# Electronics and control
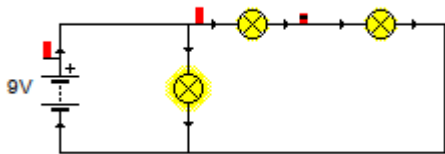
This book has been created by Ana Mª López Floría (2024)

# Electronics

# What is electronics?

In an electrical circuit the current flows through the conductors and components naturally, having the current a value that depends on the components connected in the circuit.



In an electronic circuit, a **control** is exercised over the flow of the electric current.

But this is not new, just put a switch to let flow or not the current through a light bulb. (In this way, we would be "controlling" the flow of current through the bulb).

However, the most important difference lies in the "**how" this current flow is controlled**. In an electronics circuit, an electric current flow is controlled **by another electrical signal**, this being another electric current flow or a fixed voltage.

In other words:

*In an electronic circuit … electricity is able to control electricity.*

*Information extracted from here*

# Electronic components

Electronic components can be classified in:

- **Active** components: usually can inject power into a circuit. They are made of semiconductors. E.g: Diodes, transistors.
- **Passive** components: cannot introduce net energy into the circuit. E.g: Resistors, capacitors

For a circuit to be properly called "electronic circuit" it must contain at least **one active** element.
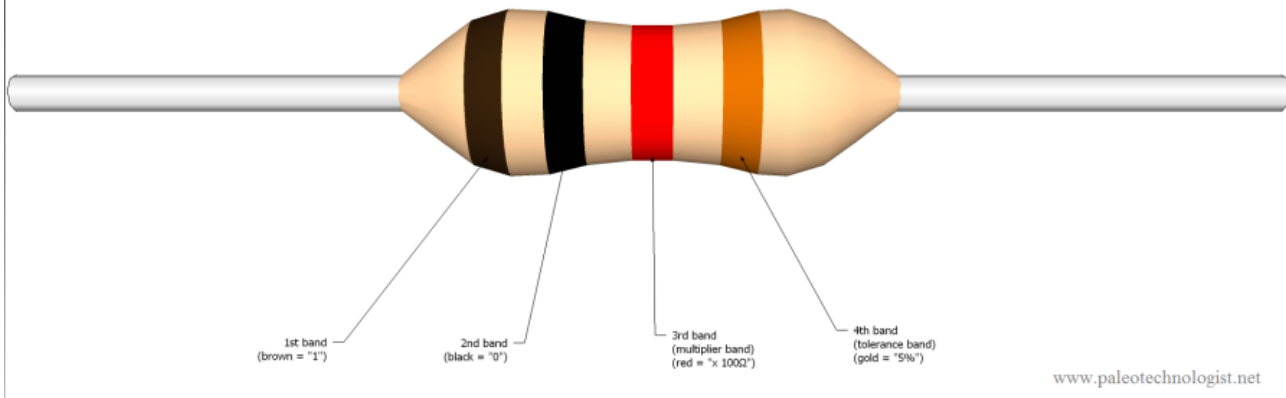
# Passive components

## Fixed resistors

- They impede the flow of electric current
- There is a colour code to know their value

| Color | Color | 1st Band | 2nd Band | 3rd Band Multiplier | 4th Band Tolerance |
|---|---|---|---|---|---|
| Black | | 0 | 0 | x1Ω | |
| Brown | | 1 | 1 | x10Ω | ±1% |
| Red | | 2 | 2 | x100Ω | ±2% |
| Orange | | 3 | 3 | x1kΩ | |
| Yellow | | 4 | 4 | x10kΩ | |
| Green | | 5 | 5 | x100kΩ | ±0.5% |
| Blue | | 6 | 6 | x1MΩ | ±0.25% |
| Violet | | 7 | 7 | x10MΩ | ±0.10% |
| Grey | | 8 | 8 | x100MΩ | ±0.05% |
| White | | 9 | 9 | x1GΩ | |
| Gold | | | | x0.1Ω | ±5% |
| Silver | | | | x0.01Ω | ±10% |

Resistor color codes: an example (a 1-kilohm 5% tolerance resistor)

1st band
(brown = "1")

2nd band
(black = "0")

3rd band
(multiplier band)
(red = "x 100Ω")

4th band
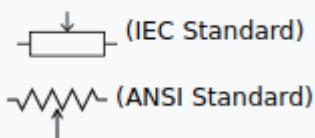(tolerance band)
(gold = "5%")

www.paleotechnologist.net

# Variable resistors

- **Potentiometer**: A potentiometer is a **three-terminal resistor** with a sliding or rotating contact that forms an adjustable voltage divider.





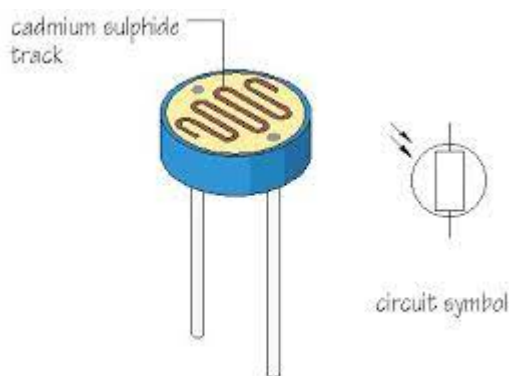Electronic symbol
(IEC Standard)
(ANSI Standard)

- **Thermistor**: semiconductor type of resistor whose resistance is strongly **dependent on temperature.** They can be
  - **Negative-temperature-coefficient** (NTC):  thermistors have less resistance at higher temperatures

- **Positive-temperature-coefficient** (PTC): thermistors have more resistance at higher temperatures
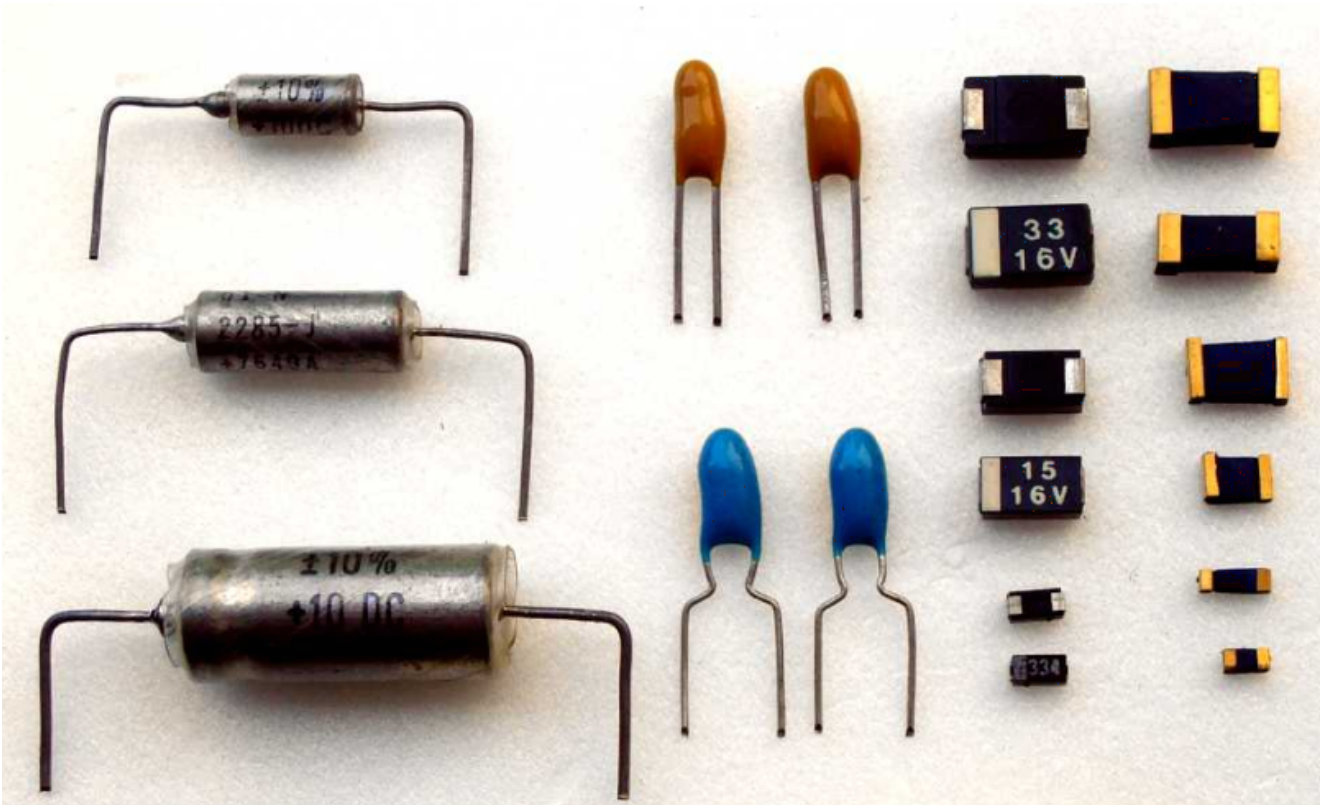


- **Light Dependent Resistors (LDR)**: passive component that **decreases resistance with** respect to receiving luminosity on the component's sensitive surface



# Capacitors

Device that **stores electrical energy** by accumulating electric charges on two closely spaced surfaces that are insulated from each other.

The property of a capacitor is the **capacitance (C)** that is defined as the amount of **charge** that can be stored at a given **voltage.** It is measured in **Farads** (F)
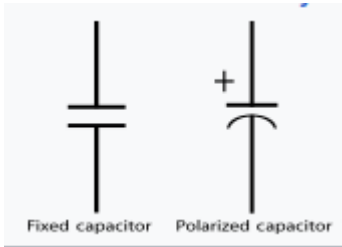


capacitance of capacitor, measured in farads (F)

charge stored, measured in coulombs (C)

$$C = \frac{Q}{V}$$

voltage across capacitor, measured in volts (V)

**Electronic symbol**
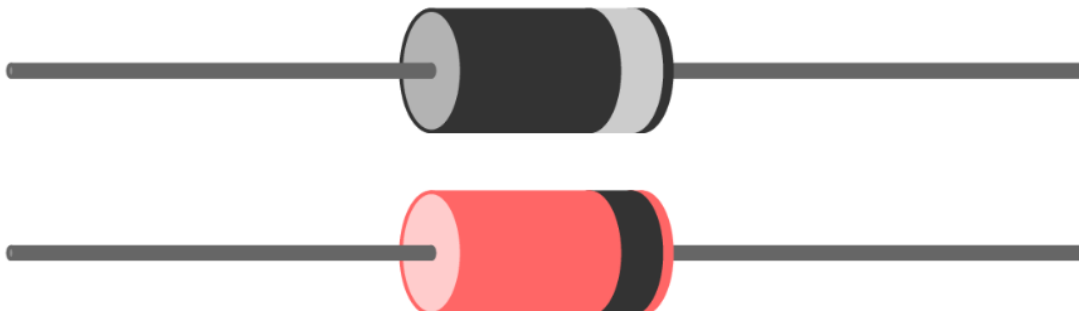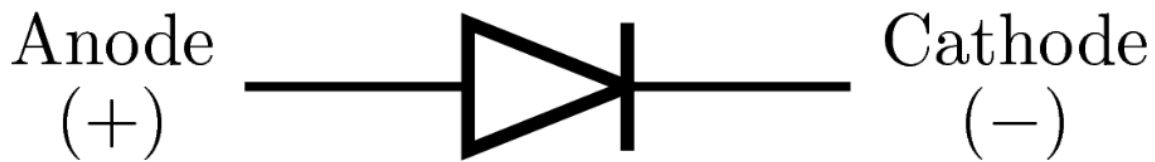
Fixed capacitor    Polarized capacitor

# Active components

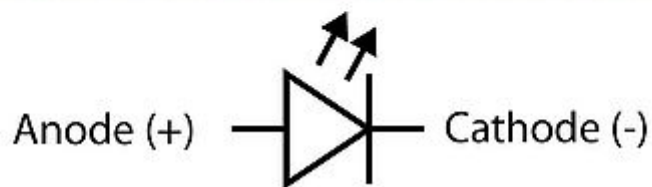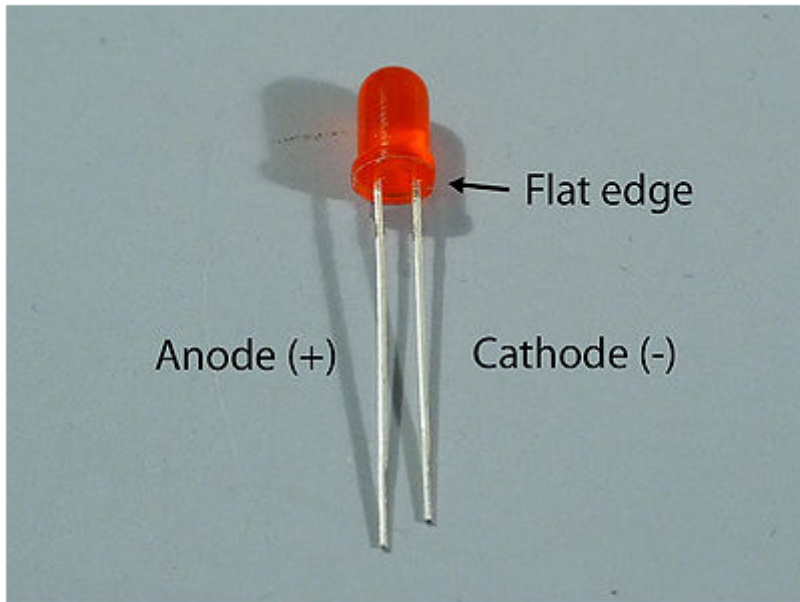They are made up of semiconductor materials, whose properties allow to introduce "control" in the circuit.

## Diodes

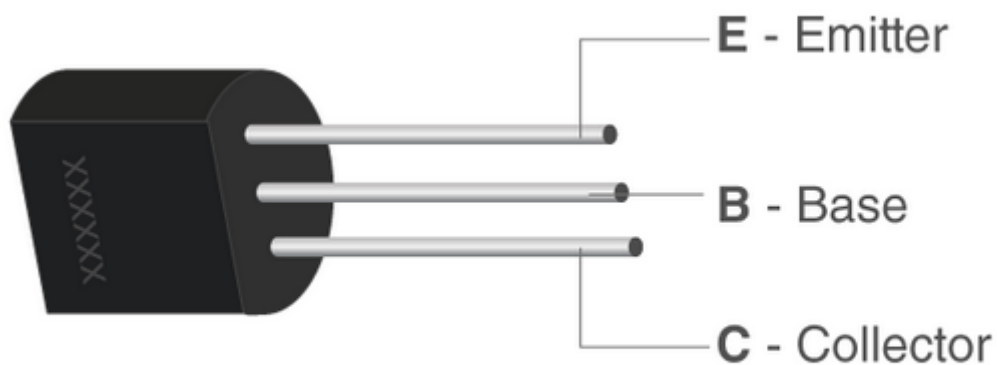Devices that allow current to flow just in one direction.



Anode (+) ──▷|── Cathode (−)

The most known are **LED**'s: Light Emitting Diode

Flat edge
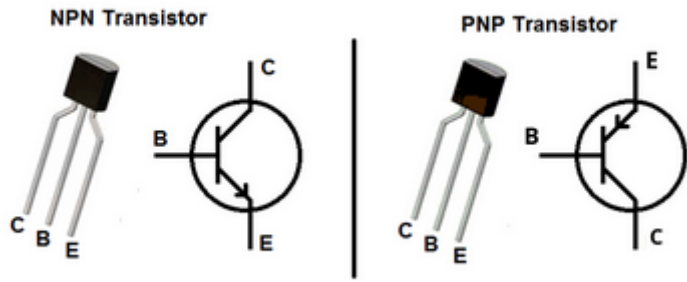
Anode (+)      Cathode (-)



Anode (+)    Cathode (-)

# Transistors

It is a semiconductor device used to **amplify or switch** electrical signals and power. It is composed of semiconductor material, usually with at least three terminals for connection to an electronic circuit. A voltage or current applied to one  of the transistor's terminals (Base) controls the current through another pair of terminals (Collector and Emitter)



E - Emitter

B - Base

C - Collector

© Byjus.com

There are two main types of transistors depending on the sense of the controlled current: NPN and PNP

Information and images extracted from:

- https://en.wikipedia.org/wiki/Electronic_component
- https://en.wikipedia.org/wiki/Capacitor
- https://study.com/academy/lesson/capacitance-units-formula.html
- http://cmra.rec.ri.cmu.edu/products/electronicsv2/basic_components/what_is_an_led/1/vid 1.html
- https://simple.wikipedia.org/wiki/Transistor
- https://byjus.com/jee/transistor/
- https://shoptransmitter.com/blog/what-is-the-difference-between-pnp-and-npn/

# Control systems

# Control systems and robotics

An **automated process** continuously repeats the action that it is designed to carry out. A set of interconnected elements which allow the automation of a process is called a **control system.**

Some automated systems only carry out the same action. Other can modify this action by changing their programs. They are **intelligent control systems.**

Intelligent control systems work in a similar way to a human being. That means, we receive information from the outside world thanks to our senses (sight, hearing, smell, taste and touch) our brain processes this information and through our muscles or our voice we perform different actions. Intelligent control systems: they receive information from the environment thanks to different **sensors**, they process this information in **controller boards** (like Arduino) and give a response using different **actuators**.

A **robot** is an **intelligent automated system** capable of:

- **sensing** its environment,
- carrying out **operations** to make decisions
- performing **actions** in the real world.

So the main elements in every robot, as we learned in programming,  will be:

- **Input**: information received by **sensors**
- **Process**: to perform operations/ make decisions with this input. This is made by the **controller** board.
- **Output**: response produced by **actuators** that can be mechanical, electric, pneumatic....

The task of a robot can be modified by changing its program.

Information extracted from:

- [https://robotsguide.com/learn/what-is-a-robot](https://robotsguide.com/learn/what-is-a-robot)

# Sensors and actuators

## Sensors

A **sensor** is an object capable of **detecting physical or chemical quantities** and transforming them **into electrical signals.**

Depending on the type of the electrical signal produced they can be **DIGITAL, ANALOG or DATA.**

- **DIGITAL**: a digital sensor only has two                                    ed, ON/OFF, 1/0, High/Low.  E.g: An electronic pushbutt                                  l sensor with two
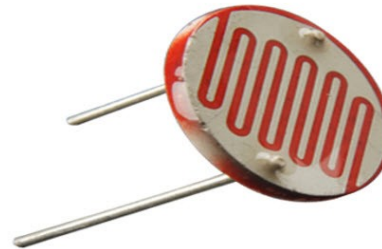


    possible states: pushed or not pushed.
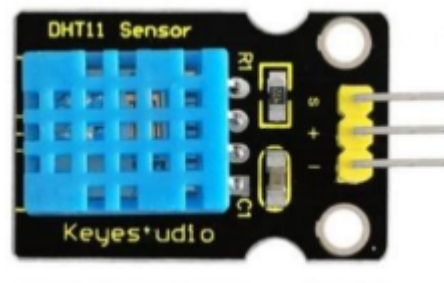

- **ANALOG**: This sensor can provide a range of values, normally a variable voltage or current value, depending on the signal detecte                                          e of its



    resistance with an increment of light detected.

- **DATA**: the sensor offers its information throu                                        DHT11



    sensor measures temperature and humidity.                                      There are

    lots of different sensors. To get further information click on [here](here).

# Actuators

An **actuator** is any device capable of **performing actions** in the physical world that we **can control** from a processor board (like Arduino)

Depending on the type of action produced they can be:

- **LIGHT**: The most common is the **normal LED**, but there is also RGB LED's, neopixel lightsaber, laser or LCD displays

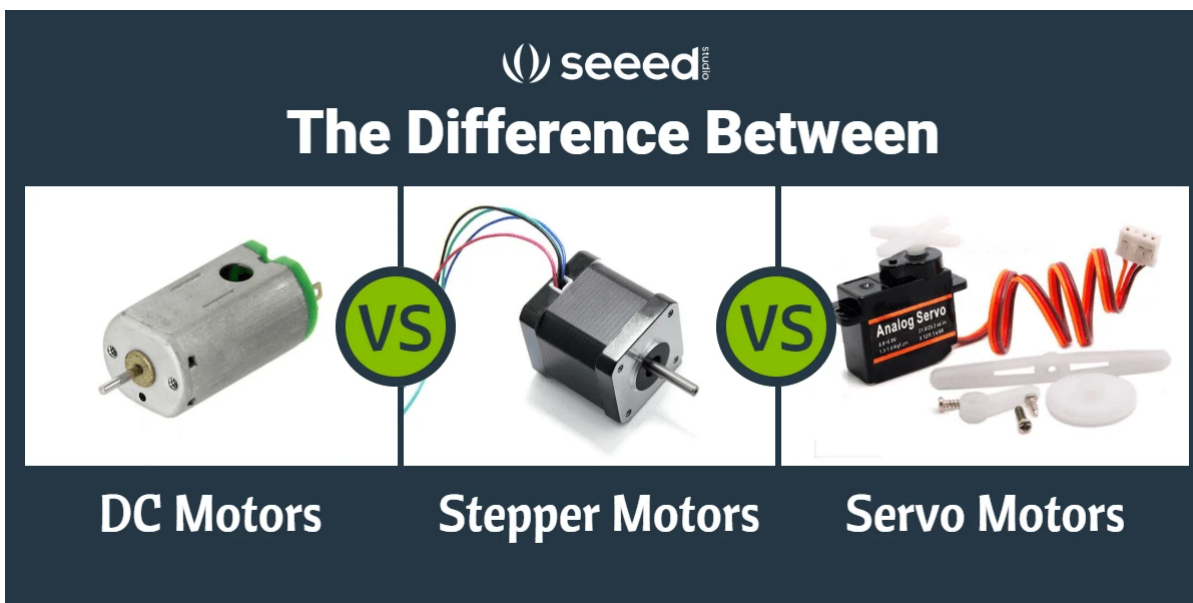## Light Actuators

LED
RGB Led
Neopíxel LED
LCD Display
Laser LED

- **SOUND**: There are active and passive **buzzers**. Active buzzers play a tone of a frequency determined when they receive a digital "1" whereas a passive buzzer only plays the wave that receives.
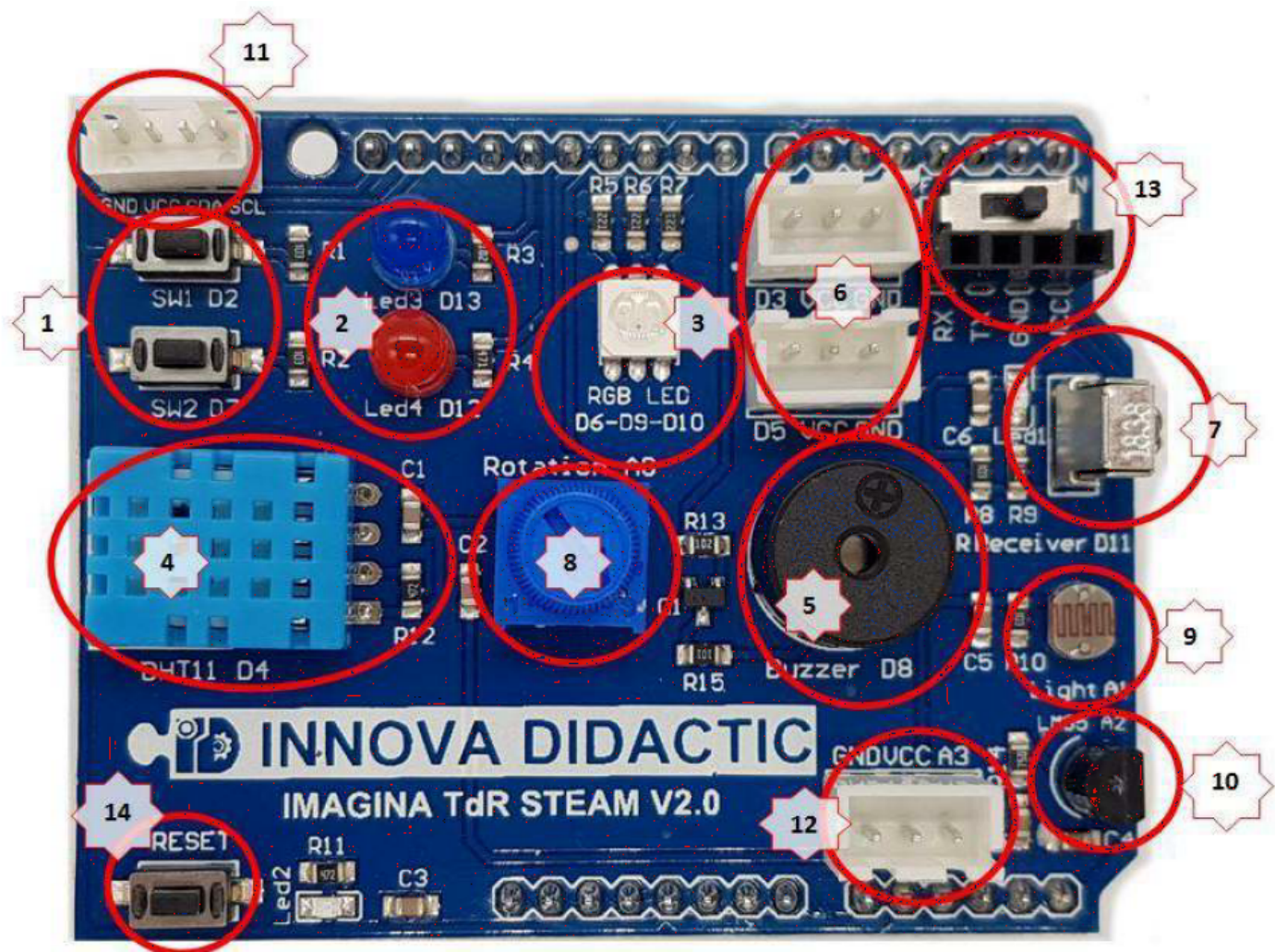
- **MOTION**: There are different types of motors depending on their properties. They usually need auxiliary elements to be controlled by processor boards, because of the voltage they require.



# Imagina TDR Steam shield

We will use in our projects one shield called **Imagina TDR Steam** which is integrable into Arduino UNO, with a multitude of integrated sensors and actuators.
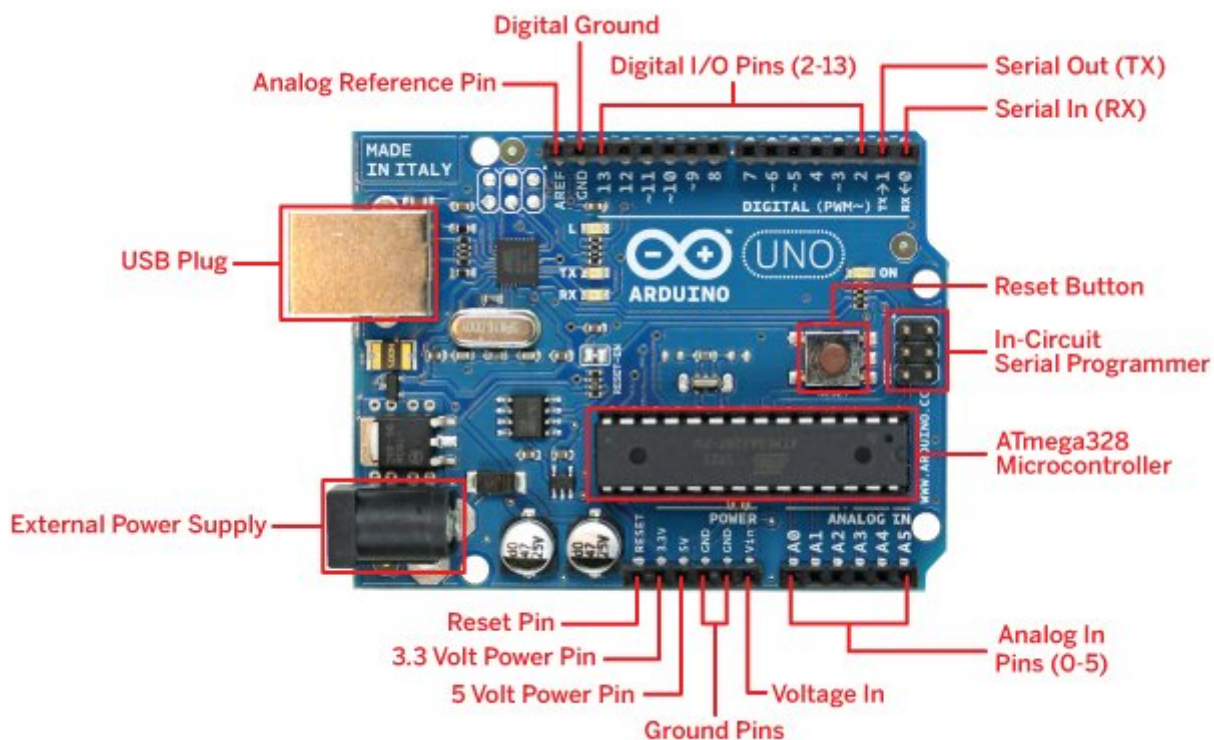
| | Sensor/Actuator/Module |
|---|---|
| 1 | Two pushbuttons (SW1, SW2) |
| 2 | Two LEDS (Blue Led3 and Red Led4) |
| 3 | Led RGB |
| 4 | DHT11 Temperature and Humidity Sensor |
| 5 | Buzzer |
| 6 | Two digital outputs/inputs |
| 7 | Infrared receiver module (IR) |
| 8 | Rotary potentiometer module |

| 9 | Light sensor (LDR) |
|---|---|
| 10 | Temperature sensor (LM35) |
| 11 | I2C Interface |
| 12 | Analogic input |
| 13 | Bluetooth and Wifi connection |
| 14 | Reset button |

# Controller: Arduino board

Arduino UNO is an **electronic card** that integrates a microcontroller and a set of **input and ouptut connections pins** that allow, through a certain program, to **interact** with the physical environment through electronic sensors and actuators. The sensors are connected to the input pins and the actuators to the output pins.

Information extracted and translated from here

Picture extracted from here

# Programming Arduino board with Arduinoblocks

Arduinoblocks is a software created by the teacher Juanjo López. Thanks to its graphical environment, it facilitates the programming of Arduino boards at all levels.

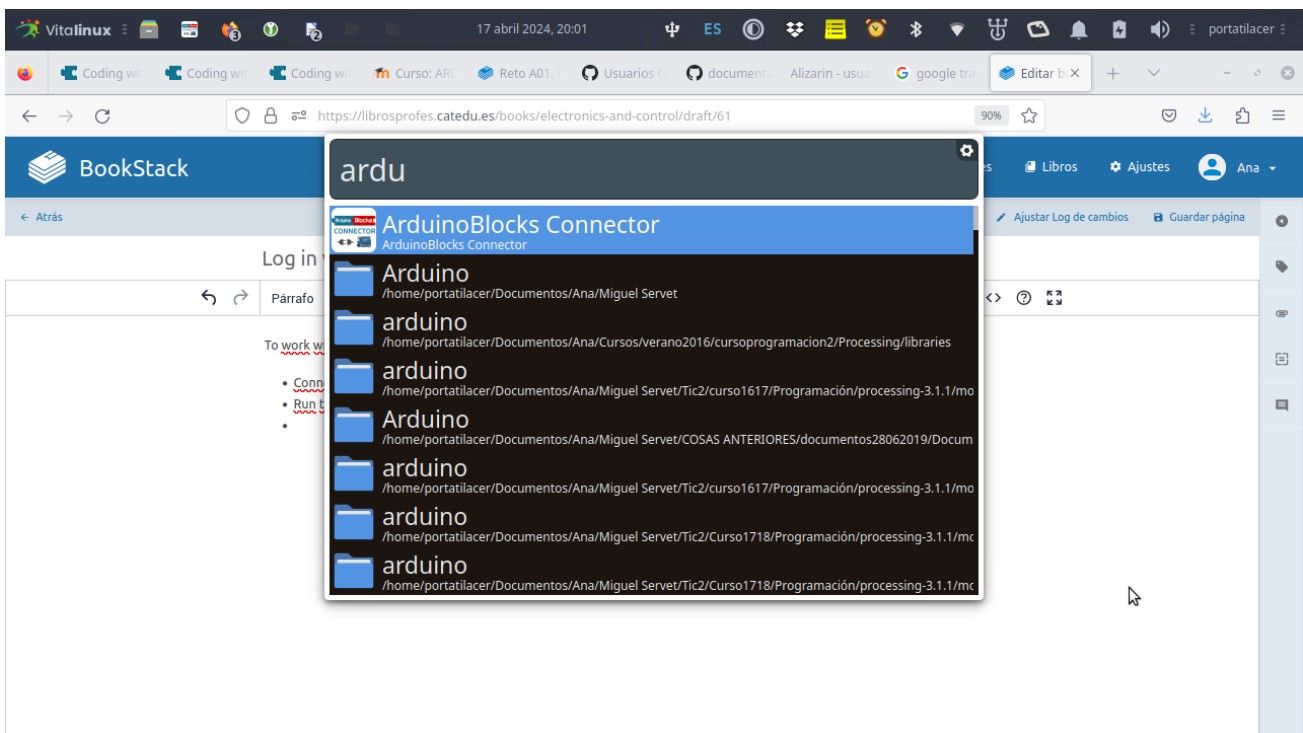It is not free software because the creator does not make public the code , but it can be used freely.

imagen.png
image not found or type unknown

Challenges to create with Arduino and Imagina TDR (in Spanish)

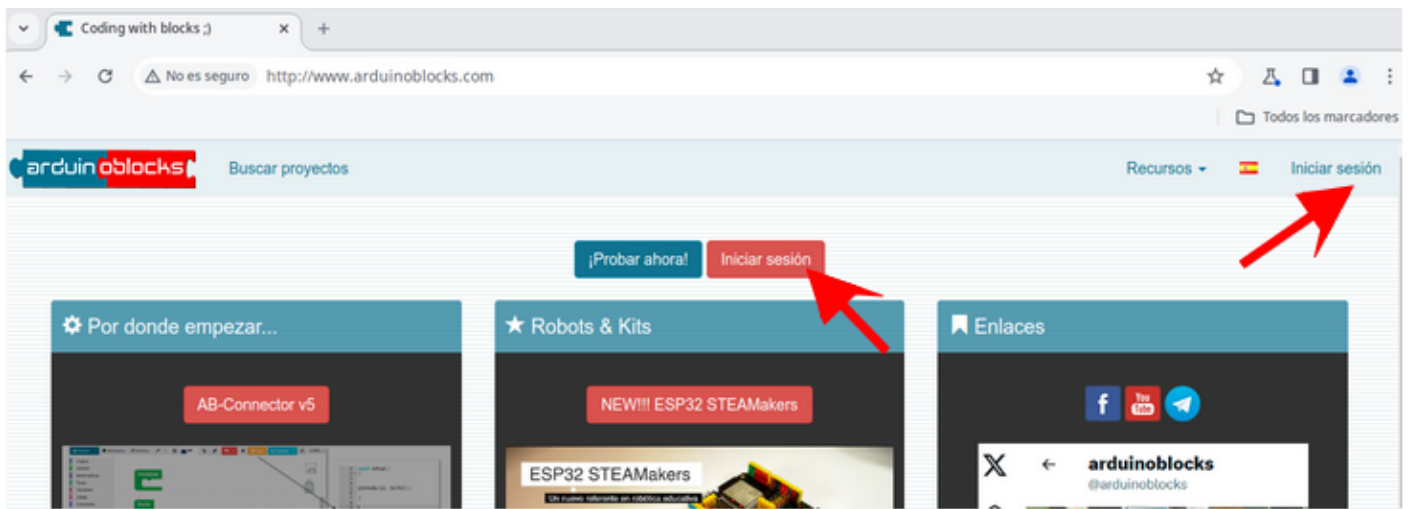# Log in with Arduinoblocks as a Student and joining a project

To work with Arduinoblocks as a student there is a series of steps to follow:

- Connect the Arduino UNO board to the computer.
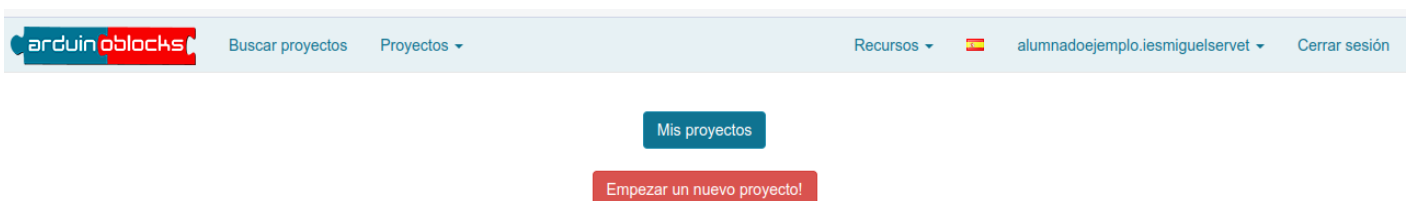- Run the program Arduinoblocks connector.



This program has to be open all the time we are using the Arduino.

- The browser opens with the arduinoblocks site. Click on the **Iniciar sesión** button

- Introduce the keys your teacher has given to you. You will be able to change the password later in your profile.
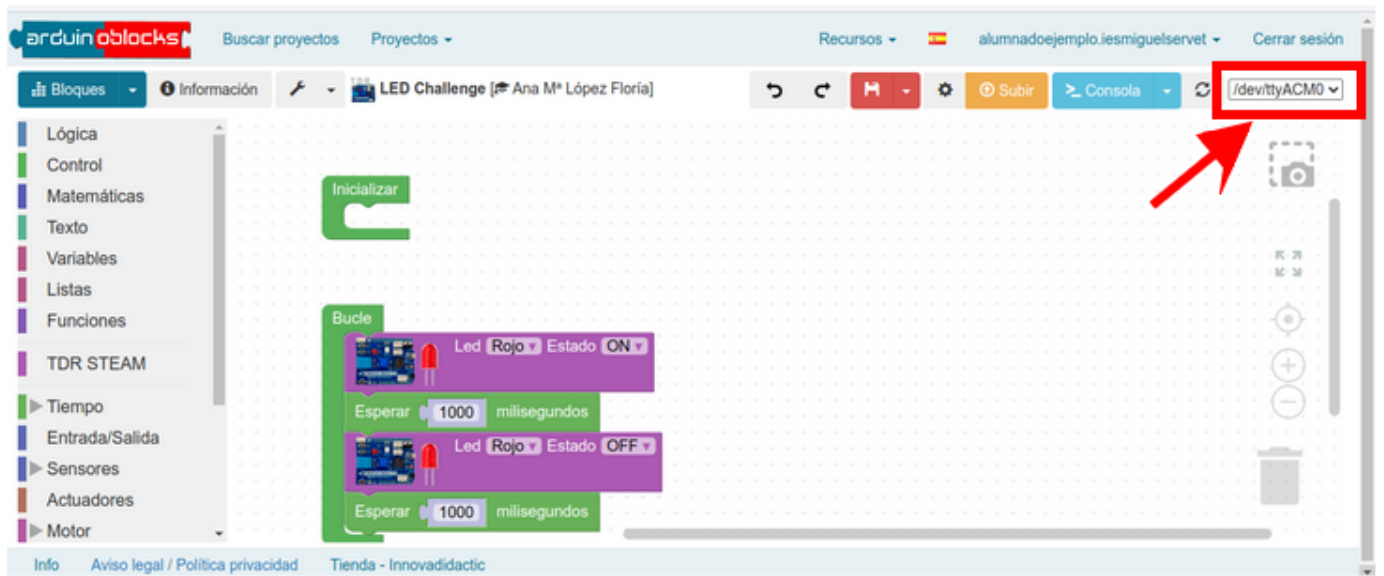

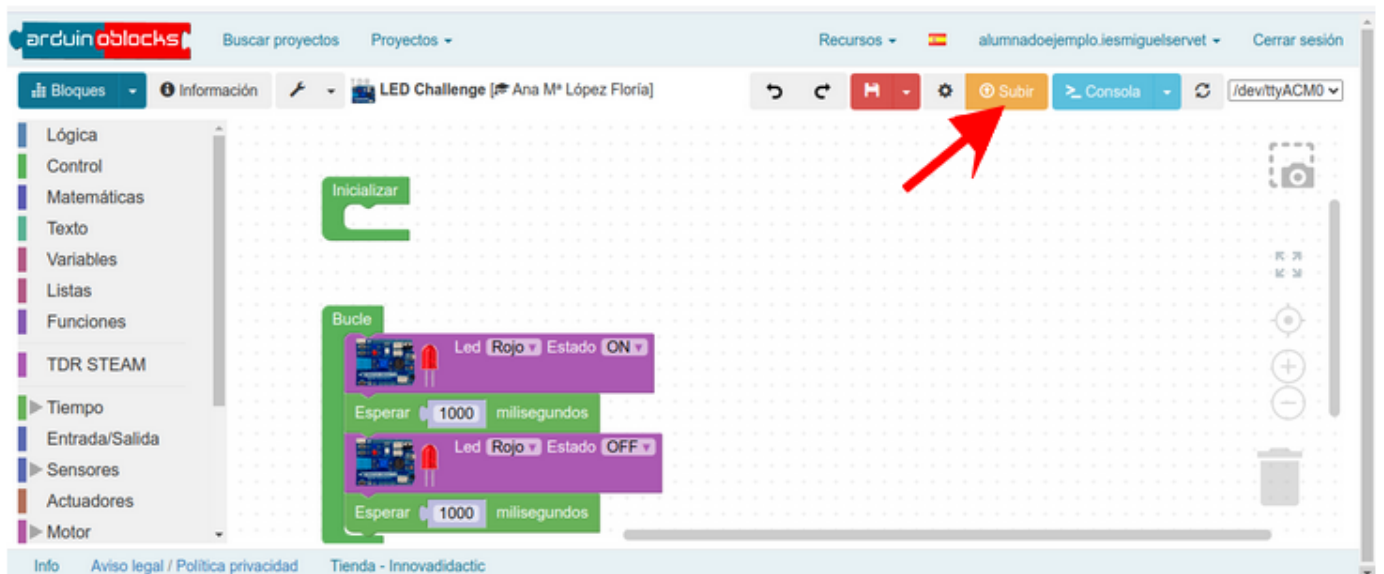
- Click on Empezar un nuevo proyecto

- Introduce the code of the project your teacher wil have provided to you and click on **Unirme...**



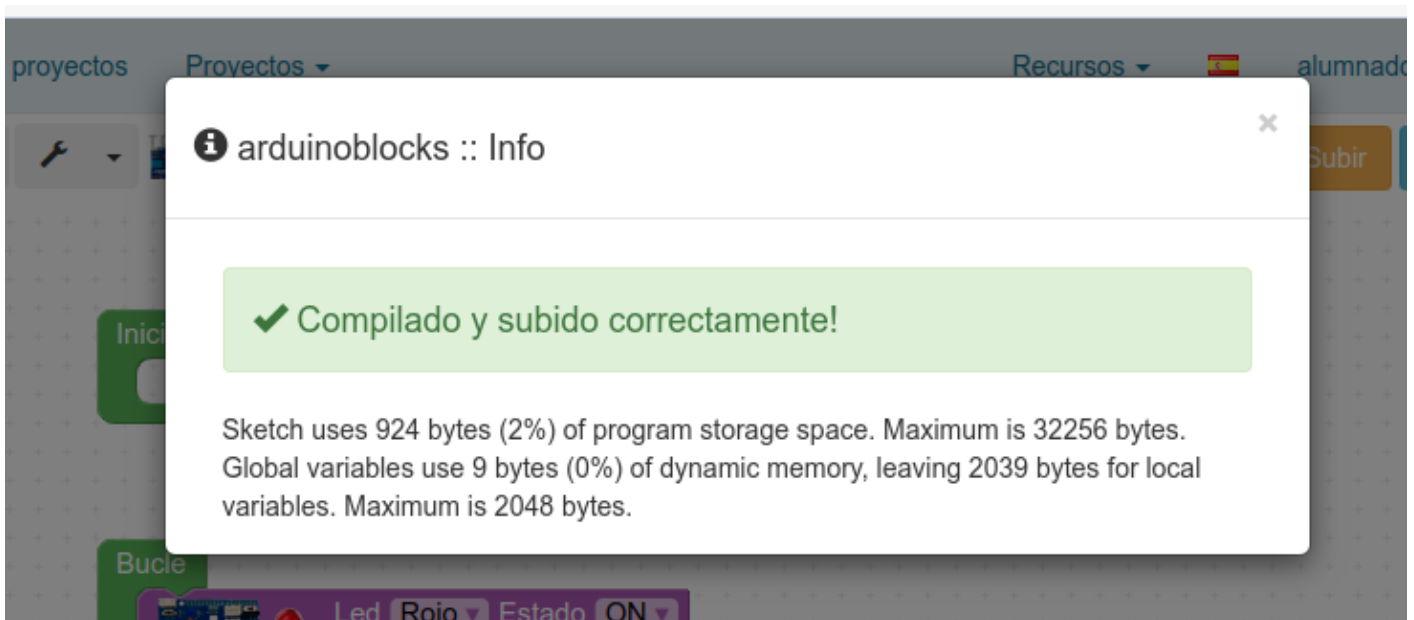- So now you can start working on your project



- First thing you have to do is checking that the Arduino Shield is well connected. You can see it at the top right of the screen. You have to see something similar to this:

- Then it is time to upload the program to the Arduino to check it works. To do that you have to click on the Subir button.



- You will see lights on the arduino shield and if everything is ok, a confirmation message.

ℹ arduinoblocks :: Info     ✕

✔ Compilado y subido correctamente!

Sketch uses 924 bytes (2%) of program storage space. Maximum is 32256 bytes.
Global variables use 9 bytes (0%) of dynamic memory, leaving 2039 bytes for local
variables. Maximum is 2048 bytes.

- From this moment on, you will see the program working on the shield.