13, LOW);  // Set pin 13 to 0V
  delay(1000);
}
```

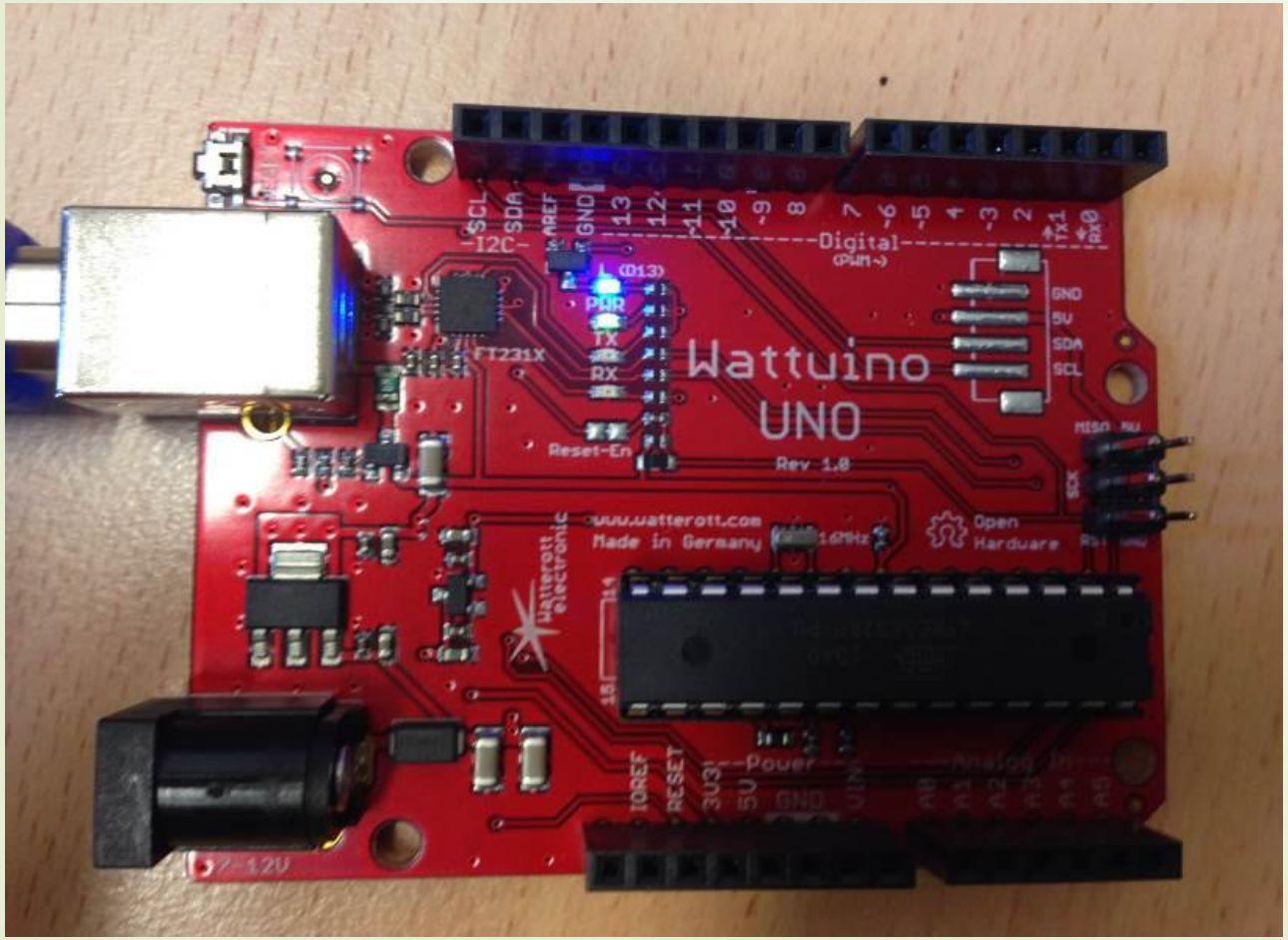
Start: Connect Arduino to computer



Upload the code to Arduino

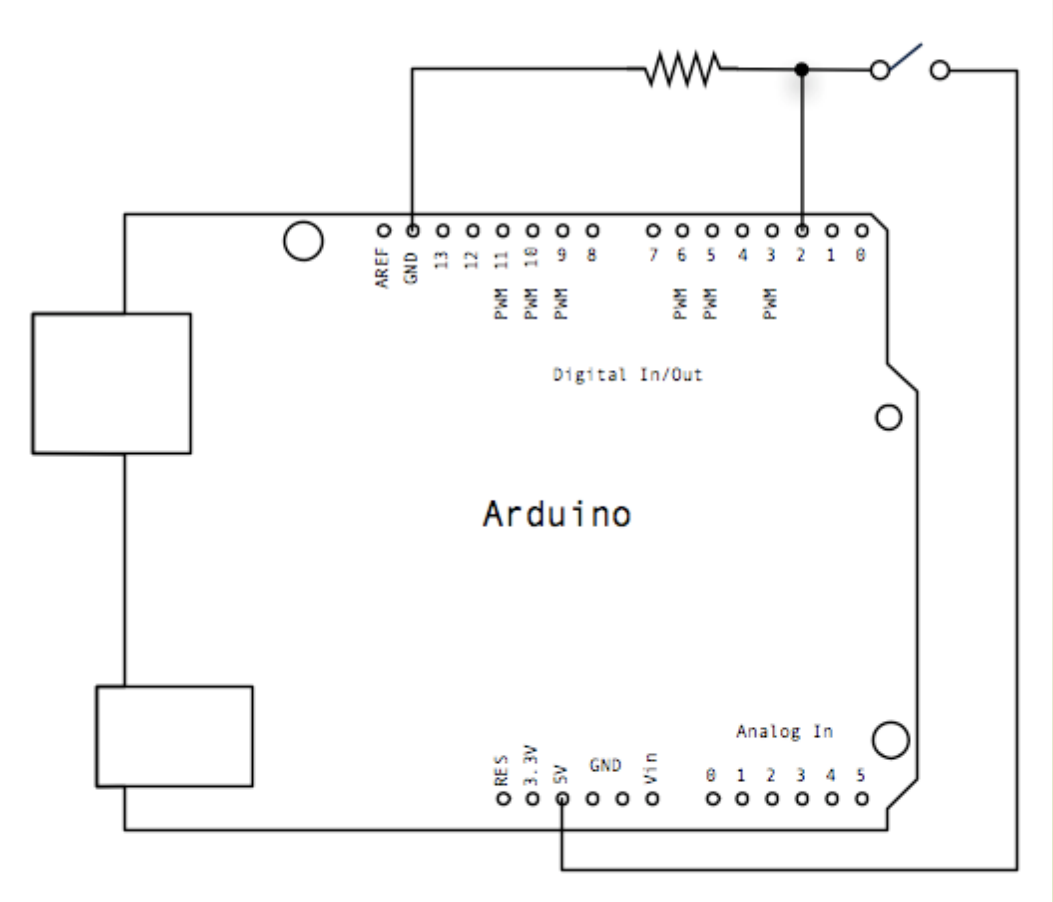


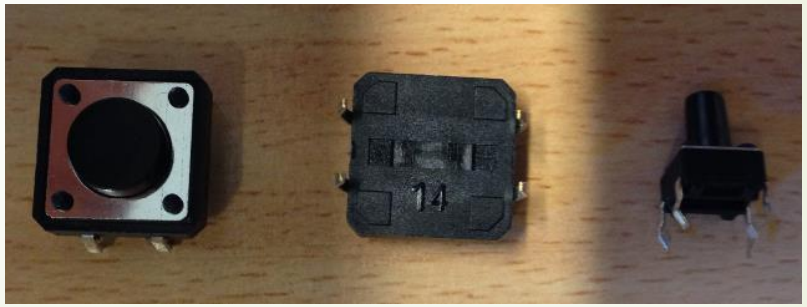
Button	Description
	Compile and check errors
	Upload codes to Arduino
	Create a new sketch
	Open an existing sketch
	Save the current sketch
	Open the serial monitor



This is the built-in LED connected internally to pin 13. It has its own built-in resistor. We are going to make the same circuit on a breadboard.

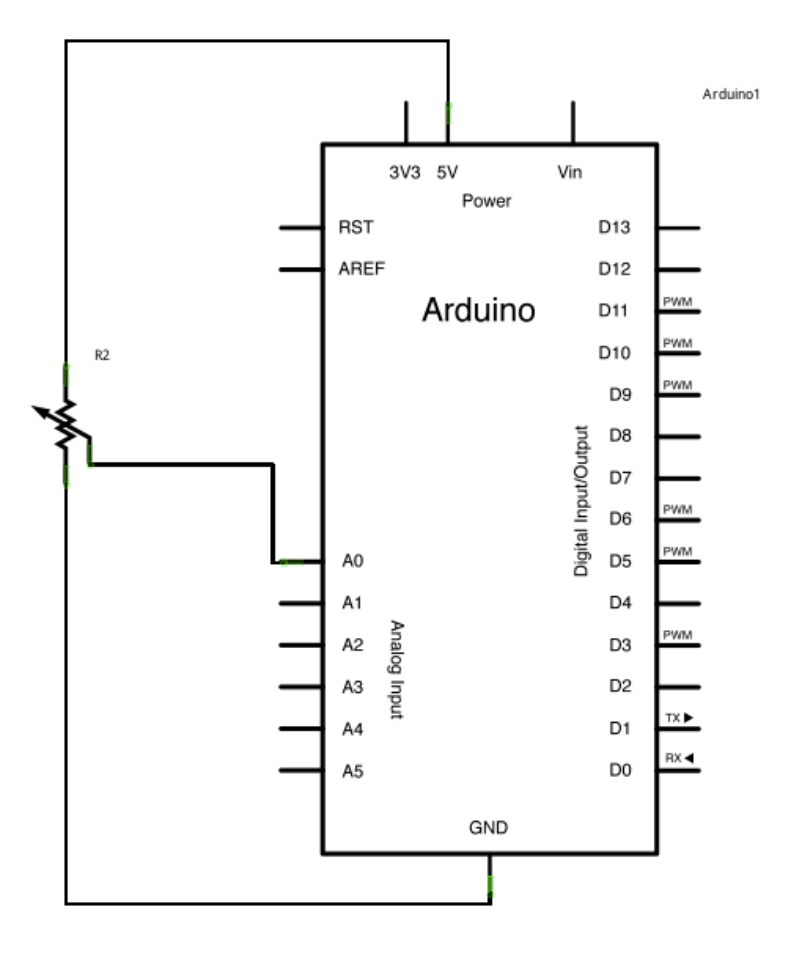
Button and Digital Read

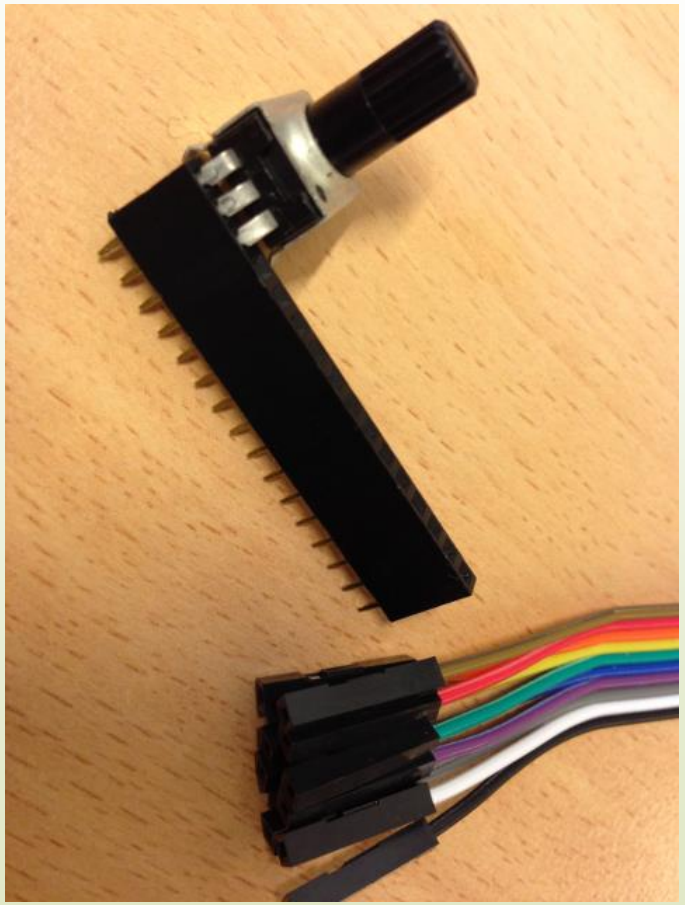





```
pinMode ( 2 , INPUT );

buttonState = digitalRead (2 );
if ( buttonState == HIGH ) {// turn LED on:
digitalWrite (13 , HIGH );
}
else {   // turn LED off:
digitalWrite (13 , LOW );
}
```

Potentialmeter and AnalogRead

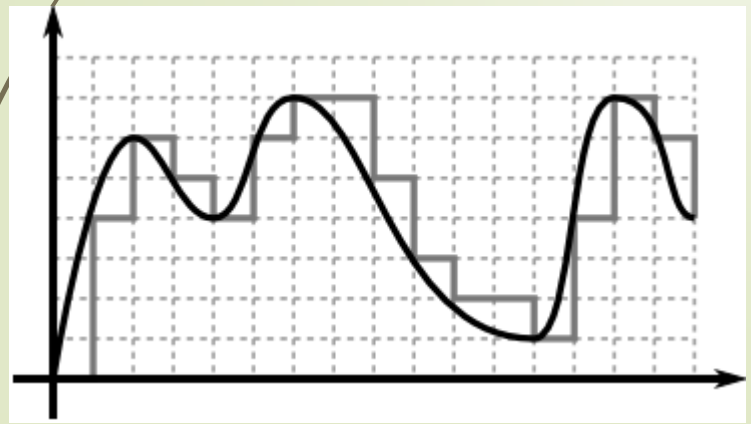




Analog-to-Digital Conversion

- The gathered data such as voltages are in continuous form --- analog signal
- Computer can only process digital data, i.e., 0, 1 sequence

Analog Signal: A0=0V~5V



Analog-to-Digital Conversion

int sensorValue= analogRead(A0);

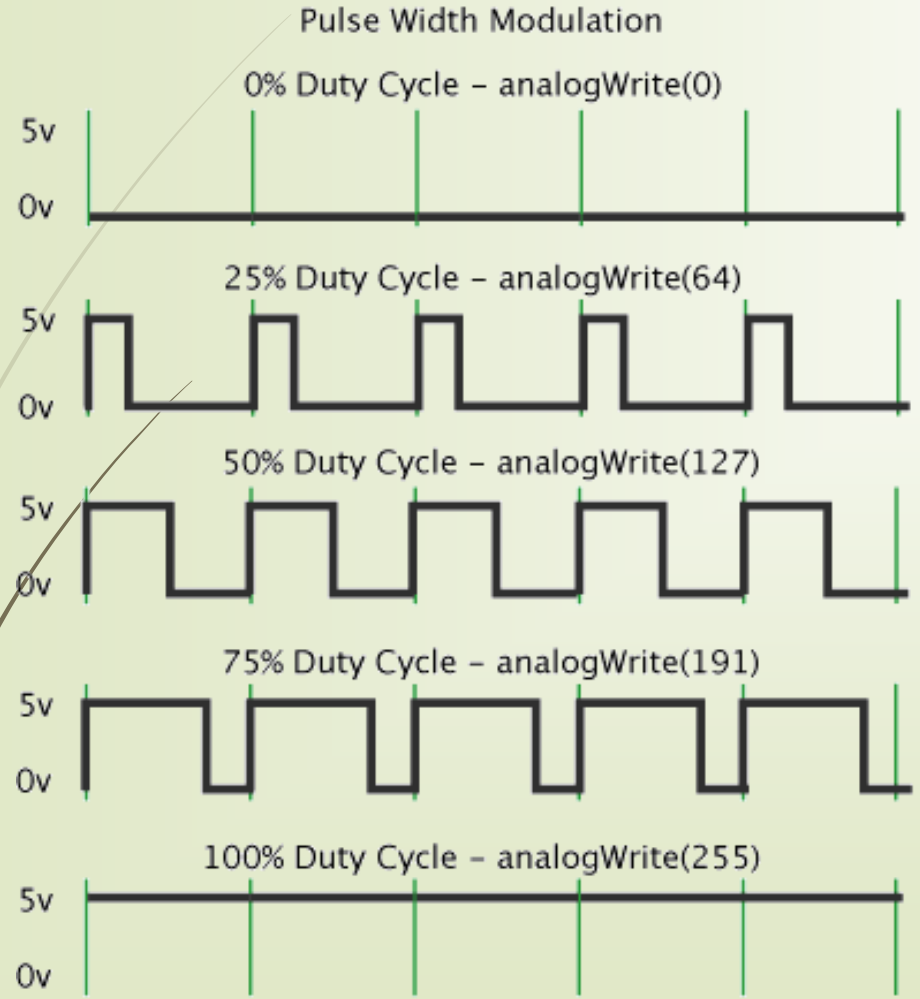
Digital Data: SensorValue

Binary	: Decimal
0000000000	: 0
0000000001	: 1
0000000010	: 2
0000000011	: 3
.....	...
1111111111	: 1023

Serial Monitor

```
void setup () { // initialize serial communication at 9600 bits per second :
Serial.begin (9600) ;
}

// the loop routine runs over and over again forever :
void loop () {

// read the input on analog pin 0:
int sensorValue = analogRead (A0);

// Convert the analog reading ( from 0 - 1023) to a voltage (0 - 5V):
float voltage = sensorValue * (5.0 / 1023.0) ;

// print out the value you read :
Serial.println ( voltage );
}
```

Digital-to-Analog Conversion

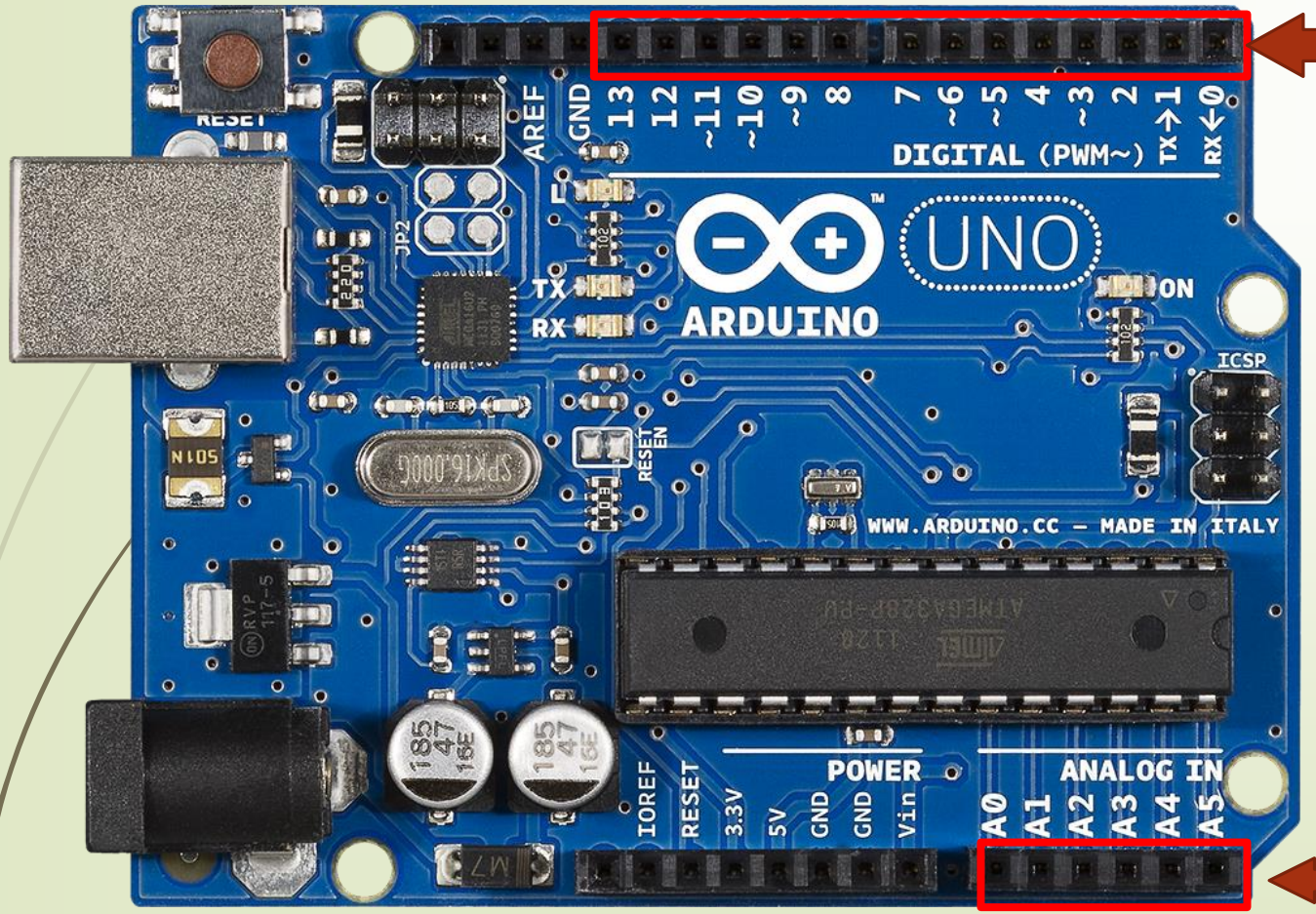


- To output "analog" signal by digital means
- It is called Pulse Width Modulation (PWM)

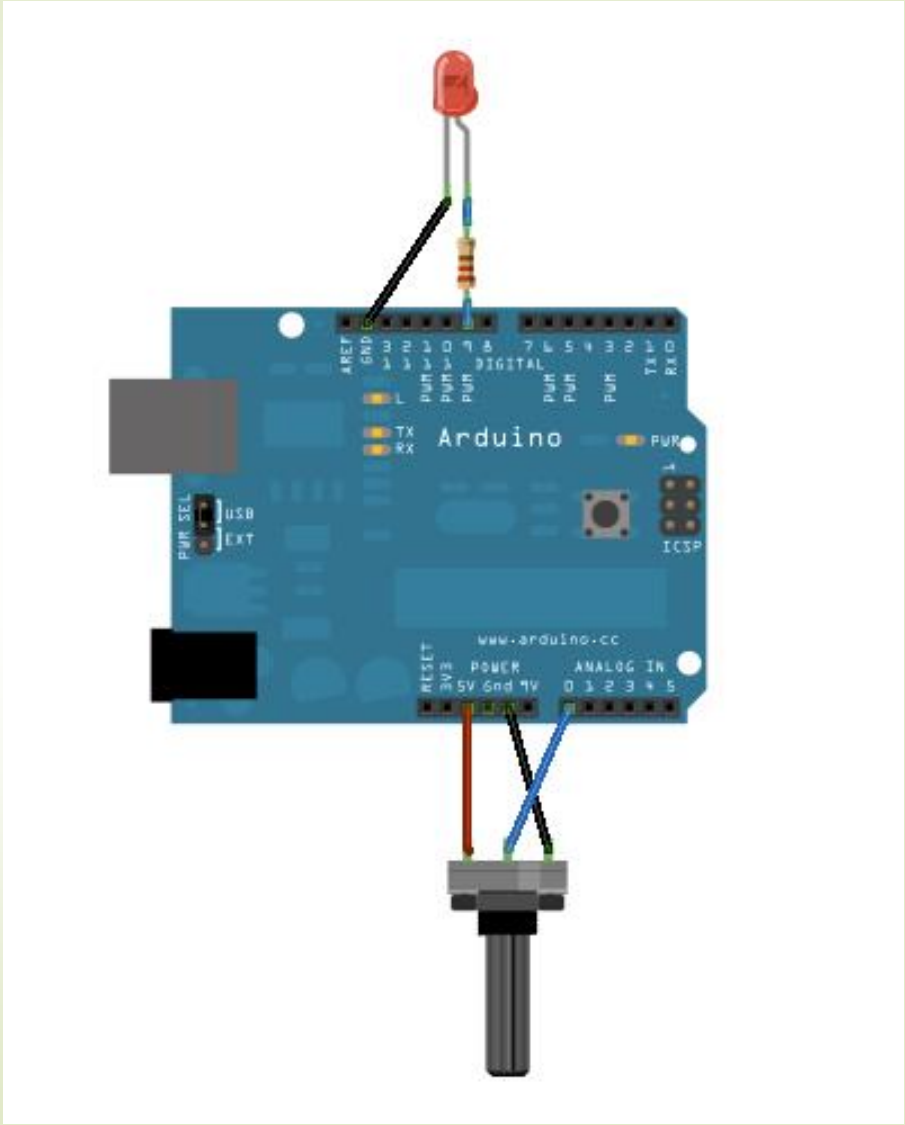
analogWrite(pin, value);

Value : 0 ~ 255

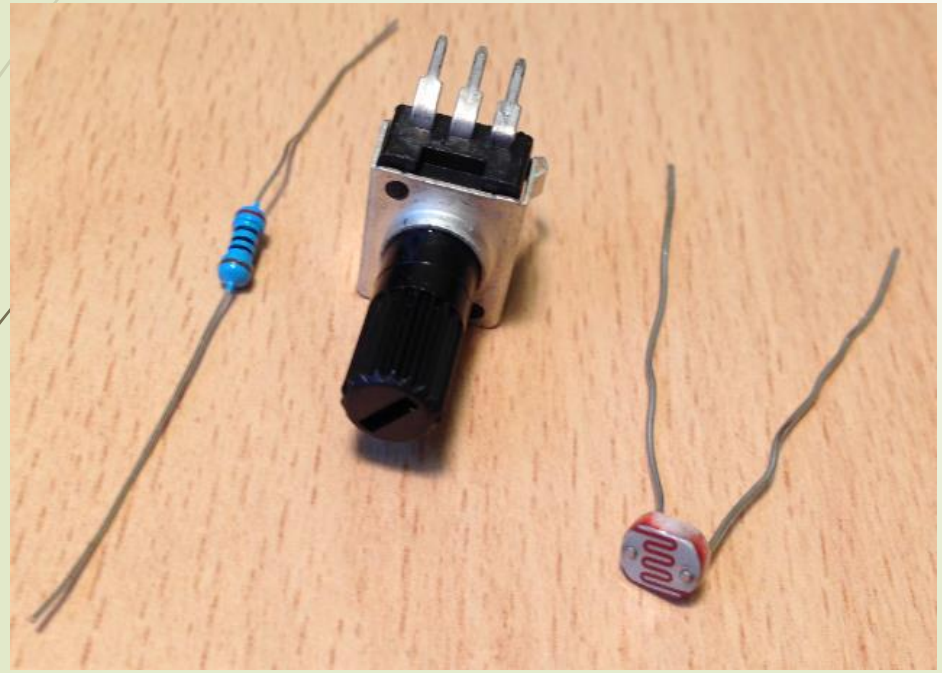
Output: 0V ~ 5V


14 Digital I/O pins
6 PWM output pins, marked with ~
6 Analog Input pins
DIGITAL (PWM~)
ARDUINO
UNO
POWER
ANALOG IN
WWW.ARDUINO.CC – MADE IN ITALY

Use Potentialmeter to control The Brightness of the LED



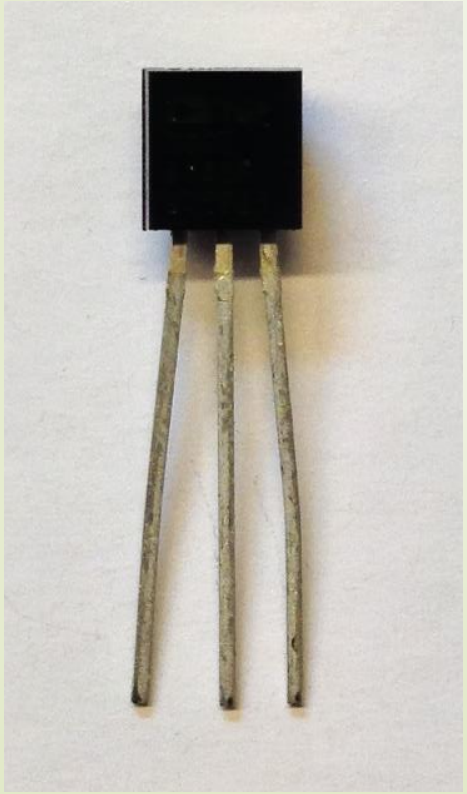
Light Dependent Resistor



Applications:

- Streetlight (Turn on when it is dark, save energy)
- Camera Light meters
- Night Clocks
- Alarm Devices (Detector for a light beam)

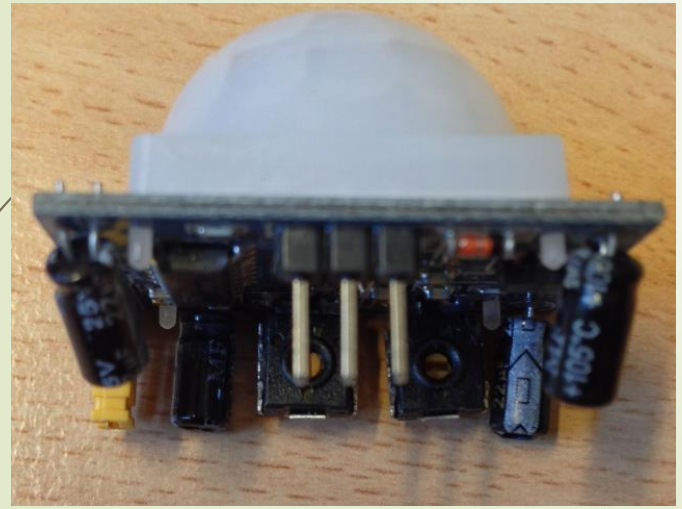
Temperature Sensor



Applications:

- Medical Application (Measure body temperature)
- Biology research (Temperature collection and control)
- Electrical Products (Avoid overheating)
- Materials research (Temperature collection and control)

Passive Infra-Red Sensor for Motion Detection



Applications:

- Security Alarms
- Automatic Lighting systems
- Animal observation systems

Ultrasonic Distance Sensor